Biotech Basics

Emily Hood Ferrin, PhD
Program Director & Resident Scientist
Biotechnology Center of Excellence
Lindbloom Math & Science Academy
Office of STEM Education Partnerships
Northwestern University

Liz Martinez
Curriculum & Professional Development
Illinois Mathematics & Science Academy
Statewide Educators Initiative

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Biotech Basics

Introduction

**Biotechnology** is the deliberate manipulation of biological systems to develop new products that will be helpful to humans. Scientists are studying cells and the processes that go on within the cells to determine how we can best harness the benefits. Growing more and better quality food, creating alternative and renewable fuels, developing new drugs, conquering diseases, developing new materials for fabrics, and reducing the human impact on the environment are just a few of the examples of biotechnology in action. In addition to the knowledge needed to become proficient in biotechnology, there are several skills. This session, will provide activities to introduce students to some of the techniques, equipment, and ideas being studied through biotechnology, and is the result of collaboration among The Biotechnology Center of Excellence at Northwestern University, BioBuilder, Great Lakes Bioenergy Center, and the Illinois Mathematics and Science Academy Fusion Program.

http://www.bcoe.net/

https://www.glbrc.org/

http://biobuilder.org

https://www.imsa.edu/extensionprograms/fusion

Contact Information:

Emily Ferrin, (emily.ferrin@northwestern.edu) The Office of STEM Education Partnerships, Northwestern University
Liz Martinez, (emartinez@imsa.edu) Statewide Educator Initiatives, Illinois Mathematics and Science Academy

Contributing Authors:

Lindsey Herlehy
Karen Togliatti
Biotech Basics: Resources & Materials

http://www.bcoe.net/ - Northwestern University’s biotechnology outreach center. Webinars, professional development courses, and support for teaching biotechnology.

https://www.glbrc.org/ - Great Lakes Bioenergy Research Center, located in Madison, lesson plans, professional development courses, and internships.

https://www.imsa.edu/extensionprograms/fusion - Professional development and student STEM enrichment programs for Illinois teachers and students in grades 4-8.

http://www.corestandards.org/ - References to Common Core are adapted from NGA Center/CCSSO © Copyright 2010. National Governors Association Center for Best Practices and Council of Chief State School Officers. All rights reserved.

http://www.nextgenscience.org/next-generation-science-standards - References to Next Generation Science Standards are adapted from NGSS. NGSS is a registered trademark of Achieve. Neither Achieve nor the lead states and partners that developed the Next Generation Science Standards was involved in the production of, and does not endorse, this product.

http://biobuilder.org/ - BioBuilder brings current science and engineering from biotechnology into the classroom via labs and collaboration. Modules, including lesson plans and student portal. Age appropriate for middle school through high school.

Fixed Volume Pipettes (We used 10μL fixed volume)
http://www.tricontinent.com/products/minipet/, Contact debbie_zeh@tricontinent.com
http://www.bio-rad.com/

Phenix Research
http://www.phenixresearch.com/, Contact bjohnson@phenixresearch.com
MPG-650101, 96 well plates, 100/box
MH-805 DG, 0.5 ml Fluorescent Microtubes, 1000/box
MH-815A, 1.5 mL Microtube, 500/box
TSP-200, 200μL Clear Tip, Bulk, 1000/pack

pH Buffers, 4-10
Indicators: Bromothymol Blue, Phenol Red, Methyl Red, Thymol Blue, Phenolphthalein,
http://www.flinmsci.com/

Agarose Tablets

Plastic Boxes
http://www.uline.com/Product/Detail/S-6277/Retail-Boxes/Plastic-Boxes-3-9-16-x-2-9-16-x-1-1-8?keywords=S-6277

Combs (Can 3-D print)
http://www.edvotek.com/Welcome?search=680
PIPET BY NUMBER
Overlay the bottom or top half of a 10 mm Petri Dish onto the image of your choice below. Use a pipet to dispense the correct color paint directly onto each letter according to the table on the left. The appropriate volume of paint to dispense for each image is printed next to the image.

Easy 10 µL

Intermediate 5 µL

Intermediate 5 µL

Advanced 5 µL

Advanced 5 µL

Advanced 5 µL

Colors:
G  Green  R  Red
K  Black  W  White
N  Brown  Y  Yellow
Biotech Basics
Water Problem

Problem

Materials

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Biotech Basics
Water Problem

Presentation Plan

Materials Needed

My Role & Responsibilities
BACKGROUND INFORMATION

Have you ever smelled rotting garbage? Believe it or not, you were smelling what may be the next fuel that could run your car’s engine! Finding alternatives to the use of fossil fuels is a challenge that many researchers are trying to solve for a variety of reasons. One of the areas being studied is called bioenergy.

Bioenergy is a type of renewable energy that uses materials which were once living. These materials are also called organic matter. Items such as soybeans, switchgrass, leaves, branches from trees, corn husks, yard clippings, manure, and vegetable oils, fats, or greases are called biomass. These biomasses or feedstocks may be chemically changed into biofuels.

**Biofuels** include two fuels you may have heard of before; ethanol and biodiesel. Ethanol fuel comes from corn. Almost all gasoline sold in the United States has some ethanol mixed with it. Biodiesel is a fuel that is made from vegetable oils, fats, or greases. These may come from soybean oil or even from recycled restaurant grease. Other biomass materials are being experimented with to see how they can be changed into fuels.

Biofuels release less greenhouse gases into the air compared to fossil fuels. When the plants were alive they took in carbon dioxide from the atmosphere. Carbon dioxide is released from plant material when it is burned for energy. Since the plants had taken in carbon dioxide before they were used to make energy, they are considered to be carbon neutral. This is one of the reasons bioenergy is being studied very carefully right now.
PROBLEM

How does the type of feedstock affect the quantity of carbon dioxide produced?

MATERIALS

- Corn Meal
- Goggles
- Graduated Cup
- 2 Hand Lenses
- Paper Towels
- Pen or Permanent Marker
- 4 Zipper Baggies
- Sawdust
- Sugar
- Spoon
- Warm Water
- Yeast

PROCEDURE

1. Work in groups of 4.
2. Using a pen or a permanent marker, label the zipper bags as follows:
   a. Yeast
   b. Yeast and Cornmeal
   c. Yeast and Sawdust
   d. Yeast and Sugar
3. Put 1 spoon of yeast in each of the four bags.
4. Add one spoon of cornmeal to the bag labeled, “Yeast and Cornmeal.”
   Observe the yeast and cornmeal using the hand lens. Record your observations in the data table.
5. Add one spoon of sawdust to the bag labeled, “Yeast and Sawdust.”
   Observe the yeast and sawdust using the hand lens. Record your observations in the data table.
6. Add one teaspoon of sugar to the bag labeled, “Yeast and Sugar.” Observe the yeast and sugar using the hand lens. Record your observations in the data table.
7. PUT ON A PAIR OF GOGGLES.
8. Fill the graduated cylinder with 50 mL of water. Pour the water into a cup.
9. Transfer the warm water into the zipper bag marked, “Yeast.” Get as much air out of the zipper bag as possible. Zip the bag closed.

10. Record the time this started on the data table.

11. Lay the zipper bag flat on your table or desk.

12. Repeat steps 9 through 11 for each of the remaining three zipper bags. Remember to record the starting times on the data tables.

13. Observe the zipper bags and record your observations. Use the hand lens to help you make your observations.

14. Write down questions you have while watching the zipper bags.

15. Follow your teachers’ directions for cleaning up the activity.

16. Wash your hands when you are done with the experiment.

17. Work with your partners to discuss and answer the questions.
## AT the PUMP

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<th>MATERIALS</th>
<th>OBSERVATIONS</th>
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DISCUSSION/CONCLUSIONS

1. What was/were the difference(s) in the data among the zipper bags?

2. What do you think caused the difference(s)?

3. What were the feedstocks that you used?

4. What would be some challenges of scaling this up to be able to make a larger quantity?

5. Both carbon dioxide and ethanol were produced in this reaction. Where do you think the ethanol was? Where do you think the carbon dioxide was?

6. If you had a chance to talk with a scientist who was researching and developing biofuels, what are a few questions that would you think would be good to ask that person?
Biotech Basics
At The Pump
**Biotech Basics**

**Gel Electrophoresis**

**Problem:** *How can materials be separated?*

**Materials:**
- 2 Small Paper Clips
- 3 – 9 Volt Batteries
- 2 Alligator Clips
- 1 Plastic Box
- 1 Gel
- 1 Pipette
- 6 Tips
- 50 mL TAE Buffer
- 1 Graduated Cup
- 1 Plastic Cup

**Procedure:**
1. Listen to your teachers explain how to unfold the paper clip so that it will fit into the plastic box.
2. Carefully unfold the paper clip. Test the paper clip in the empty box to make sure that it fits in the box. Do the same with another paper clip.
3. Set the paper clips to the side.
4. Get your power source ready. Assemble the three 9-volt batteries as instructed by your teachers.
5. Attach one alligator clip to the positive terminal.
6. Attach the other alligator clip to the negative terminal.
7. Set the power source to the side until your team is ready to connect it to the gel box.
8. List the materials that you and your team members will be placing in the wells on the diagram of the gel box.

9. As a group, decide who will load which lane.

10. Decide which colors will be loaded into each lane. Record this information on the diagram of the gel box on the next page.

11. Your teachers will help your team place or adjust the gel in the box. Carefully touch the gel. Record any observations you have about the gel.

12. Measure and pour 50 mL of TAE buffer into the gel box.

13. Carefully place the paperclips under each end of the gel according to your teachers’ directions. Be careful to not tear the gel.

14. Once your teachers have inspected your team’s setup and given the approval, your team will be ready to move ahead to the next step.

15. Take turns loading the lanes in the gel with the materials available. Fill each lane with _______ of liquid.

16. Have your teachers assist you when it is time to attach the power source to your gel box.

17. Observe the gel box for several minutes.

18. The procedure that you are completing is called gel electrophoresis. While your group is watching the process, discuss ideas about what is happening and why it is happening. Think about ideas such as why a power source is needed and why the negative terminal of the battery is by the lanes where the colors were loaded.

19. Record your observations on the diagram of the gel box in the diagram.
Observations:
Debrief Questions:

1. Gel electrophoresis needs a power source. That power source may be batteries, like your team used, or direct current from an electrical outlet. Share the ideas that your team discussed as to why power is needed. Use drawings if they help.

2. Where would it be helpful to know how DNA or other genetic material separated? Explain your ideas.
Water Problem

Objectives:

- Develop lab techniques involved in pipetting.
- Design and follow procedures.
- Collect, analyze, and interpret data.
- Work cooperatively in groups.
- Present findings to a group.

Background Information

Biotechnology is the process of using living cells to help develop solutions to problems and improve the quality of life. Vaccines, antibiotics, new medications, biofuels, agricultural products, extremely strong fibers, cleaners, cosmetics, and several food products have been derived through biotechnology. The majority of biotechnology works at the cellular level.

DNA, or deoxyribonucleic acid, is a molecule that contains instructions that make each species unique. To fit in the nucleus of a cell, DNA is tightly coiled into chromosomes. DNA is made of chemicals called nucleotides. Nucleotides consist of three parts linked together: a phosphate group, a sugar group, and one of four nitrogen bases. The four nitrogen bases are adenine (A), thymine (T), guanine (G), and cytosine (C). The order the bases are arranged in will determine the directions or instructions carried in the DNA. ATCGAC is a different set of biological instructions than ATCAAG. The DNA instruction book is called the human genome and contains about 3 billion bases and 20,000 genes on 23 pairs of chromosomes. A sequence of DNA that has instructions to make a protein is known as a gene.

It is this level of the cell and detail at which biotechnologists work with on a regular basis. Small amounts of very small items need to be transferred from one location to another during experimentation. Micro means a millionth or 10^-6 or 0.000001 and is represented by the Greek letter Mu, μ. Thus a microliter, μl, is one millionth of a liter. Pipettes or micropipettes may be used to obtain this small amount of liquid.

Specialized equipment and skills are employed in biotechnology. Small amounts may be obtained and transferred using pipets. Separation techniques are used to extract the desired portions of the cell(s) for use.
Inquiry Overview

Students will practice their pipetting skills in activity one. The first activity may be used as an introduction for first-time pipetters or as a refresher for more experienced students. Students will then determine the contamination level of various water sources during an agricultural based simulation.

Activities

Activity 1 – Pipet By Number

Objectives:

• Develop lab techniques involved in pipetting.
• Work cooperatively in groups.

Standards:

NGSS Science and Engineering Practices: SEP2

Common Core State Standards

ELA/Literacy: SL.5.1

Estimated Time: 50 minutes

• 5 minutes – Introductory Discussion
• 40 minutes – Activity
• 5 minutes - Debrief

Advanced Preparation:

1. Prepare the solutions that will be used for pipetting.
   a. Paint: Dilute 1:1 ratio of tap water. Paint brands vary on viscosity, so test ahead of time. If the paint is still too viscous, then dilute the paint a little more or trim the tips used with the pipettes to allow the viscous mixture to work.

Pipet By Number

Materials:

for advanced prep:

• 7 1.5ml microtubes per student
• 12-20 transfer pipettes
• 6 50ml conical tubes or small beakers
• acrylic paint solution – red, yellow, green, white, black, & brown
• Food coloring - optional
• Tap water
• Paper towels

for each student:

• Student Pages

for each group:

• 1 5µl fixed-volume pipette and 1 10µl fixed-volume pipette or 1 p20 pipette
• 6-10 p20 pipette tips
• 1ml food coloring solution (optional)
• 1ml each acrylic paint solution – red, yellow, green, white, black, & brown
• 1 petri dish or transparency
b. Optional: Food Coloring: 1 drop of food coloring to 50 mL of tap water

2. Decide if students will be using petri dishes or transparency film. If they are using transparency film, then cut the circles to size.

**Suggested Inquiry Approach:**

Host an introductory discussion with students using questions such as:

- What do you know about biotechnology?
- What equipment is used by people in this field?
- Would these researchers be working with small, medium, or large items? Explain.

Introduce the pipette to the students. Explain how to use the pipette. Share with the students that they are going to now practice their pipetting skills. Show students the materials they will be using. Distribute the materials.

Allow time for students to look at the illustrations on the Pipet By Number handout. Have them locate the key. Note – If using limited tips, then have groups make plans so that they will use the least amount of pipette tips. Distribute materials and assist as needed.

Have students dispose of the used tips. Wash hands as needed. Host a whole class discussion using the following debrief questions:

**Debrief Activity 1:**

- What was easy about pipetting?
- What was challenging about pipetting?
- How do you think pipetting might be used by biotechnologists?
- Why do you think such small amounts of material(s) are needed?

**Activity 2 – Eat Your Veggies**

**Objectives:**

- Design and follow procedures.
- Collect, analyze, and interpret data.
- Work cooperatively in groups.
- Present findings to a group.

**Standards:**
NOTES

NGSS Science and Engineering Practices:
SEP1, SEP2, SEP3, SEP4, SEP7, SEP8

Common Core State Standards
ELA/Literacy: RST.6-8.2, 6-8.4, SL.5.1

Advance Preparation:
1. Fill the “water sample” containers with buffers. Label the tubes 1-7.
2. Fill the biosensor tubes with indicators.
3. Determine how many class sessions will be devoted to the activity and adjust the time frame as needed.

Estimated Time: 60 minutes each session
Day 1:
- 15 minutes – Introduce Problem
- 40 minutes – Design Procedure & Data Tables
- 5 minutes – Debrief

Day 2:
- 5 minutes – Explain location of materials & Groups review their procedures
- 40 minutes – Conduct investigations
- 5 minutes – Clean up
- 5 minutes - Debrief

Day 3:
- 10 minutes – Introduce presentation expectations
- 40 minutes – Work on presentations
- 10 minutes – Debrief

Day 4:
- 45 minutes – Group presentations
- 15 minutes - Debrief

Suggested Inquiry Approach:
Day 1: Share the PowerPoint with the students. Use slides 1–15. Encourage student questions throughout the PowerPoint.

Water Materials:
for advanced prep:
- Transparencies (optional)
- 1.5 ml microtubes for “water samples”
- 1.0 ml microtubes for biosensors
- 25 ml of pH buffer 4
- 25 ml of pH buffer 5
- 25 ml of pH buffer 6
- 25 ml of pH buffer 7
- 25 ml of pH buffer 8
- 25 ml of pH buffer 9
- 25 ml of pH buffer 10
- 25 ml of 0.1% methyl red
- 25 ml of 0.1 % phenolphthalein
- 25 ml of 0.1% methyl blue
- 25 ml of 0.1% phenol red
- Pipette
- Pipette tips

teacher:
- Computer
- Projector
- PowerPoint

each student:
- Student Pages
- Goggles
- Gloves if possible

for each group:
- 1 5µl fixed-volume pipette and 1 10µl fixed-volume pipette or 1 p20 pipette
- 15-20 p20 pipette tips
- 1 microtube of each of the 7 “water” samples & each of the 5 sensors
- 96 well plate (could do this in cups or on wax/parchment paper)
- 1 trash cup
Introduce any unfamiliar equipment to the students from the list of potential materials.

Share with students that they need to develop a plan for testing the water samples.

**Day 2:** Remind students of the purpose of their research. Explain where materials are located throughout the classroom. Assist student groups as needed while they are working through the testing.

**Day 3:** Introduce students to any expectations for the presentation of their data.

**Day 4:** Have student groups share their presentations.

**Debrief Activity 2:**

**Day 1: Whole Class Debrief**

- What did you need to think about when designing the investigation?
- How will you collect and organize your data?
- Why would people be concerned about the type of water used to irrigate their crops/food?

**Day 2: Whole Class Debrief**

- How confident are you in your data? Explain.

**Day 3: Debrief Within Lab Groups**

- How is everyone in your group involved in the presentation?
- What is each person responsible for while presenting?
- What visual aids will you be using?
- What still needs to be completed for your presentation?

**Day 4: Whole Class Debrief**

- Which water samples were safe? What is your evidence?
- Which water samples were unsafe? What is your evidence?
At the Pump

Objectives:

- Observe the process of fermentation
- Produce ethanol from cellulosic sources
- Collect, analyze, and interpret

Background Information

Bioenergy derives its energy from organic matter. Organic matter is matter that is or was once living.

60% of greenhouse gas emissions come from fossil fuels being burned. Deforestation and agriculture account for almost all of the other 40% (National Geographic, 2009). And of all of these emissions, plants, oceans, and soils can only remove about 5 of the 9.1 billion metric tons of carbon dioxide per year.

The Renewable Fuel Standard (RFS) was created under the Energy Policy Act of 2005 and expanded in 2007 by the Energy Independence and Security Act (EISA). According to the USDA Biofuels Strategic Production Report (2010), by 2022 there must be 36 billion gallons of renewable fuels. For 2010 there had to be 12.95 billion gallons of biofuels, 6.5 million of which had to come from cellulosic ethanol. Since biodiesel has a higher energy density than ethanol, each gallon of biodiesel counts as 1.5 gallons toward the mandate. Only 1 billion gallons of biodiesel have been mandated because less feedstock is available.

Cellulosic refers to cellulose from living or once living organisms, such as trees, plants, and tunicates. It is the most abundant biopolymer on the earth and is considered a “green” material. Cellulose is a carbohydrate, considered carbon neutral, and has a minimal impact on the environment.

Greenhouse gas reductions were also included in this act. When compared to petroleum, the greenhouse gases had to be reduced by the following amounts for each biofuel source: corn grain ethanol, 20%; advanced biofuel, 50%; biodiesel, 50%; and cellulosic biofuel, 60% (EPA, 2010).

Ethanol produced from corn is present in almost all of the gasoline sold in the United States today. This is a renewable biofuel. There are some concerns about this technology. Corn is a seasonal crop that requires a lot of energy to plant and cultivate. The use of nitrogen fertilizer helps to create nitric oxide.
which is a more damaging greenhouse gas than carbon dioxide as far as trapping heat. Corn uses a lot of nutrients from the soil and is expensive to harvest and ship. Others have expressed concerns over the use of a food crop for a fuel.

Other biomass options being explored for possible production of ethanol include switch grass, prairie grasses, aspen, sugar cane, and corn stover. Some of these plants are native plants that do not require replanting. Once they have been established, they continue to reseed. They also have very long roots that help to take in or sequester large amounts of carbon dioxide. Many of these plants grow rapidly and would not compete with agricultural land. Ideas such as corn stover use the leftovers, or economically undesirable portions, of the corn plants to produce ethanol. All of these are called feedstocks.

The feedstocks are then transported to the biorefinery where they are processed and converted into ethanol. Yeast is used in this process. The yeast remain dormant until they have the right conditions met, temperature and food. Their food source is sugar or carbohydrate, which is the feedstock or cellulosic matter. Once ethanol is produced from the biomass, it has to be distilled or purified from the mixture. Carbon dioxide produced in the process is released into atmosphere. Heat and odor are other by-products produced in this process.

From the biorefinery, the biofuel is transported to a distribution center for consumers to purchase. Ethanol burns faster in vehicle engines, so consumers have to purchase more compared to petroleum based fuels.

**Inquiry Overview**

Students will be introduced to the idea of bioenergy through a short reading. Then they will have the opportunity to produce a biofuel through a chemical reaction caused from biomasses interacting with one another.

**Activity – At the Pump**

**Standards:**

NGSS: HS-LS1-1
NGSS Science and Engineering Practices: SEP2, SEP3, SEP5, SEP6, SEP8
Common Core Mathematical Practices: MP1, MP2, MP4, MP6, MP7

Estimated Time:
- 5 min – Introduce Activity
- 45 min – Complete Activity
- 10 min - Debrief

Advanced Preparation:

Warm water is needed for this activity. Think about how this will be handled and where this will be setup for students to obtain the needed amounts.

Suggested Inquiry Approach:

Distribute student pages.

Read the background information from the student pages together and host a discussion on their reactions, thoughts, and comments. Ask questions such as:

- Why do you think people are trying to find different types of energy?
- How is energy used in our everyday lives?
- Where have you seen the prefix bio before?
- What does bio mean?
- Why would bio be used as the prefix on so many of these words?

Read through the procedure together and clarify any questions students may have. Show students where the supplies are located in the classroom. Assist students as they work through the activity.

If you had decided to carry out the extensions, then continue with them.

Have students follow your directions for cleaning up after the activity. The contents of the zipper baggies may be washed down the drain and the zipper baggies disposed of in the trash. Students should wash their hands at the end of the activity.

Complete the debrief with the students.
Debrief Activity 1:

As a whole class, have students discuss the following questions:

- What surprised you about the results?
- Would using biomass for fuels be a good idea? Why or why not?
- What other materials could be used for biofuels?
- What else would have to change for biofuels to take the place of fossil fuels?

Extension:

- Test using alternative feedstocks, such as corn stover, powder, finely ground grass clippings, dead leaves, or composting materials.
- Contact a local nursery or U of I extension office to arrange a speaker to visit with your students and talk about other benefits of native prairie plants.
Gel Electrophoresis

Objectives:
- Carry out procedures.
- Work cooperatively in groups.
- Collect, analyze, interpret, and compare data.

Background Information

One of the components of biotechnology is being able to use and examine DNA, which requires the separation of DNA. Gel electrophoresis is a separation technique based on electrical charge and fragment size. DNA has a negative charge. The DNA sample is dragged through the gel from the negative pole to the positive pole. As this happens fragments are distributed based on fragment size. The smaller the fragment the faster and farther the distance traveled in the gel. The larger fragments of DNA travel slower and shorter distances in the gel. Gel electrophoresis can be run horizontally or vertically.

Typically DNA is separated with restriction enzymes into smaller pieces, which reveals fragment patterns that can be compared to other samples. For example, a known sample of DNA can be compared to an unknown sample to try to identify the unknown. Similarities and differences can be studied. This process is used frequently in forensics and also in molecular biology to confirm that DNA is present and/or cut in the proper format for use.

Inquiry Overview

Students will “run a gel” and experience electrophoresis.

Objectives:
- Carry out procedures.
- Work cooperatively in groups.
- Collect, analyze, interpret, and compare data.

Standards:

NGSS Science and Engineering Practices: SEP4, SEP8
Common Core State Standards
ELA/Literacy: RST.6-8.4, SL.5.1, SL. 5.3, W.5.2, W.5.8

Estimated Time:
- 5 Minutes – Introduction
- 45 Minutes – Activity
- 10 Minutes – Debrief

Advanced Preparation:
The gels need to be prepared ahead of time for the gel boxes. They may be prepared in a Pyrex measuring cup, a coffee cup, a 250 mL (or larger) beaker or flask. The gels may be made up to a few days in advance, just make sure to close the lid. Think about the following:

✓ Who will be responsible for cutting off a little slice of each end of the gel and removing it?
✓ Who will be responsible for putting the paperclips in each end of the gel box?
✓ Where will the solutions for loading the gels boxes be located?

Run Materials:
for teachers:
• 7 Agarose Tablets
• 1 Comb
• 20 Graduated Cups
• 6 Packs of Kool-Aid
• TAE Buffer

each student:
• Student Pages

for each group:
• 2 Alligator Clips
• 1 Gel (Agarose)
• 1 Graduated Cup
• 50 mL TAE Buffer
• 1 Pipette
• 1 Plastic Box
• 1 Plastic Cup
• 2 Small Paper Clips
• 6 Tips
• 3 – 9 Volt Batteries
Directions & Checklist for Preparing Gels for Run

1. Put 1 agarose tablet in 50 mL of water.
2. Let it sit for 2 minutes or until completely dissolved.
3. Heat in microwave until it boils. Roughly 45-65 seconds. Allow to boil for about 10 seconds.
6. Let the agarose cool for 3-5 minutes. Do NOT let it solidify.
7. Pour it into a plastic box.
8. Insert a comb so it rests at a hinge.
9. Allow the gel to set up. It will turn cloudy when it is setup.
10. Remove comb once gel is set up. Clean comb in soap and water.
11. Close box lid and store in refrigerator until ready to use.
12. Repeat for the other boxes.

Suggested Inquiry Approach:

During a discussion have students think about and share why/how cell parts would need to be separated by biotechnologists. Explain that they are going to practice a method of separation.

Read through the student pages together. As a class, work through each step together. Encourage students to record observations in the form of drawings.

When student groups’ gels are done running, the power should be disconnected. The gel may still be observed. When it is time to cleanup, the contents of the container may be thrown in the garbage.

You may wish to simultaneously share with students the following link: http://www.dnalc.org/resources/animations/gelectrophoresis.html.

Discuss the students’ answers to their questions and the debrief questions.
Debrief Activity 3:

- Particles are different sizes. What particles do you think would travel the shortest distance in a gel? The farthest distance in a gel? Explain your ideas.