Lesson Plan: Plant Phylogeny

NOTE: You MUST notify the ICE team at least 1 week prior to using this activity so they can be sure the live potted plants are available.

General Description
This activity is designed to introduce students to phylogenetic reconstruction using morphological characters. Students will examine live potted plants and create a hypothesis regarding their relationships.

Objectives
The student will:
1. Choose morphological characters and character states useful in phylogenetic reconstruction.
2. Use a character state matrix to reconstruct a phylogeny based on parsimony.
3. Determine if characters are ancestral or derived, or homologous or analogous based on their phylogenetic hypothesis.
4. Compare and contrast phylogenies based on different characters and data types.
5. Determine probable evolutionary relationships based on their phylogenetic reconstruction.

Concepts
parsimony, ancestral and derived character states, phylogeny, sister groups

Time
Approximately 50 minutes

Materials
7 live potted plants with accompanying pictures
phylogeny overhead
2-page student handout
2-page phylogeny comparison worksheet

Refer to the following website for more information on Angiosperm phylogenies:
http://www.mobot.org/MOBOT/Research/APweb/welcome.html
**UTI Instructions: Plant Phylogeny**

1. **[20 minutes]** Break students into groups of four and hand out the “Group Discussion” worksheet. Students should then follow the handout to guide their exploration of characters and character states for the live plants. During their group discussion, one student should be in charge of taking notes on what they discuss to help guide the presentation of their results. Each group should prepare a short presentation on the phylogeny they constructed and one student should be prepared to present their phylogeny to the class. When completed, have each team draw their phylogeny on the board.

2. **[10 minutes]** Have the groups present their ideas to the entire class, particularly regarding the 3 most important characters that determine the arrangement of the phylogeny they created.

3. **[10 minutes]** Lead a class discussion of the groups’ results:
   a. As a class, have the students compare and contrast the characters they used to create their phylogenies—did they use similar characters? Which were the most common? Does one character significantly influence the phylogeny of any group?
   b. Have students compare and contrast the phylogenies the groups came up with—are they the same? How do they differ? Do they get the same relationships between some plants, but different relationships for others? What characters do they think are responsible for the differences in the phylogenies?

4. **[5 minutes]** Put up the overhead of the molecular phylogeny of the same taxa and discuss as a class one or two of the following questions:
   a. How is the molecular phylogeny the same and different from what the class came up with based on morphology?
   b. Why might there be these differences? (Remember: this phylogeny is based on molecular data, not on morphological data)
   c. Could the same relationship be reached with morphology, if it wasn’t already?
   d. What are some limitations of simply looking at live plants for this activity?
   e. Using the molecular phylogeny, can the students determine where changes in some of the characters occurred?

5. **[5 minutes]** If required, have students complete the Individual Accountability questions.
Pre-Activity Worksheet: Plant Phylogeny

General Description
In the activity you will do this week during your learning/discussion group, you will be
learning how evolutionary biologists investigate relationships among organisms, and you will
create your own hypothesis of evolutionary relationships in a group of plants. In order to be
prepared for this activity, complete this worksheet.

Reading
Browse the “Systematics and the Phylogenetic Revolution” chapter in your text. Pay
particular attention to figures 25.4, 25.5, 25.8, and 25.15. Read carefully section 25.3.

Definitions
Write a definition of the following words. Use your text, textbook glossary, and your
previous knowledge to create the best definition possible. Remember to connect your
definitions to phylogenies.

1) cladistics
2) parsimony
3) derived character
4) outgroup
5) systematics
6) character state

Questions
Answer the following questions. You will explore your answers to these questions in-depth
during learning/discussion group. To practice looking at and understanding characters and
characters states of plants, visit the Jordan Hall Greenhouse (it is open to the public M-F
8am-4pm, S&S 9am-3pm), either by yourself or with a classmate.
1. Find two plants that differ morphologically and list 10 characters. Use the back of this
   page. Record the species you are examining.
2. Determine and record the character states for these characters for both plants.
3. Does there need to be two character lists? Why or why not?

4. Does there need to be two character state lists? Why or why not?
Plant Phylogeny

This activity is designed to allow you to explore how biologists create phylogenies to understand the relationship among organisms and the evolution of various characters. In this exercise you will create a phylogeny using the morphology of several plant species. Examine the live potted plants closely.

To determine how these plants are related to one another, examine the morphological similarities and differences among the plant species. First pick three characters with two character states from the table below. Next, with your team think of three additional characters with two character states and add these to the table below. Remember you want to choose characters that will allow you to determine which species are more closely related to one another.

<table>
<thead>
<tr>
<th>Character</th>
<th>Ancestral State (0)</th>
<th>Derived State (1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>stems</td>
<td>absent</td>
<td>present</td>
</tr>
<tr>
<td>flowers</td>
<td>absent</td>
<td>present</td>
</tr>
<tr>
<td>number of petals</td>
<td>few or none</td>
<td>many</td>
</tr>
<tr>
<td>divided leaves</td>
<td>not divided</td>
<td>divided</td>
</tr>
<tr>
<td>wood</td>
<td>absent</td>
<td>present</td>
</tr>
</tbody>
</table>

Inquiry-based Curriculum Enhancement
Your next step is to assess the states of these 6 characters in the potted plants. To do this, examine the plants closely and decide which character state each possess for the characters you chose and fill in the table below. List your characters in the left column. One example is shown.

<table>
<thead>
<tr>
<th>Character</th>
<th>Out group</th>
<th>Plant 1</th>
<th>Plant 2</th>
<th>Plant 3</th>
<th>Plant 4</th>
<th>Plant 5</th>
<th>Plant 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>flowers</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

Now, using what you have learned about the principle of parsimony and the building of phylogenies, create your hypothesis of the relationships among these organisms. Indicate on your phylogeny the likely places where characters changed from one state to the other. To begin, the outgroup moss is the most ancestral of the plants you have been given. This phylogeny is what you will present to the class, so make it easy to read. Use additional pages as necessary.
Individual Accountability: Plant Phylogeny

Demonstrate your new understanding of phylogenies by answering the following questions. In both cases, defend your answer in four or five sentences.

1. Compare and contrast the characters used by different groups. Are some easier to score? Are some more helpful when creating the phylogenies?

2. Why are phylogenies useful to scientists?