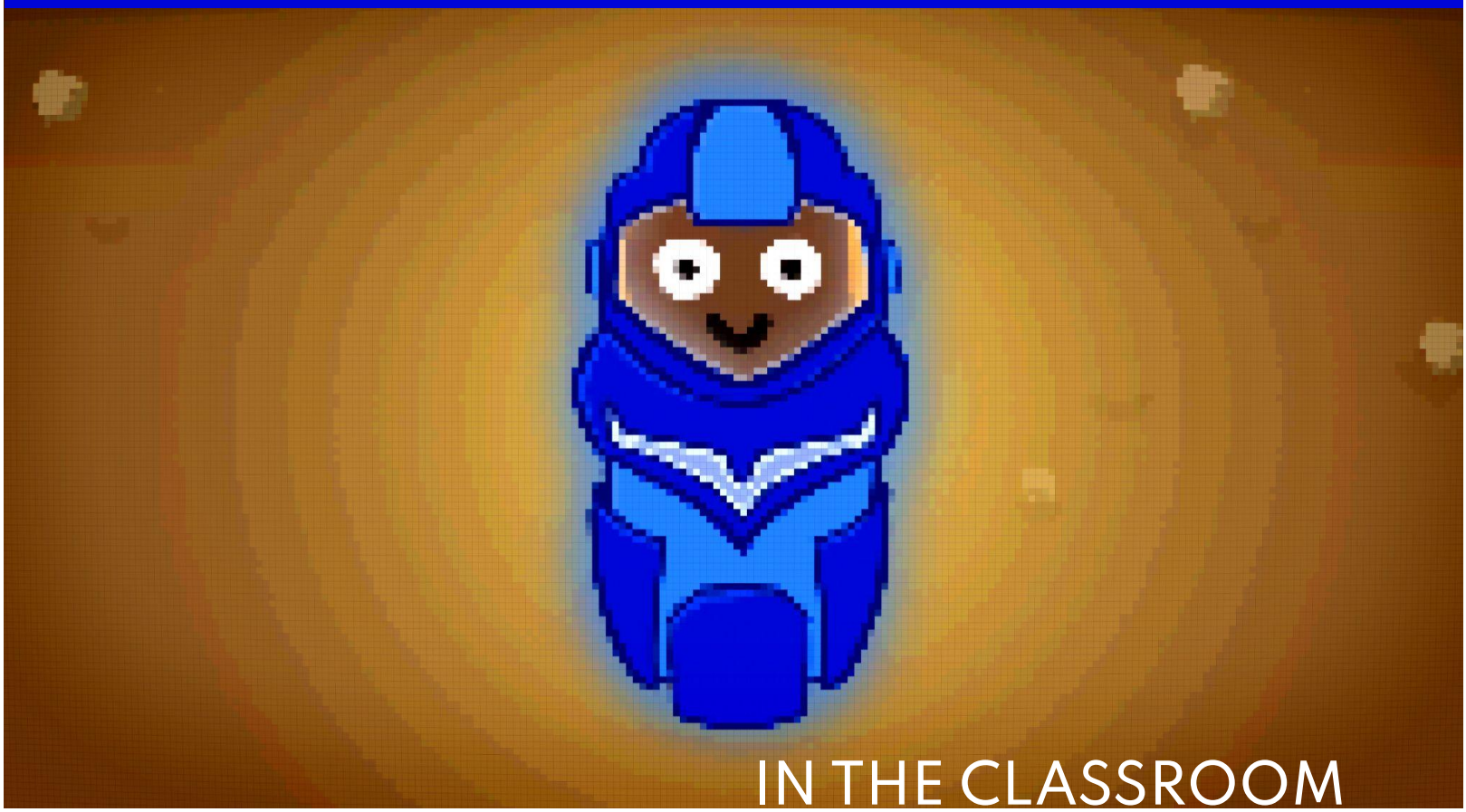
SHORT FILMS ABOUT CHEMISTRY

Mighty Microbes



CLASSROOM LESSON PLAN
GRADES 9–12

Mighty Microbes

CLASSROOM LESSON

Overview

This lesson plan contains student activities, teacher notes, and additional resource suggestions that are intended for use with the *Chemistry Shorts*® film "Mighty Microbes." The film is freely available for viewing online either at the link above or http://chemistryshorts.org. The activities stand alone, with no additional background material needed. The activities are aimed at grades 9–12. Teachers may adjust or extend discussion of the chemistry involved depending on the students' level. The plan is designed for use as a complete package, although teachers may choose individual activities.

The lesson and materials are suitable for both in-person and virtual classrooms.

Classroom Materials

- Method for viewing *Chemistry Shorts*® film "Mighty Microbes" (8 min., 45 sec.)
- Student Activity handouts (paper or digital copies)

Student Activities with Estimated Times

Pre-Class Activity Science: Are We Equal?	(5–10 min.)
In-Class Activity Redox Reactions	(15–20 min.)
In-Class Activity Fixing Nitrogen (including watching the film)	(20–25 min.)
In-Class Activity Microbes (including watching the film)	(20–25 min.)
After-Class Activity Science: Can We Be Equal?	(5–10 min.)

Related Standards

NGSS HS-PS1-2
Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.

NGSS HS-PS2-6
Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.

NGSS HS-LS2-7
Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.

NGSS HS-ESS3-4
Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

CCSS.ELA-Literacy.RST.9-10.5
Analyze the structure of the relationships among concepts in a text, including relationships among key terms (e.g., *force, friction, reaction force, energy*).

CCSS.ELA-Literacy.RST.9-10.7
Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.

CCSS.ELA-Literacy.RST.9-10.4 & 11-12.4
Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9-10 texts and topics/grades 11-12 texts and topics.

CCSS.ELA-Literacy.W.11-12.2
Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.

CCSS.ELA-Literacy.WHST.9-12.2
Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.

Pre-Class Activity Teacher Notes
Science: Are We Equal?

Suggested Extensions

- "Digital Equity Not a Luxury for Students." Intercultural Development Research Association: https://www.idra.org/resource-center/digital-equity-not-a-luxury-for-students/

  Article that discusses a lack of equity in Internet access and digital devices, along with its impact on learning with data related to Texas.

- "Heat Islands and Equity." United States Environmental Protection Agency: https://www.epa.gov/heatislands/heat-islands-and-equity

  Page that describes the heat island effect, where cities and certain areas within them, can have higher temperatures and worse air quality than surrounding areas. It discusses reasons for it, along with potential solutions.

- "The West Needs to Come to Grips with African Fertilizer Needs." Center for Global Development: https://www.cgdev.org/blog/west-needs-come-grips-african-fertilizer-needs

  Blog post that touches on interconnected issues related to farming and food supplies. Includes data on 2021 crop yields for different continents.

Question 1

The U.S. Centers for Disease Control and Prevention (CDC) offers a Vaccine Storage and Handling Toolkit. Although it is extensive (31 pages), portions of it could be useful for sharing with students or for the instructor to read as background information. For example, page 5 shows a vaccine cold chain flow chart, from vaccine manufacture to its administration. Pages 9–10 discuss refrigerators and freezers that are appropriate to use, along with ways to monitor temperature, including a digital data logger. https://www.cdc.gov/vaccines/hcp/downloads/storage-handling-toolkit.pdf

In-Class Activity Teacher Notes
Redox Reactions

Suggested Extensions

- "An Easy Copper Electroplating Demo for Your Redox Unit." ChemEd XChange: https://www.chemedx.org/blog/easy-copper-electroplating-demo-your-redox-unit

  Demonstration where students can quickly see the result of a redox reaction. A paper clip is plated with copper.

- "Greener Redox Lab." Beyond Benign: https://www.beyondbenign.org/lessons/greener-redox-lab/

  Experiment where students can carry out a redox reaction with magnesium ribbon and a solution of zinc chloride. They also calculate theoretical and percent yields.

- "Greening the Blue Bottle." Mr. Home Scientist: https://youtu.be/A-uRXhish9Q

  Video that first shows the classic color-changing blue bottle demonstration often used to illustrate redox reactions, then compares it to a version that is more environmentally friendly.

Questions 1c, 2c

Some instructors use a mnemonic to help students remember which is oxidation and which is reduction. "Leo the lion goes ger" reminds students that Leo: lose electron(s) oxidation and ger: gain electron(s) reduction. Another mnemonic is Oil Rig: "Oxidation is loss, reduction is gain."

Question 2

"Oxidation States (Oxidation Numbers)." LibreTexts Chemistry: https://chem.libretexts.org/Bookshelves/Analytical_Chemistry/Supplemental_Modules_(Analytical_Chemistry)/Electrochemistry/Redox_Chemistry/Oxidation_States_(Oxidation_Numbers)

Read more about the rules for determining oxidation states, with example problems and solutions.

In-Class Activity Teacher Notes
Fixing Nitrogen

Suggested Extensions

- "The End of Haber Bosch.": American Chemical Society. https://youtu.be/dFcaEUj43OY

  This video (13 min., 50 sec.) describes another possible way that nitrogen could be fixed locally. It also provides background on the chemistry and history of the Haber Bosch process.

- "Fritz Haber and Carl Bosch—Feed the World.": The Chemical Engineer. https://www.thechemicalengineer.com/features/cewctw-fritz-haber-and-carl-bosch-feed-the-world/

  This article describes the twists and turns it took for the Haber-Bosch process to give the desired results.

- "The Synthesis of Ammonia from Its Elements.": Fritz Haber's Nobel Lecture, 1920. https://www.nobelprize.org/uploads/2018/06/haber-lecture.pdf

  Haber's lecture when he received the Nobel Prize for the method of producing ammonia from nitrogen and hydrogen ends with a statement that relates to the film "Mighty Microbes": "It may be that this solution is not the final one. Nitrogen bacteria teach us that Nature, with her sophisticated forms of the chemistry of living matter, still understands and utilizes methods which we do not as yet know how to imitate."

Question 2

Classes could first discuss their original answers to this question. Then, they could consider if they would change their answers depending on which location they were farming.

In-Class Activity Teacher Notes
Microbes

Suggested Extensions

- "Station Science 101: Microbiology." NASA: https://www.nasa.gov/missions/station/microbiology-101-where-people-go-microbes-follow/

  Inhabitants of the International Space Station keep a close watch on the microbes that are present there. Science has helped them do it more efficiently and quickly.

- "Wherever You Go, Your Personal Cloud of Microbes Follows." National Public Radio (NPR): https://www.npr.org/sections/health-shots/2015/09/22/441841735/wherever-you-go-your-personal-cloud-of-microbes-follows

  Radio clip that discusses how we all spew our own unique combination of microbes into the space around us.

After-Class Activity Teacher Notes
Science: Can We Be Equal?

Question 3
"MIT Challenges | Designing Solutions for the Climate: Challenge Launch with Prof. Ariel Furst." MIT Curiosity Correspondents: https://youtu.be/PhFH8HaJ_Yc

Dr. Furst presents a challenge to Nord Anglia Education students similar to the one posed in the Student Activity: "Using the power of microbes and chemistry, can you turn pollutants into something beneficial?"

Name _____ Date _____

Pre-Class Activity
Science: Are We Equal?

1. Consider the last time you had an immunization at a clinic or doctor's office. Typically, medical staff bring the vaccine to you, ready in its syringe. Have you thought about what specialized needs the vaccine has during the time between when it's made to when it's injected?

a. What specialized needs do you think the vaccine has when it is:

Transported from where it is made to the doctor's office?	
Stored at the doctor's office before use?	
Injected?	

b. What if the vaccine were being used in a location with very limited resources? What are potential obstacles to the specialized needs you listed in part a?

Transported from where it is made to where it will be used?	
Stored before being used?	
Injected?	

Name _____ Date _____

Pre-Class Activity
Science: Are We Equal? (continued)

2. In the film "Mighty Microbes," Dr. Ariel Furst discusses her laboratory's focus on energy equity. She describes it as "the concept that marginalized and disadvantaged groups have often been left out of technology." She adds, "And so it's our job as researchers to develop accessible, affordable technologies for them."

a. Describe how the idea of energy equity could relate to:

i. Cooling a space

_____

_____

_____

ii. Farming a space

_____

_____

_____

b. What could potentially make each situation more accessible and affordable?

i. Cooling a space

_____

_____

_____

ii. Farming a space

_____

_____

_____

Name _____ Date _____

Pre-Class Activity
Science: Are We Equal? (continued)

3. Three areas are listed above: vaccinations, cooling, and farming. Choose a different area or product, then consider its energy equity. What has science already accomplished in this area? What could it do in the future to make it more accessible and affordable to everyone in the world? Examples include: environmental sensors, internet access, transportation, renewable energy technology, etc.

a. Area: _____

b. Science has…

_____

_____

_____

c. Science could…

_____

_____

_____

Name _____ Date _____

In-Class Activity
Redox Reactions

We depend on something called **redox reactions** to survive. The term redox comes from putting together shortened forms of the words for two types of reactions: reduction and oxidation. For example, plants use redox reactions during photosynthesis to create glucose from carbon dioxide and water, and then the human body uses redox reactions to turn glucose into usable energy.

In a redox reaction, electrons move from one atom or molecule to another.

- If electrons are removed (or "lost"), it is called oxidation.
- If electrons are added, it is called reduction.

1. Another example of a redox reaction is the formation of table salt.

$$2\ Na\ (s) + Cl_2\ (g) \rightarrow 2\ NaCl\ (s)$$

a. Using the atomic number in the periodic table squares, fill in the table below

11
Na
sodium
22.98977

17
Cl
chlorine
35.4527

	# of protons	# of electrons	Overall charge
Na atom			
Cl atom			
Cl_2 molecule			

Name _____ Date _____

In-Class Activity
Redox Reactions (continued)

b. The product NaCl is an ionic compound made up of Na^+ and Cl^- ions. The sodium ion has a +1 charge. The chloride ion has a –1 charge. What had to happen to an electron in the reactants for the two ions to have these charges?

_____

_____

_____

c. Based on the changes in charge, which reactant was oxidized? Which was reduced?

_____

_____

_____

2. Another redox reaction is one that is used to make nitrogen-based fertilizer.

$$N_2\,(g) + 3\,H_2\,(g) \rightarrow 2\,NH_3\,(g)$$

In question 1, the product NaCl has ionic bonding; electrons are transferred. Here, the product NH_3 has covalent bonding; electrons are shared. A method chemists use to help keep track of the transfer of electrons in redox reactions is oxidation numbers. This convention assigns electrons in a covalent bond to the atom that has more tendency to attract electrons to itself (i.e., higher electronegativity). It pictures the charge an atom would have if the compound it is in were ionic.

Name _____ Date _____

In-Class Activity
Redox Reactions (continued)

a. In this reaction, each reactant is combined only with itself. The atoms have the same tendency to attract electrons, so share them equally. Since no electrons would be transferred, the oxidation number for each reactant is 0. Enter it for the reactants in the table below.

	N_2	H_2	→	NH_3	
				H	N
Oxidation number					

b. In the product, which has more tendency to attract electrons to itself, N or H?

_____

c. Based on your answer for b, what would the oxidation number for the hydrogen atom be? Enter it in the table.

d. The oxidation numbers for the atoms in NH_3 should add to zero, since the overall compound is neutral. Since there are 3 hydrogen atoms, what would the oxidation number for the nitrogen atom be? Enter it in the table.

e. Based on the changes in oxidation number, which reactant was oxidized? Which was reduced?

_____

_____

_____

Mighty Microbes

STUDENT ACTIVITY

Name _____ Date _____

In-Class Activity
Fixing Nitrogen

Plants need nitrogen. We might think that since a majority of the air around us is nitrogen, they would have a ready-to-use source. However, plants cannot use it in this form. Instead, the nitrogen must be "fixed" in a form they can use.

1. The film "Mighty Microbes" describes two possibilities for obtaining fixed nitrogen. From watching the film, fill in the table below to summarize each, with its pros and cons.

	Ammonia fertilizer (nitrogen already fixed)	**Microbes that can fix nitrogen**
Source (where its from or how its made)		
Pros		
Cons		

Name _____ Date _____

In-Class Activity
Fixing Nitrogen (continued)

2. Based on the pros and cons you filled in above, which would you choose as a source for fixed nitrogen if you operated a farm? Explain why you chose it.

_____

_____

_____

_____

3. Describe possible solutions researchers are investigating (either from the film or your own searches online) to address the cons of one or both sources.

_____

_____

_____

_____

Mighty Microbes

STUDENT ACTIVITY

Name _____ Date _____

In-Class Activity
Microbes

Microbes are small organisms that cannot be seen with the naked eye. But, even though we can't see them, they are all around us. They can live in soil, in water, in air, and in other creatures, including humans. One common type of microbe is bacteria.

1. Some microbes can be beneficial. For example, the film "Mighty Microbes" describes how microbes can have a positive effect on plants. What can certain microbes do to help plants?

_____

_____

_____

2. The film "Mighty Microbes" discusses stressors that can affect microbes when they are not in their natural environment.

a. What are the four stressors demonstrated in the film?

-
-
-
-

b. What is the result of any or all of these stressors on a microbe?

_____

_____

Name _____ Date _____

In-Class Activity
Microbes (continued)

c. Which of these four stressors could potentially be present in a laboratory where the microbes are being produced for distribution?

_____

_____

d. Which of these four stressors could potentially be present in a field where crops are being grown?

_____

_____

3. In the film, what solution did Dr. Furst use to protect the microbes from stressors?

_____

_____

_____

4. What results were seen when microbes with coatings were used with crops?

_____

_____

_____

Mighty Microbes

STUDENT ACTIVITY

Name _____ Date _____

After-Class Activity
Science: Can We Be Equal?

1. How do the coated microbes described in the film "Mighty Microbes" address energy equity related to food production?

_____

_____

_____

2. What other applications of microbes in the film addressed energy equity related to other areas?

_____

_____

_____

3. Consider your answer for question 3 in the Pre-Class Activity "Science: Are We Equal?" For the area or product you chose, what could microbes potentially be used for in that area?

_____

_____

_____

Chemistry Shorts® is a film series that communicates the breadth and depth of chemistry's impact on humankind in an approachable manner, sponsored by the Camille and Henry Dreyfus Foundation. These films will celebrate the science and the people who share a passion for the vital role chemistry plays in the biggest issues, including human health, renewable energy, the nature of life, sustainability, new materials, and climate change. Each film incorporates a lesson plan that offers ideas for ways they may be incorporated into the classroom. We welcome your feedback at: chemistryshorts.org.

SHORT FILMS ABOUT CHEMISTRY