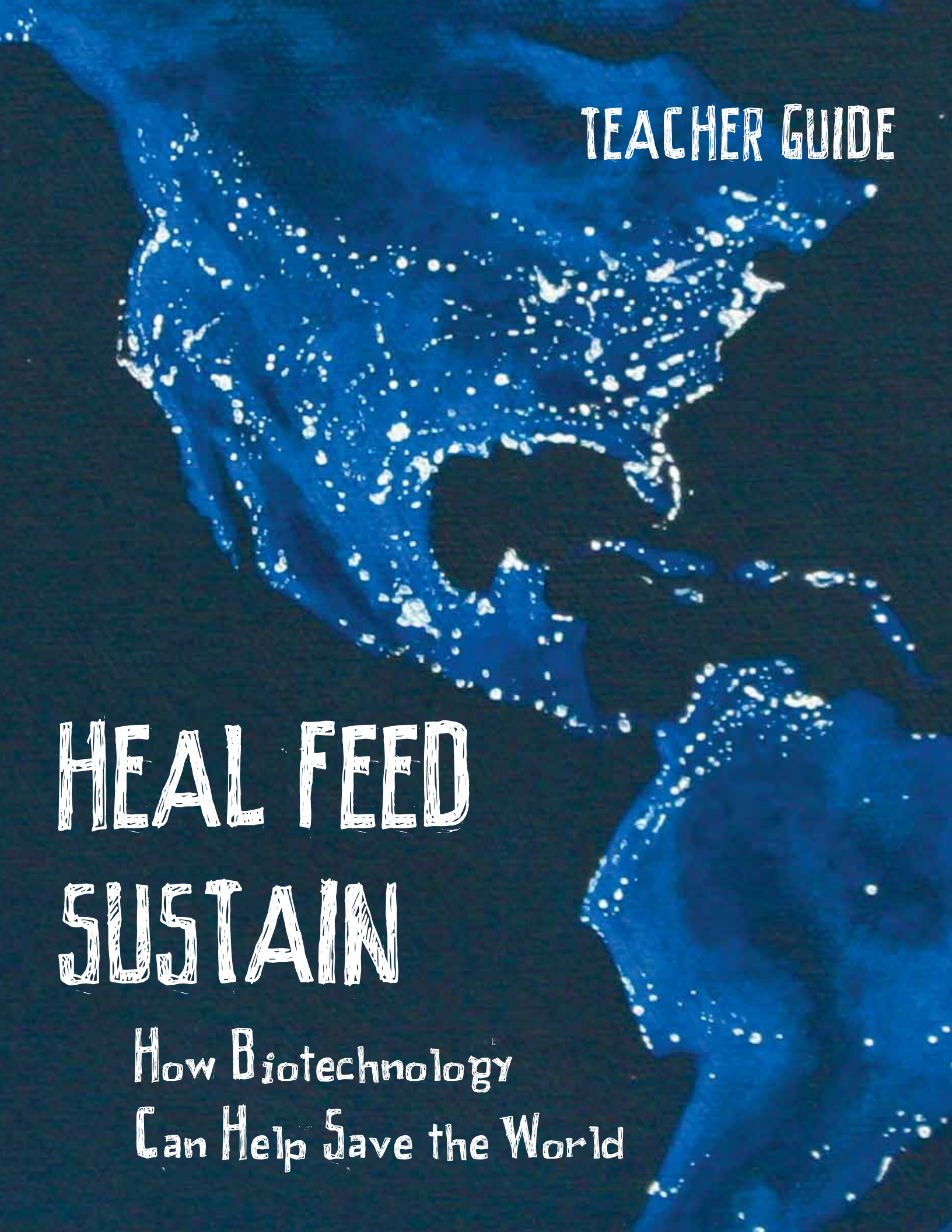




TEACHER GUIDE

HEAL FEED SUSTAIN

How Biotechnology
Can Help Save the World

ABOUT THIS GUIDE



“Heal, Feed, Sustain: How Biotechnology Can Help Save the World” is a 23-minute short film that features real North Carolina students who travel to biotech centers throughout the state to get an up-close look at the amazing research happening there. It has been reviewed and evaluated by more than a dozen middle and high school classes in North Carolina.

We’ve developed this guide as a companion to the short film for middle and high school classes. It features seven student activities, a curriculum connection matrix, general background information about biotech and online activity extensions. Each activity features a page with



teacher instructions and a student page that can be photocopied and distributed.



We urge teachers to use this guide to introduce students to the world of biotechnology.

North Carolina has the nation’s third largest concentration of biotech companies, and they offer many high-paying job opportunities for people with a wide range of skills, interests and education.

This guide and the short film also are available for free viewing and/or download at **ncabr.org/biotech**.

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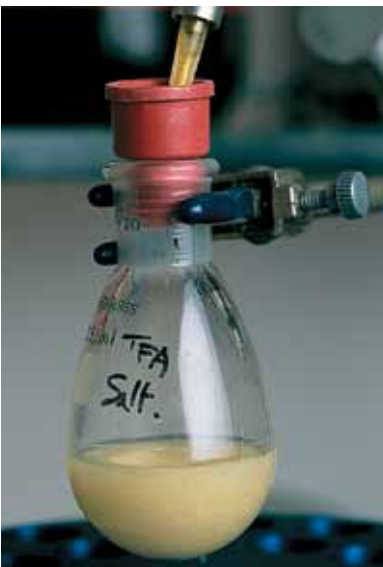
WHAT IS BIOTECHNOLOGY?

TEACHER BACKGROUND



Biotechnology is not just one technology, but a group of technologies that use the power of living cells and their molecules to solve problems or make useful products.

Scientific advances over the last 50 years have enabled us to understand how living organisms work – and how they can work for us. Biotechnology builds on this understanding to create novel solutions to many global issues. It can help feed our families, fight disease and ensure our planet is a cleaner and healthier place to live.



Companies working in energy, agriculture, pharmaceuticals or other markets use the tools of biotechnology to do a lot of different things, such as make insulin for diabetics, develop flu vaccines, grow food more safely, improve crop yields, reduce greenhouse gas emissions or even make textiles out of cornstarch.

Modern biotechnology is based in our understanding of cells, proteins and genes. These are the three basic kinds of biotechnology tools we can work with.

WHAT IS BIOTECHNOLOGY?

TEACHER BACKGROUND

Cells can make products, be products themselves or be harnessed to do jobs such as breaking down pollutants.

Proteins are essential molecules within cells. Often, the products we want cells to make are proteins.

Genes are the parts of DNA molecules that provide the blueprints for cells to make proteins. By manipulating genes, we can give cells instructions telling them how to make the proteins we want or do some other job.

For much more information about what biotechnology is, its many applications and how it is a major economic engine for the state of North Carolina, please visit ncbiotech.org/biotech-basics/.



CURRICULUM CONNECTION MATRIX

TEACHER BACKGROUND

Course	Objective	Biotechnology and You	Where Do People Work?	Cells Solving Problems	What Do People Do?	Genes Make the World Go Around	Great Places to Work	Enzymes at Work
Science Strands	Science and Technology in Society	X	X		X		X	
	Science in Personal and Social Perspectives	X	X		X		X	
	Engaging Science			X		X		X
	Science and Technology			X				X
Middle School Inquiry Goals	1.05	X						X
	1.06	X						
	1.07	X						
	1.08	X						X
	1.10							X
8th Grade Science	5.01					X		
	5.03					X		
	5.05					X		
	5.06					X		
	6.01			X				
	6.02			X				X
	7.05	X	X		X		X	
Biology	2.02			X				
	2.03			X				
	2.04							X
	3.01					X		
	3.03					X		
Contemporary Issues in North Carolina History	8.02	X						
	8.03	X						

NOTE

These standards are subject to to change. If and when they do, please visit ncabr.org/biotech for an updated version.

CURRICULUM CONNECTION MATRIX

TEACHER BACKGROUND

Course	Objective	Biotechnology and You	Where Do People Work?	Cells Solving Problems	What Do People Do?	Genes Make the World Go Around	Great Places to Work	Enzymes at Work
Exploring Biotechnology	6.01	X						
	6.02					X		
	6.03					X		
	8.03	X						
	9.03	X						
	10.01	X	X		X		X	
	10.03	X	X		X		X	
	10.04	X	X		X		X	
Biomedical Technology	3.00	X						
	9.00	X	X		X		X	
	9.01	X	X		X		X	
	9.02	X	X					
	9.03	X	X					
Biotechnology and Agriscience Research I	4.00		X		X		X	
	4.01		X		X		X	
	4.02		X		X		X	
	7.00	X						
	7.01	X						
	7.02	X						
	11.00			X				
	11.03			X				
	12.00					X		
	12.01					X		
	12.03					X		
Biotechnology and Agriscience Research II	16.00	X	X		X		X	
	16.01	X	X		X		X	
	16.02	X	X		X		X	
	16.03	X	X		X		X	
Foods II – Technology	9.00	X						
	9.01	X						
	9.02	X						

BIOTECHNOLOGY AND YOU

TEACHER INSTRUCTIONS

CORRESPONDS WITH...

Entire film

FILM CONNECTION

In the beginning of the film, Kendall, Micah and Xavier ask, "What the heck (is) biotechnology? What is it used for? And why should we care?" The film answers these questions and challenges students to find their place in the biotech world.

LEARNING OUTCOMES

Students will identify their place(s) in the world of biotechnology.

REQUIRED MATERIALS

Paper and markers for each group

PROCEDURE

1. After watching the film, divide students into small groups. Provide each group with a question, such as:
 - › With which student did you most closely identify? Micah, Xavier or Kendall?
 - › In which setting would you most like to work? Wake Forest Institute for Regenerative Medicine, BASF Plant Science or Novozymes North America? Which has made the most exciting discoveries?
 - › Which section of the video was most interesting? "Heal," "Feed" or "Sustain"?
 - › Which area do you think provides the most benefits? "Heal," "Feed" or "Sustain"?
 - › With which employee did you most identify? Dr. Christ, Katie or James?
 - › *ALTERNATE OPTION: Allow students to design their own questions. Approve questions before moving forward.*
2. Allow each student in the group to answer the question and compare answers with other group members.
3. Once the data has been collected, have each group analyze the data and create a graph on a poster. (You may ask students to practice skills for the graph(s) they are mastering, such as pictographs, circle graphs, bar graphs, etc.)
4. Provide each group with the opportunity to share its data and any conclusion(s) drawn from the data.

DISCUSSION IDEAS

- ›› What did you learn from this question?
- ›› What trends do you see in the class data?
- ›› What predictions could you make about the data if you extrapolate your data to the whole school?
- ›› Would this be an accurate model? Why or why not?
- ›› What other graphs could you have used to display your data? How would that have changed your conclusions?

CHECK FOR UNDERSTANDING

How does or how could biotechnology affect your life?

BIOTECHNOLOGY AND YOU

STUDENT ACTIVITY

Name: _____

Date: _____

Partners: _____

My question to research: _____

Data table (*Remember to list your answer choice and provide room to record your data*):

Graph:

My conclusions: _____

How does or how could biotechnology affect your life? _____

WHERE DO PEOPLE WORK?

TEACHER INSTRUCTIONS

CORRESPONDS WITH...

Entire film

FILM CONNECTION

In the "Heal" section, biopharmaceuticals and regenerative medicine are highlighted. Micah explains, "Beyond medicines, though, there are also scientists who are always helping people to heal by growing new tissue or organs for people – often right from their own cells. It sounds like science fiction, but it's real." In this amazing world of medical biotechnology, people from a variety of technical specialties who do very different jobs work together to find ways to heal the world.

LEARNING OUTCOMES

Students will explore the various jobs in the film.

REQUIRED MATERIALS

Paper, markers, printed list of several job descriptions

PROCEDURE

1. Watch all or part of the film and have students create a list of as many jobs as they can identify.
2. When the film ends, place students in small groups. Each student should share his or her job list with the group.
3. Each group should create a compiled jobs list.
4. Have groups use the paper and markers to create a poster about jobs from the film.
5. Display the posters around the room.
6. Give each student a marker and do a gallery walk, where students walk around the room without talking. Ask students to make a check mark next to one job on each poster they would love to do.
7. Provide the small groups with an opportunity to discuss their observations and draw conclusions. Have them use the printed list of several job descriptions to clarify their perceptions versus reality.

DISCUSSION IDEAS

- » What interesting things did you notice?
- » Which job(s) did you see repeated on different charts?
- » What differences did you notice between the charts?
- » Which job do you think will make the biggest impact on the world?
- » Which job do you think will change the most in the next 10 years?

CHECK FOR UNDERSTANDING

What biotechnology job would you most and least enjoy doing, and why?

WHERE DO PEOPLE WORK?

STUDENT ACTIVITY

Name: _____

Date: _____

Partners: _____

Jobs seen in the film: _____

Jobs seen in the film by my partners: _____

My conclusions from the gallery walk: _____

What biotechnology job would you most and least enjoy doing, and why? _____

CELLS SOLVING PROBLEMS

TEACHER INSTRUCTIONS

CORRESPONDS WITH...

"Heal" section of film (3:45 - 10:40)

FILM CONNECTION

In the beginning of the film, Micah explains, "Biotechnology is a toolbox that uses living things, their cells or even the tiny molecules inside the cells to make a product or solve a problem."

LEARNING OUTCOMES

Students will recognize that cells are composed of smaller parts (organelles) that each have a specific function that contributes to the functioning of the cell. Students will be able to list the basic organelles of an animal cell and their functions.

REQUIRED MATERIALS

Computer with Internet connection for each group

PROCEDURE

1. Discuss how cells perform specific jobs and how the parts of the cells, or organelles, also perform specific jobs within the cell.
2. Provide students with a list of cell functions: capture and release energy, feedback information, dispose of waste, reproduction, movement and specialized needs. Clarify the vocabulary by asking students to define the functions in their own words.
3. Place students in small groups and have them use resources such as the websites below to explore which organelles match the functions given:
 - > "Animal Cell Interaction" (cellsalive.com/cells/cell_model.htm)
 - > "Inside a Cell" (learn.genetics.utah.edu/content/begin/cells/insideacell)
 - > "Cell Explorer" (exploratorium.edu/traits/stuff.html)
4. Have each group identify other functions not given on the list and match the organelles.
5. Allow the small groups to discuss this question: "How is the cell like a community?"

DISCUSSION IDEAS

- » What is a cell? Where are cells found?
- » Which organelle was the most interesting?
- » Which function were you most surprised the cell performed?
- » How do the organelles work together?

CHECK FOR UNDERSTANDING

How do the parts of the cells work together? Be specific. Provide examples of the organelles and their functions working together.

CELLS SOLVING PROBLEMS

STUDENT ACTIVITY

Name: _____

Date: _____

Partners: _____

Cells are tools used in biotechnology. Cells also contain smaller parts called organelles. Each organelle has a specific function or job to help the cell work. Explore the resources provided and find organelles in animal cells that perform this function.

Function of Organelle	Organelle(s)
Capture and release energy	
Feedback information	
Dispose of waste	
Reproduction	
Movement	
Other function <i>(fill in yourself)</i> :	
Other function <i>(fill in yourself)</i> :	

Websites visited: _____

How is the cell like a community? _____

How do the parts of the cells work together? Be specific. Provide example of the organelles and their functions working together. *(You can use the back of this sheet if you need more space.)*

WHAT DO PEOPLE DO?

TEACHER INSTRUCTIONS

CORRESPONDS WITH...

Entire film

FILM CONNECTION

In the "Feed" section, Xavier says, "I looked into a very different part of biotechnology called 'green biotechnology,' or 'agricultural biotechnology.' Researchers working in this field are just as likely to be found in a corn field as in a laboratory." Green biotechnology can help students visualize a variety of skills that biotechnology workers may need to complete the task presented to them.

LEARNING OUTCOMES

Students will explore the various skills used by biotechnology workers in the film.

REQUIRED MATERIALS

Paper and markers

PROCEDURE

1. Before watching the film, have the class brainstorm skills that scientists use. List these for the class to see.
2. Watch all or part of the film and have students write down skills they see being used by biotechnology workers.
3. When the film ends, divide students into small groups. (*Steps 4–6 should be completed in these groups.*)
4. Have each group identify 10 skills seen in the film.
5. Have each group place these skills in order from most important to least important. Make sure students are able to articulate why they chose the specific skills to be the most and least important.
6. Allow each group to present its findings to the class.
7. *OPTIONAL: Provide students with a copy of the Bioscience Competency Model to compare skills with industry values. (See Activity Extensions, on page 20.)*

DISCUSSION IDEAS

- » What skill would be most helpful?
- » What skill would help you get along with others?
- » What skill would be the easiest to develop?
- » What skill would be most important for a scientist?

CHECK FOR UNDERSTANDING

What skill do you see as the most important for a scientist, and why?

WHAT DO PEOPLE DO?

STUDENT ACTIVITY

Name: _____

Date: _____

Partners: _____

Skills observed in the film: _____

My ranking of the top 10 biotechnology skills (*#1 is most important*):

1. _____

6. _____

2. _____

7. _____

3. _____

8. _____

4. _____

9. _____

5. _____

10. _____

I chose #1 as the most important because _____

I chose #10 as the least important because _____

What skill do you see as the most important for a scientist, and why? _____

GENES MAKE THE WORLD GO AROUND

TEACHER INSTRUCTIONS

CORRESPONDS WITH...

"Feed" section of film (10:40 - 15:25)

FILM CONNECTION

In the "Feed" section, Xavier says, "I looked into a very different part of biotechnology called 'green biotechnology,' or 'agricultural biotechnology.' Researchers working in this field are just as likely to be found in a corn field as in a laboratory." Green biotechnology can help students visualize a variety of skills that biotechnology workers may need to complete the task presented to them.

LEARNING OUTCOMES

Students will recognize how genes are involved in characteristics of offspring.

REQUIRED MATERIALS

Computer with Internet connection for each group

PROCEDURE

1. Discuss the use of genes in biotechnology. Resources for this discussion:
 - > "What is Biotechnology?" (basf.com/group/corporate/en/products-and-industries/biotechnology/what-is)
 - > "Biotechnology at BASF" (basf.com/group/corporate/en/function/conversions:/publish/content/products-and-industries/biotechnology/images/Biotechnology_at_BASF.pdf)
2. Allow students to work in small groups to identify what genes do. Provide a list of websites to explore genes:
 - > "The Gene School" (library.thinkquest.org/19037/heredity.html)
 - > "The Gene Scene" (amnh.org/ology/?channel=genetics)

DISCUSSION IDEAS

- » Who has the exact same genetic information as you?
- » What is the job of a gene?
- » How are genes passed from parents to offspring?

CHECK FOR UNDERSTANDING

How are traits passed from one generation to the next generation?

GENES MAKE THE WORLD GO AROUND

STUDENT ACTIVITY

Name: _____

Date: _____

Partners: _____

Genes	
What are genes?	
What are genes made up of?	
Where did your genetic information come from?	
Where does an offspring's (child's) genetic information come from?	
How are genes passed from parent to offspring?	
What is a dominant trait?	
What is a recessive trait?	
Why do biotechnologists remove, add or modify genes?	

How are traits passed from one generation to the next generation? _____

GREAT PLACES TO WORK

TEACHER INSTRUCTIONS

CORRESPONDS WITH...

Entire film

FILM CONNECTION

In the "Sustain" section, Kendall asks, "Is this the break room?" She is amazed at all the different environments at Novozymes North America in which people work. James explains that people work in many different areas, such as research, development, production, marketing and accounting.

LEARNING OUTCOMES

Students will recognize the characteristics of a great workplace.

REQUIRED MATERIALS

None

PROCEDURE

1. Ask students to describe the classroom in which they work the best.
2. Instruct students to watch the film and answer the questions about the workplaces seen throughout the film.
3. When the film ends, allow the students to share their ideas with a partner.
4. Discuss great work environments with the larger class.

DISCUSSION IDEAS

- » What is the most important characteristic of a great workplace?
- » How could you see that characteristic in the workplace?
- » How can you influence the environment in which you work?
- » Would you prefer to work independently, as part of a tightly knit team or somewhere in between?
- » What can you do to add the characteristics of a great workplace to your classes?

CHECK FOR UNDERSTANDING

How will you improve your workplace at school?

GREAT PLACES TO WORK

STUDENT ACTIVITY

Name: _____

Date: _____

Partners: _____

1. What is the workplace visited by Micah? _____

2. What is the goal of this place? _____

3. List several characteristics that make this a great work environment:

4. What is the workplace visited by Xavier? _____

5. What is the goal of this place? _____

6. List several characteristics that make this a great work environment:

7. What is the workplace visited by Kendall? _____

8. What is the goal of this place? _____

9. List several characteristics that make this a great work environment:

Partner discussion: Which is the best workplace, and why? _____

How will you improve your workplace at school? _____

ENZYMES AT WORK

TEACHER INSTRUCTIONS

CORRESPONDS WITH...

"Sustain" section of film (15:25 - 21:45)

FILM CONNECTION

In the "Sustain" section, James explains that Novozymes North America "make(s) enzymes for a variety of applications. The main purpose ... is that they can replace petroleum products. So it's a way to make the world more sustainable."

LEARNING OUTCOMES

Students will recognize that enzymes carry out many different functions. Students will categorize the enzymes into subgroups. Students will make observations of how an enzyme speeds up a chemical reaction.

REQUIRED MATERIALS

For each small group:

- > 2 - 3 small chunks of both raw potato and cooked potato
- > Test tube
- > Safety goggles
- > 3% hydrogen peroxide solution found in most stores (*Please dispose properly by flushing it down the drain with water. Do not eat or drink in the classroom.*)

PROCEDURE

1. Discuss how some enzymes are used in biotechnology.
2. Ask students to review the list of enzymes and their functions on the facing page.
3. Allow students to work in small groups to create an organization chart of proteins. If students want to do more research on enzymes, consider exploring another resource:
 - > "Enzymes at Work" (novozymes.com/en/about-us/brochures/Documents/Enzymes_at_work.pdf)
 - > "Enzymes in Industrial Applications" (biobasics.gc.ca/english/View.asp?x=792)
4. Have each group share and explain its organization of enzymes with the class.
5. Place the raw potato pieces in one test tube and the cooked potato pieces in a different test tube. Add hydrogen peroxide to cover the potato pieces.
6. Observe the reaction for 1 - 2 minutes. Record observations.

DISCUSSION IDEAS

- » What criteria did you use to organize the enzymes?
- » Allow students to brainstorm which enzyme caused the change to the potato pieces.
- » Encourage students to hypothesize why bubbles occurred. Have groups share their observations and conclusions.

CHECK FOR UNDERSTANDING

Why did the potato bubble in the hydrogen peroxide?

ENZYMES AT WORK

STUDENT ACTIVITY

Name: _____

Date: _____

Partners: _____

By what characteristic can you organize the enzymes listed below? _____

- » **Amylase:** An enzyme that catalyzes the breakdown (hydrolysis) of starch.
- » **Carboxypeptidase:** An enzyme that removes the C-terminal amino acid from a peptide. There are carboxypeptidases that are produced in the pancreas and function as digestive enzymes.
- » **Catalase:** An enzyme that breaks down hydrogen peroxide in living cells.
- » **Cellulase:** An enzyme that degrades cellulose – the basic structural building block in plants and the main constituent of cotton. Areas for cellulase applications include laundry detergents and the textile industry.
- » **Hemicellulase:** An enzyme that breaks down hemicellulose, another plant sugar that is not as complex as cellulose and is easier to break down.
- » **Lactase:** An enzyme that breaks down lactose (or milk sugar).
- » **Lipase:** An enzyme that catalyzes the breakdown of fats into fatty acids and glycerol. Lipases are present in the pancreatic and intestinal juice of vertebrates.
- » **Maltase:** An enzyme that catalyzes the hydrolysis of the disaccharide maltose into two molecules of glucose.
- » **Pepsin:** An enzyme that breaks down protein.
- » **Phospholipase:** An enzyme that catalyzes the hydrolysis of a phospholipid.
- » **Protease:** An enzyme that catalyzes the hydrolysis of proteins.
- » **Sucrase:** An enzyme that catalyzes the hydrolysis of the sugar sucrose (or cane sugar).
- » **Xylanase:** An enzyme that breaks down xylan, a gummy sugar present in the cell walls of plants and trees. This enzyme type is used primarily in the wood and pulp industry.

Observations from the reaction: _____

I think _____ is the enzyme at work because the evidence _____

Why did the potato bubble in the hydrogen peroxide? _____

ACTIVITY EXTENSIONS

TEACHER BACKGROUND

WHAT IS BIOTECHNOLOGY?

- » "Guide to Biotechnology" (bio.org/speeches/pubs/er/BiotechGuide2008.pdf)
- » "What is Biotechnology?" (biotechinstitute.org/what-is-biotechnology)
- » "Enzymes at Work" (novozymes.com/en/about-us/brochures/Pages/default.aspx)
- » "Biotechnology and Genetic Engineering" (basf.com/group/corporate/en/products-and-industries/biotechnology/publications)

WHERE DO PEOPLE WORK?

- » "Career Pathways" ([ncbiotech.org/sites/default/files/CareerPathways\].pdf](http://ncbiotech.org/sites/default/files/CareerPathways].pdf))
- » "I Want to Work In ... Biotechnology" (kent.ac.uk/careers/workin/biotechnology.htm)

CELLS SOLVING PROBLEMS

- » "The Virtual Cell Tour" (ibiblio.org/virtualcell)
- » "Cell Games" (sheppardsoftware.com/health/anatomy/cell/index.htm)

WHAT DO PEOPLE DO?

- » "Biomanufacturing Skill Standards" (biomanufacturing.org/bioskillstandards.html)
- » "Bioscience Competency Model" (careeronestop.org/competencymodel/pyramid.aspx?biosci=Y)

GENES MAKE THE WORLD GO AROUND

- » "Engineer a Crop: Transgenic Manipulation" or "Engineer a Crop: Selective Breeding" (pbs.org/wgbh/harvest/engineer)
(*This can be completed in a large group or small groups.*)
- » "Toothpick Fish" (genetics-education-partnership.mbt.washington.edu/download/toothpickfish.pdf)
(*This is a hands-on activity.*)

GREAT PLACES TO WORK

- » "FORTUNE Magazine's 100 Best Companies to Work For" (money.cnn.com/magazines/fortune/bestcompanies)

ENZYMES AT WORK

- » "Discovering Enzymes" (www.ccmr.cornell.edu/education/modules/documents/DiscoveringEnzymes.pdf)
(*For more information about how the reaction occurs.*)
- » "Catalase Lab" (accessexcellence.org/AE/ATG/data/released/0074-GenNelson/index.php)
(*Students perform additional experiments with catalase. Follow proper safety precautions.*)
- » "Catalase Kinetics" (science-projects.com/catalasekinetics.htm)
(*Students perform additional experiments with catalase. Follow proper safety precautions.*)

ABOUT NCABR

The mission of the North Carolina Association for Biomedical Research is to promote public understanding of and support for bioscience research. Founded in 1989 by North Carolina's leading bioscience research institutions, NCABR is the only organization in the state dedicated to advancing all North Carolinians' appreciation for the remarkable benefits of bioscience research and careers. Since 1989, NCABR has launched innovative science education outreach programs and has designed a variety of bioscience education and career-related publications – many of which are the first of their kind in the country and now are used nationally.

ABOUT NORTH CAROLINA BIOTECHNOLOGY CENTER

The North Carolina Biotechnology Center is a private, nonprofit corporation supported by the North Carolina General Assembly. Its mission is to provide long-term economic and societal benefits to North Carolina by supporting biotechnology research, business, education and strategic policy statewide.

For more information, visit the North Carolina Biotechnology Center's website, at ncbiotech.org.

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PHOTO CREDITS

Page 2: Novozymes (man and woman), Biogen Idec Foundation (extracting substance); Page 3: Novozymes

CONTENT ACKNOWLEDGEMENT

Page 19: Enzyme definitions adapted from "Enzymes at Work," by Novozymes

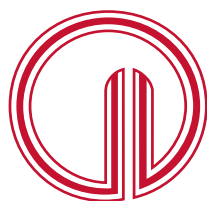
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