

TWENTY-ONE QUESTIONS



- Template for Twenty-one Questions or a Dichotomous Keys
- Sample dichotomous keys

Introduction: A dichotomous key (figure 10) is a tool for classifying organisms, rocks, or other natural items. The key asks dichotomous questions -- questions in which there are only two possible responses. After answering a series of dichotomous questions and following the appropriate directions, the object is “keyed out” or classified. Figure 11 illustrates a simplified dichotomous key used for identifying a few common beans used in cooking.

- | | |
|------------------------------|-----------------------|
| A. Bean elliptical or oblong | Go to B |
| B. Bean has dark pigments | Go to C |
| C. Bean color is solid | Go to D |
| C. Bean color is mottled | Pinto bean |
| D. Bean is black | Black bean |
| D. Bean is reddish-brown | Kidney bean |
| B. Bean is white | White northern |
| A. Bean is round | Garbanzo bean |

Figure 1 A simple dichotomous key for classifying beans used in cooking

Taxonomists classify organisms according to common characteristics. Figure 11 illustrates the classification of the magnolia, a broadleaf tree common to the southeastern United States. Each level in the classification can be reached by asking a set of specific questions in a similar fashion to that illustrated above. It should be noted that the word endings (see underlined portions) are generally associated with the level of classification. For example, Rosaceae can only refer to a family because of the “*aceae*” ending.

Classifications (plant kingdom)	Classification of <i>Magnolia grandiflora</i> , a tree common in the Southeastern United States
Kingdom	Plantae--includes all plants
Division	Magnoliophyta--flowering plants
Class	Magnoliopsida--dicots
Subclass	Magnoliidae--subclass for Magnolia-like plants
Order	Magnoliales--order for Magnolia-like plants
Family	Magnoliaceae--family for Magnolia-like plants
Genus	Magnolia--genus that includes all
Species	Magnolia grandiflora--specific epithet

Figure 2 Classification of *Magnolia grandiflora*

Classification is extremely important in science, and yet not all classification schemes are equally valuable. A popular folk game named “Twenty-One Questions” can provide an

excellent introduction to the concept of dichotomous keying and *illustrate the importance of asking good questions in a logical fashion* when developing a taxonomic key.

Rules:

- **Target:** The teacher thinks of a relevant item (e.g. a specific concept, plant, animal, rock, etc.).
- **Questioning:** Students try to determine what the teacher is thinking about by asking him “yes” or “no” questions. Since every question must be answered with a “yes” or “no”, students are effectively classifying the mystery item using a dichotomous key. Many students will try to circumvent the keying process and immediately guess a specific item. Each time they do this, they waste a question, and since only 21 questions are allowed, they decrease their chances of determining the unknown
- **Developing a dichotomous key:** With time, students should learn that dichotomous keys work best when each question divides the remaining domain into two approximately equal sub-domains. If each question splits the remaining domain exactly in half, then the number of items that can be keyed out will increase as a power of 2. One dichotomous question can key out two items (2^1), two questions can key out 4 items (2^2), three questions can key out 8 items (2^3), and so on. Theoretically, one can key out 2^{21} items (2,097,152) with twenty-one dichotomous questions. In reality, the number is much smaller because it is difficult to divide the remaining domains exactly in half. None-the-less, the process shows how the dichotomous key is a powerful tool for classifying a large set of objects.
- **Playing with multiple teams:** You may wish to break the class down into different teams and give each an identical series of terms to solve through the questioning process. Separate the groups sufficiently so they will not be able to hear the questioning process of the other groups. Select knowledgeable and impartial individuals to serve as “answer men” and appoint one to work with each team. The team members should write down each question and its answer. The team that is able to solve the puzzle with the lowest average number of questions is the winner.

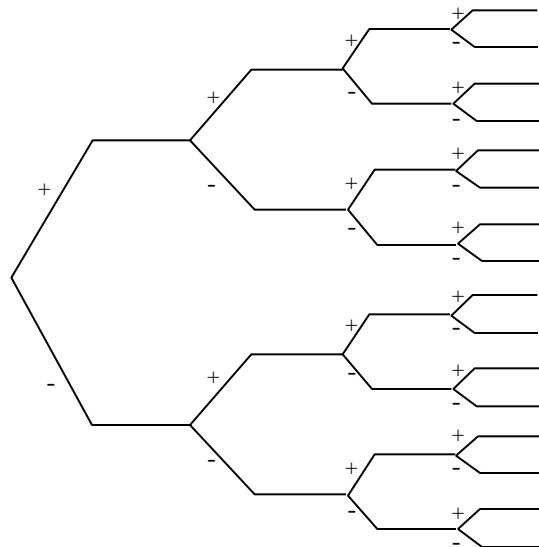


Figure 3 Dichotomous key (Decision tree) .
 Download original from website. Write the characteristic on the horizontal line A positive (+) symbol indicates that the object has that characteristic A negative (-) symbol indicates that the object being keyed does not have that characteristic

Hands-on taxonomy activity: Once students have learned the value of asking the right questions and sequencing them in a logical fashion, give them opportunity to develop their own taxonomic scheme for a set of miscellaneous objects, such as hardware (assorted nails, washers, bolts, nuts, cotter pins, dowels, tacks, etc.) Give each group a jar containing the same assortment of items and ask them to develop a logical classification scheme. Provide each team with a dichotomous decision tree such as that illustrated in figure 12.