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Creating a Dichotomous Key: Pattern Recognition in Plants for Intro Biology

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Dichotomous keys are widely used to identify organisms. The use of a dichotomous key requires knowledge of technical terminology of the organism in question. The creator of a dichotomous key requires further skills in pattern recognition and reasoning. Pattern recognition is required to group organisms according to commonalities, yet identify unique characters in each. Reason is crucial to create a functioning key with a logical series of choices. In this workshop pairs of participants will create a dichotomous key for a group of pressed herbarium specimens. Participants will use *How to Identify Plants*, by H.D. Harrington, to learn terminology relative to higher vascular plants. These terms will be incorporated throughout the key. After the keys have been created, participants will test each other's keys and modifications to the exercise will be discussed. Topics explored in this workshop include plant terminology, plant anatomy, plant diversity, pattern recognition and reasoning.

Keywords: dichotomous key, plant terminology, pattern recognition

Introduction

The use of a dichotomous key to identify organisms is an important skill, as biologists often use such keys in the lab and field. Biology students are commonly asked to use a dichotomous key at some point during their undergraduate education; however, students are seldom asked to develop a key. Compared to the use of a dichotomous key, the development of a key requires a deeper understanding of how they work (Timme 1991). In addition, when students create their own key for a given group of organisms, they become familiar with technical terms pertaining to those organisms, practice pattern recognition and apply reasoning skills.

This activity requires students to develop a dichotomous key using groups of 10 pressed herbarium specimens. To begin, the instructor should provide some background on dichotomous keys and their importance. To demonstrate the basic steps for creating a key, the instructor may provide an example using simple objects such as pens or shoes. Students work in partners to identify patterns and differences between the plants in their group and assemble a key, starting with the most obvious characteristics followed by more detailed differences (Timme 1991). Students should consult *How to Identify Plants* by H.D. Harrington (1957), or a similar text, for technical plant terminology. *How to Identify Plants* includes a table of contents and many figures, which makes it relatively easy to use.

This activity has been implemented as a lab for first year biology majors and is designed to take approximately two hours. A complementary activity, such as a detailed plant description, may be included to fill a standard 170-minute lab session. A plant description has the advantage that it forces students to look up terms required to adequately describe a specimen and allows them to become familiar with those terms before trying to create a key. Formal assessment for the activity is based on creating a key that follows the format of the examples provided, includes correct technical terminology and can reliably identify all species.

Students appreciate that this assignment is different from a traditional lab report and that the majority of the assignment is completed during lab time. A related benefit is that this activity requires different skills than a traditional lab report, challenging some students while allowing others, with different skill sets, to shine.

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Student Outline

Objectives

Describe characteristics of higher vascular plants using technical terminology
Develop a dichotomous key to a given group of plants
Understand how to use a dichotomous key to identify organisms

Introduction

Each time a new species is discovered by scientists, it is described and named by someone experienced with closely related species. The unique combination of genus and species names are linked with a number of specific characteristics, unique to that species. Note: The Latin, scientific name (genus and species) is written in italics. The genus is always capitalized whereas the species is not. For example: *Homo sapiens*. Imagine that a biologist has come across a specimen whose identity they are uncertain about. Perhaps the biologist is able to use past experience to narrow down the organism to the genus level, but is unfamiliar with the particular species. They might resort to the original published descriptions of all members of the genus, to see which one most closely resembles the specimen in hand. In most cases, this would be an extremely time-consuming exercise, particularly if the genus has hundreds of species. If the biologist is lucky, some authority will have published a dichotomous key to allow for the identification of members of the group in question. Dichotomous keys have been widely used by biologists to identify organisms since being developed by J.B. Lamarck in 1778. The key provides a series of steps, each with one pair of options. The user must decide which option is correct and will then be directed to another pair of options. One proceeds through the key until the specimen is identified. If the feature of a particular plant is ambiguous it can be useful to key out both options in the couplet. Some dichotomous keys can be used with minimal knowledge of the biological sciences. Others require a great deal of expertise with the group in question. **A key should be based on characteristics that are easily observed.** For example, since fleas can only be identified with a microscope, there is little point in using behavioral characteristics, but the identity of the host from which the flea was taken may be important information. Even microscopic examination of bacteria is likely to provide only limited structural information, and so a key to this group might rely on physiological or biochemical characteristics. Please review the following example of a dichotomous key to the vascular plant family Ranunculaceae:

Ranunculaceae (partial)

1	Flowers bilaterally symmetrical, deep blue to purple	2
1	Flowers radially symmetrical, various colors	3
2	Upper sepal hooded but not spurred; 2 petals, covered by hood	*Aconitum delphinifolium*
2	Upper sepal spurred but not hooded; 4 petals not hidden by sepals	*Delphinium glaucum*
3	Petals prominently spurred; flowers blue or red	4
3	Petals not prominently spurred; flowers usually white or yellow	5
4	Flowers red	*Aquilegia canadensis*
4	Flowers blue	*Aquilegia brevistyla*
5	1 ovary; fruits red or white berries	*Actaea rubra*
5	Usually 2 or more ovaries; fruits achenes or follicles	6
6	Fruits 2- to many-seeded follicles; split when mature	7

6	Fruits 1-seeded achenes, do not split when mature	9
7	Leaves divided into 3s, leathery, evergreen; Rhizomes bright yellow	*Coptis trifolia*
7	Leaves simple, not divided into 3s, not leathery or Evergreen; rhizomes not bright yellow (marsh marigolds)	8
8	Flowers yellow; plants usually ascending or lying on ground in mud or peat	*Caltha palustris*
8	Flowers white or pinkish; plants usually floating or creeping on mud	*Caltha natans*

(Adapted From: Johnson *et al*. 1995)

Materials

Per pair of students:
Ruler
Hand lens or magnifying glass
Two copies of *How to Identify Plants* by H.D. Harrington
Ten herbarium specimens

Assignment

Each pair will be given 10 herbarium specimens. Work with your partner to construct a dichotomous key specific to your group of specimens. Refer to the given example of a dichotomous key and those in *How to Identify Plants* by H.D. Harrington. For example, in the key above, more than one character is listed in several couplets including the final couplet where *Caltha palustris* and *Caltha natans* are identified. This is essential in case there are very similar plants, particularly from the same family or genus, in the group of species the key identifies. When developing a couplet to differentiate similar plants in your group of herbarium specimens, you should also include more than one character. For example, you can include that the flowers are yellow, but add that the seeds are in achenes and the plant is woody. Key users can be more certain about their identification if couplets contain multiple characters. You may use the ruler to measure characters such as plant height and flower size. The magnifying glass will allow you to observe smaller features such as trichomes on stems. Please use Latin names and technically correct terminology from *How to Identify Plants* by H.D. Harrington throughout the assignment. Be sure to test your key before handing it in.

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Harrington HD. 1957. How to Identify Plants. Swallow Press. 214 p.

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Lamarck JB. 1778. Flore française, ou descriptions succinctes de toutes les plants qui croissant naturellement en France. Troisieme Edition. 464 p.

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Notes for the Instructor

Provide an example on how to create a dichotomous key using simple objects such as pens. For example, obtain approximately 8 different pens and label them as species A-H. Tell the students that you know the species of each pen, but want to create a key, so that if someone else came across one of these pens, they could identify it. Begin by asking students to point out obvious differences between the pens. For example, the pens may have different ink colors, different methods of opening, etc. Based on the students' observations, write step 1 of the dichotomous key on the board, including the step to proceed to depending on the characteristic. For example:

1	Blue ink	2
1	Black ink	3

Ask students to further split each group of pens, blue ink and black ink, into two categories. Continue to record the key on the board, one step at a time, until all pens are keyed. Test the key with the class once it is complete.

Despite the pens example, some students struggle with creating a dichotomous key, as this exercise requires different skills than typical labs. To assist students who are having difficulties, encourage them to become familiar with *How to Identify Plants* by H.D. Harrington as soon as possible during the exercise. Bring the students' attention to the table of contents, which contains sections on terms relative to the flower, inflorescence, underground parts, stems, leaves, and surfaces. Most students will be familiar with these basic plant anatomy terms, but it may be helpful to explain the term inflorescence if students have not encountered it previously. Finally, many students find it helpful to physically arrange the herbarium specimens in groups with common characteristics so that patterns become apparent.

Students usually focus on flower color and leaf shape and size because they are obvious. However, these are not the most important plant characteristics from an evolutionary perspective. Leaf size and shape can vary significantly depending on the growing condition of the plant. For example, Stanton *et al*. (2010) and Xu *et al*. (2009) found that in shaded conditions, some species produce larger leaves. Since pollination and seed dispersal are key to the survival of any species, the features that affect these are much more important. Pollination depends on the shape, size, and arrangement of flowers as well as color, and seed dispersal depends on the type of seed and the features that allow distribution such as wings, hairs, "stickiness" etc. (Russell *et al*. 2013). To avoid trivial distinctions, advise students to focus on characteristics that are easily observable and important. They should start with obvious characteristics (e.g. vine or not vine) and work up to more inconspicuous characteristics.

This exercise can be made more challenging by providing students with groups of plants from the same family or genus. Plants that are closely related have many similarities and will be more difficult for students to differentiate and require more attention to detail.

If there is no herbarium available at your institution, specimens can be printed from a virtual or digital herbarium.

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