

Sample Projects and Activities in Biology



TRUSD
Curriculum and Instruction
Division
Science, PE, and Health

Sample Projects and Activities in Biology



Unit	Activity/Project Title and Description	Standards
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“I never teach my pupils; I only attempt to provide the conditions in which they can learn.”

-Albert Einstein



Take the Filter Challenge!

Introduction:

When rain falls to the ground, the water does not stop moving. Some of it flows along the surface to streams or lakes, some of it is used by plants, some evaporates and returns to the atmosphere, and some sinks into the ground. Imagine pouring a glass of water onto a pile of sand. Where does the water go? The water moves into spaces between particles of sand.

Ground water is water that is found underground in the cracks and spaces in soil, sand, and rocks. Ground water is stored in – and moves slowly through – layers of soil, sand, and rocks called *aquifers*. Aquifers typically consist of gravel, sand, sand stone and fractured rock, like limestone. These materials are permeable because they have large connected spaces that allow water to flow through.

In areas where material above the aquifer is permeable, pollutants can readily sink into groundwater supplies. Ground water can be polluted by landfills, septic tanks, leaky underground gas tanks, and from overuse of fertilizers and pesticides. If groundwater becomes polluted, it will no longer be safe to drink.

Groundwater is used for drinking water by more than 50 percent of the people in the United States, including almost everyone who lives in rural areas. The largest use for groundwater is to irrigate crops.

It is important for all of us to learn to protect our groundwater because of its importance as a source for drinking and irrigation.

Challenge: Your challenge in this activity is to treat and purify “contaminated” water with some common filtration materials. Each group will receive a sample of dirty water, along with materials to create a filter. You can use any combination of the provided filtration materials, but keep in mind it must all fit in the mouth of the funnel and allow the water to be poured through. You will have 30 minutes to build the filter and use it to get the cleanest water sample possible, so budget your time. Plan out your strategy ahead of time before you start building the filter. What materials will you use? How much of each material will you use? What order will you use them in? At the end of the 30 minutes, we will look at the samples and discuss how well each group’s filtration techniques worked.

General Lab Safety

Do NOT taste the dirty water sample. When smelling a water sample, do not stick your nose in the beaker. Instead, use your hand to waft the odor towards your nose. Be careful with the glassware (beakers). If any glass is broken, tell the teacher immediately.

Materials

Gravel	Sand	Paper clips	Activated charcoal
Coffee filter	Paper clips	Cotton balls	Drinking straw
Rubber band	Tape	Cheesecloth	Modeling clay
Scissors	Yarn	Soda bottle (cut in half)	

Questions:

- 1) What volume (how many ml) of dirty water do you start with?
- 2) On the Data Table, briefly describe the listed characteristics of the initial sample (dirty water).

NOTE: Time your filtration from when you pour the dirty sample in until you have a final sample. Your 30 minutes starts with the next section.

Data Table:

	Color	Clarity	Odor	Presence of Oil	Presence of Solids	Volume
Unfiltered Sample						
Final Filtered Sample						

Discussion Questions:

1. What were the materials your group used for building the filtration device?

2. On a scale of 1-5 (5 being the clearest), how would you rate the quality of the water sample you ended up with?

3. How would you change the design of your device if you had to construct it again?

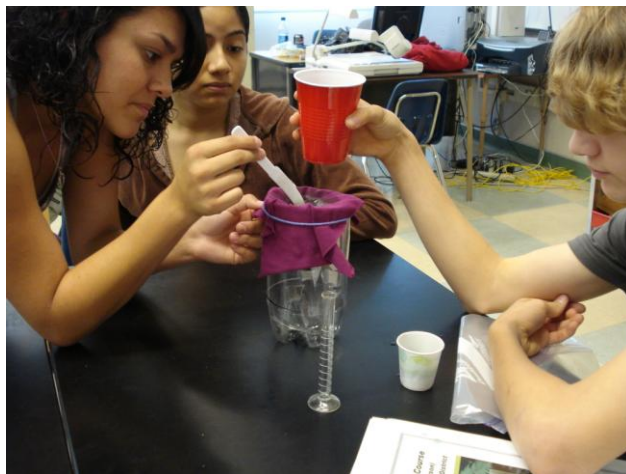
4. What percent of the original dirty water sample was recovered as “clean water”? % of water recovered = (volume of purified water / volume of dirty water)

x 100

5. What volume of liquid did you lose during purification?

volume lost = volume of dirty water – volume of purified water

6. Which group ended up with the cleanest water? How do we judge “cleanest” water? How long did the filtration take? What seemed to work the best overall? Did everything work the way you thought it would?



A. Preparation of Contaminated Water:

Prepare contaminated water by mixing the following in a bucket:

- Water
- Food coloring
- Raising or dried beans, about ½ cup
- Potting soil, ½ cup
- Baking soda
- Soy sauce
- Paper plate (torn into pieces)
- A handful of ‘natural’ items such as sticks, twigs, leaves, etc.

B. What do these items represent? [Inform students what each contaminant represents].

- Food coloring represents chemicals in water
- Raising represent animal or human waste
- Potting soil represents earth
- Baking soda represents road salt
- Soy sauce represents motor oil (You may use vegetable oil)
- Torn paper plate represents litter

C. Advanced Preparation Tips:

1. Decide how many teams you want and how many students will be on each team. It is recommended that smaller teams of 2-3 students be utilized.
2. Each team will need one 2-liter bottle cut in half. Take the top portion of the bottle and turn it upside down and place it in the bottom portion. The filter will be built inside the inverted top portion of the bottle. The base portion will act as a reservoir and collect the water that runs out of the filter.
3. Advise students of appropriate disposal procedures.
4. Each plastic bottle set up can be reused from one class to the next.

D. Take it to the next level!

- Allow students to “rebuild” their filtration device, so they can engineer a better system.
- Attach a cost factor to each material used. Incorporate the added challenge of keeping costs down.
- Challenge students to create a multi-layered filtration system.

Oil Spill Lab Challenge: What a Mess!

Introduction:

Oil tankers are the largest ships to sail in the ocean. They are designed to hold millions of barrels of crude or refined oil in relative safety, and without damage to the environment. For countries such as Japan that have no oil reserves of their own, tankers are the only way that the oil needed to power their economies can be moved.

Generally, these ships are safe, and most of the time they get to their destinations without incident. However, these ships sometimes release oil through either accidental or purposeful means. During the Gulf War of 1991, it was thought that Iraq would attack oil tankers leaving port; as a result, allied forces spent a large amount of resources and money making sure that these ships were safe. As for accidental releases of oil, the Exxon Valdez released millions of barrels of oil in the Prince William Sound in Alaska in the mid-80's.

When these ships are damaged or sunk, the oil spreads out over the surface of the water in a large slick. These oil slicks can cover hundreds of miles, causing huge environmental damage. Because oil slicks are so damaging to the environment, numerous ways of containing them and cleaning them up have been developed.

One method that people use is to surround the oil slick with something called a containment boom. Basically, a containment boom is just a large float that surrounds the slick. As the boom is pulled into a boat that can skim the oil off the top, the oil slick shrinks, until finally it is completely cleaned up. Although it is possible to clean a slick by this method, it is mainly useful for containing oil slicks which will be cleaned up by other means.

Another method to clean slicks is to spray a detergent solution on it. When detergent is sprayed on oil slicks, the oil breaks up into clumps which sink to the bottom of the ocean. Although these clumps are themselves hazardous, the problems caused by the clumps are much easier to deal with than the problems caused by oil slicks.

Oil can also be caused to clump by pouring absorbent sand on it. The oil is absorbed into the sand, which drags it to the bottom in sandy clumps.

Recently, oil-eating bacteria have been designed which can actually use the oil slick as food. As the bacteria reproduce, they eat more and more of the slick until it finally vanishes. When the slick is gone, their food source is gone and they die, leaving nothing behind at all.

If oil slicks are extremely small and contain highly flammable compounds, they are sometimes set on fire to eliminate the oil. This is very rarely done, simply because most oil slicks contain compounds that aren't

very flammable; even automobile motor oil (which is itself very light) does not burn when lit with a spark.

If the slicks are very small, as in fresh water settings, the oil can sometimes be cleaned up by absorbing it into specially absorbent pads. When the pads are full of oil, they can be easily cleaned off the surface of the water.

In this lab, your job will be to clean up a mini “oil spill” using materials similar to the ones used by petroleum engineers.

From: <http://misterguch.brinkster.net/MLX030.doc>

Pre-Lab Discussion questions:

- 1) Of the methods described in the introduction to this lab, which do you think will be most effective in cleaning up an oil spill? Explain.

- 2) How do you think oil spills can be minimized in the future? What steps do we need to take to keep the risk of environmental damage low?

Materials:

big bowl or plastic container	vegetable oil (5 tbsps)
clear plastic cup	teaspoon of cocoa powder
detergent	rags (cotton and other types)
tissue	tweezers
Styrofoam peanuts	string
cotton balls	paper towel strips
medicine dropper	

Procedure:

A. Create the oil spill:

Mix oil and cocoa powder inside the clear plastic cup. This will simulate crude oil. Fill the big bowl or container with water (3/4 full). Dump the oil into this bowl of water.

B. Oil spill clean up challenge:

Brainstorm on how you will clean up the oil spill. Take note that there is a “budget” of **\$20,000,000** for this clean up. The cost of each material is summarized on the next page:

Material	Cost
Tweezers (each)	\$1,000,000
Styrofoam peanuts	\$7,500,000
Cotton balls	\$7,500,000
Paper towels	\$5,000,000
String	\$1,000,000
Medicine dropper	\$10,000,000
Detergent	\$2,500,000

Rules for Clean Up:

- Each group must purchase at least one set of tweezers.
- Styrofoam peanuts, cotton balls, paper towels, and string cannot be touched with the fingers, only tweezers.
- Purchase of detergent allows one student the use of the “Wildlife Rehabilitation Center”
- One large zipper bag will be provided to dispose of all materials.
- Do NOT dispose of the oily water in the sink.

Write what you tried here, and how well it worked:

Total Expenses:

Materials Used	Cost:
Total	\$

Questions:

1. Which technique worked best? Which was least effective?

2. Did trying several techniques make a difference in the cleanup? Would combining several methods be effective? What about the cost?

3. Could any of these techniques be used in a river spill situation? Why?

4. Think of oil containment. What technique/s can be used to contain (prevent it from spreading) the oil?

Source: <http://www.nseced.chem.wisc.edu/Lessons/Oil%20Spill%20Write-Up.pdf>

Additional Readings on Oil Spills:

1. “The Worst Major Oil Spills in History” from http://www.associatedcontent.com/article/454782/the_worst_major_oil_spills_in_history.html
2. “The 10 Biggest Oil Spills in History” from <http://www.popularmechanics.com/science/energy/coal-oil-gas/biggest-oil-spills-in-history>
3. “Oil Spill” from http://en.wikipedia.org/wiki/Oil_spill
4. “Top Ten Worst Oil Spill” from <http://www.livescience.com/environment/Top-10-Worst-Oil-Spills-100428.html>
5. “Oil Spills and Disasters” from <http://www.infoplease.com/ipa/A0001451.html>

Floating Filter Paper Chips: An Exploration of Enzyme Activity

Brief Description: Students prepare and then use enzyme-soaked filter paper disks to investigate the different factors influencing enzymatic rate of action.

Introduction:

In this inquiry, students learn a simple tool for measuring enzyme activity. They then choose a variable that may affect enzyme function and design and conduct experiments on catalyzed reaction rates. Catalase is the enzyme studied in this lesson. Found in the cells of many organisms, catalase facilitates the conversion of hydrogen peroxide into water and oxygen gas.



This decomposition of hydrogen peroxide happens in the absence of the enzyme, but much more slowly. Hydrogen peroxide accumulates in cells as a metabolic byproduct. It can be harmful to cells and catalase functions to eliminate or at least regulate it. The source of catalase in this activity is baker's yeast (*Saccharomyces cerevisiae*).

First, students use a hole punch to make filter paper chips. These discs are filled with catalase by soaking them in a solution of baker's yeast. When dropped in a very dilute H_2O_2 solution, the catalase discs sink to the bottom. As the catalase facilitates the breakdown of H_2O_2 , bubbles of O_2 accumulate on the disks causing them to float to the top. The time it takes to until the filter paper disk rises to the top is a relative measure of enzyme activity.

After trying and observing the enzyme filter paper disk model, student groups consider variables that may affect enzyme action. Enzyme activity is influenced by factors such as temperature, pH, enzyme concentration, salinity, and substrate concentration. Students use filter paper disk model to investigate the effects of any of these variables.

Materials:

Hydrogen peroxide, 3%	Baker's yeast, 1 packet	Filter paper
Hole punch (es)	1 L beaker for making dilute H_2O_2	500 ml beaker or flask for activating yeast
Smaller beakers (150-250 ml) or plastic cups, 5-10 per lab group	Tweezers, 1 per lab group	Possibly needed: HCL solution NaOH solution Ice, hot plates Salt pH meters
	Timer or stopwatch	

Time Requirement: approximately 1 ½ hours

Preparation:

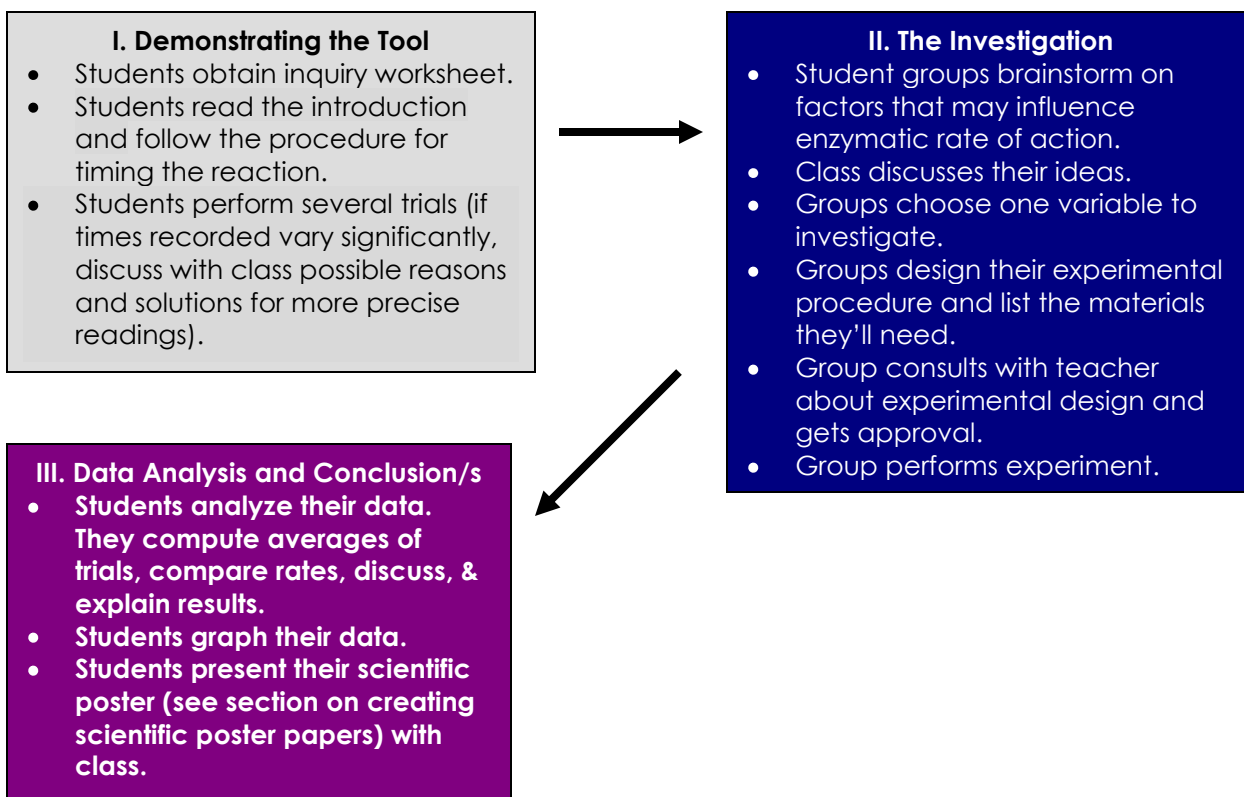
1. Yeast Activation: Dump the contents of a yeast packet into 500ml of warm water. This solution is ready to use in 30 minutes. Label this container “Catalase” or “Enzyme”.

2. H₂O₂ Solution: Dilute store-bought 3% H₂O₂ solution with tap water. Prepare a 1:1000 dilution (1 ml H₂O₂ + 1000 ml water). Test the model first. Soak a filter paper disk in the yeast solution, then add it into a test tube filled with dilute H₂O₂. It should take from 30-60 s before the disk rises to the top, If it takes longer, add more H₂O₂ to the stock solution. If the floating rate is too fast, dilute the stock solution some more with water.

3. pH Investigation: Have students add dilute HCl or NaOH to make experimental solutions.

NOTE: Students should wear goggles at all times. Caution students about the proper use and handling of acids and bases.

Lesson Outline:



An Exploration of Enzyme Activity using Filter Paper Discs

Introduction:

The chemical hydrogen peroxide (H_2O_2) spontaneously decomposes into water and oxygen gas:



This reaction happens very slowly, and over a number of years a bottle of hydrogen peroxide will convert almost entirely to water. Catalase, an enzyme, exists in the cells of many organisms, including humans, to reduce the levels of H_2O_2 , which can accumulate because it is a metabolic by-product. The rate of the catalyzed breakdown of H_2O_2 can be measured by the rate of oxygen gas (O_2) production. In this investigation, the speed with which O_2 bubbles cause a paper disk to rise indicates the relative speed of the reaction. The source of enzyme will be baker's yeast (*Saccharomyces cerevisiae*).

The Tool for Measuring Reaction Rate:

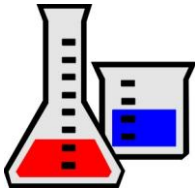
Before conducting an investigation, you will need to learn how to measure the rate of the enzyme-catalyzed reaction. Follow the steps below:

- Use a hole punch to make 10-15 disks out of filter paper. Soak the filter paper disks into the enzyme solution. Let the disks soak for 2-3 minutes.
- Fill up a test tube $\frac{3}{4}$ of the way with H_2O_2 solution.
- Using tweezers, move the paper disk from the enzyme solution into the test tube. The disk should sink at the bottom. Begin timing at the moment the disk hits the bottom.
- The disk will eventually float to the surface as it fills with O_2 bubbles.
- Stop timing when the disk reaches the surface.
- Repeat the procedure 5 times. Were the reaction times pretty consistent? Why or Why not?

II. The Investigation

- What are some factors that could influence the rate of enzymatic action (how fast or slow the reaction proceeds)? Brainstorm with your group and list your ideas. Be prepared to discuss your ideas with the class.
- Your group should choose one variable to investigate. You will need to design an experiment to test the effect of this variable on the rate of the enzyme-catalyzed reaction.
- Submit an experiment proposal (next page) to your teacher for approval.
- Perform your experiment and begin collecting data. Present your findings as a scientific poster paper.

Source: Shields, M (2006). *Biology Inquiries: Standards-Based Labs, Assessments, and Discussion Lessons*. New York: Jossey Bass Publishers, 282 pp.



Science Experiment Proposal Form

1.0 Problem: _____
_____?

2.0 Hypothesis: _____
_____.

3.0 Materials:

4.0 Procedure:

1	
2	
3	
4	
5	
6	
7	
8	

5.0 Teacher Approval:

The student/s can proceed with the experiment. They understand that they must follow safety protocols at all times during the investigation.

Teacher Signature: _____ Date: _____

6.0 Student signatures:

Student 1

Student 2

Student 3

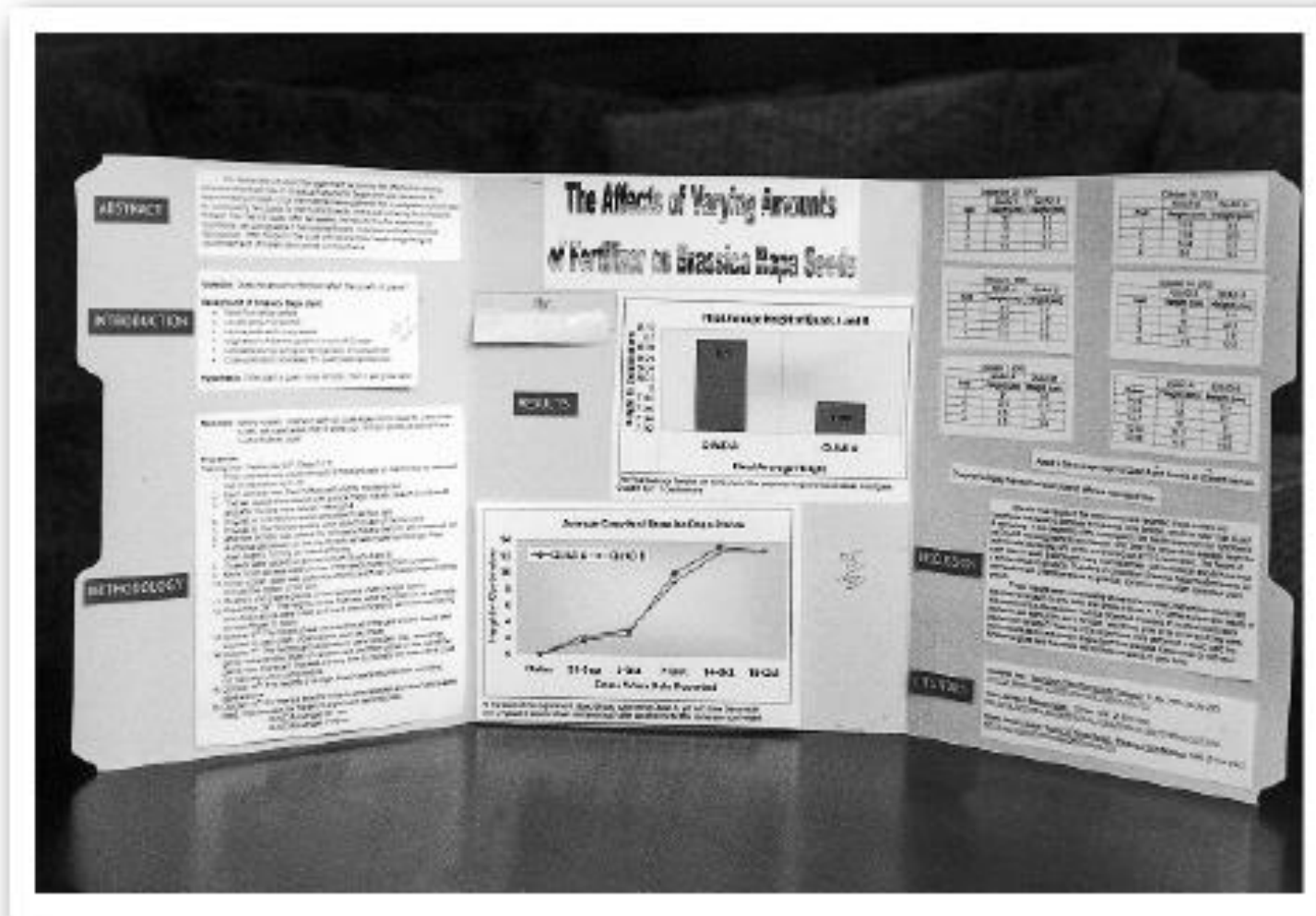


Figure 1.1. Example of a Miniposter

Abstract:

Introduction:

Procedure:

TITLE
Name (Date)

Results:

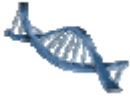
Data Tables

Graphs & Charts

Discussion:

Possible sources of errors?
Limitations of the study?
Suggestions for revisions?
Areas for future study?

Literature cited:



Make a DNA Keychain!

Introduction:

In this activity, you will translate your knowledge of DNA structure to make a keychain you can use. The keychain model you create is a simplified model of DNA, showing its three basic parts. The model should give you a good insight into how DNA can make a copy of itself- a process called DNA replication.

Materials:

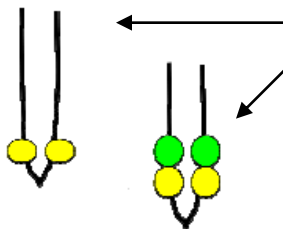
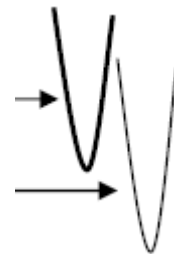
- ✓ 6 mm faceted beads - 52 beads per student (26 of two different colors)
- ✓ Seed beads (Size 6/0 or 8/0) - 24 beads per student (6 of 4 different colors)
- ✓ 20 gauge wire- 18" per student (May use 20 gauge floral wire already cut to 18" pieces)
- ✓ 26 gauge wire - 20" per student
- ✓ Lanyard hooks or key rings - 1 per student
- ✓ You will also need needle-nose pliers & wire cutters (1 for each group), plastic containers for the beads (small and large), small plastic cups for holding beads, copies of the *DNA Keychain Guide* for each group.

Procedure:

1. Choose your large beads for the sugar and phosphate molecules that make up the back bone. You will need 26 beads of 2 different colors. Color the key provided.
2. Choose your small beads for the nitrogen bases. You will need different colors for a total of 24 beads. Color the key provided.

Name _____	
<u>Backbone: Need 26 of each color</u>	
● Sugar	● Phosphate
<u>Nitrogen Bases: Need 6 of each color</u>	
● A	● T
● C	● G

3. Get a piece of **THICK** wire from your teacher and bend it in half.
4. Cut a piece of **THIN** wire – 20 inches in length- and bend it in half.

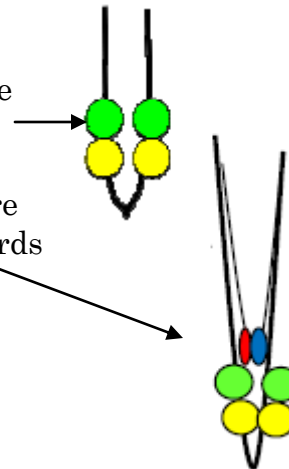


5. Add two **SUGAR** beads– one on each side- to the **THICK** wire.
6. Next add two **PHOSPHATE** beads of the other color- one on each side of the wire.

From: <http://sciencespot.net/Pages/classbio.html#DNAKeychains>

7. Place one A bead and one T bead in the middle of the top of the phosphate beads. Line up the **THICK THIN** wires on each side and hold at the top.

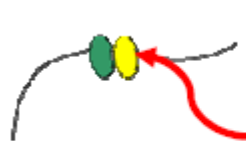
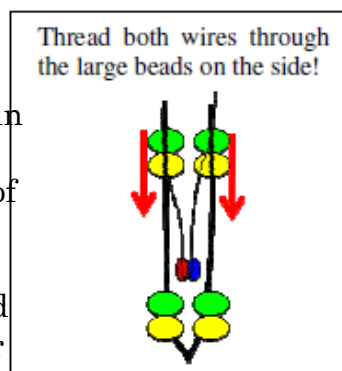
8. Slide one SUGAR bead down one end of the thin wire and thread the thick wire through as you push it towards the bottom of the keychain- both wires need to be threaded inside the large bead. Add another SUGAR bead on the other side in the same way.



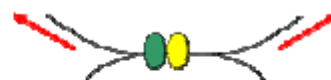
9. Slide one PHOSPHATE bead down one end of the thin wire and thread the thick wire through as you push it towards the bottom of the key chain. Both wires need to be threaded "inside" the large bead. Add another PHOSPHATE bead on the other side in the same way.

10. Pull the large beads down towards the bottom of the key chain and pull on the ends of the thin wire to make the small beads fit tightly in place.

11. Hold one of the thin wires near the end and add a G bead and a C bead. Thread the end of the other thin wire back through the G and C beads in the opposite direction make the wires form an X shape. Pull the ends as if you were "tying" a knot.



Thread the other end of the wire through the beads in the opposite direction.



Pull on both ends of the thin wire to "tie" it together

12. Add more big beads (SUGARS & PHOSPHATES) to the backbone, two on each side. Thread the thin wire through the large beads as you add them to the thick wire.

13. Continue building the DNA molecule following the same process – you'll need 26 large beads on each side and 12 pairs of bases in the middle.

Remember the process...

Thread two wires through two big beads on the sides,
Cross two wires through two small beads in the middle & tie.

From: <http://sciencespot.net/Pages/classbio.html#DNAKeychains>



14. Once you have added all the base pairs, twist the ends of the thin wire together tightly and add a key ring to the other end of the keychain.

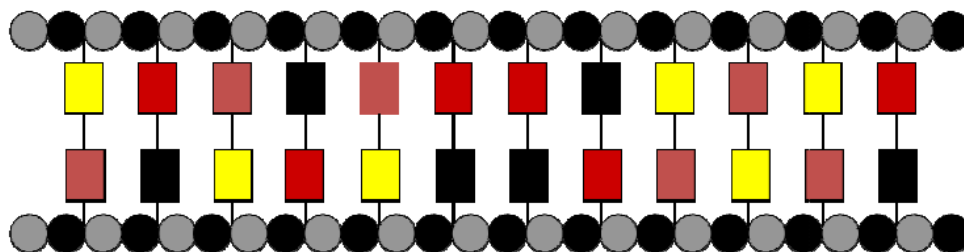
15. Use pliers to twist the ends of the thick wire and the thin wires together all at once.

16. Use the wire cutters/pliers to cut off the ends leaving it about $\frac{1}{2}$ inch long. Use the wire cutters/pliers to bend and “tuck” the ends in between the large beads so it won’t poke you.

17. Twist your DNA strand around a pencil or finger and gently pull on the ends to create the double helix shape.

CAUTION: Untwisting and twisting your keychain too many times will make it break!

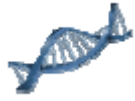
When you are done, color the BASES on a paper model of your DNA keychain. Be sure the colors of the bases match exactly!



Write your name on the back of the paper model.

Turn in your keychain and the paper model to your teacher.

From: <http://sciencespot.net/Pages/classbio.html#DNAKeychains>



DNA Keychain Project

Overview:

For this activity, students use beads and wire to create a DNA molecule that shows the sugar/phosphate backbone as well as the paired nitrogen bases. After they are done with the key chains, we use them to see what happens during DNA replication. The original lesson was taken from www.accessexcellence.org. A PowerPoint presentation that will guide students with step by step directions can be found at <http://sciencespot.net/Pages/classbio.html#DNAKeychains> .

Materials Needed:

- 6 mm faceted beads - 52 beads per student (26 of two different colors)
- Seed beads (Size 6/0 or 8/0) - 24 beads per student (6 of 4 different colors)
- 20 gauge wire- 18" per student (May use 20 gauge floral wire already cut to 18" pieces)
- 26 gauge wire - 20" per student
- Lanyard hooks or key rings - 1 per student
- You will also need needle-nose pliers & wire cutters (1 for each group), plastic containers for the beads (small and large), small plastic cups for holding beads, copies of the *DNA Keychain Guide* for each group

Helpful Hints:

- (1) You will want to make a few key chains on your own before attempting this with a class.
- (2) I purchase most of my materials through online craft stores, such as Crafts Etc or ConsumerCrafts.com. Wal-Mart or local craft stores are also good sources for wire and key chains. To offset the costs, you might consider having the students pay 50¢ each. I let my students make one keychain for free for their class assignment and then allow them to purchase materials for 50¢ to make others for their friends and family members. Usually the amount of money I raise covers a large percentage of the cost of the materials.
- (3) I have six groups of tables in my classroom, so I set up six sets of materials in rectangular plastic tubs. Each set contains one container of large beads, a smaller container of seed beads, several pieces of thick wire, a roll of thin wire, 1 pair of pliers/wire cutters, and 8 small plastic cups to keep beads in one place. At the end of each class, I am able to do a quick check of the materials and can easily see what needs restocked or if there are missing items that need to be found!

(4) Challenging tasks:

- ✓ My students have the most difficulty learning how to do the “cross two in the middle.” I used two large metal rings to show them the correct way to do the step. I placed both rings on one hand and “threaded” other hand through the rings in the other direction. Tell the students that the step is similar to tying a shoe - cross the wires and pull to form a knot.
- ✓ Some of the students did not keep the thin wire tight while they were building the model and ended up with key chains that did not look the greatest. Remind the students to keep the thin wire tight after each step - cross two in the middle or thread two on the sides.
- ✓ Many students decided to alternate the base pairs - A with T on one rung followed by G with C on the next - to make it easier. Students may choose to do all the A/T pairs before adding the G/C pairs or mix it up any way they would like as long as the correct bases are paired each time.



Lesson from: <http://sciencespot.net/Pages/classbio.html#DNAKeychains>

Leaf Chromatography

Introduction:

Leaves are nature's food factories. Plants take water from the ground through their roots. They take carbon dioxide from the air. Plants use sunlight energy to convert water and carbon dioxide into glucose. Here are some facts to remember:

- ✓ **Glucose** is a type of sugar.
- ✓ Plants use glucose as food for energy and as a building block for growing.
- ✓ The process of converting CO₂ and water to glucose is called **photosynthesis**.
- ✓ A chemical called **chlorophyll** helps make photosynthesis happen.
- ✓ Chlorophyll is a **pigment** that gives plants their green color. Pigments are compounds that absorb light.

In this lab, we will use a technique called chromatography to separate the mixture of pigments in a leaf into different bands of color.

Materials:

Assorted leaves	Filter paper	Chromatography solvent
Beaker	Scissors	Masking tape
Stirring rod	Plastic wrap	Aluminum pan
Hot water	Hand lens	Ruler
Paper towels	Map pencils	

Procedure:

1. Use a piece of masking tape to label a beaker with your name & class period.
2. Tear a leaf into small pieces. Make the pieces as small as possible.
3. Put the pieces of leaf in a beaker.
4. Pour enough solvent into the beaker to cover the leaf pieces completely.
5. Use the stirring rod to mix the leaf pieces and alcohol.
6. Cover the beaker with plastic wrap and set in an aluminum pan that is half full of hot water.
7. Let the leaves soak overnight.
8. Cut the filter into a strip that is 2cm wide and about 10 cm long.
9. Tape the strip of filter paper to a pencil.
10. Lay the pencil across the top of the beaker.
11. Wind the paper around the pencil so that the tip of the paper just barely touches the alcohol.
12. As you wait for the alcohol - pigment mixtures to travel up the filter paper, reread the background material carefully.
13. Take the filter paper strip from the beaker, place it on a paper towel to dry.
14. Observe the strip with your hand lens.

Data:

Draw & color your filter paper:	Describe your observations:

Hints:

- Spinach leaves work well.*
- Compare leaves in the summer and leaves in the fall.*
- Compares leaves from different locations within a tree.*
- compare extracts from the same leaf but taken from different locations.*

Make a Meiosis Flip Book!



INTRODUCTION:

In this project, your team will create a flip book that can be used to make a mini-movie or animation about meiosis. It should contain a minimum of 20 pages. Since the pages will need to be sturdy, plain index cards (unlined) will be used for this project. The parent cell for this project should contain 3 pairs of chromosomes. Crossing over should be shown. The last card should depict the four daughter cells at the end of telophase.

II. Materials:

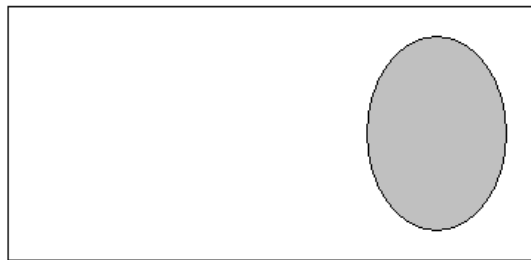
22 index cards per team (first card will be the title page)-You may use more cards but you will have to provide the additional ones.

Colored markers and/or crayons

Bull dog clip

III. Instructions:

- ✓ Use 20 slides (index cards) to create a flip book showing the sequential stages of meiosis.
- ✓ Chromosomes should be seen “moving” when the flipbook is used.
- ✓ Use different colored crayons for chromosomes so crossing-over can be clearly depicted.
- ✓ Use bull dog clip to bind the slides/index cards together.
- ✓ Draw the dividing cell at the right hand side of the flipbook, in the same position:

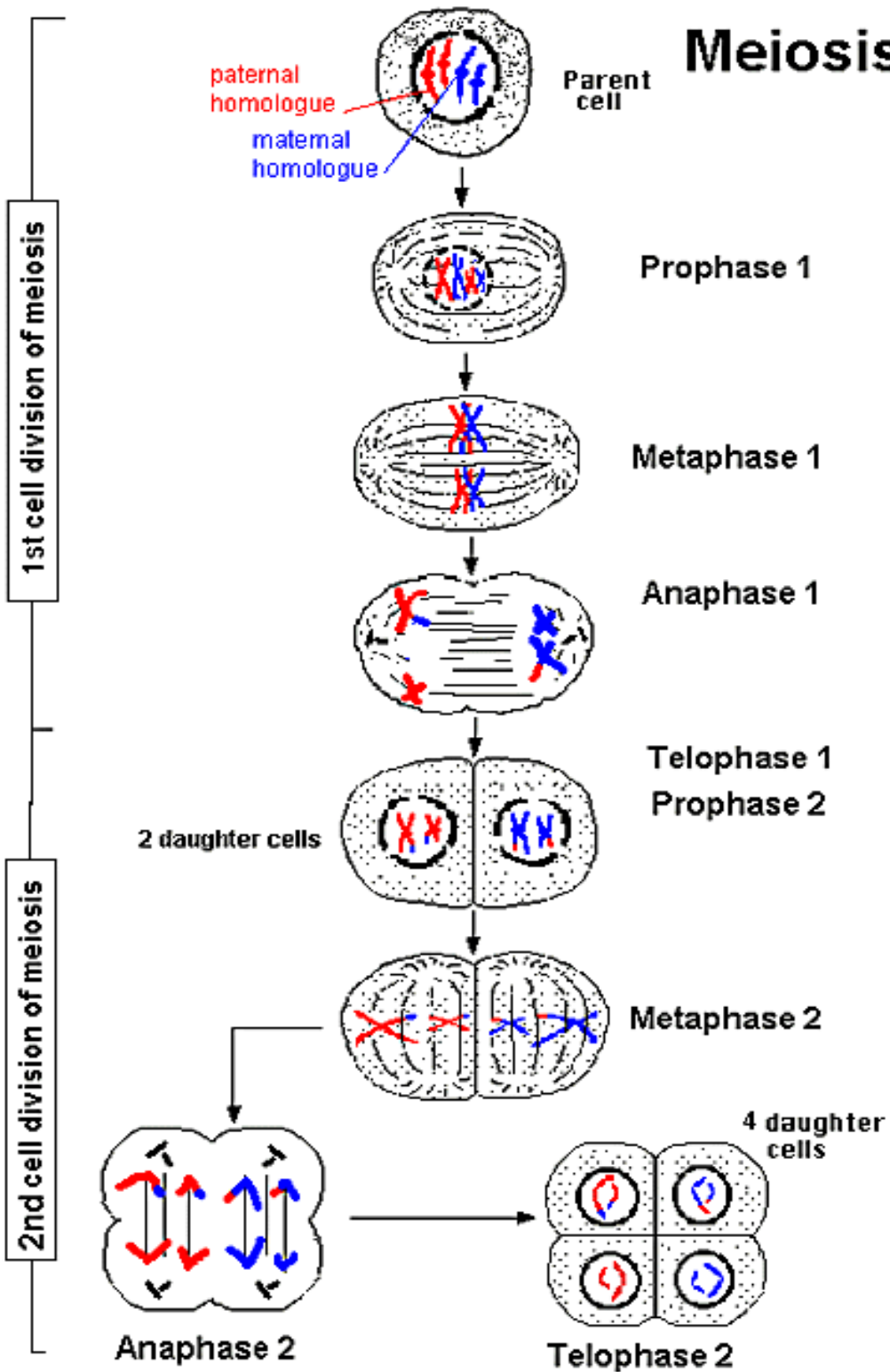


- ✓ The first page should be the Title Page. This page should contain the names of the team members.

IV. Grading: Grade will depend on accuracy of depicted stages as well as presentation.

Handout: Stages of Meiosis

Meiosis



Classifying Oaks with DNA

Unit: Evolution

Brief Description:

This inquiry activity asks students to use morphological and DNA sequence data to classify three oak leaf samples.

Introduction:

How do biologists determine whether two populations of organisms belong to the same species or not? Taxonomy has long been a fluid, exciting, and controversial area of biology. Biologists define species as a group of organisms capable of reproducing and leaving fertile offspring. But according to this definition, dogs and wolves, which readily hybridize, are the same species. However, most sources describe them as different species: *Canis lupus* and *Canis familiaris*. The value of the biological species concept is its focus on how a species came to exist- the evolution of an isolated gene pool. In reality, most species are identified by the morphological species concept. In this approach, a species is recognized as distinct based on unique structures (morphology).

Molecular biology has added a powerful new tool to the arsenal of taxonomists. The more closely related two organisms are, the more similar their DNA, RNA, and amino acid sequences. New molecular data have revolutionized some long-standing classifications. But like other methods of identifying other species, the molecular approach has some limitations. For instance, how similar do DNA sequences need to be for two populations to be considered of the same species?

Students grapple with these questions in this lesson. First, they observe and compare the two-dimensional shapes of oak leaves (Handout 1). They then compare and analyze DNA sequences representing the three leaves (Handout 2). Combining both types of data, students are challenged to decide how many species are represented by the leaves. By morphology and DNA, one of the leaves (white oak) is very different from the other two. But pin oak and red oak are similar enough to provoke student uncertainty and debate.

And optional but recommended expansion of the lesson is provided in which students collect and analyze morphological data from a large sample of leaves collected locally.

Materials:

- ✓ Copies of the handouts as well as the worksheet
- ✓ Metric ruler
- ✓ Several copies of any field guide to North American trees (or access to the internet)

Time Required: approximately 60-90 minutes

Lesson Structure:

1. Distribute Handout #1 with the three leaf drawings.
2. Initiate a discussion by asking: "How could you determine whether or not two organisms are of the same species?" Accept all answers and avoid correcting inaccuracies at this point. Also ask, "What is a species?" Be sure at this point that students at least understand that a species is a group of organisms generally more similar to one

another than they are to another group. You may want to introduce the biological species concept as well. And “Are an oak tree and a dog the same species? A dog and a cat? How about a dog and a wolf? A Labrador retriever and a golden retriever?”

Again accept varied thoughts. Finish with a rhetorical question: “ How similar do organisms have to be to be considered a species? How do biologists decide?”

3. Call the students' attention to the leaf drawings. In small groups, have them discuss the questions in the introductory part of the student worksheet.

4. Pick a few of the groups to share their ideas on the worksheet questions. Guide the class to decide on four or five quantitative characteristics to measure and compare. To help in discussing the leaves, you will want to introduce the vocabulary at this point. Distinguish the leaf blade from the leaf petiole (stalk). The oak leaf indentations are called sinuses and the extended portions are the lobes.

Data Collection and Analyses:

1. Students make and record measurements on the leaf drawings.

2. Distribute Handout 2 with the DNA sequences. Tell the students that the same gene was sequenced for each leaf and these are the results.

3. Student groups devise a way to compare the three sequences. Press them to use a “quantifiable” approach rather than just “eyeballing” it. Guide them to focus on similarities at base locations. They could focus on the number of spots at which each leaf is different from the other two. It is easiest to compare pairs: 1 with 2, 2 with 3, 1 with 3. The percentage of similarity can then be calculated between each pair.

Warm Up and Reflection:

1. Have one or more field guides available. Challenge students to identify the three leaves. From the drawings alone, it will be easy to identify white oak (no bristly points on its lobes) but more difficult to distinguish the other two from each other and to distinguish red oak from black oak in the field guide. Guide the students to focus in on the depth of the indentations and presence or absence of pointy lobe tips.

2. Students write final responses on their worksheets.





Classifying Oaks with DNA

Introduction:

In biology, a species is one of the basic units of biological classification and a taxonomic rank. A species is often defined as a group of organisms capable of interbreeding and producing fertile offspring. While in many cases this definition is adequate, more precise or differing measures are often used, such as based on similarity of DNA or morphology. Presence of specific locally adapted traits may further subdivide species into subspecies.

In this lab, you will grapple with the concept of species, by studying different oak leaves and DNA gene sequences, your team will decide how many species are represented by the sample.

Introductory Discussions:

1. In small groups, carefully observe the three leaf drawings. Discuss the following questions. Be prepared to share your ideas with the class.

a. How many species are represented- one, two, or three? _____

b. On what are basing your answer? _____

c. What distinctive features do the leaves have? _____

d. How do these features vary in different leaves? _____

e. What traits could you measure to do document differences/similarities among the leaves? _____

Data Collection: (You will need a ruler and a piece of string for this section).

Attribute	Leaf 1 (White Oak)	Leaf 2 (Red Oak)	Leaf 3 (Pin Oak)
Leaf Length			
Leaf Width			
Sinus depth			
Blade Length			

Petiole Length			
Petiole Diameter			
Number of lobes			

Molecular Data Analysis

Molecular biology provides powerful approaches to studying similarities and differences between organisms. The sequences on Handout 2 are for the same gene in the three different leaves (National Center for Biotechnology Information).

1. How can the DNA sequences be compared for degree of similarity? Devise a strategy with your group members and make your calculations. Record your results below.

2. Based on your calculations and those of other groups, what can you conclude about the three leaves? How closely related are the three? How many species do they represent?

Extension

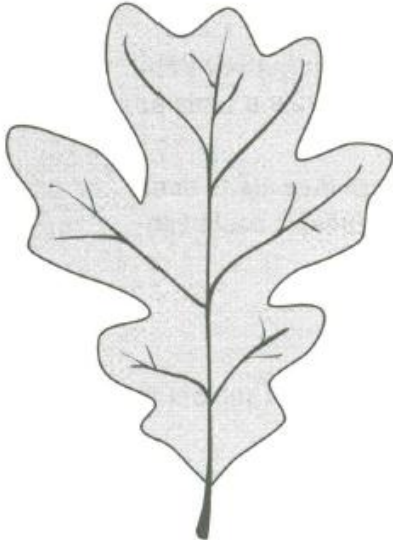
1. Use a field guide or other sources to identify the three leaves. How many species are represented? What are they?

2. Compare your analysis based on observing and measuring the leaves (morphological) to your analysis of DNA sequences. How did the two complement each other? In what ways was one more effective than the other?

3. What other information about the three leaves would have helped in deciding whether they were different species?

4. How similar do the DNA sequences need to be for two organisms to be considered the same species? How was this decided?

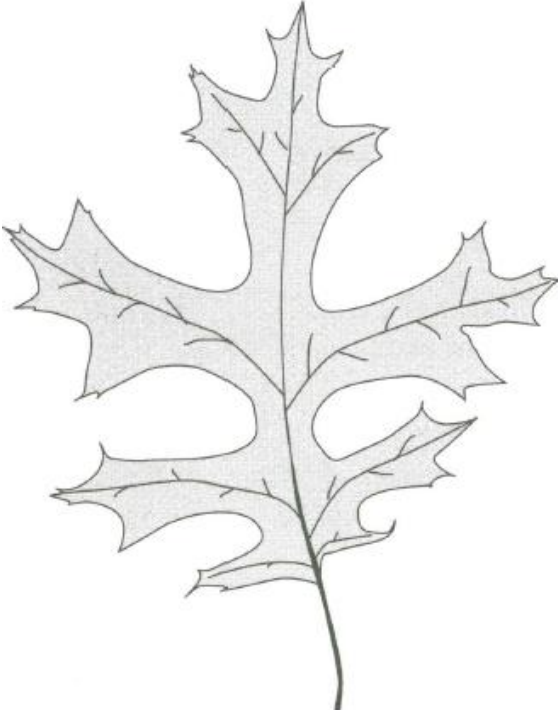
Handout No. 1: Leaves



Leaf 1



Leaf 2



Leaf 3

Handout No. 2: DNA Sequences

Leaf 1

```
1   tcgaaacctg cccagcagaa cgaccgcga attggttaca accgacgggg ggcggggggc
61  gttegtgcc ccctgcccc ctctcgggg gggggcctcg cgtctctgc ccgacaccg
121 aaccccgcg cggaacgccc caaggaaatc taaccaagag agccatgtcg gagcccccg
181 acacggtgtg cccccggcgt cggcgtctta tgaattattc aaaacgactc tcggcaacgg
241 atatctaggc tctcgcacg atgaagaacg tagcgaaatg cgatacttgg tgtgaattgc
301 agaatcccg cgaatcatcga gtttttgaac gcaagttgcg cccgaagcca ttggcccgag
361 ggcacgtctg cctgggtgtc acgcatcgtt gccccccca aactccggtt cgggcggggc
421 ggaagttggc ctcccgtgcg tgcctgcacg cgcggttagc ccaaaaagcga gtccctggcg
481 acgagcgcca cgacaatcgg tggttttttt accctcgttc ctcgtcgtgc gtgccccgtc
541 gcccgaacgc gctcctcga ccctcacgcg tcgctcgggt ggcgctccca acgc
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Leaf 2

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1   tcgaaacctg cacagcagaa cgaccgcga attggttaca accgacgggg ggcggggggc
61  gctcgtgcc ccctgcccc ccctcgggg ggggagacct gcctgcaaac cgaacccag
121 cgcggaacgc gccaaagaaa tctaaccaag agagccacgc tggaggcccc ggacacggtg
181 tgccccgac gtcggcgctt tacgaattat tcaaacgac tctcggcaac ggatatctag
241 gctcctcat cgatgaagaa cgtagcgaac tgcgatactt gatgtgaatt gcagaatccc
301 gcgaatcatc gagtttttga acgcaagttg cgcctgaagc cattcggccg agggcacgtc
361 tgcctgggtg tcacgcatcg ttgccccccc aaactccggt tcgggcgggg cggaagttgg
421 cctcccgtgc gtgctcgcgc gcgcggttag cccaaaagcg agtcctcggc gacgagcgcc
481 acgacaatcg gtggttttct tgcctcgtt cctcgtcgtg cgcgccccgt cgcccgaacg
541 cgtcctcga ccctcacgcg tcgtcgcctc ggcggcgctc ccaacgc
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Leaf 3

```
1   tcgaaacctg cacagcagaa cgaccgcga attggttaca accgacgggg ggcggggggc
61  gttegtgcc ccctgcccc ccctcgggg ggggagacct gcctgcaaac tgaacccag
121 cgcggaacgc gccaaagaaa tctaaccaag agagccacgc tggaggcccc ggacacggtg
181 tgccccgac gtcggcgctt tacgaattat tcaaacgac tctcggcaac ggatatctag
241 gctcctcat cgatgaagaa cgtagcgaac tgcgatactt gatgtgaatt gcagaatccc
301 gcgaatcatc gagtttttga acgcaagttg cgcctgaagc cattcggccg agggcacgtc
361 tgcctgggtg tcacgcatcg ttgccccccc aaactccggt tcgggcgggg cggaagttgg
421 cctcccgtgc gtgctcgcgc gcgcggttag cccaaaagcg agtcctcggc gacgagcgcc
481 acgacaatcg gtggttttct tgcctcgtt cctcgtcgtg cgcgccccgt cgctcgaacg
541 cgtcctcga ccctcacgcg tcgtcgcctc gacggcgctc ccaacgc
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Source: National Center for Biotechnology Information online database

From: 2006, Shields, Martin. *Biology Inquiries*. New York: Jossey-Bass Publishing Company.