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Cool Green Tool!

GATEWAY TO INTERACTIVE LEARNING

CHILDREN'S MUSEUM
INDIANAPOLIS

A Unit of Study for Grades 4–8

bioTech
Cool Green Tool!

A UNIT OF STUDY FOR GRADES 4–8

ACKNOWLEDGEMENTS

The Children's Museum of Indianapolis wishes to acknowledge the assistance of the following people in the preparation of this unit of study: Rick Crosslin, teacher and writer; Paul Williams, Ph.D., scientist; Dow AgroSciences

The Children's Museum of Indianapolis is a nonprofit institution dedicated to providing extraordinary learning experiences for children and families. It is one of the largest children's museums in the world and serves people across Indiana as well as visitors from other states and countries. In addition to special exhibits and programs, the museum provides the **infoZone**, a partnership between **The Children's Museum of Indianapolis** and The Indianapolis Public Library. The **infoZone** combines the resources of a museum with the services of a library where students can read, search for information, and find the answers to their questions. Field trips to the museum can be arranged by calling **317-334-4001** or **800-820-6214**. Visit the **Teachers** page at **The Children's Museum website: childrensmuseum.org**.

The Children's Museum of Indianapolis – SciencePort®
childrensmuseum.org/scienceport

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SciencePort® bioTech Cool Green Tool!

A Unit of Study for Grades 4–8

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Biotech—Cool Green Tool! is a new way to participate in science

The Children's Museum of Indianapolis has created this classroom science investigation to help students and teachers investigate an alternative fuel source—biodiesel. In this unit of study participants will grow plants, use science techniques, explore new media, and share learning on a special **SciencePort**® website. *Biotech—Cool Green Tool!* explores plant biotechnology. Biotechnology plays a crucial role in improving daily living. Scientists from Dow AgroSciences and Dr. Paul Williams have provided valuable resources for this first **SciencePort** investigation.

Students explore ways to maximize seed production of *Brassica rapa* for biodiesel. More seeds mean more oil that could be used in biodiesel production. In addition, students create videos, animations, and presentations using new media technology. Students collect data, make observations, and share what they have learned with each other and museum staff.

SciencePort is the newest permanent component of ScienceWorks and serves as the headquarters for special science investigations for families and school groups.

The museum received a grant from Dow AgroSciences to create the infrastructure, technology, learning management system, physical space, and first investigation for **SciencePort**. The investigations are centered on these key themes: 1) science affects daily life; 2) regular citizens can improve daily living by understanding basic science; 3) communicating and sharing science learning experiences enhances understanding; and 4) informal learning environments, such as the museum, provide alternative ways of learning science.

SciencePort opened in September 2007, and the first investigation focuses on the science methods and tools used to create biodiesel. The investigation is designed to serve multiple audiences (schools and families) and offers multiple levels of engagement. Central to the design of **SciencePort** investigations is free-choice learning: enabling different user groups to design a science experience that meets their needs.

The **SciencePort** program consists of online, virtual activities that can be accessed at home or school, staff-led investigation activities at the museum, and follow-up activities and resources used back in the classroom. Participants will receive a "mission" online through the museum's **SciencePort** website and will have the opportunity to explore content including videos and virtual activities. School groups will then go to the museum to continue their experience at the **SciencePort** Headquarters (HQ) and will work with staff to explore special areas of the museum's Biotechnology Learning Center and take part in facilitated scientific investigations. Once they return to their classroom, they can conduct further experiments and activities to extend their learning. **SciencePort** participants exercise free choice in when they learn, where they learn, and what they learn.

GOAL

To create an interactive science investigation program that increases science literacy to improve daily living.

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OVERVIEW

Biotechnology is the science of using living things as tools to meet our wants. It plays a crucial role in improving daily living by improving the quality and quantity of our foods. It is the focus of the Biotechnology Learning Center, Biotech website, and the "Yesterday, Today, and Tomorrow: Agricultural Biotechnology" unit of study at the museum.

Scientists from Dow AgroSciences and Dr. Paul Williams have provided valuable resources for the first investigation offered through **SciencePort**®: *Biotech—Cool Green Tool!* that allows students to investigate how to apply special techniques to increase the quality and quantity of material produced by the plants.

OBJECTIVES

- Create an environment where families and school groups learn, communicate, and share experiences from museum exhibits and experiences that enhance understanding of science.
- Create a **SciencePort** learning management system (LMS) to complete online investigations, activities, communications, and collaborations using proven technologies that maximize learning.
- Provide schools with resources to improve daily living by understanding basic science.
- Understand that science has an impact on daily life.
- Communicate and share science learning experiences.

WHAT WILL STUDENTS LEARN?

Indiana's Academic Standards and National Science Standards

This unit of study helps students achieve academic standards in Language Arts, Math, and Science. Specific academic standards are listed with each experience. Search or print the Indiana Academic Standards from https://learningconnection.doe.in.gov/Standards/Standards.aspx. In addition, Indiana Academic Science Standards and National Science Standards used are listed in the reference section at the back of this unit of study.

INDIANA'S ACADEMIC SCIENCE STANDARDS

Grade 4 – Process Standards; Core Standards 4.2.4, 4.2.5, 4.3.1, 4.3.2, 4.3.3, 4.3.4

Grade 5 – Process Standards; Core Standards 5.3.1

Grade 6 – Process Standards; Literacy Standards 6–8.RS.3, 6–8.RS.4, 6–8.RS.7, 6–8.RS.8, 6–8.WS.1, 6–8.WS.2, 6–8.WS.5, 6–8.WS.6; Core Standards 6.3.4, 6.3.6

Grade 7 – Process Standards; Literacy Standards 6–8.RS.3, 6–8.RS.4, 6–8.RS.7, 6–8.RS.8, 6–8.WS.1, 6–8.WS.2, 6–8.WS.5, 6–8.WS.6; Core Standards 7.3.1, 7.3.2, 7.3.3, 7.3.4, 7.3.5, 7.3.6, 7.3.7

Grade 8 – Process Standards; Literacy Standards 6–8.RS.3, 6–8.RS.4, 6–8.RS.7, 6–8.RS.8, 6–8.WS.1, 6–8.WS.2, 6–8.WS.5, 6–8.WS.6; Core Standards 8.3.1, 8.3.2, 8.3.3, 8.3.4, 8.3.5, 8.3.6, 8.3.7, 8.3.10

NATIONAL SCIENCE EDUCATION STANDARDS

Life Science K–8 – Content Standard A: Abilities necessary to do Scientific Inquiry; Understanding about Scientific Inquiry

Life Science K–4 – Content Standard C: Characteristics of Organisms; Life Cycles of Organisms and Their Environment

Life Science 5–8 – Content Standard C: Structure and Function in Living Systems; Reproduction and Heredity

ABOUT THE MUSEUM AND SCIENCEPORT

The Children's Museum of Indianapolis was an early leader in providing distance learning opportunities to schools in the mid-1990s. The specialized technology needed to receive the distance learning programs limited school audiences. Today the Internet has replaced much of the traditional distance learning used in schools. Improvements in Internet connectivity and use provide choice in what is seen, heard, and learned. To meet the needs of today's audience the museum created a program entitled **SciencePort**®**—Gateway to Interactive Learning**.

CONTACT INFORMATION

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LESSON ONE: Prepare for the Investigation

The goal of the *Biotech—Cool Green Tool!* Investigation is to explore ways to maximize seed production of *Brassica rapa* for biodiesel. More seeds mean more oil that could be used in biodiesel production.

EXPERIENCE 1: Biotechnology and Biodiesel

In this first lesson students are introduced to a science mystery and how science methods can help provide a solution.

TIME: 30 minutes

MATERIALS

- Computer with speakers and Internet access
- Log-on and password for the **SciencePort**® website

VOCABULARY

- biodiesel
- biotechnology

FOCUS QUESTIONS

- What is biotechnology?
- What is biodiesel?

TEACHERS: START HERE

Begin your investigation by visiting the SciencePort website dedicated to Biotech—Cool Green Tool! Go to childrensmuseum.org/scienceport and click on the green biotech button under Investigations. There you will find four modules, 16 videos, resources, and a showcase of past student projects. Familiarize yourself with the website so you can direct your students to the resources available.

PROCEDURES

- Introduce the **SciencePort** investigation *Biotech—Cool Green Tool!* View the **SciencePort** promo video on the website.
- Introduce "The Case of the Mystery Plants." Set the stage for the problem—tell students that they are part of a team that is investigating two types of seeds and three mystery powders. View Video—"The Case of the Mystery Plants" Parts 1 and 2.
- Identify the problem—how to determine which seeds and mystery powders will create the most seeds, which leads to more biodiesel.
- Tell students they will use science methods and biotech procedures to conduct a growing project to solve the problem.
- Students will share the results with classmates and on **SciencePort**.
- Direct students to view the online videos and discuss
  - What is science?
  - What is biodiesel?
- Have students write definitions or discuss with a partner the terms **biodiesel** and **biotechnology**.

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EXPERIENCE 2: Living & Non-Living Things, Cells, Biotechnology, and *Brassica rapa*

In this lesson students will investigate the characteristics of living organisms by viewing an online module and videos on the **SciencePort**® website. Each module contains activities, games, transcripts, vocabulary, and optional activities.

TIME: 60 minutes

VOCABULARY

- genetic modification
- selective breeding

FOCUS QUESTIONS

- What are the differences between living and non-living things?
- Why are cells called building blocks?
- How does Biotechnology help our daily living?

MATERIALS

- Computer with speakers and Internet access
- User name and password for **SciencePort** website

PROCEDURES

Students complete each of the following modules:

Module One—What Is Living? What Is Non-Living?

- In this module students will learn the difference between living and non-living things. Ask students to define what it means to be living. List responses. Ask what it means to be non-living. List examples of each and discuss.
- View the module "What Is Living? What Is Non-Living?" on the **SciencePort** website. Students can work alone or in teams to complete the activities and games. Discuss the module.
- Optional Activity—students can complete the "Search for Life" activity in the Resources section of the module.

Module Two—Cells, DNA, Genetics: Building Blocks of Life

- In this module students will learn how genetics determines the physical features of living things. Ask students to give examples of the smallest living thing they know. Ask them if it is smaller than a cell. Tell students that in this module they will investigate the parts of plant and animal cells. They will investigate the importance of cells. They will also learn about the life cycle of the plant *Brassica rapa*.
- View the module "Cells, DNA, Genetics: Building Blocks of Life" on the **SciencePort** website. Students can work alone or in teams to complete the activities and games. Discuss the module.
- Optional Activity—Students can complete the "Make a Model of a Cell" activity in the Resources section of the module.

Module Three—Biotechnology

- In this module students will learn how organisms are improved by selective breeding and genetic modification. Ask students what **biotechnology** means. Discuss results.
- View the module "Biotechnology" on the **SciencePort** website. Students can work alone or in teams to complete the activities, games, and videos. Discuss the module.
- Optional Activity—Students can complete the "Create a Biotech Time Line" activity in the Resources section of the module.

EXPERIENCE 3:
Investigation Teams – Control and Experimental

Students work in groups to use science methods and tools to solve a mystery.

TEAM A:
Grow Tubs and Biotech Animation

TEAM B:
Light Box and Biotech Video

TEAM C:
Bioassay Microscope Presentation

TIME: 30 minutes

VOCABULARY

- *Brassica rapa*
- control
- experimental

MATERIALS

- Computer with speakers and Internet access
- User name and password for **SciencePort** website

FOCUS QUESTIONS

- What is *Brassica rapa*?
- How can *Brassica rapa* be used in biodiesel?

INVITE STUDENTS TO VISIT THE WEBSITE TO LEARN MORE ABOUT THE PROJECT AT:

SciencePort®
childrensmuseum.org/SciencePort

Biotechnology Learning Center
childrensmuseum.org/themuseum/Biotech/index.html

PROCEDURES

- Create Investigation Teams by dividing the class into two groups: **Control** and **Experimental**.
- Within each group, form 3 teams for a total of 6 groups:
  - Control Group: Team A, Team B, Team C
  - Experimental Group: Team A, Team B, Team C
- Each group works on tasks to solve the mystery. View the module "The Case of the Mystery Plants" on the **SciencePort** website. Students work in teams to complete the activities and view videos. Discuss the module. In this module students will learn how *Brassica rapa* can be used as a tool to solve a biotechnology problem.
- Ask students to review what they have learned about *Brassica rapa,* biotechnology, and biodiesel in the investigation. Discuss responses.
- View the video "Brassica? Growth?"
- Direct students to record notes and information they learn in the modules and videos in a science journal or science notebook.
- Tell students that each team is responsible for specific tasks. They prepare for the tasks in the classroom and then travel to The Children's Museum of Indianapolis to continue work on the tasks. At the museum they will work with staff in **SciencePort**.

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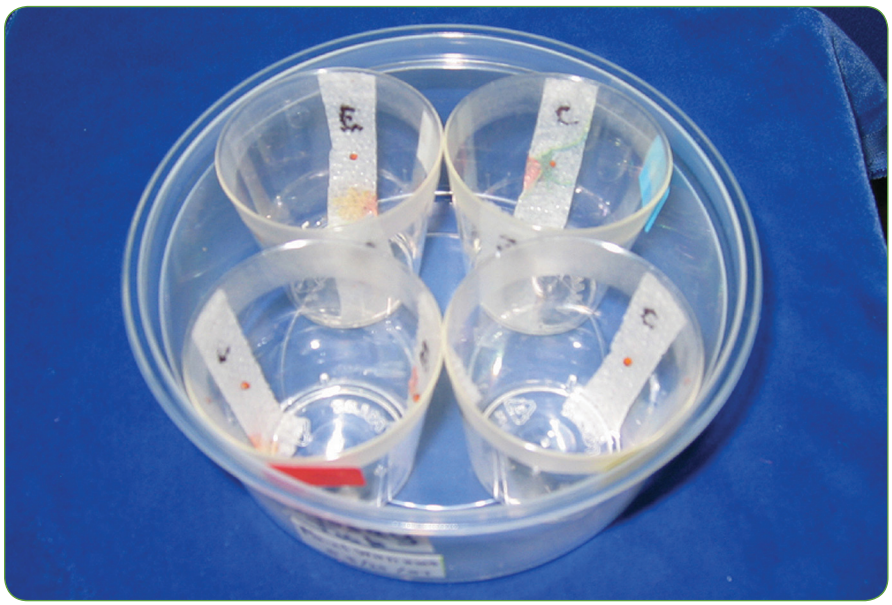
LESSON TWO: Control Group and Experimental Group

The following tasks are completed by the six student teams in the classroom prior to the visit to the museum. The teams complete the same tasks, except the Control and Experimental groups use different seeds in the plant growing part of the investigation.



EXPERIENCE 1:
Team A — Grow Tubs & Biotech Animation

PART 1: Grow Tubs: The Grow Tubs provide a system for the seeds to germinate, grow, develop, and complete a life cycle. Each team will have a grow tub that contains four grow cups. This allows many plants to be grown.

TIME: one class period

What Is *Brassica rapa*?

The genus *Brassica* includes root vegetables, leafy greens, and oilseed plants in the mustard family. The species *Brassica rapa* includes some Asian green vegetables as well as turnips and turnip greens. Some *B. rapa* seeds are used to make canola oil. Rapid Cycling *B. rapa* (RCBr) has been genetically bred for its quick growth and oil-bearing seed.

SCIENCE RESOURCES

Located on the SciencePort® Website:

- Museum Activities
- Growing *Brassica rapa* (PDF)
- Bioassay and the Mystery Powder (PDF)
- The Case of the Mystery Plants (PDF)
- Biotech Animation Examples
- Image Gallery
- Green Screen Background Images
- Images

MATERIALS

Provided in Kit – Control Group and Experimental Group:

- Case of the Mystery Plants Data Sheet Handout
- Team user name and password for the **SciencePort** website
- 2 grow tubs (8 oz.) with four holes 3/4-inch diameter drilled in the bottom
- Grow tub (16 oz.) without holes in the bottom
- 8 growing cups with small holes drilled into the bottom of each
- 8 braided wicks (12 cm)
- 16 Rapid Cycling *Brassica rapa* seeds—teams receive either Control or Experimental seeds
- 40 fertilizer pellets (5 pellets per growing cup)
- 8 Jiffy Pellets — dehydrated
- Seed covering — vermiculite
- Two toothpick pollinators (control and experimental)
- 16 bamboo skewers
- Four pipettes
- Syringe (10 ml)
- Assorted small boxes or books to support grow tubs at correct height (from classroom)
- One Daily Checklist
- Thermometer
- Invisible tape
- Two-sided tape
- 2 pre-cut aluminum foil sheets
- CFL light bulb
- Mystery Powders (red, white, blue)
- Socket adapter
- Extension power cord
- Ruler

EXPERIENCE 1: Team A, Part 1 continued.

VOCABULARY

- bamboo skewers
- distribute
- fertilizer pellets
- germinate
- grow cup
- grow tub
- life cycle
- moisten
- pipettes
- rapid cycling
- seeding mix
- seeds
- syringe
- vermiculite
- wicks

TEACHER NOTE

- Students collect this information on the provided handouts. They also use the online charts provided on the **SciencePort**® website. Online charts are provided for the data collection.

PROCEDURES

INTRODUCTION

- Have students discuss and organize within their teams the jobs that need to be done to complete the task.
- Teams will assemble the grow tubs in their classroom.
- Ask students to take notes and make observations while their team completes these tasks.

PREPARE THE TUBS

- View these videos on the **SciencePort**® website: *Grow Tubs Brassica* and *Planting Brassica*
- Review information about the **grow tub** from the classroom and the **SciencePort** videos. Each tub will support eight plants (four **growing cups** with two plants each).
- **Wicks**: Insert a wick through the drilled hole in the bottom of each growing cup. The wick should hang down at least 8 cm into the bottom of the large tub. Do not tie a knot in the wick.
- Jiffy Pellets **Seeding Mix**: soak the four **pellets** in warm water. Within 5 minutes they will hydrate (fill with water) and be ready to use. Carefully cut each pellet in half. Place each half pellet in a grow cup. Do NOT pack the seeding mix down. Make sure the wick is still in the grow cup.
- Fertilizer: Add five **fertilizer pellets** to each growing cup.
- Wet the seeding mix: Gently pour water over the seeding mix until water runs out the bottom of the growing cup down the wick.
- Fill the larger (16 oz.) grow tub half full of water. Label the tub either "Control" or "Experimental" depending upon the group.
- Place the four growing cups inside the smaller (8 oz.) tub. Arrange each growing cup so that the wicks hang down through the large hole in the 8 oz. tub. Place the 8 oz. tub inside the larger 16 oz. tub. The wicks should be in the water in the lower water-filled reservoir.
- When finished the class will have one Control Group Grow Tub and one Experimental Group Grow Tub inside the light box.

PLANT THE SEEDS

- Label the tub with each group name and date. The Red, Blue, and White represent the different treatments (Mystery Powder Solutions) that are being tested. The Yellow cup is the control cup and will not receive any Mystery Powder Solution.
- Direct the Control group to plant four grow cups with control seeds and the Experimental group to plant theirs with experimental seeds. They should place two or three seeds on top of the wet Jiffy Pellet seeding mix. They should distribute the seeds evenly and NOT press them down.
- Have the students cover the seeds with a teaspoon of vermiculite and moisten with a few drops of water using the barrel **pipette**.
- Have students place the Grow Tub in the Light Box.
- Ask Team C to treat the grow cups with the Mystery Solutions they created. Treat both Grow Tubs.
- Each person in the class uses a Case of the Mystery Plants Data Sheet Handout to make and record observations.

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EXPERIENCE 1:
Team A — Grow Tubs & Biotech Animation

PART 2: Biotech Animation: Students work in the team to create a stop-motion animation that describes part of their investigation.

TIME: 2–4 class periods

MATERIALS

- Biotech Animation Storyboard Handout, page 13
- Computer with speakers and Internet access
- Team user name and password for the **SciencePort**® website
- Construction paper, felt, colored foam, pipe cleaners, and other art supplies
- Animation directions

VOCABULARY

- animation
- dominant genes
- genes
- recessive genes
- storyboard

PROCEDURES

- Have students work as a team to prepare an **animation** about a Biotech process.
- Ask students to review what they have learned from the **SciencePort**® modules and videos, and from growing the plants. Direct students to think of one process to describe in an animation.
- Students will prepare a short animation to illustrate one of the following:
  - The Plant Life Cycle
  - Selective Breeding
  - Parts of a Plant Cell
  - Dominant and Recessive Genes
- To create the animation, the students **storyboard** and plan their project prior to the museum visit. At the museum, staff members will help them use technology to complete the animation.
- Direct students to view biotechnology animation examples found on the Science Reference section of the **SciencePort** website: Graphics Demo and Storyboard Demo
- Have the team decide what concept to animate from the list above.
- View the video "How to Plan a Video" on the **SciencePort** website.
- Use the "Biotech Animation Storyboard Handout" to describe the animation.
- Provide materials and construct the props for the animation. Instruct the students not to use any green props. If the photography is done using a green screen background, the green will all be replaced in the finished product.
- Direct students to practice the different scenes for the animation by making small movements. About a 1 cm move at a time is ideal.
- For additional tips and ideas, direct students to visit the website stopmotionpro.com. The team will use this software at **SciencePort**.
- Tell students to practice the animation until they have perfected the steps.
- Check team materials prior to the museum visit. Students have limited time at the museum.

Biotech Animation Storyboard Handout • Topic: _____ **Team:** _____

Create materials to use in the animation. Plan each scene using the storyboard boxes.

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Biotech Animation Storyboard Handout • Topic: _____ **Team:** _____

Create materials to use in the animation. Plan each scene using the storyboard boxes.

EXPERIENCE 2:
Team B — Light Box & Biotech Video

PART 1: Light Box: All plants, including Rapid Cycling *Brassica rapa,* need light to grow. Below are the materials and procedures to make a light box that provides the physical needs of light and temperature control for the investigation. Students work as a team to construct the light box. Providing light and the correct temperature are essential to the success of the investigation.

TIME: one class period

VOCABULARY

- aluminum foil
- compact fluorescent lamp (CFL)
- crate
- light
- light box
- physical needs
- rapid cycling
- socket adapter
- temperature

SCIENCE RESOURCES

Located on the SciencePort® website:

- Museum Activities
- Growing *Brassica rapa* (PDF)
- Bioassay and the Mystery Powder (PDF)
- The Case of the Mystery Plants (PDF)
- Biotech Video Examples
- Image Gallery
- Green Screen Background Images
- How to Edit a Video Tutorial

MATERIALS

- Computer with speakers and Internet access
- Team user name and password for the **SciencePort** website
- Case of the Mystery Plants Data Sheet Handout
- File crate
- Aluminum foil
- Clear tape
- Clear double-sided tape
- Socket adapter plug
- Electric extension cord
- Two small binder clips
- **SciencePort** logo sticker
- Compact fluorescent lamp (CFL), 23 W (1750 lm)
- Thermometer
- Daily Checklist

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PROCEDURES

Have students take notes and make observations while they work as a team to complete the following tasks.

- Assemble the **light box** by reviewing information in the **SciencePort**® videos.
- Unroll the two pieces of **aluminum foil**: 12" x 43" and 12" x 42". With small pieces of double-sided tape, line the **crate** with aluminum foil. Use the longer piece of foil as the back–top–front curtain. Use the shorter piece as the side–bottom–side.
- With single-sided tape, reinforce the edges of the front foil curtain. Place the **SciencePort** logo sticker on the front curtain.
- Mount the **CFL** in the top center of the crate by sandwiching the socket adapter and bulb through the top.
- The best temperature for the light box is 65–78°F (18–26°C). If needed, cut one small hole in the aluminum foil for ventilation on the side, near the top. A second hole may be necessary to maintain the proper temperature.
- Connect the electric cord to the socket adapter. Test the light by plugging it into a wall receptacle.

- Use the two binder clips to reinforce and hold the front aluminum curtain.
- Tape the Daily Checklist on the side of the Light Box.
- The light box is now ready for the two grow tubs and bioassay tub.
- Ask students to list the **physical needs** that the light box provides. They should know that all plants including Rapid Cycling *Brassica rapa* need light to grow. A light box provides the physical needs of light and temperature control for the investigation. **Light** and the correct **temperature** are essential to the success of the investigation.
- Plug in the assembled light box. Instruct the Control and Experimental groups for Team A to place their grow tubs in the light box.
- Each person in the class uses a Case of the Mystery Plants Data Sheet Handout to make and record observations.

EXPERIENCE 2:
Team B — Light Box & Biotech Video

PART 2: Biotech Video: Students work as a team to create a video that describes part of their investigation.

VOCABULARY

- animation
- dominant genes
- genes
- germinate
- life cycle
- recessive genes

TIME: 2–4 class periods

MATERIALS

- Biotech Video Storyboard Handouts
- Computer with speakers and Internet access
- Team user name and password for the **SciencePort**® website
- Script
- Props

PROCEDURES

- Students will work as a team to prepare a video about a Biotech process.
- Ask students to review what they have learned from the **SciencePort** modules and videos, and from growing the plants. Direct students to think of one process to describe in a video.
- Students will prepare a short video to illustrate one of the following:
  - The Plant Life Cycle
  - Selective Breeding
  - Parts of a Plant Cell
  - Dominant and Recessive Genes
- To create the video, the students **storyboard** and plan their project prior to the museum visit. At the museum, staff members will help them use technology to complete the video.
- Direct students to view bio-technology video examples found on the Science Reference section of the **SciencePort** website.
- As a team, students decide what concept to film from the list above. Direct students to script and storyboard their project. The video can be a game (charades, quiz show) or a skit (news show, comedy, commercial).
- Have students view the following videos on the **SciencePort**® website:
  - How to Plan a Video
  - How to Light a Video
  - How to Mic a Video
  - How to Shoot a Video
- Ask students to use the Biotech Video Storyboard Handout to create the video plan and a script that is less than two minutes long.
- Have students write the script for the video. Provide materials and small props (no green items) for the video. Decide what each person in the video will wear. Simple is always best. **Instruct the students not to wear any green.** They will be filmed in front of a green screen, and anything green will be replaced with the background image. White **SciencePort** lab coats are available for student use.
- For additional tips and ideas, direct students to visit the examples and Image Gallery on the Science Resource at the **SciencePort** website. Direct students to select several background images from those displayed on the website.
- Direct the students to write the script on large construction paper or poster board. Direct them to practice the script for the video until they have perfected the delivery.
- Check team materials prior to the museum visit. Students have limited time at the museum.

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Biotech Video Storyboard Handout • Topic: _____ **Team:** _____

Create materials to use in the video. Plan each scene using the storyboard boxes.

EXPERIENCE 3:
Team C — Mystery Powder Solutions & Bioassay Microscope Presentation

PART 1: Mystery Powder Solutions: In this task students prepare three Mystery Powder Solutions to be used in the growth project by the Control and Experimental groups. They will also use the Mystery Powder Solution in a bioassay.

SCIENCE RESOURCES

Located on the SciencePort® website:

- Museum Activities
- Growing *Brassica rapa* (PDF)
- Bioassay and the Mystery Powder (PDF)
- The Case of the Mystery Plants (PDF)

TIME: one class period

VOCABULARY

- bioassay
- microcentrifuge
- powder
- solution

MATERIALS

- Computer with speakers and Internet access
- User name and password for the **SciencePort** website
- Mystery Powder Bioassay Handout
- Case of the Mystery Plants Data Sheet Handout
- Microcentrifuge tube of Red Mystery Powder
- Microcentrifuge tube of Blue Mystery Powder
- Microcentrifuge tube of White Mystery Powder
- Three small bottles of water (8 oz./240 ml)
- Large bottle of water (16.9 oz./500 ml) (Yellow solution)

PROCEDURES

Direct students to carry out the following tasks:

- Review information about the bioassay from the classroom and the **SciencePort** videos.
- Make a Mystery Powder Solution from the Red Mystery Powder: Add the contents of the micro-centrifuge tube of Red Mystery powder to a small water bottle with the red dot. Shake it well.
- Repeat with the Blue and the White mystery powders.
- Use the water in the large bottle of water as the control solution. The bottle contains a yellow label.
- Store the water bottles in a dark place when not in use.
- Take the Mystery Powder Solutions to Team A Control and Experimental groups.
- Use the syringe to apply each treatment of Mystery Powder Solution to the plants. Apply 10 ml (full syringe) of Red Mystery Powder Solution to the red growing cup, Blue Mystery Powder Solution to the blue cup, White Mystery Powder Solution to the white cup, and plain water to the yellow cup. Rinse the syringe after each different treatment. Repeat this for each Grow Tub.
- A mixture of solutions will collect in the bottom of the reservoir. Discard all the liquid in the reservoir and replace it with fresh tap water each time before you add the Mystery Powder Solutions to the grow tubs. This will ensure that the solutions do not get soaked up into different plants.
- Each student uses a Case of the Mystery Plants Data Sheet Handout to make and record observations.

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EXPERIENCE 3:
Team C — Mystery Powder Solutions & Bioassay Microscope Presentation

PART 2: Biotech Video: Bioassay: This task prepares the students to determine how a Mystery Powder Solution affects the growth of a *Brassica rapa* seed. Students will observe the first stage of plant growth—germination. Germination is when a seed begins to sprout. Students observe, measure, and record the effect of mystery solutions on the *Brassica rapa* seeds.

TIME: 2 class periods

VOCABULARY

- agro-chemical
- beneficial
- bioassay
- cotyledon
- effective dose
- harmful
- hypocotyls
- lethal dose
- light
- light box
- pharmaceutical
- pipette
- powder
- root
- root hair
- seed coat

MATERIALS

- **Mystery Powder Bioassay** Handout 1
- **Mystery Powder Bioassay** Handout 2
- Computer access with speakers and Internet
- User name and password for the **SciencePort**® website
- Notepaper
- Four Rapid Cycling *Brassica rapa* Control seeds
- Four Rapid Cycling *Brassica rapa* Experimental seeds
- Four Bioassay cups (1 oz.)
- Bioassay tub (8 oz.) with lid
- Eight strips of paper towel (1 cm x 4 cm)
- One mini-ruler (showing millimeters)
- Hand magnifying lens
- Red Mystery Powder Solution
- Blue Mystery Powder Solution
- White Mystery Powder Solution
- Large bottle of water (16.9 oz./500 ml) with a yellow label
- Four pipettes
- Thermometer
- Watch or clock timer
- Permanent marker
- Toothpicks

EXPERIENCE 3: Team C, Part 2 continued

PROCEDURES

Have students take notes and make observations while they work as a team to complete the following tasks.

- View the following videos on the **SciencePort**® website:
  - Bioassay *Brassica rapa*
  - What Is a Bioassay?
- Introduce the terms **bioassay** and **mystery powder**. Read aloud the following paragraph and discuss its meaning:
  Bioassay (by-oh-AS-say) is a term that describes a test of a substance like a Mystery Powder on a living organism such as a *Brassica rapa* seed to determine its effect. A substance found in the environment is tested at various concentrations on a living organism to determine what concentrations are beneficial or harmful to the organism. The agro-chemical industry develops new fertilizers and crop protection products using bioassay, and most chemicals in and additives to our food are tested by bioassay. The pharmaceutical industry evaluates new medicines by bioassay. They use the information to find an **effective dose** (ED) that is ideal, or the **lethal dose** (LD) that will cause harm.
- Ask students what the three possible outcomes of a bioassay are. List on the board the three effects that a Mystery Powder used in a bioassay can have:
  - The Mystery Powder is bad and harms the plant.
  - The Mystery Powder is good or beneficial to the plant.
  - The Mystery Powder has no observable effect on the plant.
- Tell students that Dr. Williams has provided several mystery powders that may or may not be beneficial to the growth of *Brassica rapa*. Their task as **SciencePort** Investigators is to create three Mystery Powder Solutions and set up a bioassay to look at the effects of a Mystery Powder on seed germination. From these results the team predicts what effect the Mystery Powder will have on the life cycle of a *Brassica rapa* plant and on seed production.
- Distribute Mystery Powder Bioassay handouts 1 and 2 to the team. Complete the seed type (Control or Experimental) and the student names. Take this handout and the bioassay tub to the museum.

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BIOASSAY INSTRUCTIONS

- Locate the bioassay tub. It contains a tub, lid, four color-coded cups (without holes), four strips of paper towel labeled "c" and four strips of paper towel labeled "e."
- Label the side of the container "Bioassay Tub" and write your team name and date.
- Stand the strips up so they reach the top rim of the cup. You should have four cups, each containing two strips of paper towel. Write "c" on one strip and "e" on the other strip in each cup.
- With the pipette, carefully place 20 drops of water from the yellow container into the Yellow control cup. You will observe water being soaked up into the two paper towel strips. The towel strip should stick to the side of the bioassay cup in an upright position. Rinse the pipette and label it Yellow.
- Repeat with the Red Mystery Solution and the Red Experimental bioassay cup. Use a new pipette and mark it Red. Rinse the pipette completely in water.
- Repeat with the Blue Mystery Solution and the Blue Experimental bioassay cup. Use a new pipette and mark it Blue. Rinse the pipette completely in water.
- Repeat with the White Mystery Solution and the White Experimental bioassay cup. Use a new pipette and mark it white. Rinse the pipette completely in water.
- Carefully remove the experimental seeds from the microcentrifuge container by gently flipping the lid. Place one seed in the center (halfway up) of the "e" strip in the Yellow bioassay cup. Put one seed on each "e" strip in each of the other cups—Red, Blue, and White. Repeat these steps with the Control seeds and the "c" strips. When you are done, each cup should contain two seeds—one "e" and one "c." Use the toothpick to readjust the seeds or strips.
- Add 20 drops of water to the center of the bioassay tub to keep the air humid. Cover with the lid.
- Record the time to the nearest hour that you placed the seeds on the wet paper towels. Also observe, describe, and measure each seed on the paper towel. Make drawings and measurements of the seed. What color is it? What shape? How big is it? Use the hand lens and the mini-ruler. Record your measurements on the Bioassay Handout 1 (page 22). Secure the lid on the tub.
- Place the bioassay tub in the light box so it is about 10 cm from the light. Use old phonebooks to elevate the tub.
- Set up and monitor the bioassay in the light box for the next several days. As the plants grow, remove the lid and lower the tub to maintain the 10 cm distance from the light.
- Your team should determine the time period you plan to use between regular written observations. This might be every 8 or 12 hours. Decide on the best time to do the observations.
- Your team should make observations and collect data using the Mystery Powder Bioassay handouts 1 and 2. Fill in the information on when the bioassay started (when the seeds were first added and watered), and then at each observation:
  - note the time of each observation
  - note the temperature
- Be sure to note major events such as **germination** (when the seed sprouts, when the root emerges, when the stem emerges) for each seed.
- Use the ruler to measure (in millimeters) the length of the plant, length of the stem, and length of the root.
- Try to use the codes on the handout to describe the development (new parts) and the growth (measurement of the parts) of the plants. The Mystery Powder may cause the germination process to go fast or slow—this is for the team to find out.
- Remember that you are observing the plants and collecting written data to determine the effect of each Mystery Powder on the plants. Mystery Powders can:
  - be bad and harm the plant;
  - be good or beneficial to the plant; or
  - have no observable effect on the plant.
- Continue the investigation for 48 to 96 hours (2 to 4 days).
- Bring the bioassay tub with you to the museum. In **SciencePort** you will use the video microscope and computers to make a presentation about the bioassay.
- At the end of the bioassay you can plant your seedlings to continue the life cycle of the plants.

TEACHER NOTE

- Students collect this information on the provided handouts. They also use the online charts provided on the **SciencePort**® website.

Mystery Powder Bioassay Handout 1

Team Members: _____, _____, _____

Observations • Measurements (mm) • Notes

Hours	Yellow Assay Cup		Red Assay Cup		Blue Assay Cup		White Assay Cup	
	Seed E	Seed C	Seed E	Seed C	Seed E	Seed C	Seed E	Seed C
hours								
hours								
hours								
hours								

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Mystery Powder Bioassay Handout 2

Team: _____ **Members:** _____, _____, _____

Mystery Substances for Bioassay: Yellow Control, Red, Blue, and White Powder Solutions

Date assay started: _____ **Time assay started:** _____

	DATE	TEMP.	TIME	HOURS ELAPSED
1st OBSERVATION				
2nd OBSERVATION				
3rd OBSERVATION				
4th OBSERVATION				

ENVIRONMENT

Calculate the average temperature from the temperatures noted in your observations. Average Temperature: _____	How many hours were the seeds in light and how many hours were they in darkness during the experiment? Light hours/dark hours: _____	Light Intensity: ❍ strong ❍ medium ❍ low

SciencePort Germination Glossary

sc	seed coat
g	germination (seed cracks and root emerges)
r	root (development of the root)
rh	root hair
hyc	hypocotyls (hypo - below cotyledon)
c	cotyledon (seed leaf)
cp	cotyledon color pink or purple
co	cotyledon opens (two green seed leaves)
p	pink color
y	yellow color
gr	green color

Notes

_____

_____

_____

_____

_____

_____

_____

EXPERIENCE 3:
Team C — Mystery Powder Solutions & Bioassay Microscope Presentation

PART 3: Bioassay Microscope Presentation: Started on Monday prior to the visit to the museum. In this task students share what they learned from the Bioassay project by creating a video microscope presentation at the museum. They will present data to support the effect of mystery solutions on the *Brassica rapa* seeds.

TIME: two class periods (classroom and **SciencePort**)

VOCABULARY

- eyepiece
- focus
- microscope slide
- objective lens
- stage
- video microscope
- zoom

MATERIALS

- Microscope Presentation Storyboard Handout
- Computer with speakers and Internet access
- User name and password for the **SciencePort**® website
- Bioassay tub (with germinated plants)
- Mystery Powder Bioassay Handouts 1 and 2

PROCEDURES

- Give students the following instructions:
  - Work as a team to complete the following tasks. Take notes and make observations.
  - Discuss and organize within your team the jobs that need to be done to complete the task.
  - Your team will create a storyboard for a Microscope Presentation prior to the museum visit.
- Tell students that they will use a video microscope and live plants in **SciencePort** to create photographic images of the *Brassica rapa* bioassay at different stages in its life cycle. The images will then be organized into a presentation about the plant life cycle.
- Ask students to prepare for the presentation by bringing:
  - List of photos to take
  - Captions for the images
  - Prepared Microsoft PowerPoint template for the presentation, including layout, colors, etc.
- Review the life cycle of *Brassica rapa* in Module One – What Is Living? What Is Non-Living?
- Direct students to view the example Microscope Presentation on the Science Resources of the **SciencePort** website.
- Direct students to use the Microscope Presentation Storyboard Handout to plan the task.
- Check team materials prior to the museum visit. Students have limited time at the museum.

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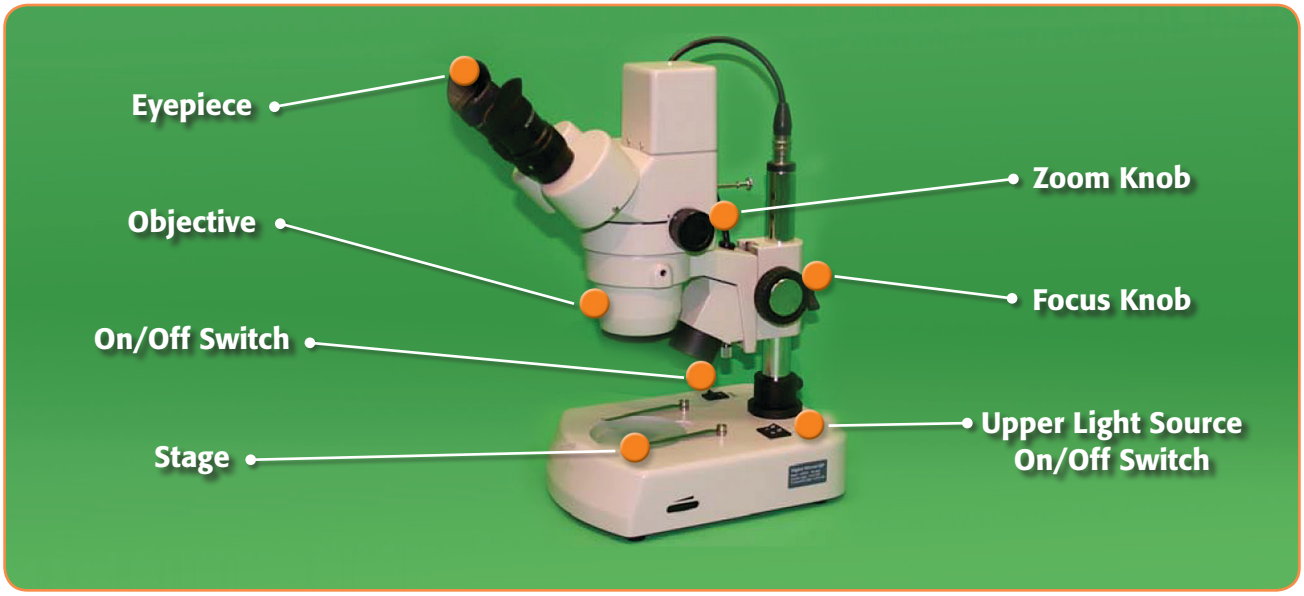
Microscope Presentation Storyboard Handout • Topic: _____ **Team:** _____

Create materials to use in the presentation. Plan each scene using the storyboard boxes.

Digital Stereomicroscope Directions



To Start

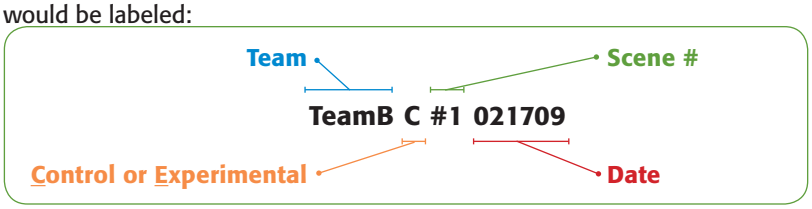
- Open **Motic Image Plus 2.0** on the computer screen.
- Turn on the MAIN button of the microscope.
- Place white opaque slide with specimen on the stage.
- Turn on the upper light source button only.
- Click the **Capture Window** button on the tool bar to focus on the slide specimen.
- Adjust image with the **zoom knob** on the microscope.
- Adjust image with the **focus knob** on the microscope.

To Capture Image

- In the **Motic MC Camera 1.1** window click on the button to capture the slide image.
- To view the image click on the **Minimize** or **Restore Down** button and it opens on the right side of the Motic Image Plus main screen.

To Save Image:

- In the **Motic Image Plus** main screen click on the image.
- **Open File** from main menu and click on **Save As.** Save the image as a jpeg in the **SciencePort Images** folder.
- Label image file with your team name, control/experimental, scene number, and date.
- Example: Team B (Control) picture of a flower taken on 02-17-09 would be labeled:



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LESSON THREE: Control and Experimental Groups

Student teams work to complete assigned tasks in **SciencePort.**® Museum staff assists the teachers and chaperones with the tasks.

TEAM A:
Grow Tubs and Biotech Animation
TEAM B:
Biotech Video
TEAM C:
Bioassay Microscope Presentation

TIME: 90 minute session per class split between **SciencePort** and the museum.

The chart below describes the teams and the tasks to be completed at **SciencePort**.

TEAM	**SciencePort**
A	Biotech Video
B	Biotech Animation
C	Microscope Presentation

MATERIALS

Visit the Science Resources section of the SciencePort website to view materials needed for the investigation.

- Before coming to the museum meet with each team to ensure they are prepared for the tasks.
- Give each student a copy of The Case of the Mystery Plants Data Sheet Handout.

PROCEDURES

- When your class of 6 teams visits the museum, 3 of the teams will go to **SciencePort**, while 3 teams explore other museum exhibits.
- While they are in **SciencePort**, each group of 3 teams will have 45 minutes to work on the identified tasks and then switch with the other group.

Students bring to SciencePort

- Case of the Mystery Plants Data Sheet Handouts 1 and 2
- Control tub with plants
- Experimental tub with plants
- Bioassay tub with plants
- Mystery Powder Bioassay Handout
- Biotech Animation Story Board and props
- Biotech Video Story Board and props, including the script
- Biotech Microscope Presentation Story Board

Case of the Mystery Plants Data Sheet Handout

❏ Control or ❏ Experimental

Team Members: _____, _____, _____

Observations • Measurements (mm) • Notes

Day	Yellow (Water) Grow Cup	Red Grow Cup	Blue Grow Cup	White Grow Cup
1 Germination Mystery Solutions Added				
4 Mystery Solutions Added				
12 Mystery Solutions Added				
15 Count and Pollinate Flowers				
18 Count Flowers Terminate New Flower Buds				
24 Count Flowers Count Pods				
32 Count Pods				
36 Count Pods Stop Watering				
40 Harvest Seeds				

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EXPERIENCE 1:
Team A — Biotech Animation – SciencePort®

TIME: 45 minutes

VOCABULARY

- animation
- props
- storyboard

MATERIALS

- Completed Biotech Animation Storyboard Handout from the classroom
- Directions for the animation equipment
- Pre-constructed materials (props) for the animation: paper, felt, etc.

PROCEDURES

- Students meet with museum staff for orientation to the **SciencePort** Investigation Station that contains the Stop-Motion animation camera and software.
- Review the Stop-Motion Animation and software directions found at the station and used in the classroom preparation.
- Students review the animation storyboard for the project.
- **SciencePort** staff assists the teacher, chaperones, and students in the animation. Students take test images using the software.
- Students rehearse the animation using the materials they brought to the museum.
- Students create the different scenes and use the software to build the animation.
- Students review and revise the movements of the animation with their props. Museum staff assists in the completion of the animation.
- Create a copy of the animation for the classroom.

EXPERIENCE 2:
Team B — Biotech Video – SciencePort®

PROCEDURES

- Students meet with **SciencePort** staff for orientation to the New Media Studio.
- Students review the script and scenes on the "green screen" stage and rehearse the program.
- Students provide **SciencePort** staff with the image numbers of the selected background images.
- **SciencePort** staff will make a test video clip and upload the background images.
- Film the various video clips for the program. **SciencePort** staff assists in the video segments and editing of the project.
- Review and revise the final video.
- **SciencePort** staff completes the final editing of the video and sends it to the school.

TIME: 45 minutes

VOCABULARY

- background images
- green screen
- storyboard

MATERIALS

- Completed Biotech Video Storyboard Handout from the classroom
- Script
- Props

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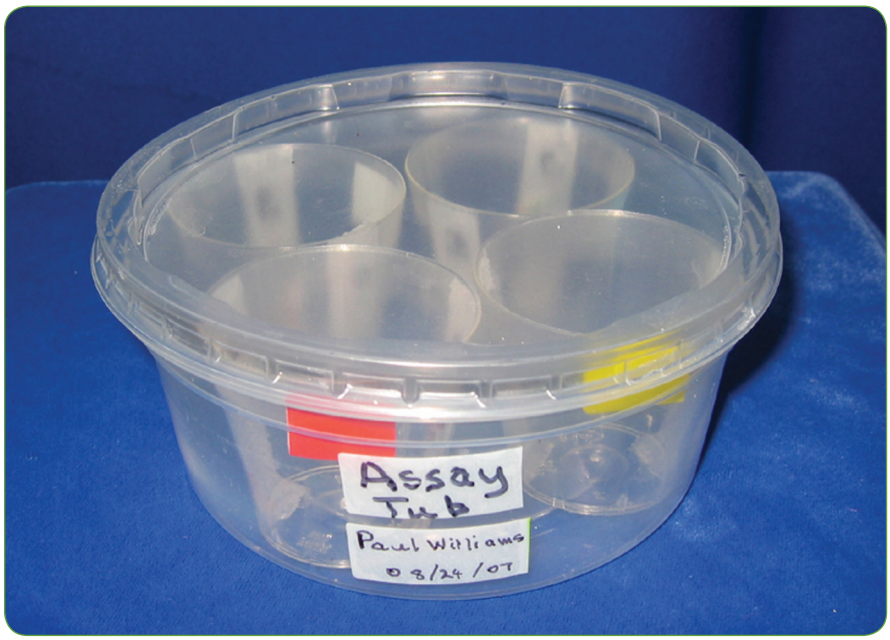
EXPERIENCE 3:
Team C — Bioassay Microscope Presentation—SciencePort®



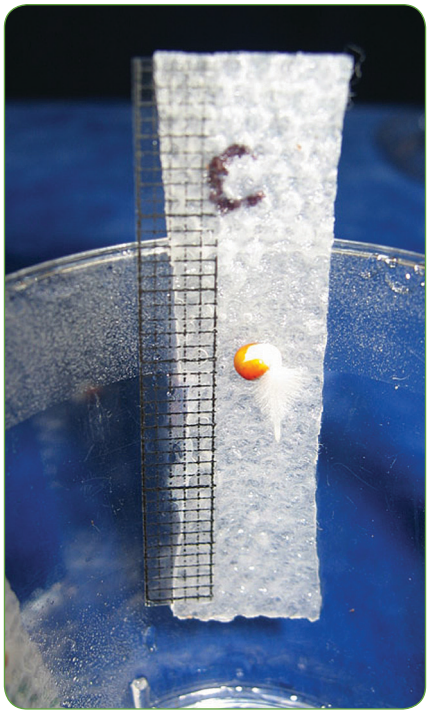
TIME: 45 minutes

VOCABULARY

- germinate
- life cycle

MATERIALS

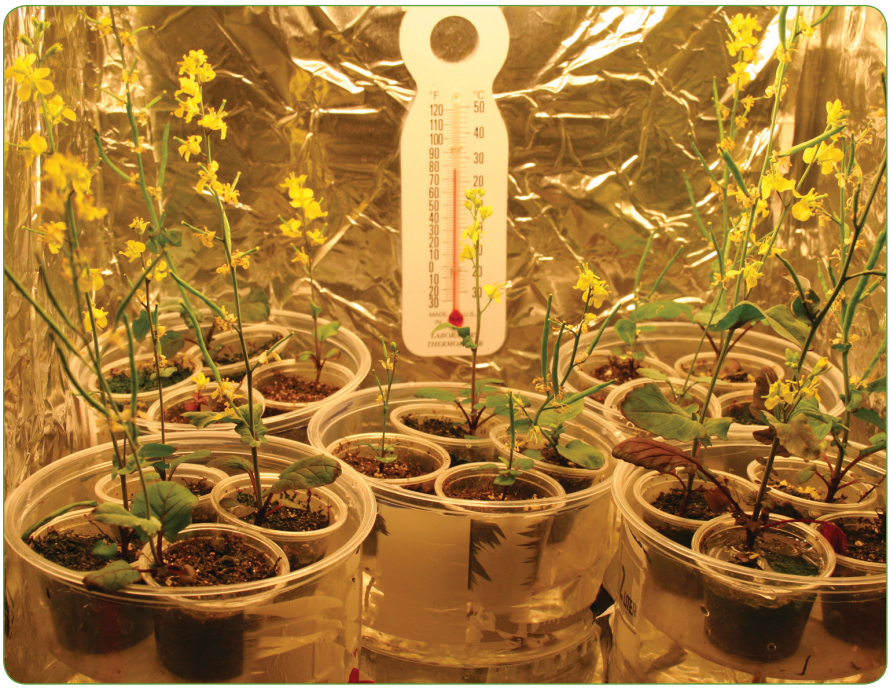
- Completed Microscope Presentation Storyboard Handout from classroom
- Video Microscope Directions
- Microscope Presentation PowerPoint file on flash drive, CD, or emailed to SciencePortCoord@ChildrensMuseum.org
- Bioassay Tub with plants
- Mystery Powder Bioassay Handout



PROCEDURES

- Students meet with **SciencePort** staff for orientation at Investigation Station 2.
- Students can bring a flash drive with a PowerPoint presentation that they started at school.
- Students review the Microscope Presentation they created in the classroom.
- Museum staff will guide students through their PowerPoint presentations. Each student will be asked to participate in discussion of their plant seeds.
- **SciencePort** staff assists in creating and saving images of the bioassay plants for the presentation.
  - Insert images into the presentation.
  - Review and revise the presentation.
  - Create a copy for the museum and for the classroom.

LESSON FOUR: Control & Experimental Tasks, Reports, and Sharing



EXPERIENCE 1:

Team A — Biotech Animation Data Collection and Report

Each team will complete their tasks in the classroom and record data on The Case of the Mystery Plants Data Sheet Handout. The three control teams and the three experimental teams monitor and observe the light box and plants. Growing instructions to complete the project are included in the Resources section at the end of this document.

TIME: 10 minutes per day for 36 days, and three full class periods

MATERIALS

- Completed tasks from the museum
- The Case of the Mystery Plants Data Sheet Handout
- *Brassica rapa* Growing Instructions Handout
- Plants growing in light box
- Biotech Animation Storyboard Handout
- Biotech Animation

PROCEDURES

- Establish *Brassica rapa* grow tubs in light box.
- Review museum tasks and activities.
- Follow growing instructions—see handout pages 36–37.
- Monitor *Brassica rapa* with team.
- Record data and observations in journal and online in **SciencePort**® charts.
- Students complete the growth cycle of the *Brassica rapa* plants.
- Students use The Case of the Mystery Plants Data Sheet to record observations, measurements, and results. The data collected should include information about variations (differences) in growth (plant height in mm), development (number of leaves on main stem), and reproduction (number of open flowers) for each plant.
  Results: The data collected is used to determine:
  - Which Mystery Powder treatment (Red, White, or Blue) produced the most seeds?
  - Was yellow the winner overall?
  - What seed type produced more seed?
- Students present the team's Biotech Animation to the class.
- Students present findings to the class on biodiesel and *Brassica rapa*.
  What was the effect of each Mystery Powder on the plants?
- Students work together to provide a class report on which plant and what Mystery Powders are the best solutions to create biodiesel. Students use their data and observations for their conclusion.
- Teacher provides culminating report to the staff at **SciencePort** headquarters.

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EXPERIENCE 2:

Team B — Biotech Video Data Collection and Report

Each team will complete their tasks in the classroom and record data on The Case of the Mystery Plants Data Sheet Handout. The three control teams and the three experimental teams monitor and observe the light box and plants. Growing instructions to complete the project are included in the Resources section at the end of this document.

TIME: 10 minutes per day for 36 days, and three full class periods

MATERIALS

- Completed tasks from the museum
- The Case of the Mystery Plants Data Sheet Handout
- *Brassica rapa* Growing Instructions Handout
- Plants growing in light box
- Biotech Video Storyboard Handout
- Biotech Video

PROCEDURES

- Establish *Brassica rapa* grow tubs in light box.
- Review museum tasks and activities.
- Follow growing instructions—see handout pages 36–37.
- Monitor *Brassica rapa* with team.
- Record data and observations in journal and online in **SciencePort**® charts.
- Students complete the growth cycle of the *Brassica rapa* plants.
- Students use The Case of the Mystery Plants Data Sheet to record observations, measurements, and results. The data collected should include information about variations (differences) in growth (plant height in mm), development (number of leaves on main stem), and reproduction (number of open flowers) for each plant. Results: The data collected is used to determine:
  - Which Mystery Powder treatment (Red, White, or Blue) produced the most seeds?
  - Was yellow the winner overall?
  - What seed type produced more seed?

- Students present the team's Biotech Video to the class.
- Students present findings to the class on biodiesel and *Brassica rapa*. What was the effect of each Mystery Powder on the plants?
- Students work together to provide a class report on which plant and what Mystery Powders are the best solutions to create biodiesel. Students use their data and observations for their conclusion.
- Teacher provides culminating report to the staff at **SciencePort** headquarters.

EXPERIENCE 3:
Team C — Bioassay Microscope Presentation, Data Collection, and Report

Each team will complete their tasks in the classroom and record data on The Case of the Mystery Plants Data Sheet Handout. The three control teams and the three experimental teams monitor and observe the light box and plants. Growing instructions to complete the project are included in the Resources section at the end of this document.

TIME: 10 minutes per day for 36 days, and three full class periods

MATERIALS

- Bioassay project
- Mystery Powder Bioassay Handout
- Bioassay and Mystery Powders: The Case of the Mystery Plants Handout
- The Case of the Mystery Plants Data Sheet Handout
- *Brassica rapa* Growing Instructions Handout
- Bioassay Microscope Presentation Storyboard Handout
- Bioassay Microscope Presentation

PROCEDURES

- Establish *Brassica rapa* grow tubs in light box.
- Review museum tasks and activities.
- Follow growing instructions—see handout pages 36–37.
- Monitor *Brassica rapa* with team.
- Record data and observations in journal and online in **SciencePort**® charts.
- Students complete the growth cycle of the *Brassica rapa* plants.
- Students use The Case of the Mystery Plants Data Sheet to record observations, measurements, and results. The data collected should include information about variations (differences) in growth (plant height in mm), development (number of leaves on main stem), and reproduction (number of open flowers) for each plant.

  Results: The data collected is used to determine:
  - Which Mystery Powder treatment (red, white, or blue) produced the most seeds?
  - Was yellow the winner overall?
  - What seed type produced more seed?
- Students present the team's bioassay project to the class.
- Students present findings to the class on biodiesel and *Brassica rapa*. What was the effect of each Mystery Powder on the plants?
- Students work together to provide a class report on which plant and what Mystery Powders are the best solutions to create biodiesel. Students use their data and observations for their conclusion.
- Teacher provides culminating report to the staff at **SciencePort** headquarters.

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Growing Rapid Cycling *Brassica rapa*

Rapid Cycling *Brassica rapa* (RCBr) is the product of 35 years of plant breeding by plant pathologist Paul H. Williams. Dr. Williams began developing the plants to speed up his genetic research at the University of Wisconsin – Madison. These plants have been used as research tools around the world by teachers, scientists, and astronauts. The rapid cycling brassicas are related to crucifers (plants in the mustard family, such as broccoli, cabbage, and turnips). RCBr completes an entire life cycle—from seed to seed—in 40 days.

All biological organisms, including Rapid Cycling *Brassica rapa*, require care and attention. **The Case of the Mystery Plants** is a science project designed to investigate two different varieties of *Brassica rapa* seeds. Your job as a **SciencePort**® Investigator is to grow plants from two different seed types. You will also investigate three different Mystery Powders and their effect on *Brassica* growth. The goal is to examine ways to increase seed production. *Brassica rapa* seeds contain oil—oil that can be used in the production of biodiesel. More seeds mean the potential for more oil. Your efforts could lead to a deeper understanding of *Brassica rapa* as a renewable alternative fuel source. As a **SciencePort** Investigator you are provided with the growing tools to complete your investigation. The most important tools to have are an inquisitive mind and an observant eye. Use the procedures below and the tools in the kit to explore **The Case of the Mystery Plants**. Remember, as Dr. Williams says, "Science is for everyone."

Optimum Conditions for Successfully Growing Rapid Cycling *Brassica rapa*

Physical Environment

Continuous fluorescent light	Lights should be on 24 hours a day.
Consistent room temperature	Optimal room temperature: 65–78°F (18–26°C). Keep a thermometer near the plants and check the temperature regularly.

Chemical Environment

Water	Water should be present in the growing container at all times.
Fertilizer	Use the time-release nutrient pellets that are included in the kit.
Potting Mix (pellets)	The plant roots need the aeration that a light potting mix provides, so use the peat potting mix included in the kit.
Seed covering	Vermiculite

SciencePort® Challenge – Germination Key

Scientists like Dr. Williams develop methods for note taking. Your job as a **SciencePort** Investigator is to try new science methods. Below is list of words that are important to plant germination. This list of words and codes was made to help you with your investigation. Try to use some of the following science words used by Dr. Williams and the **SciencePort** staff. This science language will help us keep track of the hundreds of seeds and investigations going on.

sc	seed coat
g	germination (seed cracks and root emerges)
r	root (development of the root)
rh	root hair
hyc	hypocotyls (hypo – below cotyledon)
c	cotyledon (seed leaf)
cp	cotyledon color pink or purple
co	cotyledon opens (two green seed leaves)
p	pink color
y	yellow color
gr	green color

The Case of the Mystery Plants — *Brassica rapa* and Biodiesel

Students chart the growth and development of the plants and calculate the seed yield—the number of seeds produced. Rapid Cycling *Brassica rapa* (RCBr) has the potential to be used in the production of biodiesel. Plants can be grown and the seed collected. Plant seeds contain oil, which is removed from the seeds and mixed with other substances to make biodiesel fuel. More seeds mean more biodiesel. Biodiesel is usually mixed with petroleum diesel to make a biodiesel blend.

Biodiesel is a **renewable energy resource** because it is made from plants. Students can grow more plants to make more biodiesel.

Petroleum fuels, such as gasoline, come from the Earth and are a nonrenewable energy resource. Nonrenewable energy resources are resources that cannot be replaced once they are used up.

G (growth) + D (development) + R (reproduction) = SY (seed yield)

G	measure the height of the plant
D	count the number of leaves
R	count the number of pollinated flowers and pods
SY	count the number of seeds

Brassica rapa Growing Instructions – Growth and Development

Day 1

Plant the Seeds: Teams construct the light box, grow tubs, and bioassay tub.

Add Mystery Powder Solution: Use the syringe to add 10 milliliters (ml) of each Mystery Solution to each color-coded cup. Use only the Red Mystery Powder Solution for the seeds in the Red cups. Use the Blue Mystery Solution in the Blue cup plants. Use the White Mystery Solution in the White cup seeds. Use water in the Yellow cup seeds. Do this to both the Control seeds and the Experimental seeds. Rinse the syringe completely after each different solution. Pour out all of the water in the reservoir and replace with fresh tap water each time you add the Mystery Solutions to the grow tubs.

Put the Grow Tubs and Bioassay Tub in Light Box: Prop the grow tubs up so the top of the tub is about 10 cm below the light. Turn on the light and leave it on 24 hours a day. Replenish the water in the bottom reservoir often. Monitor the temperature inside the light box.

Days 2 – 3

Monitor the Plants: Check each plant, and make observations and drawings. Measure any growth (how the plant gets larger) and new development (new parts, such as leaves or flower buds) that appear. Continue taking observations, drawing pictures, and writing notes every few days. Be sure to record the temperature daily and keep the plant about 10 cm below the light as it grows. Continue this until Day 40.

Day 4

Thin and/or Transplant the Plants: After the seeds germinate, you should remove all but two plants per cup to prevent crowding. This is called thinning. Use a toothpick and carefully dig up one plant and transplant or move it so that each grow cup has no more than two plants. Add the Mystery Powders as described below.

Repeat the Mystery Powder Solution: Use the syringe to add 10 milliliters (ml) of each Mystery Solution to each color-coded cup. Use only the Red Mystery Powder Solution for the plants in the Red cups. Use the Blue Mystery Solution in the Blue cup plants. Use the White Mystery Solution in the White cup plants. Use water in the Yellow cup plants. Do this to both the Control Seeds and the Experimental Seeds. Rinse the syringe completely after each different solution. Pour out all of the water in the reservoir and replace it with fresh tap water each time you add the Mystery Solutions to the grow tubs.

Days 5 – 12

Tend the Plants: Replenish the water often—a big growth spurt is coming! Every other day, adjust the growing systems so the top of the plants is 10 cm from the light. Remember to keep carefully measuring and recording all of your observations!

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Day 12

Repeat Mystery Powder Solution: Use the syringe to add 10 milliliters (ml) of each Mystery Solution to each color-coded cup. Use only the Red Mystery Powder Solution for the plants in the Red cups. Use the Blue Mystery Solution in the Blue cup plants. Use the White Mystery Solution in the White cup plants. Use water in the Yellow cup plants. Do this to both the Control Seeds and the Experimental Seeds. Rinse the syringe completely after each different solution. Pour out all of the water in the reservoir and replace with fresh tap water each time you add the Mystery Solutions to the grow tubs.

Days 15 – 17

Count and Pollinate Flowers: Use one of the toothpick pollinators for the Control plants and the other one for the Experimental plants. Brush the flannel tip of the toothpick pollinator into the flowers to pick up and distribute pollen. Transfer pollen back and forth among several plants. (Rapid Cycling *Brassica rapa* does not self-fertilize.) Pollinate the flowers every day for two to three days. Look at the flannel patch on the tip of the pollinator to see if it is picking up pollen. It should be yellow with pollen. Do not switch toothpick pollinators between the Control and Experimental growing tubs.

For each plant, be sure that you count and record the number of flowers you pollinated.

Day 18

Count Flowers and Terminate Buds: One day after the final pollination, cut off any new flowers or buds so the plant can channel its energy toward seed growth. Do NOT cut off flowers that were pollinated. For each plant, be sure that you count and record the number of flowers that you pollinated.

Days 19 – 35

Count, Measure, Observe Pods: Keep the reservoir tubs full of water until Day 36. Remember to keep carefully measuring and recording all of your observations!

Day 36

Stop Watering: Twenty days after final pollination, remove plants from the water and allow them to dry for one full week in the tubs until they are brown and crispy. Keep them in the light box and keep the light on.

Day 40

Harvest Seeds: Cut off the stems and seed pods with scissors. Do this separately for each plant so you can determine which plants produced the most seeds.

To harvest a few seeds, place seed pods between two pieces of clear tape with the ends folded over. Crush the pods inside the tape, then peel open to get the seeds. To harvest many seeds: Place the stems and pods in a paper bag and crush them inside. Pour the contents into a dish, blow off the chaff (seed coats and pod pieces) and pick out the seeds.

Count Seeds: Make careful observations. Count all the seeds from each plant. Make a note as to how many pods and seeds each plant produced. Record your findings.

Store Seeds: Store the seeds in a small labeled paper envelope in a sealed jar in a cool, dry place or plant them for another experiment or activity.

Clean Up: Soak the reservoirs, tubs and wicks for 30 minutes in a solution of 95% water and 5% bleach. Scrub, rinse, and let air dry.

Tips and Troubleshooting

All biological organisms require care and attention. Rapid Cycling *Brassica rapa* has been bred to require only minimum maintenance, but occasionally problems occur. This section offers tips for growing successful plants as well as trouble-shooting suggestions. For more tips, suggestions, or investigation ideas, see fastplants.org.

Poor Germination

- Seeds planted too deep in growing cup: replant.
- Potting mix was compacted during planting: replant.
- Potting mix was not sufficiently watered after planting: Try watering the top of the grow cups until water drips from the bottom of the cups.
- Seeds washed out of growing cup: replant.
- Room temperature is too high or low: adjust temperature.
- No seedlings by Day 4 after planting: start over.

Plants Grow Slowly

- Too cool: Make sure the temperature isn't lowered on weekends. Move plants away from drafty windows or air conditioner vent.
- Not enough light: Keep the light on 24 hours a day.
- Not enough water: Replenish the water often. Verify that wicks are moist and touching the water. Are the wicks positioned correctly in the bottom of each tub so that they are touching both the seeding mix and the water? Is the wick reaching into the water in the bottom reservoir? Are the wicks thoroughly wet?
  If the reservoir ran dry and the plants are wilting (but not yet crispy), you may be able to save them. Water the growing cups from the top to resat-urate the seeding mix and reestablish the capillary action of the wicks. Be sure that the wicks are dripping and the potting mix is thoroughly moistened.

Plants are Spindly

- Not enough light: Keep the light on 24 hours a day.
- Too many plants per growing cup: Remove all but one or two plants per cup (best done at Day 4).

Plants Tip Over

- Tall plants: Stake the plants, using bamboo skewers and ties (Days 11—20).

Plants Wilt

- Not enough water: see above.

Plants Die

- Not enough water: see above.
- Old wicks: Soak the wicks for 5 minutes in a solution of 5% vinegar and water to clean them. Rinse thoroughly and return them to the growing cups.
- Plants were damaged during handling: start over.

Seeds are not produced

- Inadequate pollination: Was pollen transferred among many different plants? Rapid Cycling *Brassica rapa* plants do not self-fertilize.
- Was pollination done on Days 15–17 using toothpick pollinator? Was pollen (yellow dust) visible on the toothpick pollinator? Did you transfer pollen to the tip of the pistil (the stigma) of each flower?
- Room temperature too high: adjust temperature. Plants may lose the ability to produce pollen at high temperatures.

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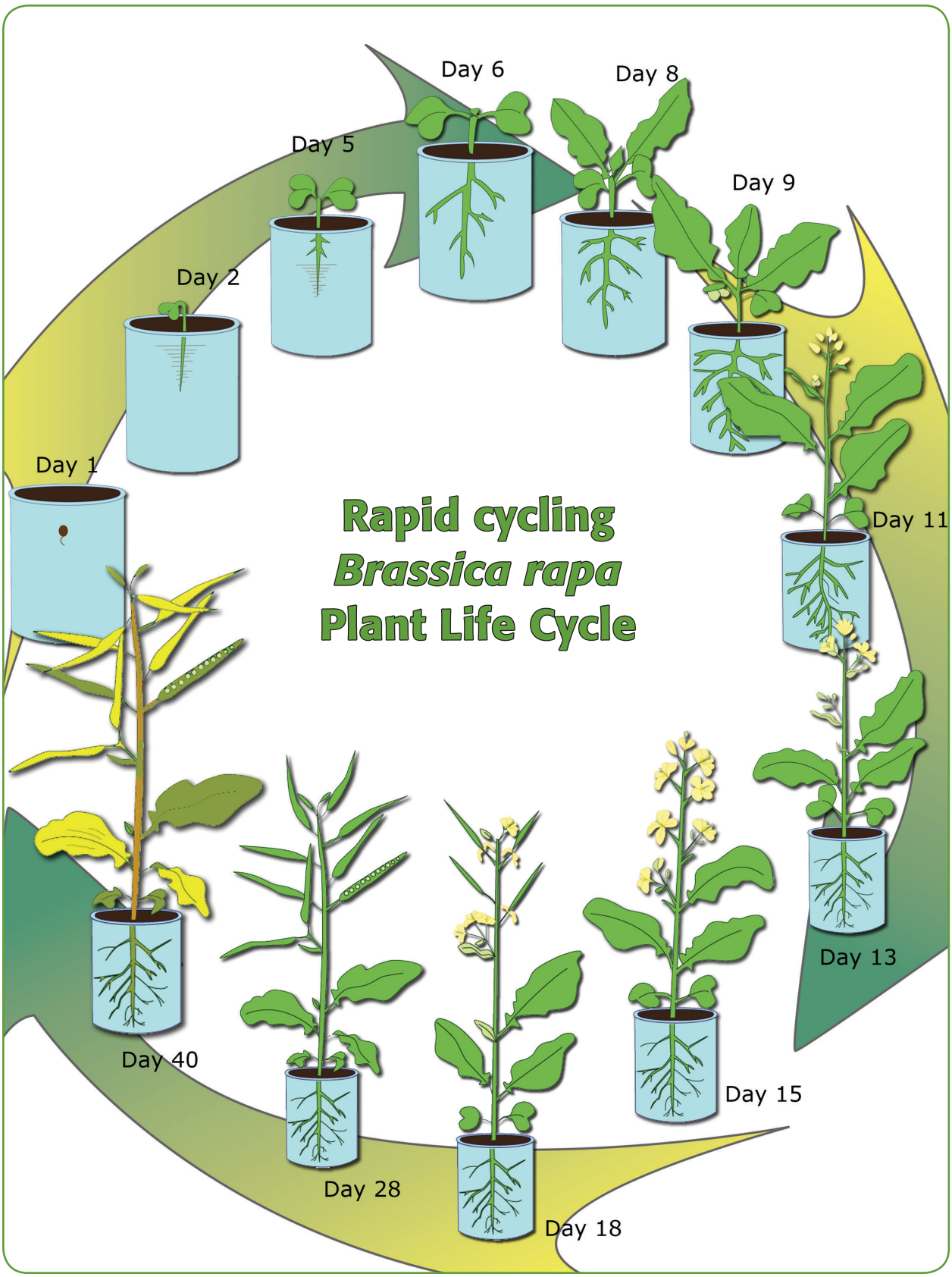
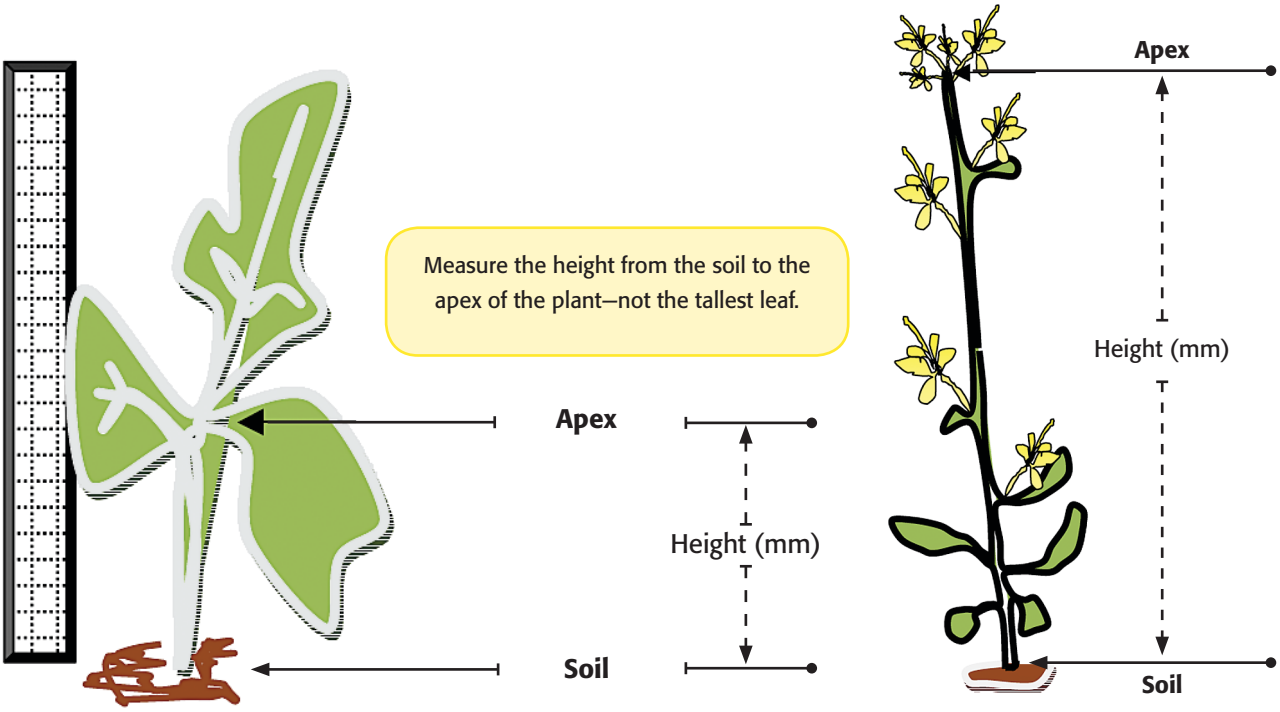

Rapid cycling
Brassica rapa
Plant Life Cycle
Day 1
Day 2
Day 5
Day 6
Day 8
Day 9
Day 11
Day 13
Day 15
Day 18
Day 28
Day 40

Growth

Measure the height of the plants.

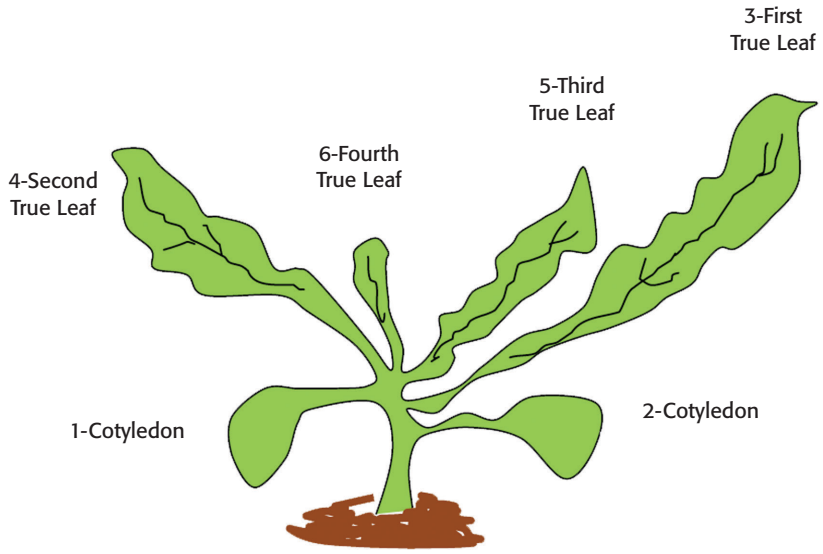
This is a **quantifiable phenotype** trait of *Brassica rapa*. **Quantifiable** means it can be measured. **Phenotype** means the trait can be seen. Use the centimeter ruler to measure the height of the plants.



Development

Count the number of leaves.

Development means new parts on the plant. The first two leaf-like structures are the cotyledons and are not true leaves. Make a drawing and count and label the cotyledons and true leaves that develop.



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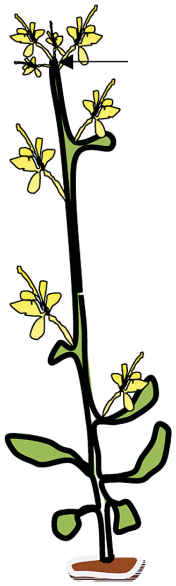
Reproduction

Count all the flowers that develop and are pollinated on days 15 to 17. Cut off and discard any additional flowers that may start to grow. Count, measure, and record the pods that develop from the pollinated flowers.

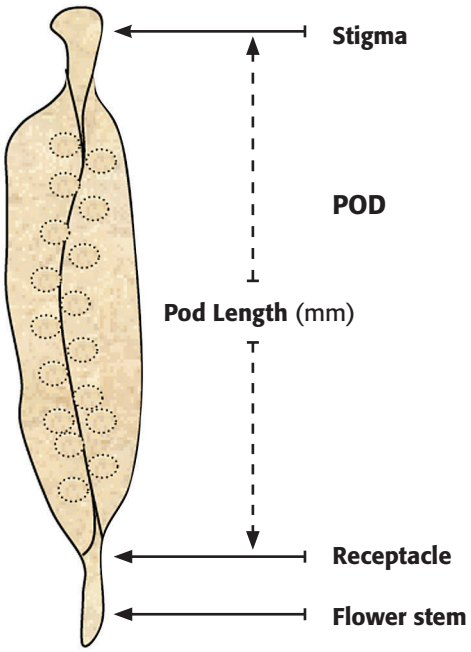


Flowers
Day 16 = 6 Flowers

Seed Pods
Day 20 = 5 Seed Pods

Seed Yield

Count the number of seed pods. Measure the pods from the stigma to the receptacle and record the length.



Seed Harvest

- Approximately 20 days after the last pollination, when the ends of the pods are changing from green to brown, remove the grow tubs from the water reservoir.
- Let the plants dry for seven days until the pods are crisp and brown.
- Cut the plants off and place them in a paper bag.
- Label the bag with the planting and pollination information. If the pods are not crisp, let them dry further in the bag.
- Staple the bag shut, and then break up the pods thoroughly by crushing them in the bag to release the seeds.
- Pour the seed and chaff into a shallow tray.
- Pick out the large pieces of stems, leaves, and the remaining pod pieces.
- Gently blow on the remaining mixture. The chaff should blow away, leaving clean seeds. You may wish to do this outside.
- Place your clean, dried seeds into a labeled envelope.
- Store the envelopes in a zipper-type sandwich bag in the refrigerator. For optimal long-term (12-month) storage, add silica gel in the bag to remove any remaining moisture. Seeds stored under these conditions may remain viable for many years.

Fast Plants® Paul's Sand Box

Dr. Paul Williams is known as The Father of Fast Plants because his research brought Fast Plants to the world. Paul's Sandbox is the website where Dr. Williams shares many of his latest ideas and innovations. You can find great resources for this and many more *Brassica rapa* investigations at **fastplants.org**

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Biotech – Cool Green Tool!: Content Outline for Online Modules

Module Title	Module Content	Interactivities
MODULE ONE **What Is Living?** **What Is Non-Living?**	What makes something alive? Differences between living and non-living. Nutrients, water, and sunlight. Plant growth and life cycle explored. Optional Activity: **Search for Life**	**Game:** Characteristics of Life – to sort living and non-living items. **Game:** Non-Living Things – to sort non-living things. **Game:** Knowledge Climb – game to review content **Game:** Plant Life Cycle – matching game
MODULE TWO **Cells, DNA, Genetics – Building Blocks of Life**	What is a cell? Differences between plant and animal cells. Parts of a cell explored. Optional Activity: **Make a Model of a Cell**	**Click & Drag:** Interactive Microscope – students click on an image of a plant, animal, or bacteria cell to investigate. **Match:** Plant & Animal Cells – roll over, drag, and drop cell parts and labels.
MODULE THREE **Biotechnology**	What is Biotechnology? Examples of genetically engineered organisms explored. Optional Activity: **Create a Biotech Time Line**	**Timeline:** History of Biotechnology **Rollover:** Biotechnology Techniques – students click on different genetically modified organisms (GMO) to learn more about each one. **Video:** Dow AgroScience – Biotechnology
MODULE FOUR **The Case of the Mystery Plants**	Growth Project – Introduced at the museum and completed at home. Different *Brassica rapa* species – kale, cauliflower, broccoli, Brussels sprouts, mustard introduced. Biodiesel examples provided. Optional Activity: **Grow *Brassica rapa* and Bioassay**	**Videos:** Dr. Paul Williams – Science, *Brassica rapa,* Biodiesel, Bioassay

Grade 4 Science Standards

Process Standards
The Nature of Science
Students gain scientific knowledge by observing the natural and constructed world, performing and evaluating investigations, and communicating their findings. The following principles should guide student work and be integrated into the curriculum along with the content standards on a daily basis.

- Make predictions and formulate testable questions.
- Design a fair test.
- Plan and carry out investigations—often over a period of several lessons—as a class, in small groups, or independently.
- Use measurement skills and apply appropriate units when collecting data.
- Test predictions and multiple trials.
- Keep accurate records in a notebook during investigations and communicate findings to others using graphs, charts, maps, and models through oral and written reports.
- Identify simple patterns in data and propose explanations to account for the patterns.
- Compare the results of an investigation with the prediction

Standard 2: Earth Science
Core Standard: Describe how the supply of natural resources is limited and investigate ways that humans protect and harm the environment.

4.2.4 Investigate earth materials that serve natural resources and gather data to determine which ones are limited by supply.
4.2.5 Describe methods that humans currently use to extend the use of natural resources.

Standard 3: Life Science
Core Standard: Observe, describe, and ask questions about structures of organisms and how they affect their growth and survival.

4.3.1 Observe and describe how offspring are very much, but not exactly, like their parents or one another. Describe how these differences in physical characteristics among individuals in a population may be advantageous for survival and reproduction.
4.3.2 Observe, compare, and record the physical characteristics of living plants or animals from widely different environments. Describe how each plant or animal is adapted to its environment.
4.3.3 Design investigations to explore how organisms meet some of their needs by responding to stimuli from their environments.
4.3.4 Describe a way that a given plant or animal might adapt to a change arising from a human or non-human impact on its environment.

Grade 5 Science Standards

Process Standards
The Nature of Science: Students gain scientific knowledge by observing the natural and constructed world, performing and evaluating investigations, and communicating their findings. The following principles should guide student work and be integrated into the curriculum along with the content standards on a daily basis.

- Make predictions and formulate testable questions.
- Design a fair test.
- Plan and carry out investigations—often over a period of several lessons—as a class, in small groups, or independently.
- Use measurement skills and apply appropriate units when collecting data.
- Test predictions and multiple trials.
- Keep accurate records in a notebook during investigations and communicate findings to others using graphs, charts, maps, and models through oral and written reports.
- Identify simple patterns in data and propose explanations to account for the patterns.
- Compare the results of an investigation with the prediction.

Standard 3: Life Science
Core Standard: Observe, describe, and ask questions about how changes in one part of an ecosystem create changes in other parts of the ecosystem.

5.3.1 Observe and classify common Indiana organisms as producers, consumers, decomposers, predator, and prey based on their relationships and interactions with other organisms in their ecosystems.

Grade 6 Science Standards

Process Standards
The Nature of Science
Students gain scientific knowledge by observing the natural and constructed world, performing and evaluating investigations, and communicating their findings. These principles should guide student work and be integrated into the curriculum along with the content standards on a daily basis.

- Make predictions and develop testable questions based on research and prior knowledge.
- Plan and carry out investigation—often over a period of several class lessons—as a class, in small groups, or independently.
- Collect quantitative data with appropriate tools or technologies and use appropriate units to label numerical data.
- Incorporate variables that can be changes, measured, or controlled.
- Use the principles of accuracy and precision when making measurements.
- Test predictions with multiple trials.
- Keep accurate records in a notebook during investigations.
- Analyze data, using appropriate mathematical manipulation as required, and use it to identify patterns. Make inferences based on these patterns.
- Evaluate possible causes for differing results (i.e., valid data).
- Compare the results of an experiment with the prediction.
- Communicate findings through oral and written reports by using graphs, charts, maps, and models.

Reading for Literacy in Science
Key Ideas and Details
6–8 R.S.3 Follow precisely a multistep procedure when carrying out experiments or taking measurements.
Craft and Structure
6–8.RS.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific context relevant to Grades 6–8 texts and topics.
Integration of Knowledge and Ideas
6–8.RS.7 Integrate quantitative information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table.
6–8.RS.8 Distinguish among facts, reasoned judgment based on research findings, and speculation in a text.
Writing for Literacy in Science
6–8.WS.1 Write arguments to focus on discipline-specific content.

- Introduce claim(s) about a topic or issue, acknowledge and organize the reasons and evidence logically.
- Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources.
- Use words, phrases, and clauses to create cohesion and clarify the relationships among claim(s), counterclaims, reasons, and evidence.

6–8.WS.2 Write informative/explanatory texts, including scientific procedures/experiments.

- Introduce a topic clearly, previewing what is to follow; organize ideas, concepts, and information into broader categories as appropriate to achieving purpose; include formatting, graphics, and multimedia when useful to aiding comprehension.

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- Develop the topic with relevant, well-chosen facts, definitions, concrete details, quotations, or other information and examples.
- Use precise language and domain-specific vocabulary to inform about or explain the topic.

Production and Distribution of Writing

6–8.WS.5 With some guidance and support from peers and adults, develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on how well purpose and audience have been addressed.

6–8.WS.6 Use technology, including the Internet, to produce and publish writing and present the relationships between information and ideas clearly and efficiently.

Content Standards

Standard 3: Life Science

Core Standard: Describe that all organisms, including humans, are part of complex systems found in all biomes.

Core Standard: Understand that the major source of energy for ecosystems is light produced by major nuclear reactions in the sun.

6.3.4 Recognize that plants use energy from the sun to make sugar (i.e., glucose) by the process of photosynthesis.

6.3.6 Recognize that food provides the energy for the work that cells do and is a source of the molecular building blocks that can be incorporated into a cell's structure or stored for later use.

Grade 7 Science Standards

Process Standards

The Nature of Science

Students gain scientific knowledge by observing the natural and constructed world, performing and evaluating investigations, and communicating their findings. These principles should guide student work and be integrated into the curriculum along with the content standards on a daily basis.

- Make predictions and develop testable questions based on research and prior knowledge.
- Plan and carry out investigation—often over a period of several class lessons—as a class, in small groups, or independently
- Collect quantitative data with appropriate tools or technologies and use appropriate units to label numerical data.
- Incorporate variables that can be changes, measured, or controlled.
- Use the principles of accuracy and precision when making measurements.
- Test predictions with multiple trials.
- Keep accurate records in a notebook during investigations.
- Analyze data, using appropriate mathematical manipulation as required, and use it to identify patterns. Make inferences based on these patterns.
- Evaluate possible causes for differing results (i.e., valid data).
- Compare the results of an experiment with the prediction.
- Communicate findings through oral and written reports by using graphs, charts, maps, and models.

Reading for Literacy in Science

Key Ideas and Details

6–8 RS.3 Follow precisely a multistep procedure when carrying out experiments or taking measurements.

Craft and Structure

6–8.RS.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific context relevant to Grades 6–8 texts and topics.

Integration of Knowledge and Ideas

6–8.RS.7 Integrate quantitative information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table.

6–8.RS.8 Distinguish among facts, reasoned judgment based on research findings, and speculation in a text.

Writing for Literacy in Science

6–8.WS.1 Write arguments to focus on discipline-specific content.

- Introduce claim(s) about a topic or issue, acknowledge and organize the reasons and evidence logically.
- Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources.
- Use words, phrases, and clauses to create cohesion and clarify the relationships among claim(s), counterclaims, reasons, and evidence.

6–8.WS.2 Write informative/explanatory texts, including scientific procedures/experiments.

- Introduce a topic clearly, previewing what is to follow; organize ideas, concepts, and information into broader categories as appropriate to achieving purpose; include formatting, graphics, and multimedia when useful to aiding comprehension.
- Develop the topic with relevant, well-chosen facts, definitions, concrete details, quotations, or other information and examples.
- Use precise language and domain-specific vocabulary to inform about or explain the topic.

Production and Distribution of Writing

6–8.WS.5 With some guidance and support from peers and adults, develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on how well purpose and audience have been addressed.

6–8.WS.6 Use technology, including the Internet, to produce and publish writing and present the relationships between information and ideas clearly and efficiently.

Standard 1: Physical Science

Core Standard: Explain that energy cannot be created or destroyed but instead can only be changed from one form into another or transferred from place to place.

7.1.3 Recognize and explain how different ways of obtaining, transforming, and distributing energy have different environmental consequences.

7.1.4 Recognize and provide evidence of how light, sound, and other waves have energy and how they interact with other materials.

Standard 3 Life Science

Core Standard: Understand the cellular structure of single-celled and multi-cellular organisms.

7.3.1 Explain that all living organisms are composed of one cell or multiple cells and that the many functions needed to sustain life are carried out within cells.

7.3.2 Understand that water is a major component within all cells and is required to carry out many cellular functions.

7.3.3 Explain that, although the way cells function is similar in all living organisms, multi-cellular organisms have specialized cells whose specialized functions are directly related to their structure.

7.3.4 Compare and contrast similarities and differences among specialized sub-cellular components within plant and animal cells (including organelles and cell walls that perform essential functions and give cells shape and structure).

7.3.5 Explain that cells in multi-cellular organisms repeatedly divide to make more cells for growth and repair.

7.3.6 Explain that after fertilization a small cluster of cells divide to form the basic tissues of an embryo and further develops into all the specialized tissues and organs within a multi-cellular organism.

7.3.7 Describe how various organs and tissues serve the needs of cells for nutrient and oxygen delivery and waste removal.

Grade 8 Science Standards

Process Standards
The Nature of Science
Students gain scientific knowledge by observing the natural and constructed world, performing and evaluating investigations, and communicating their findings. These principles should guide student work and be integrated into the curriculum along with the content standards on a daily basis.

- Make predictions and develop testable questions based on research and prior knowledge.
- Plan and carry out investigation—often over a period of several class lessons—as a class, in small groups, or independently
- Collect quantitative data with appropriate tools or technologies and use appropriate units to label numerical data.
- Incorporate variables that can be changes, measured, or controlled.
- Use the principles of accuracy and precision when making measurements.
- Test predictions with multiple trials.
- Keep accurate records in a notebook during investigations.
- Analyze data, using appropriate mathematical manipulation as required, and use it to identify patterns. Make inferences based on these patterns.
- Evaluate possible causes for differing results (i.e., valid data).
- Compare the results of an experiment with the prediction.
- Communicate findings through oral and written reports by using graphs, charts, maps, and models.

Reading Standards for Literacy in Science
Key Ideas and Details
6–8 R.S.3 Follow precisely a multistep procedure when carrying out experiments or taking measurements.
Craft and Structure
6–8.RS.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific context relevant to Grades 6–8 texts and topics.
Integration of Knowledge and Ideas
6–8.RS.7 Integrate quantitative information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table.
6–8.RS.8 Distinguish among facts, reasoned judgment based on research findings and speculation in a text.

Writing for Literacy in Science
6–8.WS.1 Write arguments to focus on discipline-specific content.

- Introduce claim(s) about a topic or issue, acknowledge and organize the reasons and evidence logically.
- Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources.
- Use words, phrases, and clauses to create cohesion and clarify the relationships among claim(s), counterclaims, reasons, and evidence.

6–8.WS.2 Write informative/explanatory texts, including scientific procedures/experiments.

- Introduce a topic clearly, previewing what is to follow; organize ideas, concepts, and information into broader categories as appropriate to achieving purpose; include formatting, graphics, and multimedia when useful to aiding comprehension.
- Develop the topic with relevant, well-chosen facts, definitions, concrete details, quotations, or other information and examples.
- Use precise language and domain-specific vocabulary to inform about or explain the topic.

Production and Distribution of Writing
6–8.WS.5 With some guidance and support from peers and adults, develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on how well purpose and audience have been addressed.
6–8.WS.6 Use technology, including the Internet, to produce and publish writing and present the relationships between information and ideas clearly and efficiently.

Content Standards
Standard 2: Earth and Space Systems
Core Standard: Describe how human activities have changed the land, water, and atmosphere.
8.2.7 Recognize that some of the Earth's resources are finite and describe how recycling, reducing consumptions, and the development of alternatives can reduce the rate of their depletion.
Standard 3: Life Science
Core Standard: Understand the predictability of characteristics being passed from parents to offspring.
Core Standard: Explain how a particular environment selects for traits the increase the likelihood of survival and reproduction by individuals bearing those traits.
8.3.1 Explain that reproduction is essential for the continuation of every species and is the mechanism by which all organisms transmit genetic information.
8.3.2 Compare and contrast the transmission of genetic information in sexual and asexual reproduction.
8.3.3 Explain that genetic information is transmitted from parents to offspring mostly by chromosomes.
8.3.4 Understand the relationship between deoxyribonucleic acid (DNA), genes, and chromosomes.
8.3.5 Identify and describe the difference between inherited traits and the physical and behavioral traits that are acquired or learned.
8.3.6 Observe anatomical structures of a variety of organisms and describe their similarities and differences. Use the data collected to organize the organisms into groups and predict their relatedness.
8.3.7 Recognize and explain that small genetic differences between parents and offspring can accumulate in successive generations so that descendants may be different from their ancestors.
8.3.10 Recognize and describe how new varieties of organisms have come about from selective breeding.

National Science Education Standards

Life Science K–8
Content Standard A:
Abilities necessary to do Scientific Inquiry
Understanding about Scientific Inquiry
Life Science K–4
Content Standard C:
Characteristics of Organisms
Life Cycles of Organisms and their Environment
Life Science 5–8
Content Standard C:
Structure and Function in Living Systems
Reproduction and Heredity

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agrochemical: A contraction of **agricultural chemical**, referring to various chemical products used in agriculture, such as fertilizers, pesticides, herbicides, and fungicides, or to the industry that creates them.

aluminum foil: A very thin, flexible sheet of aluminum that can be used to reflect heat and maintain humidity.

animation: The rapid display of a sequence of images in order to create the illusion of movement.

background images: Scenes or props displayed behind the main action in an animation or a video.

bamboo skewers: Long, thin woody sticks made from dried plant fibers.

beneficial: Helpful to or good for something.

bioassay: A contraction of **biological assay**, referring to the measurement of the effects of a substance on living organisms.

biodiesel: A type of engine fuel made from renewable materials, such as plant oils. Biodiesel is usually mixed with petroleum diesel at a blend of 5% to 20%

biotechnology: The use of living things, such as microorganisms, to make new products or modify existing substances.

***Brassica rapa*:** The botanical name for the turnip mustard plant.

compact fluorescent lamp (CFL): An energy-efficient tube, often twisted into a spiral shape, that lasts longer and generates more light than an incandescent bulb.

control: A standard against which other conditions are compared in a scientific experiment.

cotyledon: The first leaf produced by a germinating seed, from which the seedling takes its food.

crate: A sturdy box or open basket.

distribute: To spread or scatter throughout a defined area.

dominant gene: A gene that requires only one of two copies (inherited from either parent) to cause expression of a trait, such as flower color.

effective dose: The amount of a substance applied, such as fertilizer on a plant, that produces the desired result. In an agricultural bioassay, it is the quantity of a chemical required to produce the desired result in 50% of the experimental group.

experimental: A variable condition compared to the control in a scientific experiment.

eyepiece: A magnifying lens at the end of a microscope closest to the viewer's eye.

fertilizer pellets: Small, dehydrated, compressed balls of plant nutrients released over time as moisture is added.

focus: The point at which an object being viewed is at maximum clarity; the adjustment on a microscope that brings an image into clear view.

gene: A sequence of DNA or RNA that represents a fundamental unit of heredity, encoding traits that are transmitted from generation to generation.

genetic modification: A process that changes the characteristics of a living organism by duplicating, adding, or deleting one or more new genes or by altering the activity of an existing gene.

genotype: The genetic constitution of an individual organism.

germinate: The process by which a seed sprouts and begins to grow into a plant.

green screen: A green background used in video production. People or props are used in front of the green screen during filming, and that background is later replaced with other images.

grow cup: A planting pot used to germinate seeds and hold seedlings until they are tall enough to transplant.

grow tub: A receptacle used to hold and support multiple grow cups.

harmful: Damaging or causing injury; not beneficial.

hypocotyl: The first leaf-like structure that appears on a germinating seed. It grows upward in response to light.

lethal dose: The amount of a substance that causes death. In an agricultural bioassay, it is the quantity of a substance required to kill 50% of the experimental group.

life cycle: All of the life stages of an organism. A plant starts with seed, then goes to seedling, plant, flowers, and seed.

light: Waves of electromagnetic energy rays that produce illumination. Plants grow toward light.

light box: A container or enclosure that concentrates fluorescent light on objects. In plant biology, the light box is used to increase plant growth. Rapid cycling plants require intense fluorescent light.

microcentrifuge: A motor-driven piece of laboratory equipment that spins small samples of biological material at high speed in order to separate the components.

microscope slide: A small, flat, rectangular piece of glass on which specimens are mounted for viewing under magnification.

moisten: To make something slightly wet.

objective lens: The lens or system of lenses in a microscope closest to the object being viewed.

pharmaceutical: Relating to medicinal drugs. The pharmaceutical industry evaluates new medicines using bioassays.

phenotype: The observable traits or characteristics of an organism, such as size or color; the physical expression of a genotype.

physical needs: The light and temperature required for plants to grow.

pipettes: Graduated glass tubes used to measure or transfer precise volumes of liquid.

powder: A solid that has been crushed into tiny, loose particles.

props: The visual elements of a scene other than the set itself, including handheld objects and furniture.

rapid cycling: In agriculture, an accelerated plant life cycle due to genetic modification of the plant's DNA.

recessive: A gene that requires two copies (one inherited from each parent) to cause expression of a trait, such as flower color.

root: The usually underground organ of a plant, lacking buds, leaves, or nodes; it absorbs water and mineral salts, and usually anchors the plant in the soil or other growing medium.

root hair: A thin hairlike structure on the root of a plant, through which nutrients are absorbed from the soil.

seed coat: The protective outer layer of a seed that protects the embryonic plant inside.

seeding mix: A mix of soil or other substrate, often combined with other organic components, in which to germinate seeds.

seeds: Tiny embryonic plants enclosed in coverings called seed coats.

selective breeding: In agriculture, the process of growing organisms, such as plants, to develop particular genetic traits in new generations.

socket adapter: An electrical device that enables connection of one type of socket to a different type of plug.

solution: A dissolved mixture of two or more substances, often in water.

stage: A scene or setting for exhibiting or performing; a small platform on a microscope where the specimen is mounted for examination.

storyboard: A roughly sketched-out sequence of images or drawings that describe the planned content of a film or video.

syringe: A scientific instrument used to withdraw or inject liquids.

vermiculite: A mineral used in planting mix to retain moisture and provide aeration for the plant's roots.

video microscope: A special microscope that allows a specimen to be viewed on a video screen or to be examined by a computer using image analysis software.

wicks: Loosely woven cords that draw liquid by capillary action, such as those that absorb moisture from a grow tub into the soil around plants in grow cups.

zoom: A lens on a camera or microscope that magnifies the object being viewed and pulls it into close focus.

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