ECOS
Ecologists Educators and Schools: Partners in GK-12 Education

ECOS Inquiry Template

1. CONTRIBUTOR'S NAME: MIKE MACHURA
BROOKE MCBRIDE
ALLISON GREENE

2. NAME OF INQUIRY: AN INTRODUCTION TO DICHOTOMOUS KEYS AND CLASSIFICATION: A GREAT USE FOR A CLASSROOM PET!

3. GOALS AND OBJECTIVES:
   a. Inquiry Questions:
      - What are characteristics that can be used to group similar objects and organisms?
      - How can characteristics of an organism be used to create a dichotomous key?
      - How can a dichotomous key be used to identify an unknown object or organism?
      - What are some common characteristics of different groups of animals (or plants)?
   b. Ecological Theme(s): Classification, description, diversity of life
   c. General Goal: Teach students how to use a simple dichotomous key and introduce them to the concept of classification.
   d. Specific Objectives:
      - Students will learn that a universal system of classification allows scientists to communicate with each other.
      - Students will learn how to construct and use a dichotomous key to identify organisms.
      - Students will use the ECOS On-Line Nature Guide and other references to identify characteristics common among taxa.
   e. Grade Level: 4
   f. Duration/Time Required:
      → Prep time: 12 hours
      → Implementing Exercise During Class: 1 60-minute class period (additional periods or homework needed if computer/book research is incorporated, see SCALABILITY section).
      → Assessment: 20 minutes

4. ECOLOGICAL AND SCIENCE CONTEXT:
   a. Background (for Teachers): With thousands of different kinds of plants and animals in the world, scientists need some way of grouping animals on the basis of their similarities and differences. Physical traits can be used for this purpose. (Other ways of classifying organisms include DNA analysis). For example, all humans, dogs, cats and mice have hair, and this common feature (along with several other) results in us all being classified as "mammals." Within the mammals, however, humans are obviously very different from mice, and humans and mice can therefore be separated into their own, smaller groups. This hierarchical grouping process, developed by Carolus Linnaeus (1707-1778), results in an organization

of living things that can be seen like a pyramid or tree with seven major levels or categories: ***Kingdom, Phylum, Class, Order, Family, Genus, Species***. Human beings, for example, belong to the kingdom Animalia, phylum Chordata, class Mammalia, order Primates, family Hominidae, genus Homo, and species sapiens. While this inquiry does not focus on the details of Linnaeus' classification system, it is important to understand that all living things can be sorted into groups of progressively finer levels of resolution, and that all organisms of one class (Mammalia, for example) are related in some way. Similarly, all organisms of one kingdom (Animalia, for example) are related in a more general way. Having a classification and corresponding naming system that is agreed upon by scientists around the world allows people to communicate and describe organisms across language and cultural barriers.

With so many different organisms in the world, identification of an unknown organism can be very difficult. While it may be common sense to identify a tree as a plant (and hence belonging to the plant kingdom), references and guides often must be used to identify that tree to the level of order, family or genus. Determining which species something is often becomes impossible for anyone other than an expert, as many related species are virtually identical.

One method of identifying organisms is to use a dichotomous key. A dichotomous key considers the similarities and differences between objects using a series of paired statements. The paired statements describe contrasting characteristics (it is best to use observable, physical characteristics). One statement is selected out of the pair that happens to be true of the object being identified. The statement chosen may ask you to go on to another pair of statements or it may give you the name of the organism.

In this inquiry, students will be introduced to the concept of a dichotomous key by first constructing a key from scratch for common items such as nuts, bolts and washers. They will then practice this technique using plastic amphibians or similar animals available in many toy stores, and then finally key out a mystery organism (using a key created by the teacher) in class.

b. Background (to present to Students): Classifying involves grouping things into categories based on similar characteristics. Like comparing, it is something we do in our day-to-day lives. We classify the clothes we put into our closet. We classify the food we put in our kitchen cabinets. We can also classify plants and animals, based on similarities and differences in characteristics we can observe.

5. MOTIVATION AND INCENTIVE FOR LEARNING: Students will get to play with plastic toys as they construct their own dichotomous key in groups. Then they will classify a "mystery organism" which could involve going outside to a pre-selected tree in the schoolyard, or bringing a live animal into class. This could be a great way to introduce a class pet, such as a goldfish, frog, or hamster (provided that

you, as the teacher, are able to find out enough information about that particular and other related organisms in order to create a dichotomous key (see below)).

6. VOCABULARY:

Classification: The systematic grouping of organisms into categories on the basis of evolutionary or structural relationships between them; taxonomy.

Genus: A taxonomic category ranking below a family and above a species and generally consisting of a group of species exhibiting similar characteristics.

Species: A fundamental category of taxonomic classification, ranking below a genus and consisting of related organisms capable of interbreeding.

7. SAFETY INFORMATION: If live animals are used, students should be instructed on any rules involving handling, feeding or touching the animals. For the nuts and bolts exercise, avoid sharp or pointy objects.

8. MATERIALS LIST (including any handouts or transparency masters):

- A random collection of nuts, bolts, washers etc, available from a hardware store. Between 8 and 12 is an ideal number. No two items should be identical, but many should share some similarities. For example: 1 long Phillips screw, 1 short Phillips screw, 1 long flathead screw, 1 short flathead screw, 1 large washer, 1 small washer, 1 large hex nut, 1 small hex nut.
- A collection of small toy animals (such as plastic amphibians) that are all unique but also share many similarities. These can be found in many toy stores. Students will work in small groups with these, so separate them out so that each group has between 8 and 12 individuals that are all unique. These can be kept in small bags.
- Several large sheets of paper and markers (enough for each group plus the teacher to have at least one sheet).
- "Mystery organism." This can be a plant brought in from outside, a pre-selected and pre-identified plant or tree outside, or a live animal brought into the classroom (perhaps a new classroom pet). It is important that you know enough detail about what the animal is so that the students will have something novel to discover. For example, an angelfish should not just be identified as a fish, because students will already know that this is a fish and there will be no new information to learn. Rather, it should be identified as an "angelfish" or even as "*Pterophyllum scalare*," the scientific name. Most pet stores should be able to tell you the scientific and common names of their animals. This is also a good opportunity to bring in local wildlife experts.
- Mystery organism key. This should be made prior to the lesson, and can be as simple or complicated as you would like. Some research will be required to find similar organisms to include on the key, and pictures are a helpful addition. A total of approximately 8 organisms is an ideal number to work with. If using fish, you can go through the fish section of the pet store and take pictures of many of the other similar fish, including the one purchased for the class. To make the dichotomous key, follow the same

method that the students will use to make theirs (see below), but use a more sturdy poster board. First, separate all of the fish (or whatever organism you choose) into two very broad categories: (eg. has black spots vs. does not have black spots). Write this on the key as two diverging lines, leading to the next decision question (see Figure 1). Continue to divide each group until you are left with only one organism in each group, and glue the corresponding picture with its name in that position. Note in Figure 1 that there will also be several "unknowns" – the key could continue on at these points, but in an effort to limit the size and complexity, question marks are recommended at these locations. Finally, tape paper or cardboard flaps over each picture and question mark so students will lift a flap to determine if they are correct (as opposed to simply identifying the organism by comparing it to all the pictures, Figure 2).

- Computers with an internet collection, or field guide books (see references) describing different species of plants or animals.

9. METHODS/PROCEDURE FOR STUDENTS:

a. Pre-investigation work:

1. Begin by asking students to recall the different plants and animals they have observed in the schoolyard. You can list some of these on the board. Then ask them to tell you how some of these organisms are similar and how they are different. Key characteristics they might focus on are color, smell (of plants or flowers), size, and habitat (or the location where they are found). Group similar organisms on the board.

2. Tell them scientists often group things based on their similarities, and then give groups names. This process of assigning organisms to groups is called "classification." Ask if they ever classify things in everyday life. (Possible answers include: sorting (classifying) clothing to put away into separate drawers; separating lights from darks for the wash; helping parents put away groceries based on the fact that all canned goods go together, all cold things go together in the fridge, etc.) Ask them why it is important for scientists to classify organisms. (Possible answers include: so they can better understand an organism by comparing it to similar related organisms; assigning animals to groups and giving those groups names allows them to communicate with other scientists about a group of animals, etc.)

3. Tell them that they will be learning how to classify organisms into groups based on similarities, and also how to identify a plant or animal within a group based on its unique characteristics (how it is different from others in that group).

b. Investigation work:

1. *Nuts and Bolts (led by the teacher).*

i) Gather all students around the teacher on the floor and spread out one large sheet of paper. With the collection of nuts and bolts in a paper bag, tell the students that you have a sample of alien creatures, which they are going to separate out into groups by comparing similarities and differences between them. Empty out the bag and let the students look at the collection.

ii) Ask students if there is a way to split the entire collection into just two groups. (Possibilities might include long and circle shaped, pointy and not pointy, etc. There is no one correct answer, so the students should be allowed to determine the categories, as long as they can be applied to the objects at hand). Then, physically separate the objects into those two groups at the left side or top of the paper and write the classifying terms below each group (Figure 3).

iii) Now, starting with the first group, ask students to separate the objects in that group by making up two new categories (for example, grooved and not grooved, hole in center and no hole in center, etc). Be sure they focus only on the one group. When they have decided on categories, slide those objects to the right, and write the new categories below the new groups. Connect these groups with lines to the previous original grouping (Figure 4). Repeat this process with the other grouping, and continue to repeat this process with each new group until each group consists of only one item. The resulting tree is a dichotomous key.

iv) Now collect all of the alien creatures (nuts and bolts) from the paper and put them back in the bag. Select one student to take the bag to another part of the room and tell that student to choose one object from the bag. He/she should keep that object in their hand and not show anyone else (including the teacher). Tell the students that they can use their newly created dichotomous key to identify the object in the other student's hand. They start at the beginning of the key, and ask the student holding the object which of the two characteristics it has. For example, the first question might be "is it round, or is it long and stick-like." The student should look at the object and answer. The rest of the group then follows the appropriate branch of the key to the next question, and continues this process until the object is (hopefully) identified. This can be repeated several times, with a new student choosing a different object from the bag, until you are confident that they can use a dichotomous key.

2. Plastic frogs (student activity).

i. Divide the students into small groups, with each group getting a large sheet of paper and markers, and a bag of plastic frogs. Tell them they are now to make their own dichotomous key, using the objects they have been given. (If they have difficulty, remind them to consider characteristics such as color, shape of legs, shape of body, presence of a shell (e.g. is it a turtle?). Figures 5 and 6 show two possible results.

ii. Assessment: After they have made their key, collect all but one of their animals and have them identify the one remaining animal. Go around to each group and make sure that they have correctly followed the key and identified that animal. Ask them what features they have used and why.

3. Mystery organism, or classroom pet.

i. Tell students they are now ready to do what real scientists do and identify an unknown organism. Show them your pre-selected organism (classroom pet, plant, or outdoor tree) and take out your pre-constructed key. Lead students through each question. Do not correct them if they make a mistake and choose an incorrect path – they should see this when they reach the end of the key and uncover the wrong picture.

They can then start over. If they incorrectly reach a question mark, inform them that their choices have led them to an unknown organism that this key can not identify, but perhaps they should try again.

10. ASSESSMENT: See part *2. ii.* above.

11. EXTENSION IDEAS: Dichotomous keys can be constructed for anything. Have students create a key for a group of objects of their own choosing, such as items in their desk. Students can then take turns leading the class through their key.

12. SCALABILITY: For this exercise, students should use the ***ECOS Guide to the Ecology of the Northern Rockies*** available at: http://www.bioed.org/nhguideweb/NHGuide/PlantGuide.aspx. Field guide books such as Peterson's Guides and Amphibians and Reptiles of Montana (listed in the References) also describe characteristics of different species within a genus, and can also be used, though they may be more difficult to navigate).

    1. Older students can use internet or book resources to research different species within a common genus. Remind students that they have been grouping items based on similarities and differences in order to create a key, and then using that key to identify mystery organisms. Scientists have used this process of grouping based on similarity in order to name organisms. All organisms are known by two names. The first name is the genus, and the second name is the species. (You can also inform students that there are other names in categories above genus and species: kingdom, phylum, class, order and family).

    2. Using one of the mentioned resources, students should identify two or more species belonging to a single genus. For example, in the ECOS plant guide, scroll down the list of scientific names (left hand panel, make sure you have clicked "sci name" and not "common name") and look at the first name of each individual. The first three organisms are all *Acer*, meaning they all belong to the genus *Acer*.

    3. Students are to examine all listed organisms belonging to one genus. (Note: if field guides are used, it may be easier to examine every family belonging to a particular order). Reading through the descriptions, they should write:
        - in what ways the species are all similar
        - in what ways the species are all unique

        For example, *Acer glabrum* and *Acer platanoides* are both maple trees that have wing-shaped fruit. However, the leaves of *glabrum* contain 3-5 lobes, while those of *platanoides* have 5-7 distinct lobes.

13. REFERENCES:

Internet School Library Media Center (http://falcon.jmu.edu/~ramseyil/vertebrates.htm)

Using a dichotomous key (http://www.usoe.k12.ut.us/curr/science/sciber00/7th/classify/sciber/taxokey.htm)

Peterson Field Guides, Borror and White, 1970
(http://www.houghtonmifflinbooks.com/peterson/petersonhome.cfm)

Amphibians and Reptiles of Montana, Werner, Maxell, Hendricks and Flath, 2004

14. LIST OF EXPERTS AND CONSULTANTS

15. EVALUATION/REFLECTION BY FELLOWS AND TEACHERS OF HOW IT WENT:

Students really enjoyed this inquiry, and most immediately grasped the concept of separating a group of organisms into two dichotomous subgroups. We used this activity to bring frogs into the classroom as their classroom pets, and many were able to write the full common name of the frogs (Columbia spotted frogs) in their journals. After identifying the animals, they were very curious in lifting up the flaps to see what the other animals on the key were.

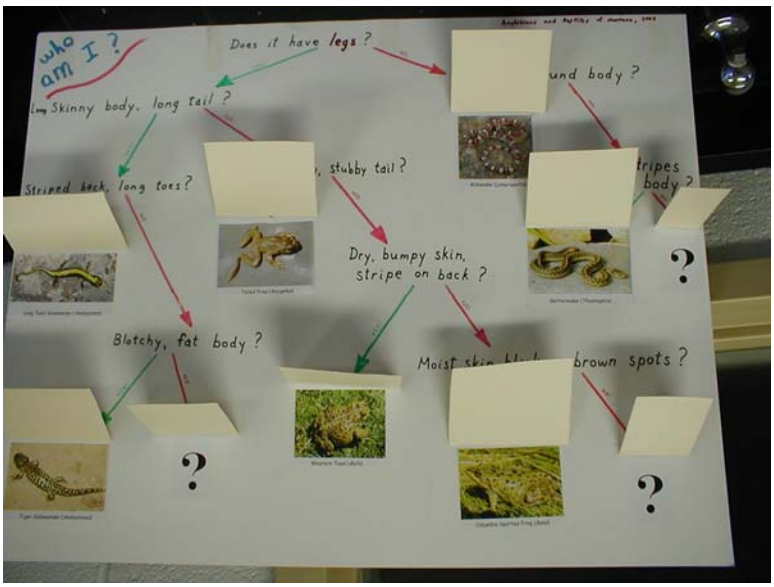

Figure 1. Example of a dichotomous key prepared to identify the mystery organism (which in this case was a spotted frog, lower right). The first question asks "Does it have legs?" *Yes* leads to salamanders and frogs, while *No* leads to snakes.

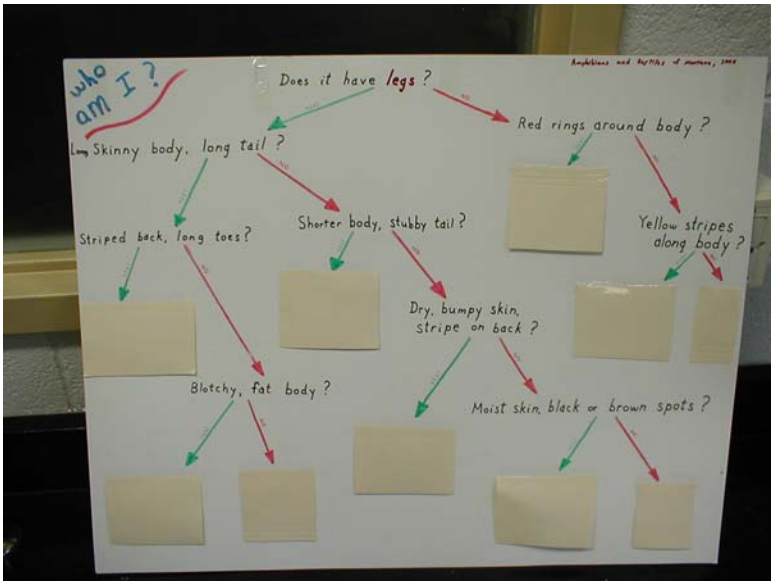

Figure 2. The same key as in Figure 1, with pictures and names covered with flaps of poster board.

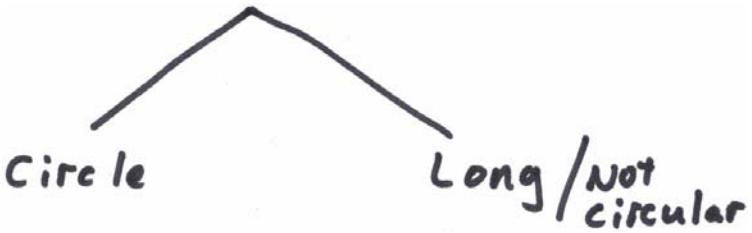

Figure 3. One possibility for the first division of nuts and bolts.

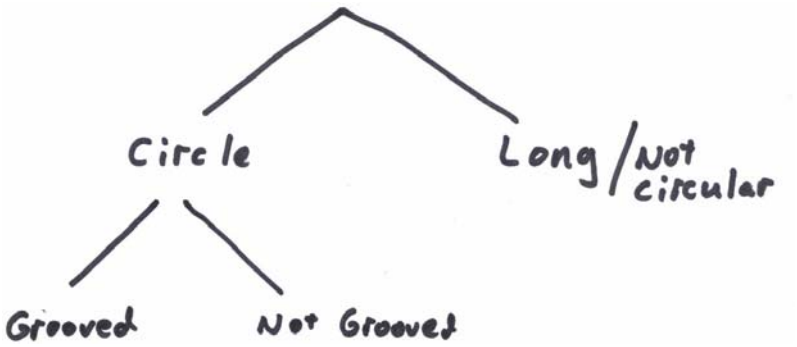

Figure 4. A possible division of circular objects in the nuts and bolts collection.

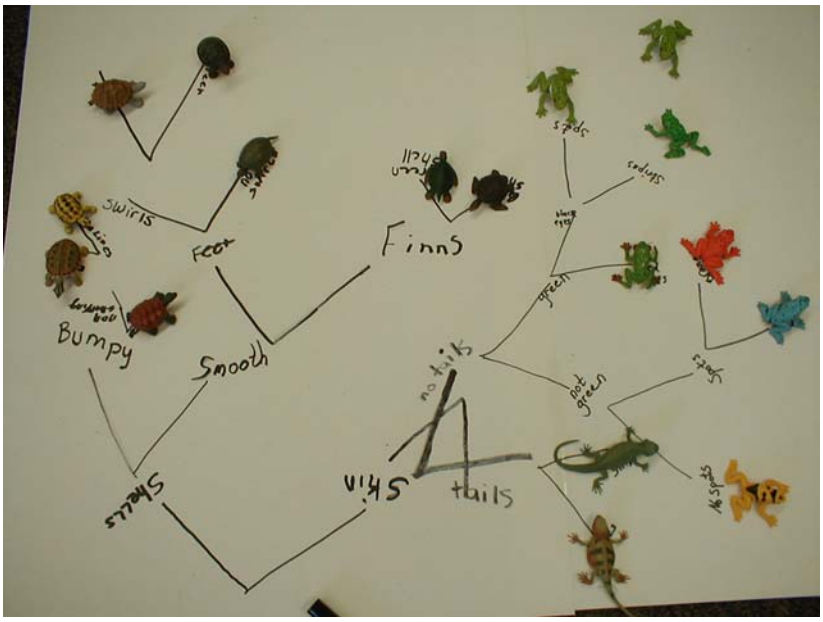

Figure 5. Creation of a dichotomous key using plastic reptiles and amphibians.

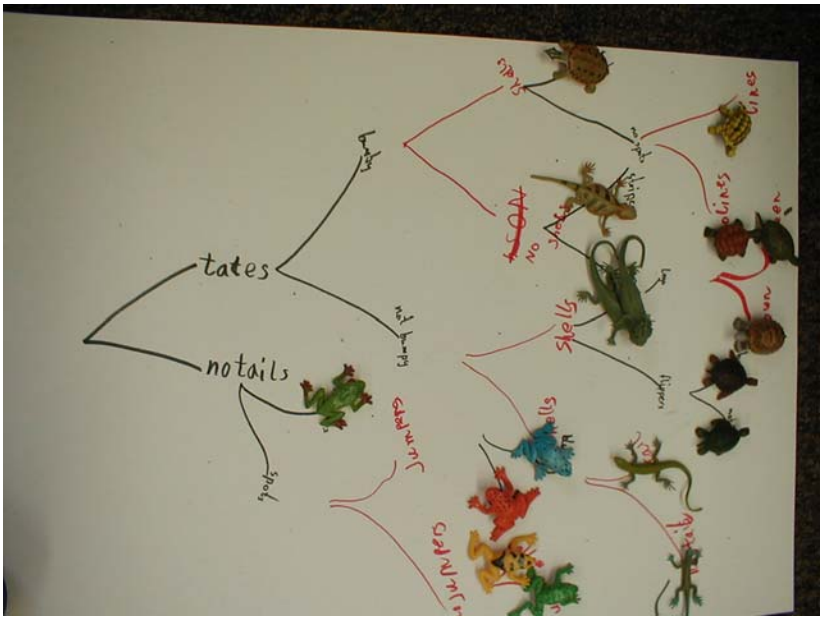

Figure 6. Another example, using similar plastic animals.