

A Guide to Developing Literacy Practices in Science

Engaging in Socioscientific Argumentation: Increasing Oxygen in the Blood

Strategy Guide

The Learning
Design Group



THE LAWRENCE
HALL OF SCIENCE

Earth Science

Grades 6–8

Overview

What's in this guide? This strategy guide introduces students to writing a socioscientific argument, which is based on scientific evidence and also brings in students' value-based opinions. This guide includes a plan for introducing students to writing a socioscientific argument through reading the article *Blood Doping: Messing with Metabolism to Win Races*, which explains the effect that the controversial practice of blood doping has on an athlete's metabolism.

Why have students make socioscientific arguments? Argumentation in science involves complex critical thinking and reasoning based on scientific evidence. Making socioscientific arguments helps students bring these skills, as well as the scientific ideas they have learned, to bear on issues outside the classroom. This helps students see that science is relevant to daily life and promotes evidence-based decision-making.

How This Fits Into Your Science Curriculum

This strategy guide can be used as a culminating activity in a unit that focuses on the way in which matter gets to the body's cells and on the transfer of energy on a cellular level. The *Blood Doping: Messing with Metabolism to Win Races* article reinforces the concept that an increase in oxygen results in an increased capacity for energy release through cellular respiration. In order for students to apply their understanding of the relationship between red blood cells, glucose, oxygen, and energy release, they should know that oxygen and glucose are delivered to the bodies' cells through the bloodstream. Students will also need prior exposure to the process of cellular respiration as a reaction that takes place in the mitochondria inside the cell. In addition, students should be familiar with the basics of scientific argumentation—they should know that scientists make claims to answer questions about how the natural world works and use scientific evidence to support their claims.

Addressing Standards

NEXT GENERATION SCIENCE STANDARDS

Disciplinary Core Ideas

LS1.C: Organization for Matter and Energy Flow in Organisms: Within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules, to support growth, or to release energy.

Crosscutting Concepts

Structure and Function: Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among its parts; therefore, complex natural and designed structures/systems can be analyzed to determine how they function.

Science and Engineering Practices

Engaging in Argument from Evidence: Use an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.

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COMMON CORE STATE STANDARDS FOR ELA/LITERACY

Reading Standards for Literacy in Science and Technical Subjects 6–12

RST.6–8.1: Cite specific textual evidence to support analysis of science and technical texts.

Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects 6–12

WHST.6–8.1b: Write arguments focused on discipline-specific content. Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources.

Science Background

Metabolism is the process of **matter** entering **cells**, reacting, and releasing **energy** in order for the body to grow, move, and repair. Red blood cells are responsible for carrying **oxygen molecules** from the lungs to every cell in the body. The bloodstream is also responsible for carrying **glucose** (from starch in the foods we eat) from the small intestine to every cell in the body. In the **mitochondria** of cells, oxygen combines with glucose in a chemical reaction called **cellular respiration**, which releases energy. A person's metabolism is constantly working in all the cells of the body. The rate of energy release can be increased naturally by athletic training—this increases the number of mitochondria per cell, promotes a larger lung capacity, and increases the heart rate. However, in the highly controversial practice of blood doping, an athlete gains a competitive edge by saving her own oxygenated blood and injecting it into her circulatory system before or during an athletic competition. Thus, the amount of available blood cells is increased, and more oxygen can be delivered to the cells. This increases the release of energy and improves an athlete's performance. An increase in red blood cells can also happen naturally when an athlete trains at high altitudes where oxygen is scarce.

Getting Ready: Day 1

1. Prepare to model finding key ideas in the article *Blood Doping: Messing with Metabolism to Win Races*. Make sure you have a way to project the article during class.
2. Make one copy of the article and one copy of the Writing Notes from Text copymaster for each student.
3. On the board, write "What did you learn about blood doping from reading the article?" and "How does blood doping improve an athlete's performance?"

Before Beginning the Instructional Sequence

1. Distribute one copy of the article and one copy of the Writing Notes from Text student sheet to each student. Have students read through the article once.
2. Using methods you have established with your class, encourage students to read thoughtfully and carefully and to make a record of their thinking by annotating the text with questions, comments, and connections as they read.
3. For more information about ways to engage students in an initial reading of *Blood Doping: Messing with Metabolism to Win Races*, see the Engaging with Text Through Active Reading: Wind Currents strategy guide.

Reviewing the Article (10 minutes)

1. **Pose question.** Ask students to use the information in the article to answer the

question on the board: *What did you learn about blood doping from reading the article?*

2. **Students respond.** Allow a few minutes for students to think about and record their responses to this question individually. Alternatively, you could ask students to discuss their ideas with a partner. You may also want to have students identify an interesting question or comment they wrote as an annotation on their article.
3. **Lead students in a discussion.** Call on students to share their ideas about what they learned from reading the article. Accept all responses and encourage students to refer back to the text to support their ideas as needed.
4. **Set context.** Say, "**Since blood doping is a controversial topic, many people have differing opinions about whether it should be allowed. Soon, you'll make an argument about this topic. First, we should make sure that we understand how blood doping works. Then, you will be able to use this information to weigh whether or not you think it should be allowed.**"
5. **Set purpose for rereading.** Explain that to figure out how blood doping works, students will return to the text to reread specific sections that will help answer the question *How does blood doping improve an athlete's performance?* Once students find information that helps answer this question, they will write notes to record what they found.

Rereading for a Purpose (20 minutes)

1. **Model finding a relevant section of the text.** Project the article. Say, "I will look for evidence to help answer the question *How does blood doping help improve an athlete's performance?* I will use subheadings to help me locate information about blood doping." Point out and read aloud the subheadings in the article. Say, "I think the 'What Is Blood Doping?' section will help me answer the question, so I will reread this section carefully."
2. **Students reread and write notes.** Have students use the subheadings to decide which portions of the article to reread. Then, students should reread the "What Is Blood Doping?" and "How Blood Doping Works in the Body" sections and record the evidence from the text and diagrams that help explain how blood doping improves an athlete's performance. Encourage students to work in pairs and discuss ideas as they find them in the text.
3. **Circulate and offer support.** As students read and write notes, circulate and offer support to those who may have trouble identifying specific sections of the text to return to for evidence. Make sure students understand that they do not have to reread the entire text. Instead, they should select sections of the text to reread. Encourage students to think about what is depicted in the visual representations as well.

Discussing Blood Doping (15 minutes)

1. **Students share.** Have students discuss evidence they found in the text about how blood doping improves an athlete's performance. Encourage students to be as specific and thorough as possible in their explanations of how blood doping works in an athlete's body. You can ask questions such as:
 - How does the body of an athlete who has used blood doping function differently than that of an athlete who has not used blood doping?
 - How does blood doping help the body get more energy?
 - How are high-altitude training and blood doping similar?
2. **Review key ideas.** Make sure students understand that blood doping adds oxygen to the body, which affects cellular respiration.

Discuss why an athlete would be concerned about cellular respiration and the release of energy in the body. You may want to return to the section on high-altitude training ("A Legal Alternative") for another example of how an increase in oxygen would increase the rate of cellular respiration in the body and then cause an increased release of energy in the body.

Getting Ready: Day 2

1. Make one copy of the Template for Writing a Socioscientific Argument copymaster for each student.
2. On the board, write "Should blood doping be allowed?" Also write two possible claims: "Blood doping should be allowed." and "Blood doping should not be allowed."

Introducing Socioscientific Argumentation (15 minutes)

1. **Introduce the question.** Remind students that now that they understand how blood doping affects an athlete's body, they will consider the question *Should blood doping be allowed?*
2. **Introduce two possible claims.** Point out that two potential answers to this question are:
 - Blood doping *should* be allowed.
 - Blood doping *should not* be allowed.

Explain that students will have to decide which claim they want to support with their arguments.

Types of Argumentation

Scientists engage in argumentation in order to construct the best possible understanding of how the world works, based on scientific evidence. Of course, science has a huge impact on all areas of society, and people are increasingly called upon to use scientific understanding and evidence to make decisions about a variety of topics. In this guide, students gather evidence from the article they have read to explain how athletes improve performance through blood doping. Students then use this evidence to make a judgement about whether or not they think blood doping should be allowed. From this, students write a socioscientific argument, which is based on scientific evidence and also brings in values and opinions. Understanding the distinction between a scientific and a socioscientific argument can help students understand the practice of scientific argumentation and, simultaneously, see how science is relevant to people's lives.

3. **Project Two Types of Arguments.** Explain that this argument about blood doping is different than other scientific arguments because it is a *socioscientific* argument. Whereas scientific argumentation aims to explain how the natural world works, socioscientific argumentation is about making the best possible decision about an issue, informed by scientific evidence as well as opinions and/or values. Point out that students will need to use both scientific evidence (which they recorded as they read the article) and their own values or opinions to back up their claims.
4. **Project Should Soda Be Banned in Schools? Claim #1.** Explain that this is one example of a socioscientific argument that answers the question *Should soda be banned in schools?* Read aloud Claim #1, "**Soda should be banned in schools.**" as well as the two arguments that support this claim. Have students discuss what they notice about the two arguments.
5. **Point out the use of scientific evidence in a socioscientific argument.** Make sure students notice that the first statement includes only opinions, while the second includes scientific evidence. A complete argument supporting the claim would include both statements.
6. **Project Should Soda Be Banned in Schools? Claim #2.** Again, have students discuss what they notice. Point out that, regardless of whether the writer supports or does not support the banning of soda in schools, the argument is more effective when it also includes scientific evidence as support for the claim and that all the evidence included backs up the claim the writer has chosen.

Writing an Argument (20 minutes)

1. **Distribute writing template.** Distribute one copy of the Template for Writing a Socioscientific Argument student sheet to each student.
2. **Select a claim.** Explain that when writing a socioscientific argument, students should always try to choose the claim that is most strongly supported by both their ideas, based on values, *and* scientific evidence. Have students select the claim they believe to be the strongest and record this on their templates. **Note:** If most students seem to be in support of one of the claims, you may decide to assign a few students to the other claim to encourage a deeper

discussion around blood doping and to challenge some students to write about the other side of the argument.

3. **Encourage writing about both sides of the argument.** Point out that students might consider explaining why the claim they did *not* select is less supported by scientific evidence. They could do this by explaining why the other claim is not a good choice in comparison. For instance, if they argue that blood doping *should* be allowed, then they might use the support that high-altitude training is legal, involves the same process of speeding up cellular respiration in the body, and has the same side effects.
4. **Provide language for students to use.** Encourage students to use the sentence starters provided on the writing template. These sentence starters can help students craft their arguments, making a claim that is supported by both opinion *and* scientific evidence.
5. **Students write.** Provide time for students to write their arguments. Support individual or small groups with their writing as necessary. You may need to help students make the connection between their opinions about allowing blood doping and using scientific evidence to support their opinions. For instance, if they believe blood doping should *not* be allowed because it is dangerous for athletes, encourage students to use scientific evidence to explain *why* blood doping is a dangerous practice.

Discussing Arguments (10 minutes)

1. **Students share.** Have volunteers discuss their ideas based on their written arguments.

Supporting English Language Learners

Language models help ELLs engage in science discussions and writing, which can be a challenge if ELLs are unfamiliar with scientific language. For students who may have difficulty converting their evidence into written paragraphs, you may wish to provide an example of a strong argument about a topic with which students are familiar. Point out the claim and explain how the scientific evidence is used to support the claim. Highlight words and phrases in the argument that signal connections between the evidence and the claim. Encourage students to refer to your example to help with the transitions and structure of their written arguments.

Encourage all students to share their opinions and make connections to scientific evidence to support their opinions.

2. **Encourage respectful debate.** Encourage students to respond directly to one another's ideas, using phrases such as: *I disagree with you because . . .* or *I agree with you because . . .*. Students may also build on or counter one another's evidence.
3. **Debrief.** Point out that discussing socioscientific arguments is something that scientists do. They may disagree with one another and make different claims in an effort to answer the same question. However, the discussion is always centered around scientific evidence, even if there are differing opinions about how that evidence should be applied to address an issue.

Connecting to Standards

Writing scientific arguments is an approach that capitalizes on the overlap between the science practices in the Next Generation Science Standards (NGSS) and the Common Core State Standards (CCSS) for English Language Arts. Writing arguments to support claims (NGSS Science Practice 7: Engaging in Argument from Evidence) includes supporting claims with logical reasoning and relevant evidence that demonstrate an understanding of the topic or text (CCSS.ELA–Literacy.WHST.6–8.1). In addition, the ability to clearly state or summarize a scientific concept orally or in writing (NGSS Science Practice 8: Obtaining, Evaluating, and Communicating Information) guides students in citing specific textual evidence to support central ideas (CCSS.ELA–Literacy.RST.6–8.1).

Generalizing This Practice

Engaging in socioscientific argumentation—and understanding the distinctions between socioscientific arguments and scientific arguments—is an approach that can be used throughout your science curriculum with a variety of topics. A benefit of this approach is that it can motivate students to carefully think through how evidence supports or does not support a claim. Socioscientific argumentation provides a rich context for encouraging students to explain their reasoning clearly. In addition, considering both sides of an issue encourages flexible, evidence-based thinking. Finally, discussing a relevant topic of interest is motivating for students and can encourage them to make connections to science and their everyday lives.

Preparing Your Topic and Evidence

1. **Identify a relevant question.** Identify a topic or social issue that is relevant to the content you are teaching. Be sure that the topic or question will require students to use scientific evidence and ideas that they have been learning and not be centered only around opinions or values.
2. **Write question and identify claims.** Create a question as well as possible claims that answer this question. These should address a decision that needs to be made, using scientific evidence as well as value-based ideas. Sometimes, you will want students to consider possible claims and have everyone conclude that one claim is better supported than the other claims. At other times, you might want students to consider a range of possibilities that seem equally valid scientifically.
3. **Define evidence.** Find or create evidence that students can use to support the claim(s), along with their opinions. Ideally, this evidence should come from firsthand investigations, texts, and other sources with which students are familiar. Evidence can consist of text and/or images.

Teaching the Instructional Sequence

1. **Introduce the social issue or topic.** Provide students with necessary background knowledge and/or different viewpoints central to the topic. Explain that because they will be making a socioscientific argument, they will need to consider their opinions and values and also find scientific evidence to support their claims.
2. **Review the difference between scientific and socioscientific arguments.** Discuss the two kinds of arguments, using examples as needed. Make sure students understand that they will be making socioscientific arguments.
3. **Introduce the question and possible claims.** Introduce the question and have students discuss their initial ideas and opinions about what should be done about the problem or situation.
4. **Students explore evidence.** Provide students with time to gather, examine, evaluate, and discuss the evidence with their peers. You may wish to include a graphic organizer into which students can record the evidence they gather that helps support their ideas.
5. **Select claims.** Have students weigh the evidence and select a claim that they feel best addresses the evidence and their opinions. Encourage students to think about all sides of the issue.
6. **Have students write socioscientific arguments.** Provide time for students to write arguments in support of the claims they selected, using evidence as well as their opinions to support their claims. You may wish to include a writing template or sentence starters for students to use while writing their arguments. Circulate and offer help as students write.
7. **Allow time for discussion of socioscientific arguments.** Once students have constructed their arguments, have them use these as they participate in a discussion. You can conduct this as a whole-class discussion or have groups of four or five students discuss. Encourage all students to participate in the discussions and to share their ideas respectfully.

Name: _____

Date: _____

Writing Notes from Text

Question: Why do some athletes use blood doping?

Notes	Page number

Date: _____

Template for Writing a Socioscientific Argument

Directions: Use the sentence starters in the table below to help you write a socioscientific argument. Make sure to include scientific evidence as well as opinions in your argument.

Sentence starters for opinions	Sentence starters for scientific evidence
<ul style="list-style-type: none"> • I believe that blood doping <i>should</i> be allowed because • I believe that blood doping should <i>not</i> be allowed because 	<ul style="list-style-type: none"> • When an athlete blood dopes, • Blood doping can cause • Blood doping improves an athlete's metabolism by

Question: Should blood doping be allowed?

Claim: _____

This image shows a single sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

Two Types of Arguments

Scientific argument	Socioscientific argument
<ul style="list-style-type: none">• The purpose is to answer a question about how the natural world works.• Provides scientific evidence that supports the claim.	<ul style="list-style-type: none">• The purpose is to answer a question about what should be done, taking science knowledge into account.• Provides scientific evidence that supports the claim.• Also includes opinions or values that support the claim.

Should Soda Be Banned in Schools?

Claim #1: Soda *should* be banned in schools.

Using only **opinions** to support the claim:

A school's most important job is to keep students safe and healthy. Therefore, schools should have the right to ban anything that can harm students.

Using **scientific evidence** to support the claim:

Studies show that children and adolescents who drink large amounts of soda can increase their risk of diabetes. Studies of people's eating habits show that it is hard to resist sweet foods and drinks. Therefore, soda should be banned in schools.

Should Soda Be Banned in Schools?

Claim #2: Soda should *not* be banned in schools.

Using only **opinions** to support the claim:

Students have a right to make their own choices about what to eat and drink, whether those choices are good or bad. Therefore, soda should not be banned in schools, since students can choose for themselves whether or not to drink it.

Using **scientific evidence** to support the claim:

Doctors and scientists agree that as long as students eat a well-balanced diet—including protein, starch, and lots of fruits and vegetables—a small amount of sugar is okay. Children and adolescents who drink soda can increase their risk of diabetes, but only if they drink large amounts of soda. Students can safely have small amounts of soda, so soda should not be banned in schools.

BLOOD DOPING: MESSING WITH METABOLISM TO WIN RACES

To win international bicycle races, you can't just be in good physical shape—you have to be in **AMAZING** shape. Your metabolism has to work like a well-oiled machine. The world's top cyclists have their muscles and body systems perfected so they can process oxygen, glucose, and amino acids better than almost any other humans on Earth.



Wikimedia/PLameiro

A Cyclist's Metabolism

What's so special about a top cyclist's metabolism? Cyclists' muscle cells contain unusually high numbers of mitochondria, where glucose and oxygen combine to release energy. That means their muscles can release more energy than most people's muscles. To bring in more oxygen, top cyclists breathe hard—up to 75 breaths per minute. To bring in more glucose, they eat lots of carbohydrates, even while they're riding! Cyclists often slurp down special gels filled with glucose while they're on their bikes, one hand on the handlebars, and the other popping open the gel. To transport these molecules more quickly to their muscle cells, their hearts beat fast—up to 200 beats per minute.

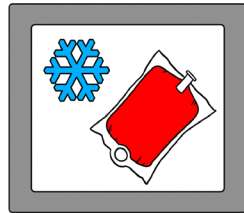
The problem for top cyclists is that even all that isn't enough. Every cyclist in the race is in perfect physical shape, and everyone is looking for an edge to help them win. Sadly, that means that some decide to break the rules . . . not by taking a shortcut on the racecourse or breaking a competitor's bike, but by messing with their own metabolism. This is known as blood doping—injecting yourself with extra blood. Blood doping is illegal, but some cyclists do it secretly to improve their performances. The most famous example is Lance Armstrong, known as the best cyclist in the world until he admitted in 2013 to illegal blood doping.

What Is Blood Doping?

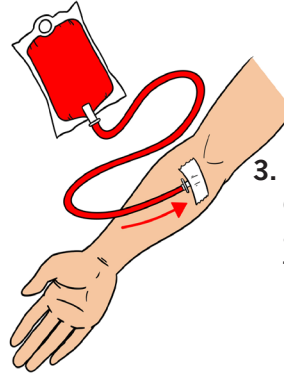
In most cases of blood doping, an athlete drains some of his or her own blood, chills the blood to keep it fresh, and stores it for several weeks or even months. The athlete's body naturally works to replace the lost red blood cells. Then, just before a competition, the athlete injects the stored blood back into his or her body. Injecting blood increases the number of red blood cells in the athlete's body.

BLOOD DOPING

1. Athlete drains some blood.



2. Athlete stores the blood for later.



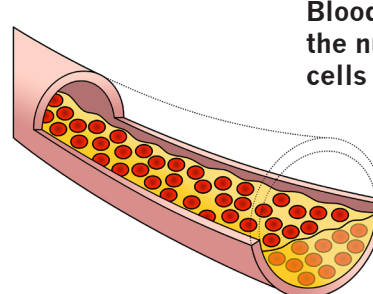
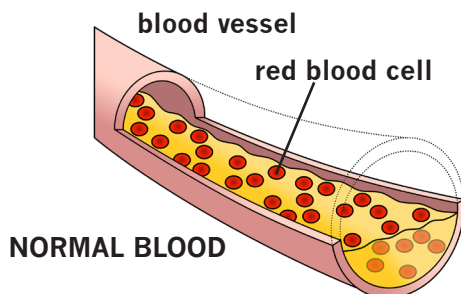
3. Before a competition, athlete injects the stored blood back into his body.

How Blood Doping Works in the Body

Red blood cells carry oxygen from your lungs to every cell in your body, including the muscle cells, so they are important to athletic performance. There is a limit to how much oxygen your blood can carry at any one time. The red blood cells fill up with oxygen in the lungs and then are pumped out to the cells where they drop off the oxygen and return to the lungs. Each red blood cell can only carry a certain amount of oxygen. Once your red blood cells are full, you can't get any more oxygen into your blood with that breath, no matter how hard you breathe or how much air you take in.

Blood doping improves the body's ability to carry oxygen by increasing the number of red blood cells in the circulatory system. These additional red blood cells can carry extra oxygen. The extra oxygen, delivered to the body's cells, can help an athlete perform better for a longer time, without becoming tired. This happens because oxygen is necessary for the release of energy in the body.

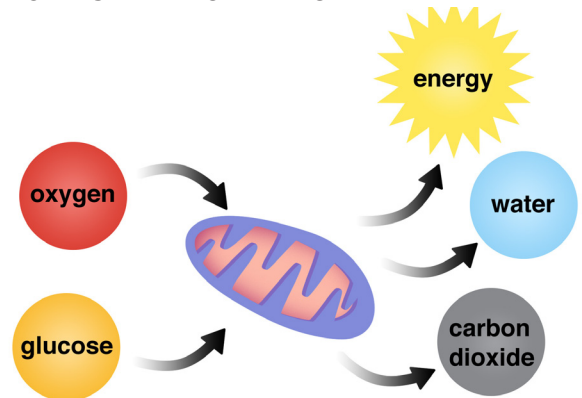
BLOOD DOPING AND RED BLOOD CELLS



Blood doping increases the number of red blood cells in the body.

The body's cells release energy through a chemical reaction called cellular respiration. For cellular respiration to happen, cells need both oxygen and glucose. Oxygen enters the body through the respiratory system and is then delivered to all the cells of the body by the circulatory system. At the same time, the circulatory system provides the cells with glucose produced by the breakdown of food in the digestive system. Inside the cells, the glucose and oxygen react to produce carbon dioxide and water, releasing energy for the body. More oxygen in the body means a faster rate of cellular respiration and an increased release of energy.

CELLULAR RESPIRATION



In the parts of cells called mitochondria, glucose plus oxygen combine to make carbon dioxide plus water, releasing energy. This is called cellular respiration.

Catching Blood Dopers

Blood doping is very difficult to detect. Since the body always contains red blood cells, it is difficult to prove that an athlete has injected extra red blood cells. One detection method involves testing the age of the red blood cells in a blood sample. The human body constantly produces new red blood cells to replace cells that have died. Blood doping means injecting stored blood, and the red blood cells in stored blood are older than the new red blood cells constantly being produced in the body. If a blood sample shows an unusually high number of older red blood cells, this is evidence of blood doping.

Dangerous Side Effects

One serious potential side effect of blood doping is that increasing the number of red blood cells also increases the thickness of the blood. This unusually thick blood makes the heart work harder and can even cause heart failure.



High-altitude training has similar effects to blood doping, but it's legal.

Wikimedia/scattata da F.Grifoni per conto di Laura Fortunato (Archila')

A Legal Alternative

There is a legal way for athletes to increase the number of red blood cells in the body: high-altitude training. In the weeks leading up to a competition, some athletes train in the mountains or other high-altitude locations where there is less oxygen in the air. The athlete's body adjusts to the lack of oxygen by producing more red blood cells. High-altitude training has the same effect as blood doping, but is not considered cheating. However, high-altitude training may have the same harmful side effect of increasing the thickness of blood in the body.

About Disciplinary Literacy

Literacy is an integral part of science. Practicing scientists read, write, and talk, using specialized language as they conduct research, explain findings, connect to the work of other scientists, and communicate ideas to a variety of audiences. Thus, the Next Generation Science Standards (NGSS) and the Common Core State Standards (CCSS) alike call for engaging students in these authentic practices of science. Through analyzing data, evaluating evidence, making arguments, constructing explanations, and similar work, students engage in the same communicative practices that scientists employ in their profession. Through supporting and engaging students in science-focused literacy and inquiry activities that parallel those of scientists, students master discipline-specific ways of thinking and communicating—the disciplinary literacy of science. Strategy guides are intended to help teachers integrate these disciplinary literacy strategies into the science classroom.

About Us

The Learning Design Group, led by Jacqueline Barber, is a curriculum design and research project at the Lawrence Hall of Science at the University of California, Berkeley. Our mission is to create high-quality, next-generation science curriculum with explicit emphasis on disciplinary literacy and to bring these programs to schools nationwide. Our collaborative team includes researchers, curriculum designers, and former teachers as well as science, literacy, and assessment experts.



The Learning
Design Group



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