Name _____ Period _____ Date _____

Laboratory Activity #1 — Student Laboratory Packet

Relationships and Biodiversity

A Laboratory Activity for the Living Environment

Introduction

Botana curus is a valuable plant because it produces Curol, a compound used for treating certain kinds of cancer. Curol cannot be produced in the laboratory. *Botana curus* grows very slowly and is on the endangered species list, so its ability to provide Curol in large quantities is limited.

Species that are more closely related to *Botana curus* are more likely to produce the important substance Curol. Three similar plant species that are plentiful (X, Y, and Z) may be related to *Botana curus*. You will work as a researcher to:

- gather structural and molecular evidence to determine which plant species is most closely related to the hypothetical species, *Botana curus*
- use this evidence to decide which plant species is most likely to serve as a source of the important substance Curol

Safety

- You will need to wear goggles while conducting Tests 4 and 5.
- Do not eat or drink anything in the laboratory while doing this laboratory activity.

Important Note: *Record all of your data and answers on these laboratory sheets. You will need to keep them for review before the Regents Examination. Later, you will need to transfer your answers to a separate Student Answer Packet. Your teacher will use the packet in grading your work, and the school will retain it as evidence of your completion of the laboratory requirement for the Living Environment Regents Examination.*

Structural Evidence for Relationships

Perform the following tests and record your observations in Table 1 on page 8 of this packet. Use a hand lens or microscope as needed.

Test 1—Structural Characteristics of Plants

a. Do not remove the plant samples from the plastic bags/cards.
b. Compare the structural characteristics of the plant samples. Record your observations in Table 1 (see page 8).

Test 2—Structural Characteristics of Seeds

a. Do not remove the seed samples from the plastic bags/cards.
b. Compare the structural characteristics of the seed samples. Record your observations in Table 1.

"Relationships and Biodiversity" is a laboratory activity produced by the State Education Department for use in fulfilling part of the laboratory requirement for the Regents Examination in Living Environment. Reproducing any part of this laboratory activity by other than New York State school personnel is illegal.

The University of the State of New York • The State Education Department • Albany NY 12234 • www.nysed.gov

Test 3—Microscopic Internal Structure of Stems

a. Use the lowest magnification on your microscope to examine the slides that show cross sections through stems of *Botana curus* and Species X, Y, and Z. Compare the arrangement (circular or scattered) of the bundles of conducting tissue in the specimens. Refer to Figure 1.

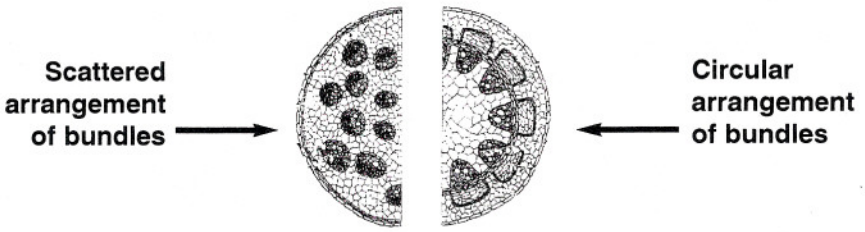


Figure 1

b. Record your observations (using words and/or diagrams) of the conducting tissue arrangements in Table 1.

Hypothesize: Tests 1-3

a. Based on your data for structural relationships, which species (X, Y, or Z) would you hypothesize is most likely to produce Curol? _____

b. Explain how the evidence from your data table supports your hypothesis. You will test your hypothesis by completing additional tests in the second part of this laboratory activity.

_____

_____

_____

Molecular Evidence for Relationships

Test 4—Paper Chromatography to Separate Plant Pigments

a. You must wear safety goggles when performing this part of the activity.

b. Draw a pencil line 2 cm from the bottom of the chromatography paper. Use a pencil to label the top edge of the chromatography paper Bc (*Botana curus*), X, Y, and Z as shown in Figure 1.

c. Use a clean microtip dropper to transfer two drops of plant extract from *Botana curus* just above the pencil line as shown in Figure 1.

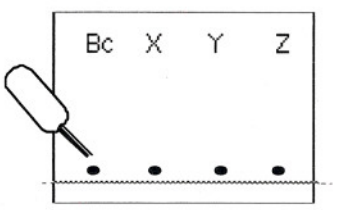


Figure 2

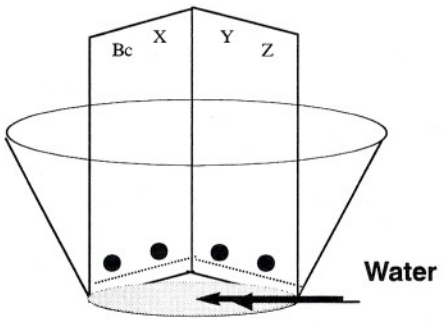


Figure 3

d. *Using a clean dropper each time*, repeat the procedure to place drops of the other plant extracts in the appropriate locations on the paper.

Reproducing any part of this page by other than New York State school personnel is illegal.

e. Add just enough water to cover the bottom of the cup approximately 1 cm deep. The water line should NOT be high enough to touch the spots of plant extract on the chromatography paper when the paper is placed in the cup.

f. Fold the chromatography paper and stand it in the cup as shown in Figure 2.

g. The chromatography paper must be removed from the cup before the water line reaches the pencil labels at the top of the chromatography paper. While the plant extracts are moving up the chromatography paper, go on to Test 5, but keep checking on the progress of the water moving up the paper so that you can remove it at the proper time.

h. Once the chromatogram is done, record your observations of the colors and relative amounts of pigments in Table 1.

i. Clean the microtip droppers thoroughly by rinsing them with water. Carefully pour solutions from the chromatography cup into the waste container. Discard the used chromatography paper.

Test 5—Indicator Tests for Enzyme M

a. You must wear safety goggles when performing this part of the activity.

b. It is not practical to test a plant directly for Curol. However, if enzyme M is present, a plant may produce Curol.

c. Test the plant extract from *Botana curus* for the presence of enzyme M. Put one small scoop of indicator powder into one depression of the well tray. Use a clean microtip dropper to add 5 drops of *Botana curus* extract to the indicator powder. A fizzing reaction indicates that enzyme M is present.

d. Repeat the test for enzyme M using the other plant extracts.

e. Record the results of your tests for enzyme M in Table 1.

f. Clean the microtip droppers thoroughly by rinsing them with water. Rinse the well tray and blot it dry using a paper towel.

Reminder: Complete the chromatography tests and observations before going on.

Test 6—Using Simulated Gel Electrophoresis To Compare DNA

a. For this test, you will use the plastic bags containing colored paper strips representing portions of DNA molecules. The letters on these strips represent the sequence of bases in DNA molecules isolated from *Botana curus* and Species X, Y, and Z.

b. To compare DNA molecules, scientists use enzymes that bind to and cut specific base sequences within the DNA. Imagine that you are using an enzyme that binds to the base sequence CCGG and cuts between the C and G. Simulate this cutting process as follows:

   b1. Remove one of the colored paper strips from the plastic bag labeled *Botana curus*. Locate and lightly shade all CCGG sequences on the DNA from *Botana curus*. The shaded areas represent where the enzyme would bind to cut the DNA.

   b2. Use scissors to cut off all the "white space" above and below the string of letters representing the DNA bases. Also remove the white paper to the left and right of the string of letters. (This will enable them to fit better in the spaces provided in Table 2 on page 9.)

   b3. Now cut the strip between the C and G within each of the shaded enzyme recognition sites. This will result in several fragments of DNA.

c. Scientists use *gel electrophoresis* to separate the DNA fragments resulting from this binding and cutting process. In an electrical field, the negatively charged DNA molecules migrate through a gel-like material toward the positively charged pole. The smaller molecules migrate more rapidly through the gel than the larger ones do.

Reproducing any part of this page by other than New York State school personnel is illegal.

d. Simulate the electrophoresis process by placing the DNA fragments from *Botana curus* in the appropriate well on the Simulated Electrophoresis Gel (Table 2). Simulate the effect of electrical current on the DNA fragments by counting the number of letters (bases) in each of the fragments and moving them to the appropriate location on the electrophoresis gel. Refer to the number of DNA letters indicated along the left side of the gel to determine the final position for each fragment.

e. Call your teacher over to check your work for *Botana curus* before you continue with the DNA from the other species.

f. Mark a horizontal line to indicate the final position of each fragment of *Botana curus* DNA on the simulated electrophoresis gel (Table 2), then record the size on the fragments (number of bases in each) in Table 1.

g. Repeat this process for each of the other species (X, Y, and Z): lightly shade the CCGG sequences, cut the DNA, and separate the resulting fragments.

h. Mark the final position of the DNA bands for each species on the gel (Table 2), then record the size of the fragments (number of bases in each) in Table 1.

i. Discard the used paper DNA fragments and return all other materials to their original location.

Test 7—Translating the DNA Code To Make a Protein

a. The sequences of DNA bases below represent parts of the genes responsible for the production of one type of protein, an enzyme, produced by *Botana curus* and Species X, Y, and Z.

b. Under each DNA sequence, write the complementary messenger RNA base sequences that each of these gene fragments would produce. *Note:* Unlike during DNA replication, in the production of messenger RNA, the DNA base "A" specifies the RNA base "U."

c. Use the universal genetic code table your teacher provides to translate the messenger RNA base sequences into sequences of amino acids in the protein produced by each species. Write the sequences of amino acids under the messenger RNA sequences.

Botana curus CAC GTG GAC TGA GGA CTC CTC

Sequence of bases in mRNA produced _____

Sequence of amino acids in the protein _____

Species X CAC GTG GAC AGA GGA CAC CTC

Sequence of bases in mRNA produced _____

Sequence of amino acids in the protein _____

Species Y CAC GTG GAC AGA GGA CAC CTC

Sequence of bases in mRNA produced _____

Sequence of amino acids in the protein _____

Species Z CAC GTA GAC TGA GGA CTT CTC

Sequence of bases in mRNA produced _____

Sequence of amino acids in the protein _____

Reproducing any part of this page by other than New York State school personnel is illegal.

- State how the amino acid sequence you obtained from the gene fragment for *Botana curus* compares with the sequences for the other three species.

- Summarize your observations of the number of differences in Table 1.

Analysis of Results

1. Using the information in Table 1, identify which plant is most closely related to *Botana curus* and therefore most likely to produce Curol. _____ Explain your choice by citing specific evidence from your research.

2. Did the addition of molecular evidence support or refute the hypothesis that you made earlier based on structural evidence only? _____ Explain why or why not.

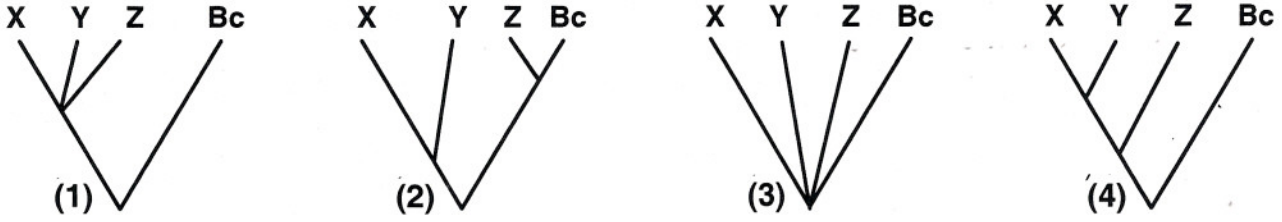
3. Which kind of evidence—structural or molecular—is most helpful in making decisions about relationships between species? _____ Explain why.

4. Based on your observations, list three characteristics (structural or molecular) that all four species have in common.

Reproducing any part of this page by other than New York State school personnel is illegal.

5. Provide a biological explanation for the common characteristics that these species share.

6. Scientists frequently use branching tree diagrams to represent graphically the relationships between species. Which branching tree, shown below, best represents the relationships among the four species? _____



Explain how you used the information on the data table to select this tree.

7. State two additional kinds of evidence you might use to further support your hypothesis about the relationship between *Botana curus* and species X, Y, and Z.

Base your answers to questions 8 through 10 on the reading passage below and on your understanding of biology.

The Biodiversity Crisis

Plant and animal species are being lost at a rate that is unprecedented in the history of life. Human activities are responsible for much of this biodiversity crisis. Some biologists estimate that within the next century, half of Earth's current species may become extinct.

Extinction and the loss of biodiversity occurs when species do not have adaptations that enable them to survive environmental changes. Human activities such as destruction of natural habitats and pollution are thought to be the major environmental factors causing the decline of species, but others are also important. Overhunting, introduction of foreign species that compete with native species, and removal of predators have also played a significant role in endangering some species.

Why should we worry about the loss of biodiversity? We depend on many species for food, clothing, shelter, oxygen, soil fertility—the list goes on and on. Large-scale extinctions of other species may be a warning to us that we are altering the biosphere so rapidly that our species is threatened too.

Biodiversity ensures the availability of a rich variety of genetic material that may lead to future agricultural or medical discoveries having significant value to humankind. Some species have been used as sources for medicines and other useful products. Scientists now use genetic engineering to transfer desirable genes from one species to another. As diversity is lost, potential sources of these genetic materials may be lost with it.

Biodiversity also increases the stability of the ecosystem. Every population is linked, directly or indirectly, with many others in an ecosystem. Disruptions in the numbers and types of one species can upset ecosystem stability. This means that extinction of one species can accelerate the rate of extinction for other species.

Endangered species hold medicinal, agricultural, ecological, commercial, and aesthetic value. They must be protected so that future generations can experience their presence and value.

Assume that the plant you identified as being closely related to *Botana curus* grows rapidly, survives in many environments, and produces Curol. News reports indicate that *Botana curus* plants may become extinct unless expensive efforts are made to preserve the species. Members of your research team disagree as to whether or not *Botana curus* should be saved.

8. State three examples of human activities that could endanger *Botana curus*.

9. State three reasons why it might be important to preserve *Botana curus*.

10. State two arguments people might make for NOT preserving *Botana curus*.

Reproducing any part of this page by other than New York State school personnel is illegal.

Table 1: Comparison of *Botana curus* with Species X, Y, and Z

	Structural Evidence			Molecular Evidence			
Species	**Structural Characteristics of Plants**	**Structural Characteristics of Seeds**	**Microscopic Stem Structure**	**Paper Chromatography**	**Test for Enzyme M**	**Differences in Amino Acid Sequences**	**Gel Electrophoresis DNA Banding Pattern**
Botana curus							
Species X							
Species Y							
Species Z							

Reproducing part of this page by other than New York State school personnel is illegal.

Table 2: Simulated Electrophoresis Gel

- Negative Pole -

Wells → # of DNA bases	*Botana curus*	Species X	Species Y	Species Z
24				
23				
22				
21				
20				
19				
18				
17				
16				
15				
14				
13				
12				
11				
10				
9				
8				
7				
6				
5				
4				
3				
2				
1				

+ Positive Pole +

Reproducing part of this page by other than New York State school personnel is illegal.

Universal Genetic Code Chart

Messenger RNA codons and the amino acids they code for.

FIRST BASE	SECOND BASE: U	SECOND BASE: C	SECOND BASE: A	SECOND BASE: G	THIRD BASE
U	UUU, UUC → PHE	UCU, UCC, UCA, UCG → SER	UAU, UAC → TYR	UGU, UGC → CYS	U
	UUA, UUG → LEU		UAA, UAG → STOP	UGA → STOP; UGG → TRP	C, A, G
C	CUU, CUC, CUA, CUG → LEU	CCU, CCC, CCA, CCG → PRO	CAU, CAC → HIS	CGU, CGC, CGA, CGG → ARG	U, C, A, G
			CAA, CAG → GLN		
A	AUU, AUC, AUA → ILE	ACU, ACC, ACA, ACG → THR	AAU, AAC → ASN	AGU, AGC → SER	U, C
	AUG → MET *or* START		AAA, AAG → LYS	AGA, AGG → ARG	A, G
G	GUU, GUC, GUA, GUG → VAL	GCU, GCC, GCA, GCG → ALA	GAU, GAC → ASP	GGU, GGC, GGA, GGG → GLY	U, C, A, G
			GAA, GAG → GLU		

Note: Amino acid abbreviations are in bold type (*e.g.*, PHE, LEU, SER, etc.)

Reproducing any part of this page by other than New York State school personnel is illegal.