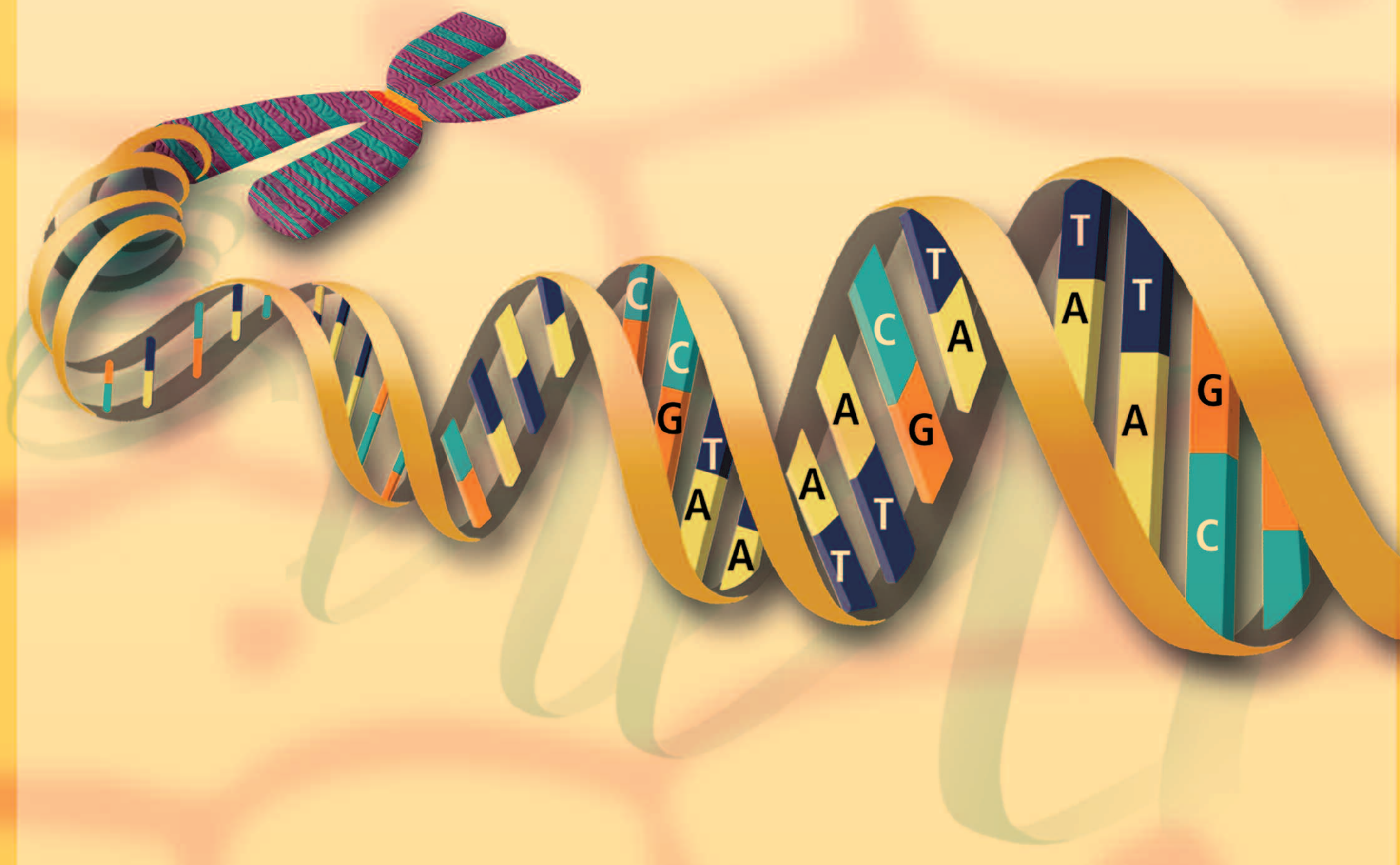
Yesterday, Today and Tomorrow

Agricultural Biotechnology

A Grade 6 – 8 Unit of Study



The Children's Museum
of Indianapolis

Acknowledgements/Information About The Children's Museum

The Children's Museum of Indianapolis wishes to acknowledge the assistance of the following individuals and organizations in preparation of this unit of study:

Dow AgroSciences LLC, for both content and financial support
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The Children's Museum of Indianapolis

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 nations. The museum provides special programs and guided experiences for students as well as teaching materials and professional development opportunities for teachers. Field trips to the museum can be arranged by calling (317) 334-4000 or (800) 820-6214. Visit **Just for Teachers** at The Children's Museum Web site: www.childrensmuseum.org.

Table of Contents

Yesterday, Today and Tomorrow

Agricultural Biotechnology

A Grades 6 – 8 Unit of Study

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Enduring Idea

Throughout history people have modified food and plants. Now, with current information about DNA and the cell, agricultural biotechnology is helping to create new products for our future.

Take your students on a journey through the history of biotechnology from the past to the future. Start by allowing your students to see that humans have experimented with agriculture and food for centuries. Agricultural biotechnology is a new process for producing plant products that is going to change our future! In order to understand how biotechnology works, students must first examine cells and DNA. Then students can begin to discuss the implications of genetic engineering. This unit of study will help them uncover the products, possibilities, controversies and implications of this innovative science!

What will students learn?

Experiences in this unit help students achieve standards in:

- **Science**
- **Language Arts**
- **Social Studies**
- **Math**

Unit lessons integrate science, language arts, social studies and math. Each learning experience is designed to address specific academic standards for grades 6, 7 and 8.

What's ahead

Lesson 1

The History of Biotechnology

During these experiences, students research the Biotechnology Time Line posted on The Children's Museum Web site. Students define biotechnology-related terms, research famous scientists and organize scientific discoveries chronologically as they prepare presentations on the development of biotechnology.

Lesson 2

Cells

During these experiences, students review cell parts and functions. Students create a cell model using the layout of their school as a template. Students evaluate each cell presentation and choose which cell model best depicts the qualities of an actual cell.

Lesson 3

DNA — The Code of Life

During these experiences, students create DNA models using paper clips. Students follow directions and use scientific equipment measuring accurately to successfully extract DNA from wheat germ.

Culminating Activity — Agricultural Biotechnology of Tomorrow

In this experience, students identify agricultural issues, devise possible solutions and create displays to share with the class.

What will students be able to do?

Unit Goals:

- Research and describe the development of agricultural biotechnology.
- Identify and describe the parts and functions of both animal and plant cells.
- Develop a better understanding of the structure and function of DNA.
- Increase their awareness on current agricultural issues and possible solutions involving biotechnology.

Getting Started

Family Connections:

Before beginning this unit, let families know that your class will explore the science of biotechnology. Some families have relatives who are farmers, scientists or nutritionists who could come to the class to speak. Also keep in mind that this science is still very new and often misunderstood by the public. Some parents may express reservations about the topic of genetically modified organisms. Assure them that this unit is designed to help students gain an understanding of the science behind the issues and therefore allow them to make better-informed judgements. This unit does not suggest that biotechnology is a blanket solution for problems we face as humans. Encourage families to discuss these kinds of issues with their students. Also encourage them to keep an eye out for newspaper and magazine articles about biotechnology and send them to school with their students. Let families know ahead of time that students will celebrate their work with an Agricultural Biotechnology Fair and invite them to attend.

Classroom Environment:

Create a rich environment full of resources where your students can find information in books, pamphlets, posters, models and current-event publications. Students will also need access to the Internet to do their research. It may be a good idea to have the students keep a journal through the course of the unit.

Museum Links

Using resources in the community as a supplement to this unit can enhance students' learning. A visit to the Biotechnology Learning Center at The Children's Museum of Indianapolis can provide a unique opportunity for your students to learn more about biotechnology. With the financial and intellectual support of Dow AgroSciences, the BLC has become a place for teachers, students and families to discover the possibilities of biotechnology. Look for **Museum Links** throughout this unit for suggested museum resources. Many of the print selections listed in the **Resources** section of the lessons are available through **infoZone**, a branch of the Indianapolis-Marion County Public Library located in The Children's Museum. Professional development opportunities related to biotechnology and other museum resources are also available. To register for these, call (317) 334-4000 or visit the museum's Web site.

Glossary:

Please see the museum's Web site at http://www.childrensmuseum.org/biotech/glossary.htm for a glossary of words used in this unit of study.

Lesson 1
The History of Agricultural Biotechnology

Today, we are trying to achieve goals similar to those of our ancient ancestors: growing enough high-quality food to meet the needs of our increasing population. Throughout history people have cultivated crops and experimented with plants to improve food quality and quantity. Because of advances in technology, scientists have been able to develop new approaches to plant production. This lesson invites students to travel back in time to observe the history and development of agricultural biotechnology.

Photo courtesy of Dow AgroSciences, LLC.

Scientist covers corn tassel with a brown paper bag to collect pollen for making pollinations.

Objectives

Students will:

- Define agricultural biotechnology and discover its history by investigating the time line found on The Children's Museum Web site.
- Travel back in time to research and then present a person, topic or event involved with the development of agricultural biotechnology.
- Analyze the important discoveries and determine what marks the turning point in the history of biotechnology.

Biotech Terms

- agriculture
- *Arabidopsis thaliana*
- biotechnology
- chymosin
- Crick, Francis
- DNA (deoxyribonucleic acid)
- FlavrSavr® tomato
- genetics
- golden rice
- hybrid corn
- insulin
- Mendel, Gregor
- microscope
- Pasteur, Louis
- pasteurization
- Leeuwenhoek, Antonie van
- Watson, James
- yeast

Focus Questions

- Who is a scientist?
- What do scientists do?
- What type of equipment do scientists use while experimenting?
- Who do you know today that is like a scientist? Why?
- Where are some places that scientists might work?
- What is technology?
- How do humans use technology compared to other species?
- How does technology influence living things?
- How does society influence the type of technology that is developed?
- Why are plants important to humans?
- How can food production affect the way people live and work?

Experience 1

Biotechnology Through Time

Using the computer or books from the library, students research the history and development of agricultural biotechnology. Students complete the **Biotechnology Through Time** handout (page 28) to organize thoughts, define vocabulary terms, record data and make drawings.

Indiana's Academic Standards

Science
Standard 1: The Nature of Science and Technology (6.1.1, 6.1.5, 6.1.9, 7.1.5, 7.1.6, 7.1.9, 7.1.10, 8.1.8)
Standard 2: Scientific Thinking (6.2.7)
Standard 4: The Living Environment (7.4.10)

Social Studies
Standard 1: History (6.1.21)
Standard 5: Individuals, Society and Culture (6.5.5, 7.5.4, 8.5.7)

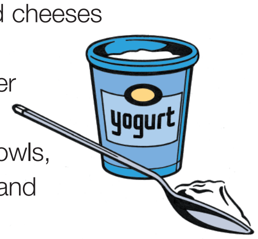
Language Arts
Standard 1: Reading — Word Recognition, Fluency, and Vocabulary Development (6.1.4, 7.1.2)
Standard 4: Writing — Writing Process (6.4.1, 6.4.2, 6.4.5, 6.4.6, 7.4.1, 7.4.4, 7.4.5)

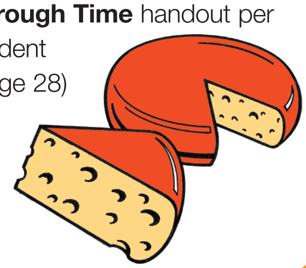
You will need ...

Time: One to two class periods, 40 – 50 minutes

Materials:

- Assorted cheeses
- Bread
- Root beer
- Yogurt
- Cups, bowls, spoons and napkins
- Access to a computer lab — bookmark computers to the Web site www.childrensmuseum.org/biotech/timeline.htm
- Library resources
- One **Biotechnology Through Time** handout per student (page 28)





Teacher Preparation

- Check to see if any of your students have food allergies and adapt accordingly.
- Review the agricultural biotechnology time line on The Children's Museum Web site. www.childrensmuseum.org/biotech/timeline.htm. You may choose not to have students research Barbara McClintock due to the advanced level of genetics involved with her discoveries.
- Prepare a student sign-up sheet to include scientists, topics and events from the time line.
- Set up computer lab time in advance.

Procedures

- Create a Bio-Fest by displaying and sharing root beer, assorted cheeses, bread and yogurt for the students.
- Encourage them to make observations about the foods they are tasting by using all of their senses.
- While eating the different foods, ask students:
  - How are cheese, yogurt and root beer made?
  - What makes bread rise? What gives root beer its fizz?
  - What do all of these things have in common?
  - What other foods have been created with the help of living organisms?
  - How has the process of making foods changed over time?

Below: A biotechnology time line can be found on the museum's Web site at: www.childrensmuseum.org/biotech/timeline.htm

Procedures *continued.*

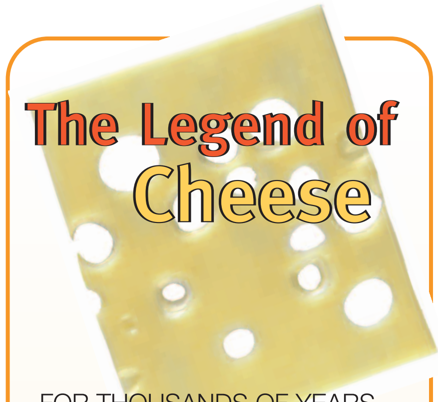
- Explain to students the legend about cheese and how living things are used to change food over time.
- Write the word *biotechnology* on the board and elicit from students a definition for biotechnology. Discuss their definitions.
- Break the word into three parts and explain their meanings.

  Bio — living
  Tech — tools
  ology — study of
- Define biotechnology as the process by which humans use living things as tools to make new products.
  - Write the word *agriculture* on the board and elicit from students a definition for agriculture.
  - Break the word into two parts and explain their meanings.

    Agri — field
    Culture — cultivate, till
  - Inform students they are going to use computers to research the history of agricultural biotechnology. Review good note-taking and documentation techniques. Student research should model the way scientists work. Before starting an investigation, scientists first study what is known about a topic.
- While browsing, instruct students to pay attention to the development of agricultural biotechnology over time.
- Instruct students to choose one event, topic or scientist from the time line to research for a class presentation.
- Make sure that there are no duplications and that most of the events on the time line are represented.
- Allow approximately five minutes for students to investigate the time line. At the end of five minutes, have students select and sign up for a scientist, topic or event.
- Distribute one **Biotechnology Through Time** handout (page 28) to each student as they sign up. This will help guide their research and writing. Allow students to complete their handouts during the remainder of the class; they should have at least five facts listed.

Assessment

Check the students' progress while they are researching on the computers. Students should be using their handout to organize information and improve note-taking skills. Each student should be able to name the scientist, event or topic he or she has chosen and the related time period. Students' handouts should include important facts about their scientist, event or topic.



The Legend of Cheese

FOR THOUSANDS OF YEARS, people have been changing food to make it better. What about cheese? Does it just come naturally the way we buy it? No, it was "created" a long time ago. There is an old legend about cheese. The story says that cheese was invented by a shepherd, carrying milk in a pouch made from a sheep's stomach. Rennet, the lining membrane of a sheep's stomach, and heat from the sun separated the milk into curds and whey. Rennet contains an enzyme that coagulates milk. Although the legend might be an exaggeration, cheese has been around for a very long time. Today cheese is still made from rennet, but now scientists make a genetically engineered enzyme, called *chymosin*, in a lab instead of taking it from an animal's stomach. The scientific process by which they make chymosin is an example of biotechnology. Actually, this is the first product of biotechnology to be used in food production. See the museum's Web site for more information: www.childrensmuseum.org/biotech/cheese.htm

Experience 2

Hanging Biotech Wallpaper

Students gather and discuss ideas for writing using their completed **Biotechnology Through Time** handout. Students transfer the research information found on their scientist, event or topic to their time-line sheet and include facts, details, examples and drawings. Students organize their research chronologically by creating a large biotech-nology time line on the wall or chalkboard.

Indiana's Academic Standards

Science
Standard 1: The Nature of Science and Technology (6.1.1, 6.1.5, 6.1.9, 7.1.5, 7.1.6, 7.1.10, 8.1.8)
Standard 4: The Living Environment (7.4.10)

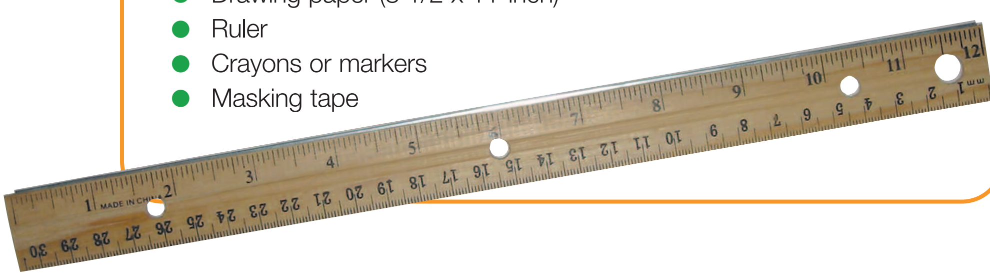
Social Studies
Standard 1: History 6.1.16, 6.1.21)
Standard 5: Individuals, Society and Culture (6.5.5, 7.5.4, 8.5.7)

Language Arts
Standard 4: Writing: Writing Process (6.4.1, 6.4.2, 7.4.1)
Standard 6: Writing (6.6.4, 7.6.5, 7.6.8, 7.6.9)

You will need ...

Time: One class period 40 – 50 minutes

Materials:
For each student:
- Student completed **Biotechnology Through Time** handout
- Drawing paper (8 1/2 x 11-inch)
- Ruler
- Crayons or markers
- Masking tape



Procedures

- Distribute one sheet of 8 1/2 x 11-inch drawing paper to each student and instruct them to turn the paper to the "landscape" position (horizontal).
- Instruct students to use a ruler to draw a line across the top of their paper 1 inch from the top. Mark the year of their event at the center of the line.
- Instruct students to use their **Biotechnology Through Time** handout as a resource to record the name of their scientist, event or topic, important facts and drawings on their drawing paper.
- The important facts should be written in at least two paragraphs.
- Help students review and edit their work to conform to English language conventions, including grammar, capitalization and spelling. Have students revise their work for display.
- When completed, instruct students to tape their papers on a wall in a designated area of the room.
- When all papers are displayed, ask the class to sequence the dates in chronological order to form a biotechnology time line.

Assessment

Evaluate students by checking to see if their papers include the time period, name of the scientist, event or topic, important facts and a drawing. Check to see that students have edited their papers for correct grammar, spelling and capitalization. Once the time line is displayed, check to see if the time line is in chronological order.

Experience 3

The Time Line Tour

Students tour the biotechnology time line displayed in the classroom and present their portion of the time line to the class.

Indiana's Academic Standards

Science

Standard 1: The Nature of Science and Technology (6.1.1, 6.1.5, 6.1.9, 7.1.5, 7.1.6, 7.1.9, 7.1.10, 8.1.8)
Standard 2: Scientific Thinking (8.2.7)
Standard 4: The Living Environment (7.4.10, 8.4.3)
Standard 6: Historical Perspectives (7.6.1, 7.6.2, 7.6.3)

Social Studies

Standard 1: History (6.1.16, 7.1.17, 8.1.27)
Standard 5: Individuals, Society and Culture (6.5.5, 7.5.4, 8.5.7)

Language Arts

Standard 7: Listening and speaking — Listening and Speaking Skills, Strategies and Applications (6.7.4, 6.7.5, 6.7.7, 6.7.11, 7.7.3, 7.7.4, 7.7.5)

You will need ...

Time: One class period
40 – 50 minutes

Materials:

- Time line created from previous lesson

Procedures

- Line up students in single file to tour and observe the biotechnology time line.
- Encourage students to formulate 2 – 3 questions about the time line.
- Discuss the criteria of a good presentation. (See Language Arts Listening and Speaking Skills on this page.)
- Encourage students to include biotechnology terms in their presentations.
- Starting at the beginning of the time line, have students present their research to the class.
- Discuss the development of biotechnology over time.
- Elicit from students when early practices of agricultural biotechnology, such as hybridization, advanced to more recent practices, like gene replacement. Ask them what event marked a turning point in biotechnology.

Tips for Teacher

- Turn BioFest into a session on making observations. Work with students to make good observations.
- The BioFest should take place in a room other than a lab, as eating in a lab is not a good idea. Remind students that tasting things in a lab setting is not appropriate.
- Students may work in groups of two or in teams to research their topics, create their time line sheets and give their presentations.
- Place key dates on the time line ahead of time to aid in the sequencing of the events.
- Use the assessment to create a rubric for grading the presentations.
- During the presentations, continue to ask the students how each event, topic or scientist has relevance to biotechnology.
- Student presentations should address Standard 6, Historical Perspectives in grade 7; however, to fully implement the standard, the teacher should provide additional information and a deeper discussion of the work of Louis Pasteur.

Assessment

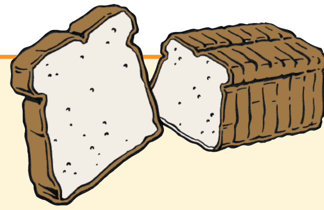
Evaluate students on their presentations and grasp of biotechnology facts. Use language arts listening and speaking skills below as a guideline.

Language Arts Listening and Speaking Skills

Does the student:

- present the material in an organized manner?
  - introduction
  - transitions
  - conclusion
- follow the main idea and concepts?
  - state the time period
  - discuss important facts
  - include drawings
  - biotechnology terminology
- use effective timing, tone, language and body gestures to sustain interest?
  - eye contact
  - voice modulation
  - precise language
  - action verbs
  - sensory details
  - adjectives and adverbs
  - active voice
  - appropriate grammar
  - clear annunciation
- ask questions after others have presented?

Bonus



Extending Experiences

- Ask students to define the biotechnology terms before beginning Lesson 1.
- Use a bread machine to make bread in the classroom. Discuss the importance of yeast, a living organism, in this process.
- Make cheese as a class. See The Children's Museum Web site for directions: www.childrensmuseum.org/biotech/index.htm
- Mix yeast, glucose and water together in a pop bottle. Place a balloon over the mouth of the bottle. Observe the balloon inflating as the yeast converts the glucose to carbon dioxide gas. See the museum's Web site for more information.
  www.childrensmuseum.org/biotech/worldofyeast.htm

The Children's Museum of Indianapolis.

The Biotech Time Line outside the Biotechnology Learning Center at The Children's Museum of Indianapolis.

Museum Links

Students can see a graphic display of the Biotechnology Time Line in front of the Biotechnology Learning Center at The Children's Museum. The time line is also found as a student handout on page 27. An expanded version of this time line can be found on the museum's Web site at:
www.childrensmuseum.org/biotech/timeline.htm

Time line photo credits:

(Page 7, left to right and page 27, top to bottom)

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Resources

For Students:

Web sites:

The Children's Museum of Indianapolis Biotechnology Time Line
www.childrensmuseum.org/biotech/timeline.htm

Books:

- Smith, Linda Wasmer. "Louis Pasteur: Disease Fighter." New Jersey: Enslow Publishers, Inc., 1997.
- Yount, Lisa. Antoni Van Leeuwenhoek: "First to See Microscopic Life." New Jersey: Enslow Publishers, Inc. 1996.
- Klare, Roger. "Gregor Mendel: Father of Genetics." New Jersey. Enslow Publishers, Inc., 1997.

Magazines:

- "Your World, Biotechnology and You," Vol. II, Issue No. 2. Pennsylvania Biotechnology Association: 1993.
- "Your World, Biotechnology and You," Vol.10, Issue No. 1. The Biotechnology Institute: 2000.

For Teachers:

Web sites:

The Children's Museum of Indianapolis Biotechnology Time Line
www.childrensmuseum.org/biotech/timeline.htm

Council for Biotechnology Information
www.whybiotech.com/

Access Excellence at the National Museum of Health
www.accessexcellence.org/AB/

Biotechnology Institute
www.biotechinstitute.org/

The International Food Information Council Foundation
www.ific.org/

Pamphlets:

- "Foods from Genetically Modified Crops," by San Diego Center for Molecular Agriculture. E-mail mchrispeels@uscd.edu for copies.
- "Food Biotech and You," by Council for Biotechnology Information. Call (202) 467-6565 for copies.
- "Food Biotechnology, Enhancing our Food Supply," IFIC. E-mail foodinfo@ific.org for copies.

Lesson 2
Cells

Until the invention of the microscope in 1683 by Antonie van Leeuwenhoek, scientists knew very little about cells. Today we know that cells are the building blocks of life. These building blocks join together to make living things. Cells are composed of tiny organelles that carry out specific jobs and function to run the cell. Compare the cell to your school. Just like the cell, the parts of a school work together to run the school. Without the office, hallways, classrooms, cafeteria, restrooms, students, faculty and staff, the school would not exist. The same is true about the cell. Without the nucleus, cell wall, endoplasmic reticulum, ribosomes, mitochondria and Golgi bodies, the cell would be incomplete and unable to function. This lesson enables students to look inside the cell and compare it to their school!

Model of an animal cell.

Objectives

Students will:

- Explain that all living things are made of cells.
- Recognize the parts and functions of the cell.
- Compare plant and animal cells.
- Apply their knowledge of the cell to design a new "school cell" using the school as a template.
- Present the school as a cell and evaluate and justify its relationship to an actual cell.

Focus Questions

- What are the characteristics of all living things?
- What is a cell?
- How do plant and animal cells differ? How are they alike?
- Where is the genetic information located in a cell? Why is this important to the cell?
- How is your school like a cell?
- What other things could you compare to a cell?
- What would happen if one of the parts of a cell was not working?

Cell Terms

- cell
- cell membrane
- cell wall
- chloroplast
- cytoplasm
- DNA (deoxyribonucleic acid)
- endoplasmic reticulum
- Golgi apparatus
- lysosome
- mitochondria
- nucleus
- organelle
- ribosomes
- vacuole

Experience 1

Focusing on the Cell

Students investigate and explain that all living things are composed of cells. Students locate and define the parts and functions of the cell. Students distinguish between plant and animal cells.

Indiana's Academic Standards

Science

Standard 4: The Living Environment (6.4.1, 6.4.5, 6.4.6, 6.4.7, 7.4.5, 7.4.7)
Standard 7: Common Themes (7.7.2)

You will need ...

Time: One class period 40 – 50 minutes

Materials:

Per Student:

- Blank **Plant and Animal Cell** handouts (pages 30 and 31)
- **Cell Parts and Functions** handout (page 33)
- Scissors
- **Body Part Picture Cards** handout (one page per student) (page 29)

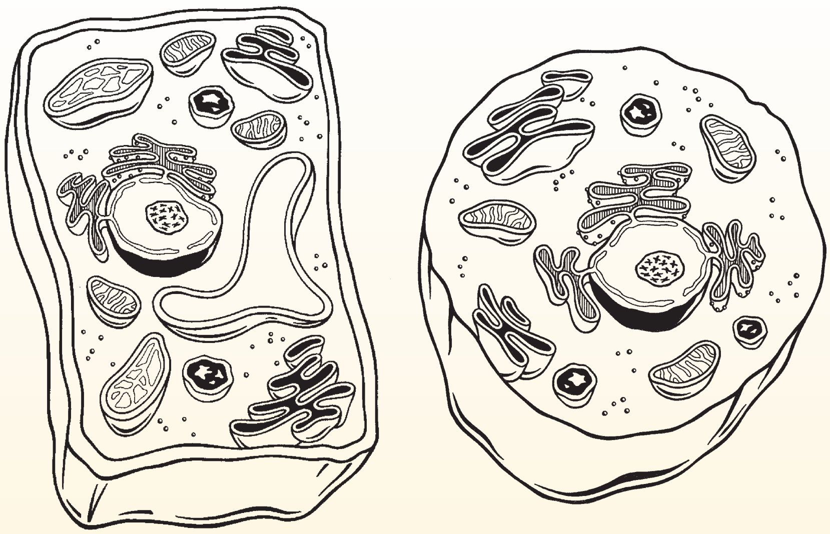
Per Class:

- Blank **Plant and Animal Cell** overhead transparencies.
- Completed **Plant versus Animal Cell** overhead transparency.
- Masking tape

Procedures

- Distribute the **Body Part Picture Cards** handout (page 29) to each student and have them cut the cards out.
- Elicit from students:
  - the body parts/systems drawn on the cards. (As students identify the body parts/ systems, instruct them to tape the cards on the corresponding parts of their body.)
  - the function of each body part/system.
  - the impact the body part/system would have on the body if it malfunctioned.
  - how each of these body parts/systems works together.
- Ask students: What is the smallest living part of the body? (The cell.) Can it be seen with the naked eye? (No, only with a microscope.)
- Inform students the body is like a cell. It is made up of many different parts that are interdependent upon one another.
- Distribute the **Cell Parts and Functions** handout (page 33) and the blank **Plant and Animal Cell** (pages 30 and 31) handouts to each student.
- Challenge students to use a pencil to complete the drawings of the plant and animal cells by interpreting the **Cell Parts and Functions** (page 33) handout.

- Display the blank **Plant and Animal Cell** (pages 30 and 31) transparencies on the overhead. When students have completed their drawings, ask for volunteers to draw the cell parts on the overhead. Discuss the cell parts and functions.
- Display the overhead transparency pictures of the completed **Plant versus Animal Cell** (page 32). Compare the real plant and animal cell pictures to the drawings created by the students. Have the students correct their cell drawings if needed.
- At this time, discuss the major differences between plant and animal cells. Also discuss the similarities among cells.



Plant and Animal Cells:

The major difference between plant and animal cells is that plant cells have cell walls and chloroplasts, and animal cells do not. Chlorophyll is the substance found in green plants that allows them to make their own food, through the process of photosynthesis. Plant cells have large vacuoles, where animal cells have small ones. But more important than their differences are their similarities. The basic functions of cells, such as growing, making energy and getting rid of wastes, are similar among all organisms. Because of this similarity, scientists can move DNA from one organism to another.

Tips for Teacher

- Your students may need a basic review of the core differences between animals and plants in general. This also would be a good time to review the process of photosynthesis.
- Depending on the level of your students, a lesson on cell division and growth could be included to implement Science Standard 4 in grades 7 and 8.

Assessment

Check to see that all students have drawn and labeled the cell parts on their handouts.

Experience 2

How Is Your School Like a Cell?

Using a school map as their template, students extend their knowledge of cell parts and functions by creating an analogy to generate a new "school cell."

Indiana's Academic Standards

Science
Standard 4: The Living Environment (6.4.7, 7.4.5, 7.4.7)
Standard 7: Common Themes (6.7.2)

Language Arts
Standard 1: Reading — Word Recognition, Fluency and Vocabulary Development (7.1.1, 8.1.1)
Standard 4: Writing: Writing Process (6.4.3)

You will need ...

Time: One class period
40 – 50 minutes

Materials:

Per Group:
- Map of your school
- **Cell Parts and Functions** handout (page 33)
- Student-completed **Plant and Animal Cell** handouts (pages 30 and 31)

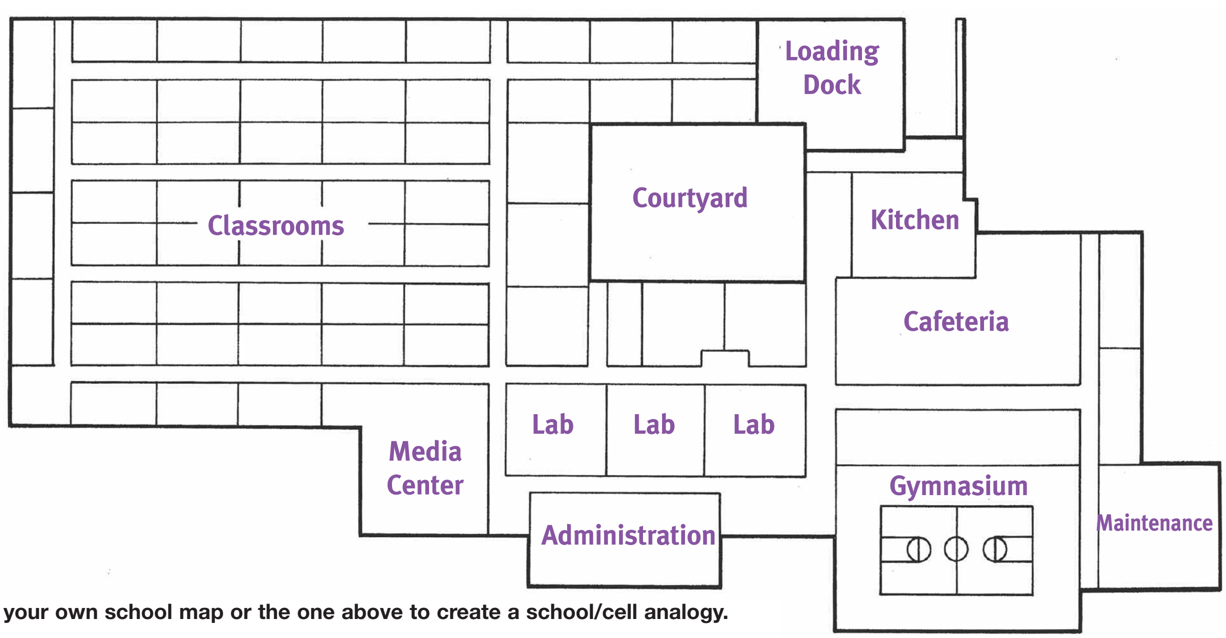
Per Class:
- Completed **Plant versus Animal Cell** transparency (page 32)

Assessment

Check to see if cell parts are labeled on students' school maps. Discuss why evidence does or does not support the idea that an area of the school resembles a cell part. Students should document analogies by comparing the real cell to the school cell. Written compositions should clearly support the analogies with specific details and examples.

Procedures

- Break the students into groups of four to five. Have them work in teams to complete this experience.
- Review the parts and functions of the cell.
- Distribute one map of your school to each group of students.
- Inform students the school represents a plant or animal cell and the map represents a drawing of the cell.
- Challenge students to make analogies between parts of a cell and parts of a school. Example: The school office represents the nucleus. The nucleus controls the activities of the cell. The office controls the activities of the school. Some examples are scheduling, discipline, school policies and procedures, and extracurricular activities.
- Instruct students to label the respective cell parts on their school map and describe their reasoning in several well-organized paragraphs on a separate sheet of paper.
- Allow students the remainder of the class time to generate their school cell.
- Inform students they will be presenting their school cell in the next lesson.

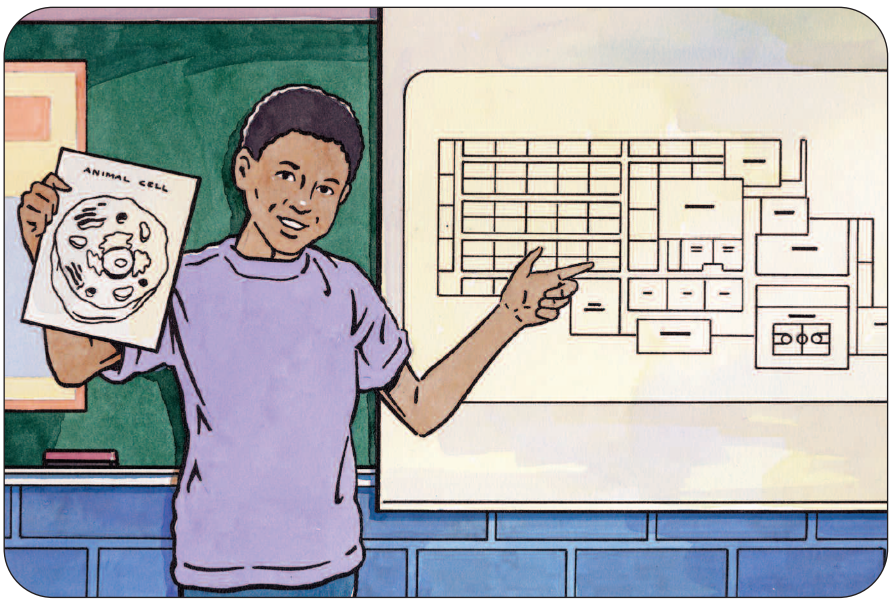


Use your own school map or the one above to create a school/cell analogy.

Experience 3

The Life Processes of the School

Students evaluate the processes of a cell and compare them to the newly developed processes of their "school cells." Students judge each of the "school cell" presentations, justifying the parts and functions of a cell.



Indiana's Academic Standards

Science

Standard 4: The Living Environment (6.4.7, 7.4.5, 7.4.7)

Standard 7: Common Themes (6.7.2)

Language Arts

Standard 1: Reading — Word Recognition, Fluency and Vocabulary Development (7.1.1, 8.1.1)

Standard 7: Listening and Speaking — Listening and Speaking Skills, Strategies and Applications (6.7.5, 6.7.7, 7.7.1, 7.7.3, 7.7.4, 7.7.5, 8.7.1, 8.7.2, 8.7.5, 8.7.6)

You will need ...

Time: One class period 40 – 50 minutes

Materials:

Per Group:

- Overhead transparency map of your school

Procedures

- Help students review strategies for making and participating in oral presentations.
- Display the map of your school on the overhead.
- Allow each group to use the map and their notes to present their school as a cell.
- As a class, evaluate each presentation. Decide which school structures represent the most accurate description of a cell based on student explanations.
- Display school cells.

Assessment

Students should display a clear understanding of cell parts and functions through their analogies of the school cell. Pay close attention to the reasoning in their analogies. Students may be creative in their choices, but should have logical reasons to support them. Students should demonstrate effective listening and speaking strategies by presenting main ideas in an organized manner and using appropriate grammar and word choices. They should use appropriate timing, volume, eye contact and body gestures. Students should be asking questions to elicit information and supporting their statements with details and examples.

Tips for Teacher

- If available, set up stations to include microscopes and prepared plant and animal slides.
- Also set out cell models and posters to enhance learning.
- To save time, have body part cards precut and laminated.

Museum Links

Find more information on plant and animal cells on the museum Web site at www.childrensmuseum.org/biotech/index.htm

Bonus

Extending Experiences

- Challenge students to make an edible cell model using food. See the museum's Web site for instructions: www.childrensmuseum.org/biotech/ediblecellpuddingcup.htm
- Challenge students to make cell models using clay.
- Compare the structure of a cell to a factory or town.
- Have students design a cell using a blueprint of their home.

Use models or posters like these to enhance learning in the classroom.

Resources

For Students:

Web sites:

The Children's Museum of Indianapolis, Biotechnology Learning Center
www.childrensmuseum.org/biotech/index.htm
http://www.brainpop.com/science/
Cells Alive
http://www.cellsalive.com/

Books:

- Balkwill, Fran and Mic Rolph. "Enjoy Your Cells." China: Cold Spring Harbor Laboratory Press, 2002.
- Baeuerle, Patrick and Norbert Landa. "The Cell Works — Microexplorers." New York: Barrons Educational Series, 1998.

For Teachers:

Web sites:

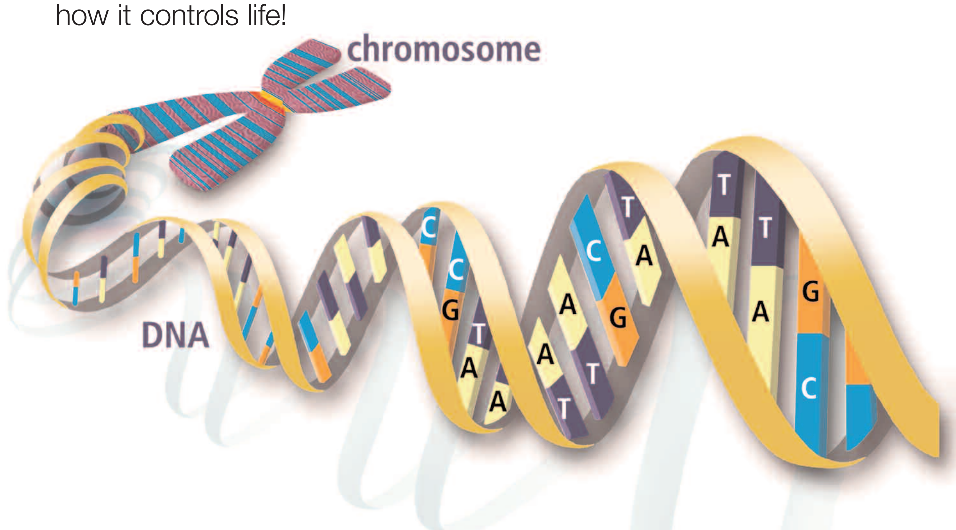
The Children's Museum of Indianapolis, Biotechnology Learning Center
www.childrensmuseum.org/biotech/index.htm
Cells are Us, by Texas A & M University
http://peer.tamu.edu/curriculum_modules/Cell_Biology/index.htm

Books:

- Dawson, Douglas, Stacy Hill, and Jill Rulfs (editors) "Biotechnology, The Technology of Life." Iowa: Kendall/Hunt Publishing Co., 1995.
- "Biotechnology School Enrichment Grades 5 – 6." Iowa State University Extension and Office of Biotechnology, 1997.
- "Biotechnology School Enrichment Grades 7 – 8." Iowa State University Extension and Office of Biotechnology, 1997.

Lesson 3
DNA — The Code of Life

DNA (deoxyribonucleic acid) is found in the nucleus of every cell. It is the genetic code of life. Segments of DNA contain genes that carry genetic information or codes, which are passed from parents to offspring. Genes determine characteristics of living things. Genes determine if a plant produces flowers, smells sweet, tastes sour, contains thorns, produces fruit that ripens quickly, grows tall, grows wide or loses leaves. Genes give plants their many variations. Because of advanced technology, scientists can transfer genes found in DNA to obtain a desired trait. This lesson shows and describes the DNA molecule and how it controls life!



DNA Terms

- adenine
- chromosome
- cytosine
- deoxyribonucleic acid
- double helix
- gene
- guanine
- thymine

Objectives

Students will:

- Define DNA.
- Use jumbo and colored paper clips to make a model of DNA.
- Extract DNA from wheat germ.

Focus Questions

- What makes each of us unique? Why are we different from each other, but similar to our parents?
- What is DNA? What is DNA made of? How do we know this?
- Where is DNA found in the cell?
- Can DNA be extracted from organisms? Can it be transferred among organisms?
- Why would scientists want to extract DNA?
- Should there be limits to what someone can do with DNA?
- What about your own DNA? Are there any privacy issues related to use of your DNA by other people?

Experience 1

The Ladder of Life

Students identify the DNA base pairs guanine, cytosine, thymine and adenine. Students create a DNA model using colored paper clips to resemble these base pairs.

Teacher Preparation

- Separate paper clips by color and size and place into respective buckets or containers.
- Display other DNA models from Web sites and posters.

Indiana's Academic Standards

Science

Standard 7: Common Themes (6.7.2, 7.7.2)

Language Arts

Standard 7: Listening and Speaking — Listening and Speaking Skills, Strategies and Applications (6.7.3)

You will need ...

Time: One class period 40 – 50 minutes

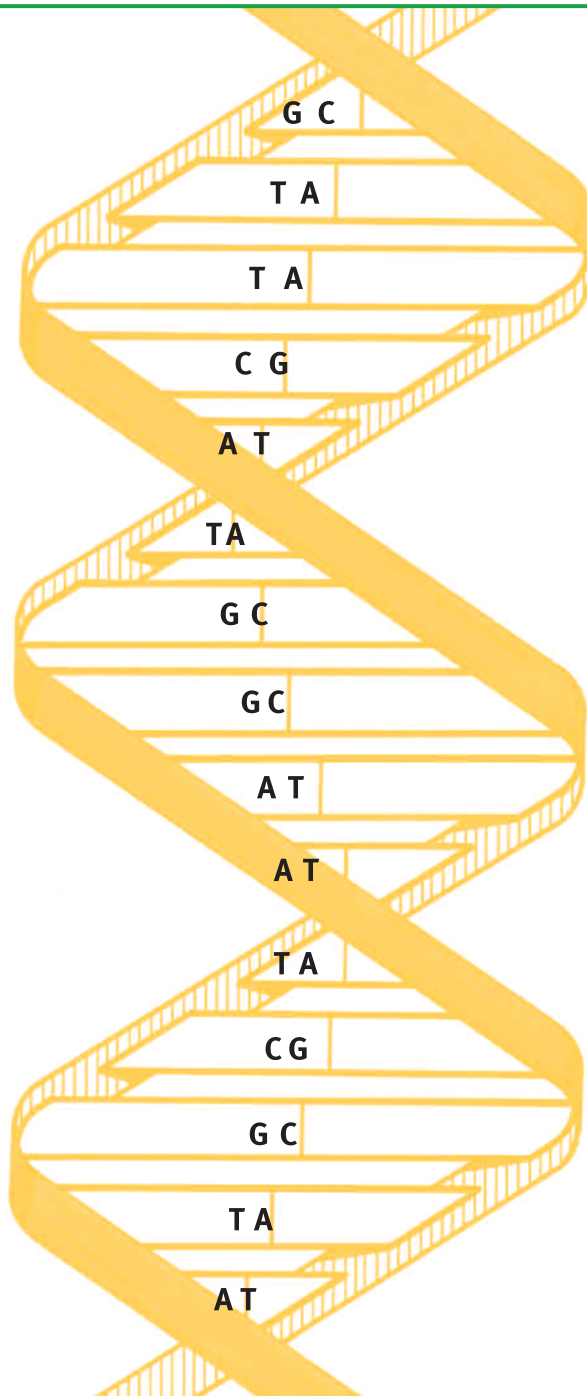
Materials:

Per Student:

- **Ladder of Life** handout (page 34)
- 6 x 18-inch piece of construction paper (Color does not matter, as long as paper clips are visible.)

Per Class:

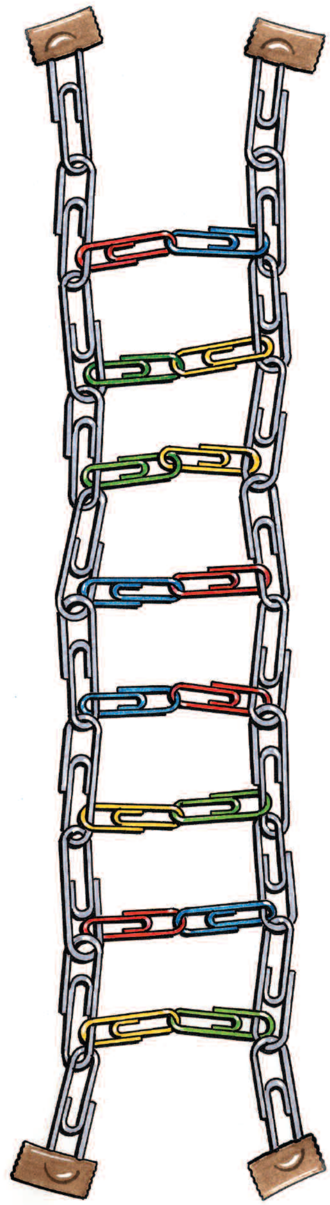
- Jumbo metal paper clips (about 600)
- Plastic-coated colored paper clips (red, blue, green and yellow) (about 500)
- four small buckets or containers
- scotch tape



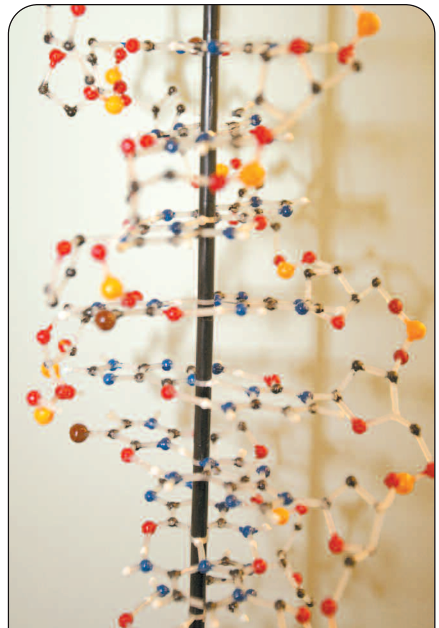
Procedures

- Write the code 4-5-15-24-25-18-9-2-15-14-21-3-12-5-9-3-1-3-9-4 on the board and challenge students to decode the numbers using the alphabet sequence with A=1, B=2, C=3 et cetera. (Code word = deoxyribonucleic acid)
- Elicit from students what they know about DNA. Explain that the DNA code is like a blueprint for each living thing. The combination of the base pairs determines who, how and what something is.
- Distribute the **Ladder of Life** handout (page 34). Have students read the top paragraph and discuss what they have read. Challenge students to complete the missing base pairs. Discuss the correct answers when finished.
- Distribute 20 large paper clips to each student and instruct them to connect 10 large paper clips to resemble one side of a DNA strand.
- Instruct students to connect the remaining 10 large paper clips to make a second side of the DNA strand. These strands represent the sides of the ladder. Emphasize that DNA is a double-stranded helix. It is like a twisted ladder.
- Provide students with the key:

  A = adenine = red
  T = thymine = blue
  G = guanine = green
  C = cytosine = yellow
- Display four buckets containing red, blue, green and yellow plastic-coated paper clips.
- Challenge students to design a DNA strand using eight pairs of the plastic-coated paper clips. Instruct students to place a base pair where each of the large paper clips joins together.
- Remind students of the following rule: A pairs with T, and G pairs with C. Check to make sure their designs are accurate.
- After DNA models have been approved, tape the models to construction paper. Challenge students to locate other students in the classroom with an identical DNA strand and discuss their findings. Why would it be difficult to find a match for your DNA in real life?



After the DNA paper clip model is assembled, it should look like this.



DNA Quick Hits:

- The sequences formed by the base pairs in our DNA carry our genetic code.
- We are each unique because of individual variations in the sequence of the base pairs.
- There are millions of different combinations that can be made using only four base pairs.
- The DNA models created in class are many, many times larger than a real DNA strand.
- A human DNA strand is approximately 6 feet long, but it is so small and tightly coiled that it can fit inside the nucleus of a single cell.

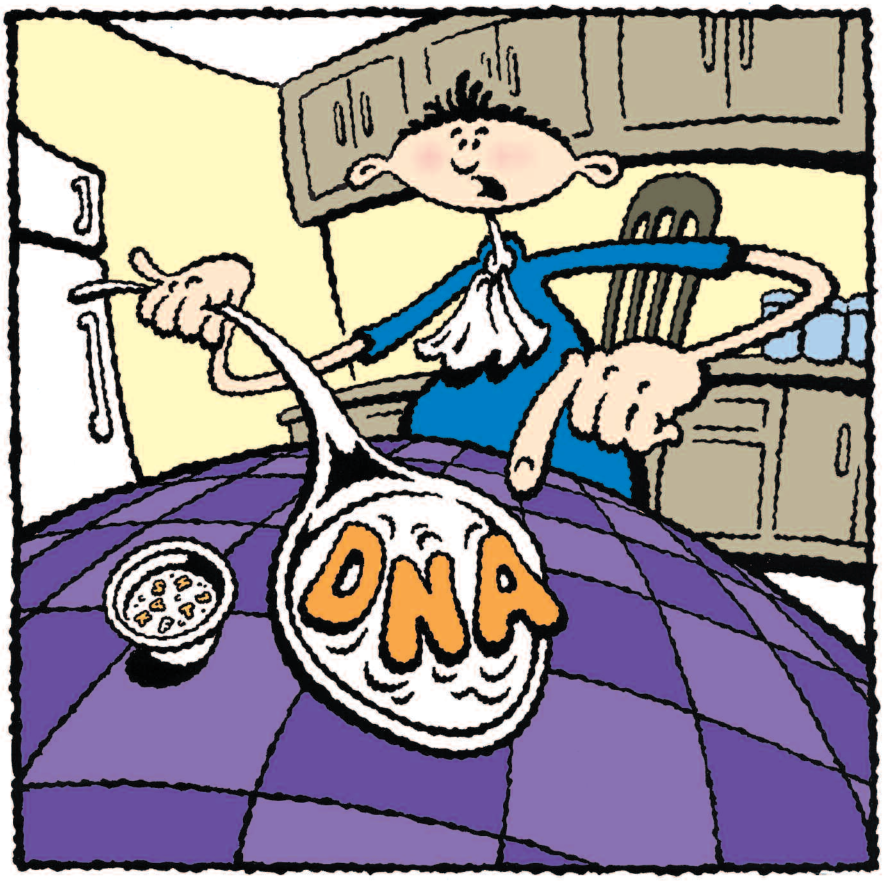
Assessment

Check each constructed DNA strand making sure red paper clips pair with blue paper clips and green paper clips pair with yellow paper clips.

Experience 2

Is That DNA in My Food?

In this experience, students extract DNA from wheat germ.



Is there really DNA in my soup?

You will need ...

Time: One class period
50 minutes

Materials:

Per Class:

- hot plate
- 600 mL beaker
- beaker tongs or glove
- 300 mL of water
- thermometer
- several balances
- liquid dishwashing detergent
- dry wheat stalks (from hobby or flower store)

Per Group:

- 1 gram of raw wheat germ
- test tube
- test tube stopper
- 100 mL graduated cylinder
- 1 mL pipette
- 15 mL of ice-cold rubbing alcohol
- two wooden sticks
- **Extracting DNA From Wheat Germ** handout (page 35)
- safety glasses (one pair/student)
- paper towel

Teacher Preparation

- Pour 300 mL of water into a 600 mL beaker.
- Place the beaker of water on a hot plate.
- Turn the hot plate on low.
- Heat the water to 50 – 60ºC.

Indiana's Academic Standards

Science
Standard 1: The Nature of Science and Technology (6.1.5, 6.1.7, 6.1.9, 7.1.7, 8.1.8)

Language Arts
Standard 7: Listening and Speaking — Listening and Speaking Skills, Strategies and Applications (6.7.3)

Math
Standard 5: Measurement (6.5.1)

Students participate in a facilitated experience in the Biotechnology Learning Center.

Procedures

- Show students a wheat plant and ask them what they think it is. Have them create a list of foods that they have eaten this week that contain wheat.

Wheat germ is the embryo of the wheat seed. This part of the seed contains many nutrients. Lots of foods are made with wheat: breads, pastas and cereals — and anything made with flour. Foods made from whole wheat contain the wheat germ, whereas foods made only from white flour do not. (See Web site, http://gslc.genetics.utah.edu/units/activities/wheatgerm/background.cfm, for more information on wheat germ.)

- Remind students that wheat is a plant, a living thing with cells and DNA. So yes, there is DNA in our food!
- Instruct students to extract wheat germ DNA by following the directions on the **Extracting DNA From Wheat Germ** handout (page 3).
- Help students to understand that the DNA they have extracted came from the wheat germ. They also need to understand that they broke open billions of cells and extracted the DNA from all of those cells. The reason the DNA glob is visible to the naked eye is because of the amount of DNA involved. This is not just one or two strands, but the strands that were in each of the billions of cells that we opened.
- Discuss with students what the scientists in a biotechnology lab might do with the DNA once it is extracted. Extraction of DNA is just the first process in genetic engineering.

DNA Extraction — How It Works:

The DNA in raw wheat germ is located in the nucleus of the cell. We must first get to the DNA before we can extract it. Each step of the procedure plays an important part.

- The warm water softens the cell and nuclear membranes so that they can be opened to get to the DNA. The water temperature is also important because at 50 – 60° Celsius it denatures the enzymes that would cut the DNA into fragments. If the DNA were cut into fragments, it would be too short to be visible. At 80° Celsius the DNA itself would denature and then we would not be able to do the activity.

- The detergent pulls the fatty lipid membranes that surround the cell and nucleus apart to release the DNA. It works much like dishwashing soap that cuts through the fatty grease when you wash dishes.

- The DNA is floating around in the solution and cannot be seen. Cold alcohol precipitates it out of solution so it can be seen.

Scientist working in a biotechnology lab at Dow AgroSciences LLC.

Gene Transfer

Once scientists have extracted the DNA they then have to purify it and isolate the gene of interest. They use special enzymes that work like scissors to cut that gene out from the rest of the DNA. There are several different methods used to transport the gene into the plant cell. One method is to use Agro bacterium, a type of bacteria that injects part of its DNA into plants. Scientists replace part of the bacterium's DNA with the desired gene. It then becomes a "gene shuttle," transporting the desired gene into the plant cell. Once inside the cell, the gene can join the DNA of the plant. The plant cells are treated with chemicals that cause them to start growing into whole new plants. This is a special property of plants; most animal cells cannot regenerate this way. When they get big enough, the young plants are transferred to soil. Eventually the plants with the gene of interest are crossed with commercial varieties of the plant. Many plants with the gene must be created so they can be studied. After about six years of experiments, the government decides if a genetically modified plant will be safe to eat and safe for the environment. Farmers then plant seeds of genetically modified plants, and harvest them at the end of the growing season. For an animation on gene transfer, see our website at www.ChildrensMuseum.org/biotech/index.htm and click on "The Buzzzzzzz about Biotechnology – Animation!"

Assessment

Supervise students during the DNA extraction process. Monitor students' safety precautions, ability to follow directions, ability to work as partners, ability to measure and use scientific equipment and check to see if they successfully extracted DNA.

Tips for Teacher

- Have students use science journals or lab notebooks to record observations and notes.
- Before isolating DNA, review lab safety, accurate measuring and contamination procedures.
- Do not use toasted wheat germ. Toasting can destroy the DNA.
- A glass stirring rod or long cotton swab can be used to isolate the DNA instead of a wooden stick.
- Be sure students shake gently in Step 5. It helps to minimize the amount of foam to be removed in Step 6. (See **Extracting DNA From Wheat Germ** handout, page 35.)
- Laminate the **Extracting DNA From Wheat Germ** handout (page 35), so it can be used more than once.
- Contact the Biotechnology Learning Center staff at biotech@ChildrensMuseum.org for help with the extraction.

Resources

For Teachers:

Web sites:

The Children's Museum of Indianapolis, Biotechnology Learning Center
www.childrensmuseum.org/biotech/index.htm

Genetics Science Learning Center at the University of Utah
gslc.genetics.utah.edu/units/activities/wheatgerm/background.cfm

University of California, Davis
http://ceprap.ucdavis.edu/Transformation/transform1.cfm

Department of Soil and Crop Sciences at Colorado State University
www.colostate.edu/programs/lifesciences/TransgenicCrops/animation.html

Purdue University
www.agriculture.purdue.edu/agbiotech/images/leafdisk1.html

University of Wisconsin Biotechnology Education Outreach Center
www.biotech.wisc.edu/education/FunFoodStuff/default.htm

For Students:

Web sites:

The Children's Museum of Indianapolis, Biotechnology Learning Center
www.childrensmuseum.org/biotech/index.htm

Cold Spring Harbor Laboratory
http://www.dnaftb.org/dnaftb/

Books:

- Balkwill Fran, and Mic Rolph. "Have a Nice DNA." China: Cold Springs Harbor Laboratory Press, 2002.
- Balkwill Fran, and Mic Rolph. "Gene Machines." China: Cold Springs Harbor Laboratory Press, 2002.
- Aronson, Billy. "They Came from DNA." New York: W.H. Freeman and Company, 1993.

Museum Links

Let the museum teach this experience for you! Sign up for the museum's Cells, DNA and Life! facilitated program in the Biotechnology Learning Center at The Children's Museum. See the Web site at www.childrensmuseum.org/catalog/catalog.asp?C=75 for a current listing of programs, dates and times.

Bonus

Extending Experiences

- DNA can be extracted from onions, strawberries and kiwi as well. Check out this Web site for protocols. www.biotech.iastate.edu/publications/ed_resources/Laboratory_protocols.html
- Try the DNA Dance™©; see Web site for directions. www.biotech.wisc.edu/education/dnadance.html
- Turn this activity into an experiment by having the students change a variable, such as the amount of soap used, or the temperature of the water and/or alcohol.
- See how many words students can make using the letters found in the words deoxyribonucleic acid.

Culminating Activity:
Agricultural Biotechnology of Tomorrow

A guided-inquiry project

There are many stages in implementing agricultural biotechnology. During the developmental stages, scientists must research, identify problems in agriculture, problem solve, propose solutions, follow safety guidelines, meet state and federal regulations, and identify the risks and benefits of implementing a biotechnology practice. In this experience, students will identify agricultural issues, devise solutions and create displays to share with the class. As they begin, students imagine the capabilities scientists may have in the near future with the use of advanced technology.

Indiana's Academic Standards

Science

Standard 1: The Nature of Science and Technology (6.1.8, 6.1.9, 7.1.3, 7.1.8, 7.1.9, 7.1.10, 8.1.4, 8.1.7, 8.1.8)

Standard 2: Scientific Thinking (6.2.7, 8.2.7)

Standard 4: The Living Environment (6.4.13, 7.4.9, 7.4.10, 8.4.8)

Social Studies

Standard 3: Geography (6.3.13, 6.3.14, 6.3.16, 6.4.10)

Objectives

Students will:

- Research existing agricultural biotechnology techniques.
- Identify common agricultural issues and create solutions to these issues by incorporating biotechnology.
- Identify controversial issues related to agricultural biotechnology.
- Discuss safety, regulation, environmental risks and benefits, nutrition, farming and farmers, and consumer factors involved when implementing biotechnology.
- List the pros and cons for implementing agricultural biotechnology techniques.
- Advertise or display an agricultural biotechnology problem and solution to the class.

Focus Questions

- What are some agricultural issues of today?
- What are the pros and cons of implementing agricultural biotechnology?
- What are possible controversial issues that are related to agricultural biotechnology?
- How does the implementation of agricultural biotechnology affect farming, farmers and consumers?
- What are the environmental risks and benefits of implementing agricultural biotechnology?
- Should the government regulate agricultural biotechnology? Why or why not?

You will need ...

Time: As many days as desired, but at least four days in class. Time outside of class will also be needed.

Materials:

- **Ag Biotech of Tomorrow** handout (page 36)
- Resources for students to do research, library access and internet access
- Tables, signs or invitations for the Ag Biotech Fair

Procedures

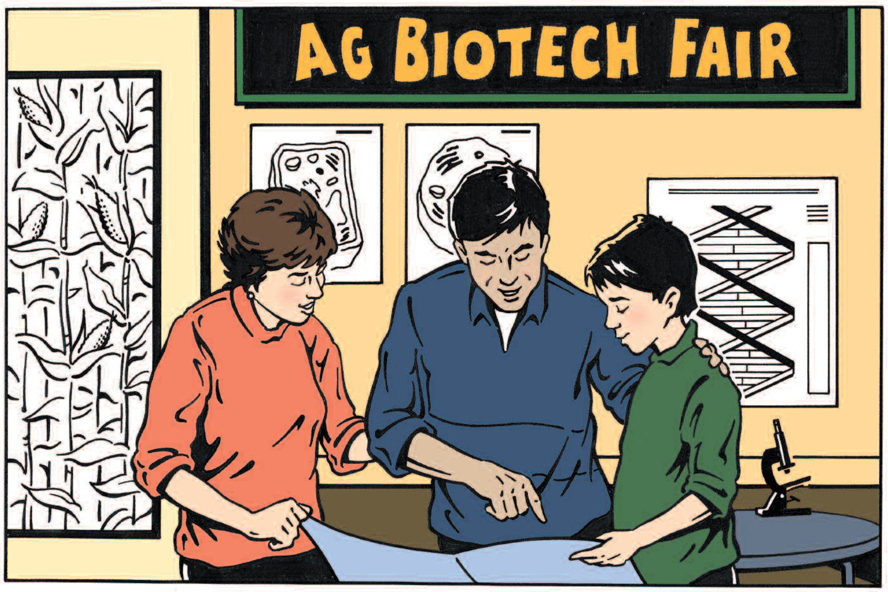
Day 1

- Plan a day when you can have an Ag Biotech Fair. You may want to invite parents, other classes or teachers to observe the displays. Explain to the students that on this day they will be required to present their findings at the fair. Have them keep this in mind as the experience continues.
- Present some common agricultural problems farmers experience today:
  - Loss of crops to insects.
  - Environmental problems due to pesticides.
  - Need to increase the yield (or quantity) of food produced per acre.
  - Need to increase the quality of food produced.
  - Crops destroyed by drought, flood or disease.
- Elicit additional agricultural problems from students and record responses.
- Elicit from students some of the biotechnology practices being implemented today that they discovered on the time line. Ask students if these practices may be attempts to solve specific problems. Examples:
  - **Tomatoes** can now contain a gene that produces an enzyme to make tomatoes ripen without turning soft.
  - Yellow daffodils contain a substance that can be converted into vitamin A if consumed. Genes that cause the yellow color of daffodils were recombined with rice seeds. The newly modified **golden rice** seeds now contain the substance that the body converts to vitamin A.
- Introduce two additional biotechnology practices being implemented today. Examples:
  - **Soybeans** contain proteins that some people are allergic to. Scientists have identified the main allergen in soybeans and can eliminate it using biotechnology, thereby eliminating the allergy.
  - **Bacillus thuringiensis,** or **Bt** is a bacterium that produces a protein called Bt toxin. Bt toxin kills insects and larvae that eat these bacteria. Scientists have taken this Bt gene and have recombined it with corn and cotton crops so they can produce their own Bt toxin, thereby reducing the need for pesticides on these specific crops.
- Give students an example of an agricultural problem consumers might be facing today.
  - For example: Some people are allergic to certain foods, such as seafood, peanuts or milk. Ask the question: What if allergens could be removed from foods? Suggest a solution to the problem: Remove the gene from the plant that causes the allergy using biotechnology.
- Have an open discussion on the possible controversial issues involved with biotechnology.
  - Safety — people, crops, other plants, animals and insects
  - Regulation — necessary steps to become approved by the government. Ask the students: Why is it important for scientists to keep clear and honest records?
  - Environmental benefits and risks
  - Nutrition
  - Farmers
  - Consumers
- Challenge students to brainstorm with a partner and identify a problem involved in agriculture today. Allow them some time to use the Internet to do this. Once a problem is selected, have students discuss it with you to determine if it is an appropriate selection.
- Challenge groups to design a solution using agricultural biotechnology. Their solutions can be creative and hypothetical regarding advances in biotechnology in the future. Encourage them to think out of the box and use biotechnology to find a possible solution.

Days 2 and 3

- Pass out the **Ag Biotech of Tomorrow** handout (page 36) and instruct groups to:
  - identify an agricultural challenge.
  - propose a solution.
  - identify controversial issues related to agricultural biotechnology.
  - list the pros and cons of using agricultural biotechnology techniques for this particular problem and solution.
  - discuss safety, regulation, environmental risks and benefits, nutrition, farming, farmers and consumer factors.
- Allow students some time to work on these in class as well as at home.
- Allow them to share their topics choosing one of the methods below at the Ag Biotech Fair.
  - PowerPoint presentation
  - Informative brochure
  - Series of cartoons
  - Poster board
  - Model of the product

Culminating Experience



A student shares his display with his family at the Ag Biotech Fair.

Day 4

- Have a celebration of work and hold an Ag Biotech Fair. Allow the students to observe each other's displays and make comments.

Assessment

Use the rubric provided on page 37 for grading displays at the fair or create your own. Share your criteria with students. The categories to be graded could include: stating the problem, explaining the solution, listing pros and cons, identifying controversial issues, mentioning safety, regulations, environmental risks and benefits, nutrition, farming and farmer or consumer factors.

Museum Links

Have the students use the various links on the museum's biotech Web site, www.childrensmuseum.org/biotech/index.htm to do their research. They can check out the **In the News** section to find recent articles relating to biotechnology.

Family Connections:

Share with families the scope of this project and have them help with locating articles and information about biotechnology. Invite parents to attend the fair.

Tips for Teacher

- Adapt complexity of focus questions to meet students' needs.
- Students may need some guidance in deciding where to search for their problem. Here are some print suggestions: "Newsweek," "Time," "New York Times," "USA Today" and your local papers.
  Here is a site with some Internet suggestions:
  www.biotech.iastate.edu/publications/ed_resources/News_links.html
- Some students will need extra guidance in their research. Allow some class time for their work; they may need to ask questions about how to look for things.

Resources

For Students:

Web sites:

The Children's Museum of Indianapolis, Biotechnology Learning Center
www.childrensmuseum.org/biotech/index.htm

Council for Biotechnology Information
www.whybiotech.com/

Biotechnology Institute
http://www.biotechinstitute.org/

Books:

- Bramwell, Martyn. "Food Watch." New York: Dorling Kindersley Limited, 2001.
- Dowswell, Paul. Genetics: "The Impact on Our Lives." Austin: Steck-Vaughn Company, 2001.
- Jefferis, David. "Cloning: Frontiers of Genetic Engineering." New York: Crabtree Publishing, 1999.

For Teachers:

Web sites:

The Children's Museum of Indianapolis, Biotechnology Learning Center
www.childrensmuseum.org/biotech/index.htm

Office of Biotechnology at Iowa State University
www.biotech.iastate.edu/

University of Wisconsin Biotechnology Center
www.biotech.wisc.edu/education/

Books:

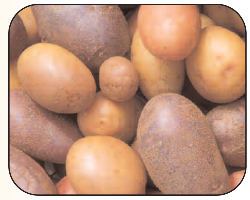
- National 4-H Council, "Field of Genes: Making Sense of Biotechnology in Agriculture." Maryland: National 4-H Council, 1997.
- Zinnen, Tom and Jane Voichick, "Biotechnology and Food." Madison: Cooperative Extension Publications, 1994.

Agricultural Biotechnology Time Line

4000 B.C.
Egyptians use yeast to make leavened bread and wine.

4000 B.C.

3000 B.C.



3000 B.C.
Peruvians select and cultivate potatoes.

1683
Antonie van Leeuwenhoek invents the microscope.

1683

1861

1861
Louis Pasteur invents pasteurization.

1865
Gregor Mendel begins the study of genetics.

1865

1879

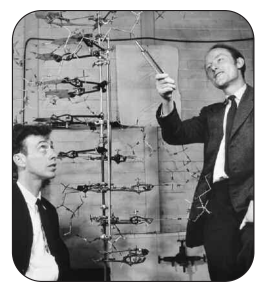
1879
The first hybrid corn is developed.

1950
Barbara McClintock discovers jumping genes.

1950

1953

1953
James Watson and Francis Crick uncover the structure of DNA.



1982
Human insulin is the first genetically engineered product.

1982

1990

1990
Chymosin is the first product of recombinant DNA in food supply.

1994
The FlavrSavr® Tomato is the first genetically whole food in the food supply.

1994

1999

1999
German and Swiss scientists develop Golden Rice.

2000
The first entire plant genome, *Arabidposis thaliana,* is sequenced.

2000

Name: ____

Biotechnology Through Time

Date of your event, object or scientist.

Where did this event or object occur? Where did this scientist live and work?

Choose three vocabulary words introduced during your research with your event, object or scientist. Define them in your own words.

How has this event (or scientist) affected us today?

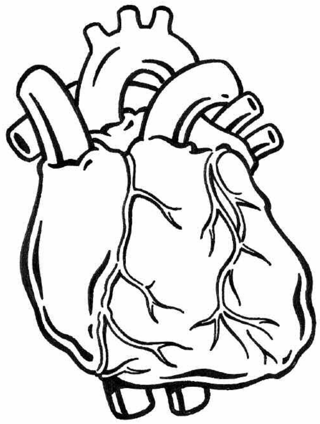
How did this event, object or person improve what was already known?

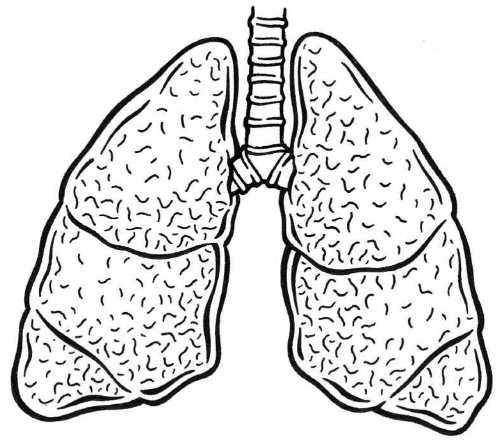
Why was this event or person special enough to be included on the time line?

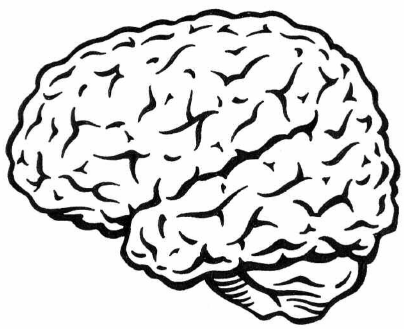
On a blank sheet of paper include a drawing of this event, object or person.

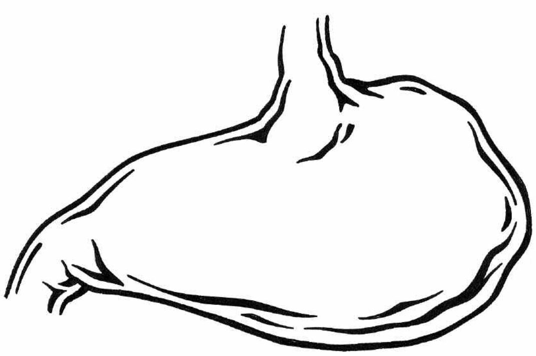
Name: ____

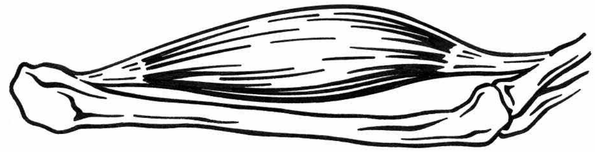
Body Part Picture Cards





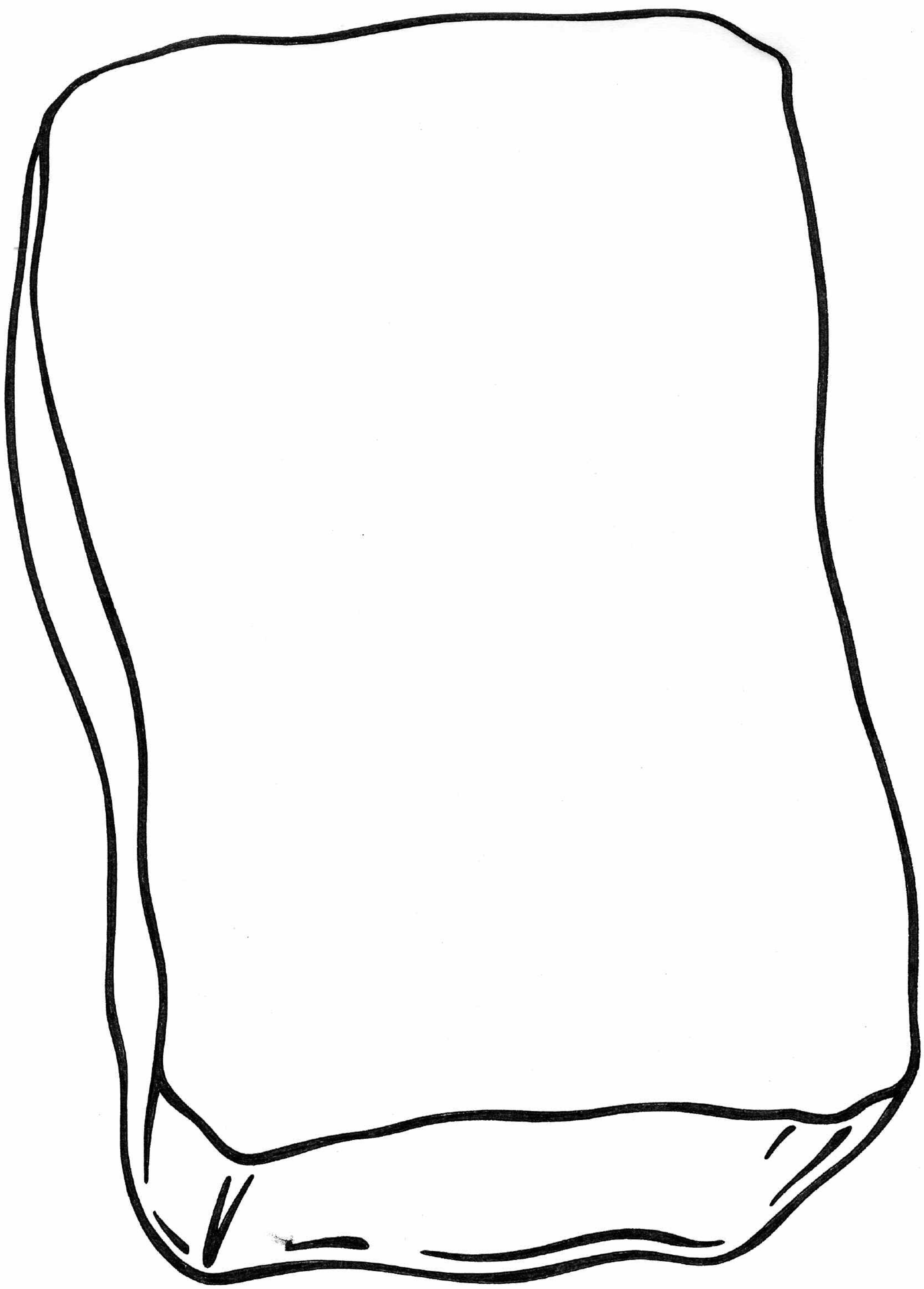






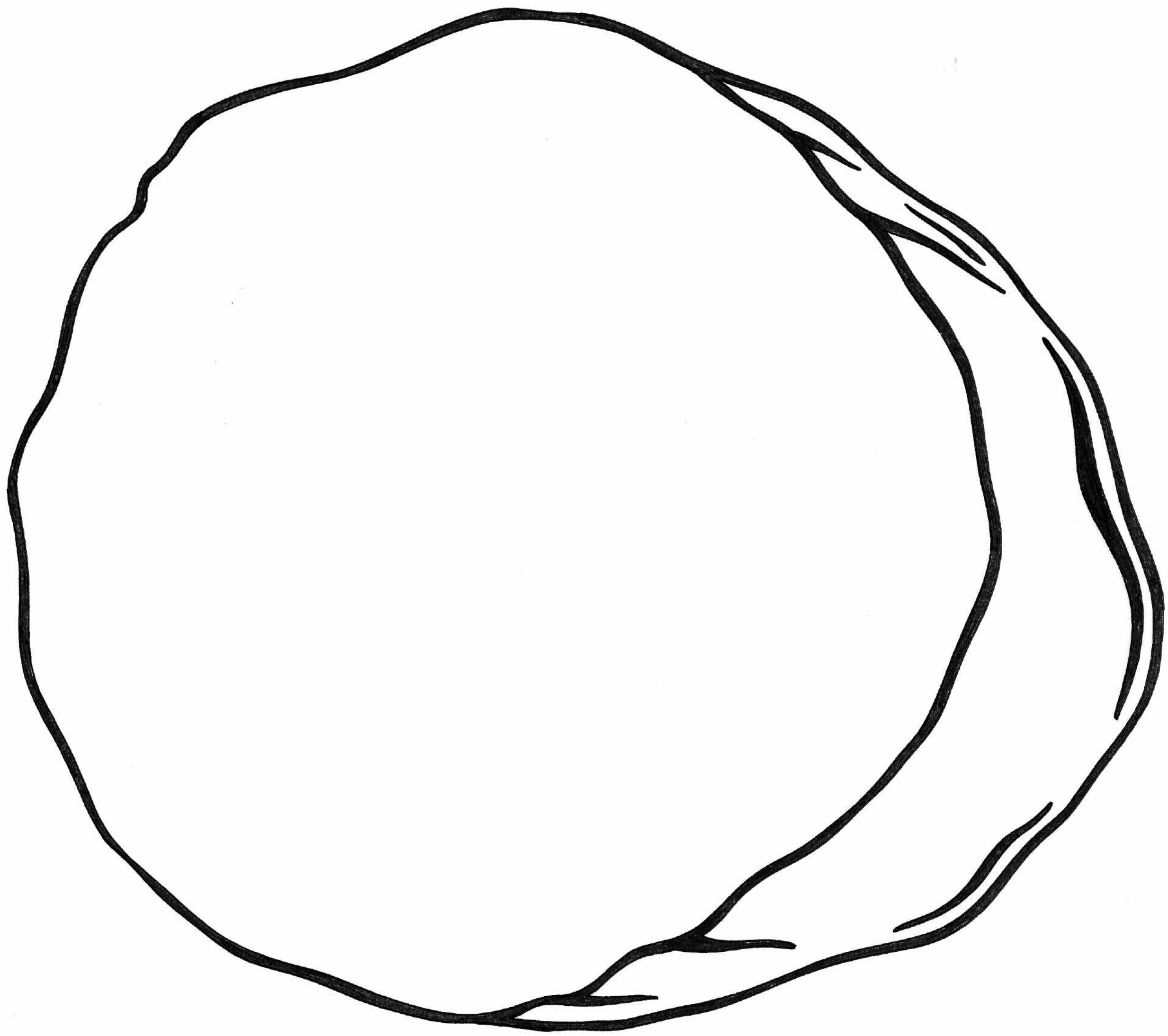
Name:____

Plant Cell



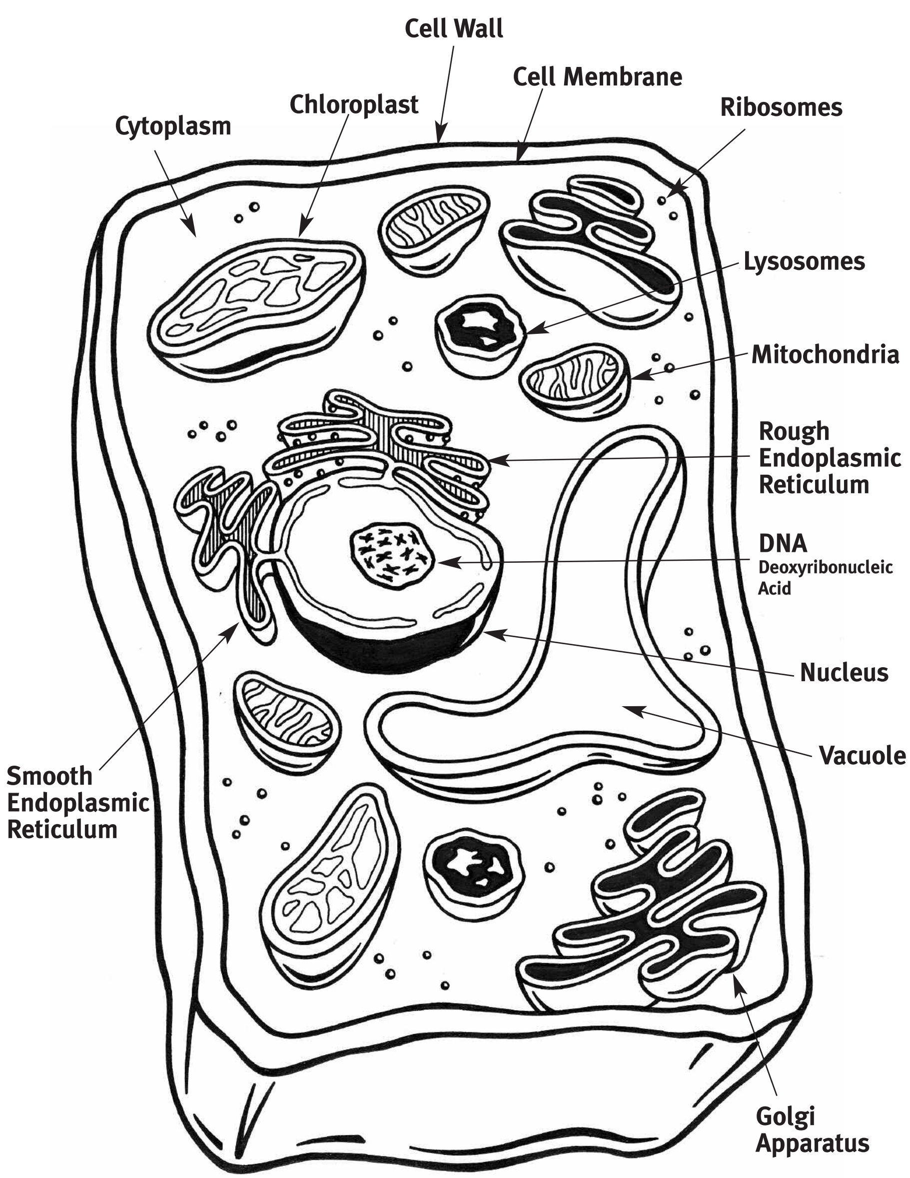
Name:____

Animal Cell

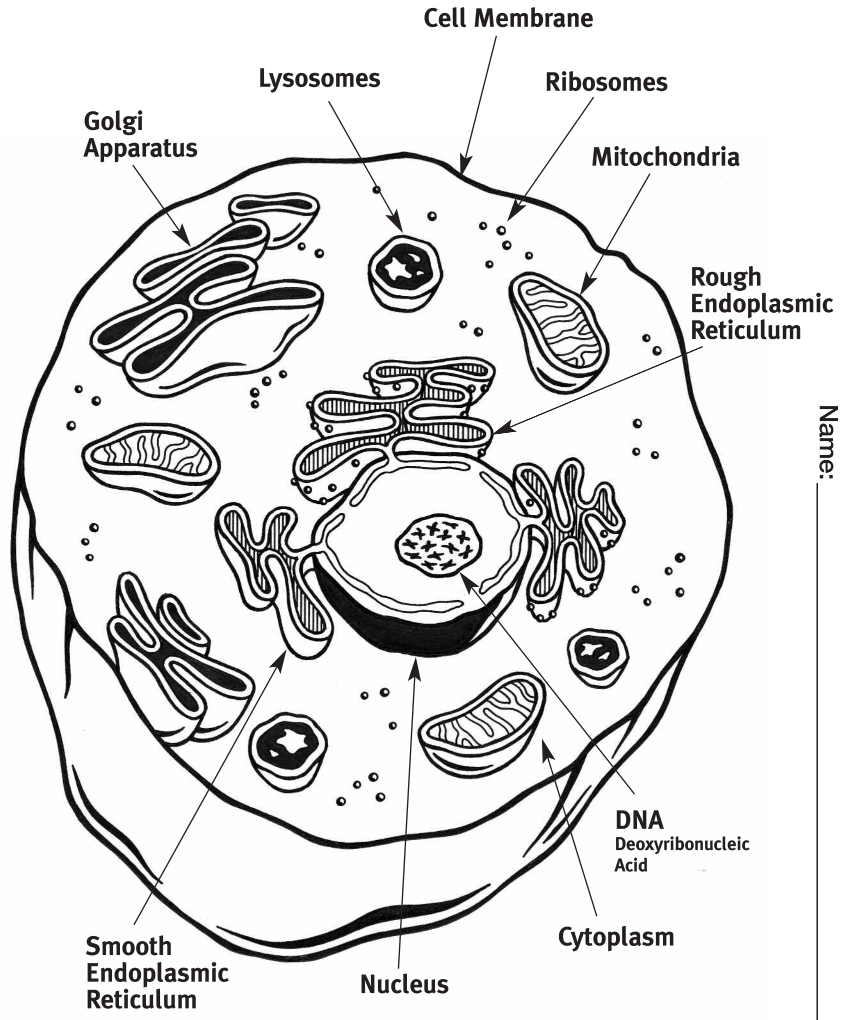


Name: ____________________

Plant Cell



Animal Cell



Name: ____

Cell Parts and Function

Cell Membrane — the outer boundary of the cell that controls the movement of materials in and out of the cell. Found in both plant and animal cells.

Cytoplasm — the fluid within the cell that contains organelles and aids in moving things around in the cell. It is inside the cell membrane surrounding the nucleus. The cytoplasm is made up of about two-thirds water.

Nucleus — One of the larger organelles found in all cells. The nucleus is usually the shape of a sphere and contains the cell's genetic material. It is the control center of the cell. It is found floating in the cytoplasm.

DNA (deoxyribonucleic acid) — DNA looks like a twisted extension ladder. It is found in the nucleus and controls everything inside the cell.

Mitochondria — produces the energy to power the cell's activities. It changes the energy stored in food compounds into a useful form of food. It is a kidney-bean-shaped organelle floating around the cytoplasm.

Endoplasmic reticulum — a network of membranes that stores, separates and transports substances within the cell. It is like a ribbon floating throughout the cytoplasm.

> **Smooth endoplasmic reticulum** — makes lipids, processes carbohydrates and modifies toxic chemicals in the cell.
>
> **Rough endoplasmic reticulum** — contains ribosomes on its surface and makes proteins to be secreted by the cell, makes new cell membranes.

Ribosomes — tiny ball-like structures found at the surface of the endoplasmic reticulum and floating in the cytoplasm. Proteins are formed in the ribosomes.

Golgi apparatus — flat pancake-like sacs where protein molecules are sorted, changed, packaged and distributed throughout the cell.

Lysosome — small spheres floating around the cytoplasm that contain digestive enzymes to help break down bacteria and viruses within the cell.

Vacuole — a sac that absorbs water, stores proteins, ions and waste products. Vacuoles are large in plant cells and small in animal cells. They provide support for plant cells.

Cell wall — the tough, rigid outer covering that surrounds the cell membrane of plant cells. It protects plant cells and helps the plant keep its shape.

Chloroplast — green oval-shaped structures that enable plants to make sugars through photosynthesis.

Name: ______________________________

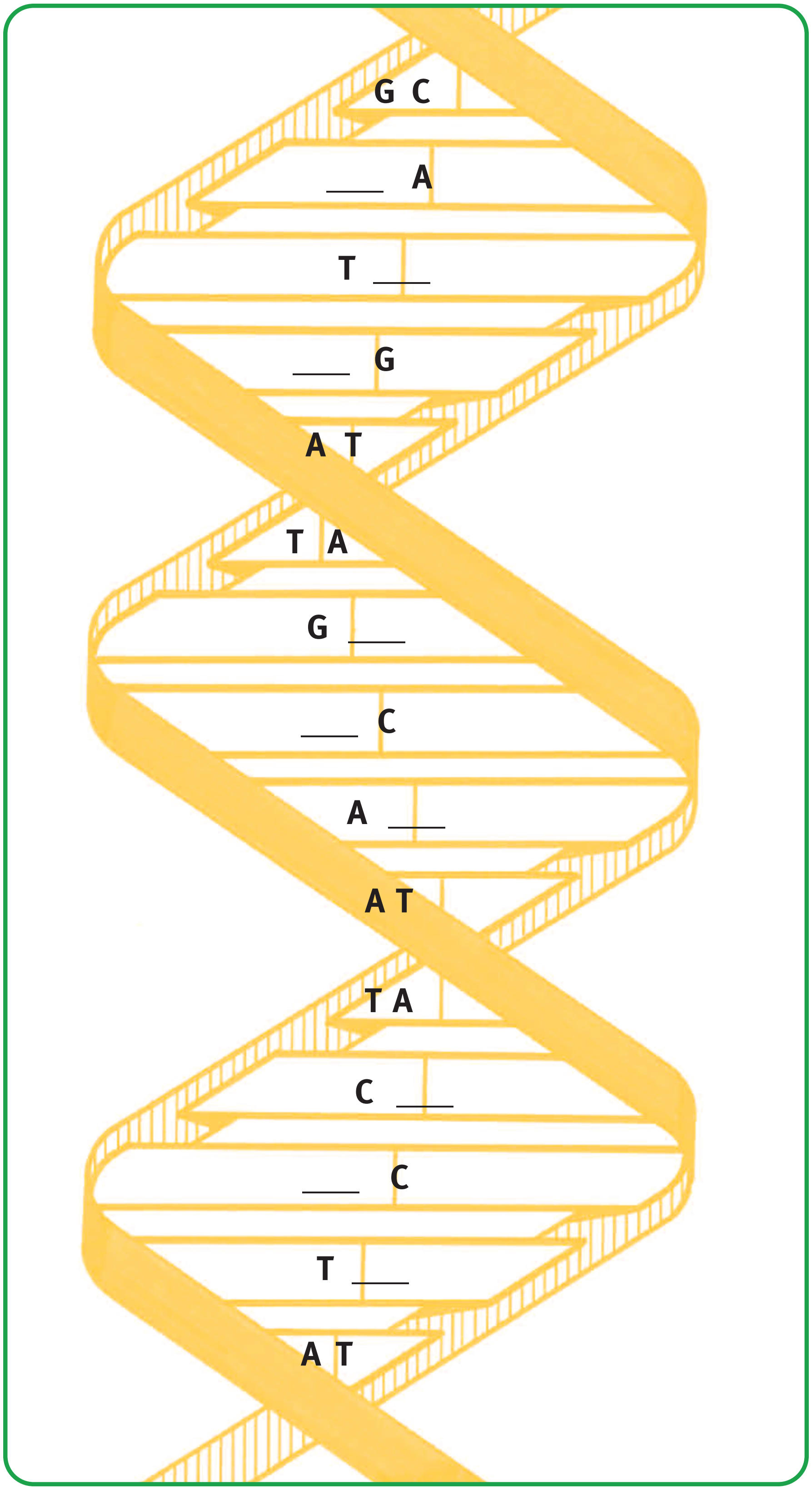
The Ladder of Life

DNA (deoxyribonucleic acid) is the master molecule of life! It controls many of life's processes. DNA molecules are large and complex, and store a vast amount of information. The nucleus of every cell in your body contains about 6 feet of DNA coiled up inside of it.

If you were able to magnify DNA, it would look like an extension ladder. Imagine holding the ladder at each end and twisting the ladder in two different directions. This would form a helix. Its appearance is much like that of a twisted stairwell.

Each rung of the ladder is made up of two chemicals attached in the middle. Each rung contains a different combination of chemicals. The chemicals that make up the rungs are called bases. There are four base pairs: adenine, thymine, cytosine and guanine. We call them base pairs because adenine always pairs up with thymine and guanine always pairs up with cytosine.

Can you complete the missing base pairs on the DNA strand shown? Remember: A goes with T and C goes with G.



Name:______________________________

Extracting DNA From Wheat Germ

***Read all instructions before beginning the lab activity.**
Remember to wear safety glasses at all times. Avoid contamination.

1

Measure 1 gram of wheat germ and pour it into a test tube. Add 20 mL of 50 – 60°C water.

***Be careful when working near a hot plate! Use hand protection when handling the warm water!**

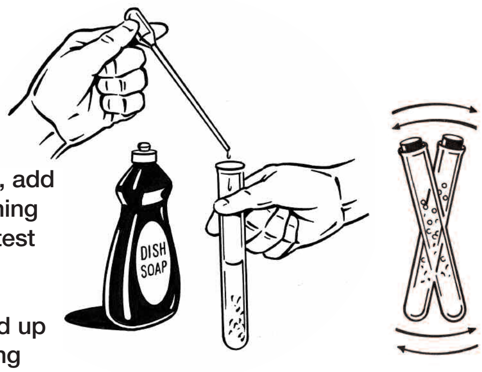
2

Stopper the test tube and shake for five minutes.

3

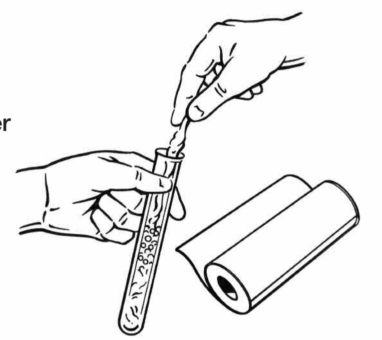
Using the pipette, add 1 mL of dishwashing detergent to the test tube.

Minimize the build up of foam by shaking the test tube gently for three minutes.



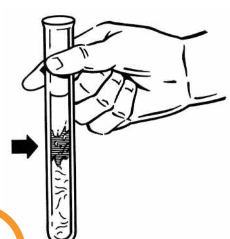
4

Use strips of twisted paper towel to remove the foam.



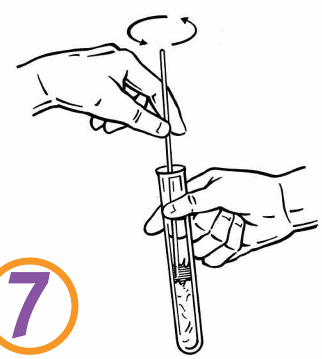
5

Tilt the test tube at an angle and slowly add 15 mL of ice-cold ethanol or rubbing alcohol, so that the alcohol floats on top of the water.



6

Observe the white glob forming where the water and alcohol meet.



7

Remove the white glob with a wooden stick by inserting the stick into the test tube just below the glob, slowly twirling or spooling it, and carefully pulling it out.

8

Make and record observations of the extracted DNA.
Have your teacher check your DNA glob.

Name: ____

Ag Biotech of Tomorrow

Describe the agricultural problem or issue that you will be researching.

Describe the possible solution to this problem or issue. How is it related to agricultural biotechnology?

Discuss the following issues related to your new agricultural biotechnology invention:

controversial issues

pros

cons

safety

regulation

environmental benefits and risks

nutrition

farming/farmers

consumers

Rubric for Ag Biotech Fair

Key Question	3	2	1	0	
What is the agricultural problem?	The problem is agricultural and has been thoroughly researched.	The problem is agricultural but has not been thoroughly researched.	The problem stated is not agricultural based.	No problem is stated.	
Does hypothetical solution use biotechnology with supporting research?	A possible and realistic solution using biotechnology has been suggested with supporting research.	The solution using biotechnology does address the problem, but has no supporting research.	The solution does not address the problem, or does not use biotechnology.	No solution is mentioned.	
What are the pros of this solution? Why?	Pros have been mentioned and are thoroughly supported.	Pros have been mentioned and are partially supported.	Pros have been mentioned but are not supported.	No pros have been mentioned.	
What are the cons of this solution? Why?	Cons have been mentioned and are thoroughly supported.	Cons have been mentioned and are partially supported.	Cons have been mentioned but are not addressed.	No cons have been mentioned.	
What controversial issues are involved with this solution?	Controversial issues are listed and addressed appropriately and thoroughly.	Controversial issues are listed and partially supported.	Controversial issues are listed but not addressed.	No controversial issues have been listed.	
What safety issues are involved with this solution?	Safety issues are mentioned and are well thought out.	Safety issues are mentioned and are partially supported.	Safety issues are mentioned, with no explanation.	No safety issues are addressed.	
What regulations should the government require? Why?	Several steps for regulation are listed and explained.	A few regulations are mentioned with weak explanations.	A few regulations are mentioned with no explanations.	No regulations are mentioned.	
What environmental risks and benefits are involved with this solution?	Environmental risks and benefits are listed and thoroughly addressed.	Environmental risks and benefits are listed and partially addressed.	Environmental risks and benefits are listed but not addressed.	No environmental risks or benefits are mentioned.	

Total Score

National Standards

Science Education (5 – 8)

Content Standard A — Science as Inquiry

Fundamental concepts and principles that underlie this standard include:

Understandings about Scientific Inquiry

- Different kinds of questions suggest different kinds of scientific investigations.
- Scientific investigations sometimes result in new ideas and phenomena for study, and generate new methods or procedures for an investigation, or development of new technologies to improve the collection of data.

Content Standard C — Life Science

Fundamental concepts and principles that underlie this standard include:

Structure and function of living systems

- Living systems at all levels of organization demonstrate the complementary nature of structure and function.
- All organisms are composed of cells.
- Cells carry on the many functions needed to sustain life.

Reproduction and Heredity

- Hereditary information is contained in genes, located in the chromosome of each cell.

Content Standard E — Science and Technology

Fundamental concepts and principles that underlie this standard include:

Understandings about science and technology

- Many different people in different cultures have made and continue to make contributions to science and technology.
- Technological solutions have intended benefits and unintended consequences.

Content Standard F – Science in Personal and Social Perspectives

Fundamental concepts and principles that underlie this standard include:

Risks and Benefits

- Important personal and social decisions are made based on perceptions of benefits and risks.

Science and Technology in Society

- Science influences society through its knowledge and worldview.
- Societal changes often inspire questions for scientific research, and social priorities often influence research priorities through the availability of funding for research.
- Technology influences society through its products and processes.
- Science and technology have advanced through contributions of many different people, in different cultures, at different times in history.
- Scientists and engineers work in many different types of settings, including colleges and universities, business and industries, specific research institutes and government agencies.
- Science cannot answer all questions and technology cannot solve all human problems or meet all human needs.

Content Standard G — History and Nature of Science

Fundamental concepts and principles that underlie this standard include:

Science as a Human Endeavor

- Women and men of various social and ethnic backgrounds — and diverse interests, talents, qualities, and motivations — engage in the activities of science, engineering and related fields such as the health professions.

History of Science

- Many individuals have contributed to the traditions of science.
- In historical perspective, science has been practiced by different individuals in different cultures.
- Tracing the history of science can show how difficult it was for scientific innovators to break through accepted ideas of their time to reach conclusions that we currently take for granted.

Language Arts

Standard 4: Students adjust their use of spoken, written and visual language (such as conventions, style and vocabulary) to communicate effectively with a variety of audiences and for different purposes.

Standard 5: Students employ a wide range of strategies as they write and use different writing process elements appropriately to communicate with different audiences for a variety of purposes.

Standard 6: Students apply knowledge of language structure, language conventions (such as spelling and punctuation), media techniques, figurative language and genre to create, critique and discuss print and non-print texts.

Standard 8: Students use a variety of technological and informational resources (such as libraries, databases, computer networks and video) to gather and synthesize information and to create and communicate knowledge.

Agricultural Biotechnology Survey

Please take a few minutes to help the museum evaluate the usefulness of this unit of study by filling out the survey below and sending it to the museum. Fold along dotted line, tape shut and drop in the mail. Thanks for your input!

NAME

ADDRESS

CITY STATE ZIP CODE

PHONE

E-MAIL

NAME OF SCHOOL

GRADE(S) YOU TEACH _____ PUBLIC _____ NON PUBLIC

How did you get this unit of study?

❏ Workshop ❏ Institute ❏ Online
❏ Other (Please explain)

How much of the unit of study have you used in your classroom this school year?

❏ 100% ❏ 75% ❏ 50%
❏ 25% ❏ none

Why did you use that percentage? ____________

How many students have benefited, or do you expect to benefit, from the unit?

❏ 10 – 20 ❏ 21 – 30 ❏ 31 – 40 ❏ 40 – 50
❏ 50 – 60 ❏ 60+

How well does the unit of study match your teaching plans?

❏ Strong match ❏ Fair match
❏ Not a good match

Please explain: ____________

Please check all that apply:

❏ I took my class to the museum during the current school year as a result of:
- ❏ attending an institute
- ❏ attending a workshop
- ❏ using the unit
- ❏ something unrelated to the above. *(Please explain.)*

❏ I did not take my class to the museum during the current school year because

Please check all that apply:

❏ I plan to take my class to the museum in the coming school year.

❏ I have shared the unit of study materials with other teachers.

In conjunction with this unit of study, I have taken my class to the following other museums in the current year:

Suggestions/Comments: *(If more room is needed, please feel free to e-mail the Biotech Web site at: biotech@childrensmuseum.org.)*

The Children's Museum
of Indianapolis
P.O. Box 3000
Indianapolis, IN 46206-3000

Nonprofit Org.
U.S. Postage
PAID
Indianapolis, IN
Permit No.
1067

THE CHILDREN'S MUSEUM OF INDIANAPOLIS
School Services Director
P.O. Box 3000
Indianapolis, IN 46206-3000

Fold here.

Fold here.