

## **Interactive Exploration of Kingdom Animalia Using the Animal Diversity Web**

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Cynthia Sims Parr received BS in biology from Cornell University and an MS and PhD from University of Michigan, where she studied social behavior and vocal communication in American crows. She studied molecular systematics and behavioral ecology of magpies during a postdoctoral fellowship at Seoul National University in Seoul, Korea. In her current position as the Content Development Director for the Animal Diversity Web, she uses web technology to help instructors at many institutions teach about animal ecology and evolution. She is particularly interested in combining sophisticated technology with the allure of natural history to help students improve their research, writing, and scientific inquiry skills.

Philip Myers has an undergraduate degree from Swarthmore College and a PhD from the University of California, Berkeley. He currently is an Associate Professor of Biology and Associate Curator of Mammals at the University of Michigan. His research interests are in the ecology and systematics of mammals. He began working with the World Wide Web as a means of doing a better job of delivering information about biodiversity to students in classes at University of Michigan, and was immediately entranced by the possibility of using the web both for building large databases and for using the databases for inquiry-based learning. He has also explored using the Animal Diversity Web as a means of making the contents of research museums available globally for teaching and research.

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## Introduction

Classrooms increasingly turn to the World Wide Web for their information needs. Material is available 24 hours a day at home or at public facilities, and can be updated quickly. College instructors now develop their own course web sites, but also augment their teaching with a variety of web-based programs, some of which require a subscription.

University of Michigan Museum of Zoology's Animal Diversity Web (ADW) is a free, interactive, multimedia web site offering natural history information on thousands of animals worldwide. Species-level text is written by college students who have read about their species but who are not necessarily expert biologists; text on higher levels is written by systematists. The site is enriched by images of live animals, still and spinning images of skulls representing almost all mammalian orders, and sounds from birds and frogs and other animals. Our database is organized hierarchically according to current animal taxonomy. It is also easily searched so that the information can be organized to suit any learner, whether they are looking for a virtual textbook, a virtual museum, or a virtual encyclopedia. College students across the United States use ADW as part of formal courses in non-majors and majors Introductory Biology, Mammalogy, Herpetology, Ornithology, Vertebrate Natural History, and Conservation Biology.

There are many ways to use ADW in college teaching. Instructors can use our images, sounds, or spinning skulls by cutting and pasting them into PowerPoint presentations. Students can follow hyperlinks to become familiar with the hierarchical organization and nomenclature of Kingdom Animalia. Students can use ADW to compile life lists of Phyla or other taxonomic levels. Several more lengthy exercise ideas are presented below. More information can be found at <http://animaldiversity.umich.edu/teach> behind the For Instructors link from our main page.

## Lab Exercises

### Activity 1 Question Authority

**Goal:** To improve critical thinking by questioning sources of information.

In-class activities for small discussion groups in a computer lab:

Animal Diversity Web has two main parts. First we have pages about higher taxonomic levels like Phyla, Classes, Orders, and Families. Second, we have species accounts. Who are the authors of the first part, and who are authors of the second part? What are their credentials? Do they cite their sources of information, or references?

Choose a species account and look at the references that are cited. Which kinds of references are likely to have higher quality information?

Go to one of the web sites in the references (that is, a web page that is not part of the Animal Diversity Web). Does this web site clearly state the author of the information, and the author's credentials? What sources did the author use? Can you tell if the information is current? Why is the author posting the information on the web? Can you find corroboration of this information in a book or in another web site?

Peruse the ICYouSee: T is for Thinking page, <http://www.ithaca.edu/library/Training/hott.html> in class, and complete the out-of-class activity.

Out-of-class activities:

Critique us: Look for errors in species accounts. Submit an error report to [adw\\_errors@umich.edu](mailto:adw_errors@umich.edu) that includes a citation for a credible reference that has the correct information.

Examine our bibliographies. Add to our bibliographies by searching indices in your college library such as Zoological Record or BIOSIS using scientific names. Annotate our existing references as well as the sources you found.

## Activity 2 Contribute species accounts

**Goals:** Learn natural history terminology, practice effective writing, practice choosing good sources and citing them, learn about conservation lists, learn about specific animals

Ask your students to submit species accounts as brief term papers or for extra credit. You might focus on species of local interest, introduced species, or endangered species. You might assign biomes to different groups of students and ask each team member to write about a species from a different class (e.g. bird, amphibian, fish, snail) specific to that biome. Or allow students to choose any animal for which we don't already have text. We have online tools to assist students in preparing and editing the report in our standard format, and to assist you in reviewing reports online. Once you feel the report is ready for publishing, you submit it to us and we do a final edit. Please contact us at [adw.zookeeper@umich.edu](mailto:adw.zookeeper@umich.edu) or go to <http://animaldiversity.ummz.umich.edu/teach/request.html> if you are interested in involving your course.

## Activity 3 Do-it-yourself phylogenetic analysis

**Goal:** Understand the techniques used in systematics.

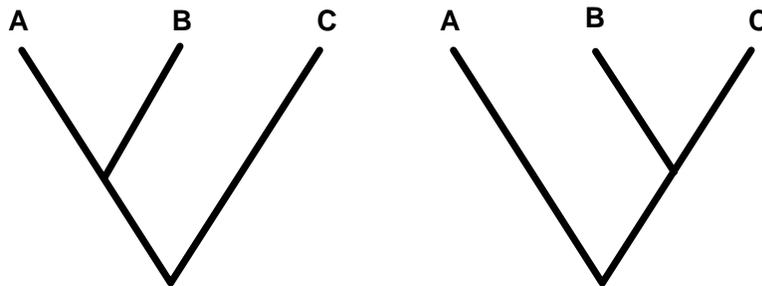
The ADW is organized hierarchically by animal classification. We can show the relationships among animals only by naming groups of related animals. In this exercise, we will try to get a little more specific and draw a family tree. Your data will be drawn from characteristics described in our text or visible in our images.

You will compare two methods used to construct trees, or phylogenies. In the *phenetic* method, overall similarity is used to group closely related animals. In the *cladistic* method, some similarities are not used because they are considered *primitive*. You wouldn't

want to use the characteristic “presence of a full coat of fur” to argue that house mice are more closely related to raccoons than to naked mole rats (a kind of rodent that mostly lacks hair, [http://animaldiversity.ummz.umich.edu/accounts/heterocephalus/h.\\_glaber](http://animaldiversity.ummz.umich.edu/accounts/heterocephalus/h._glaber)), because the presence of a full coat of fur is a characteristic originally shared by all mammals, except for a few lineages that have lost their fur. Instead, cladists argue you should use similarities that are unique to those species you are considering, different even from other closely related species. These are *synapomorphies*, shared derived characters.

Browse the Animal Diversity Web, <http://animaldiversity.ummz.umich.edu>, and choose a group of animals for which we have text or pictures for three or four species in the same genus, as well as a number of species in the same family as that genus. For example, try genus *Hyla* in the frog family Hylidae, genus *Graptemys* or genus *Pseudomys* in the turtle family Emydidae. Choose three of these species to work closely on, to make this exercise simple. If we had reason to believe that this group of species includes all species descended from a common ancestor, we would call this group of species a *clade*.

On a separate sheet of paper, draw the possible trees to describe relationships among your three species. If you have three species, there are only two possibilities, shown below in Figure 1. In your own drawing, replace Species A, Species B, and Species C with the actual species names. These are the hypotheses you will be testing.



**Figure 1.** Possible cladograms for three species.

Read through the accounts of your species. Find a set of characteristics that are described for each of the species in your dataset. These might be physical features, behavioral traits, size categories, food or habitat preferences. Make a table with the species listed in columns and the characteristics in rows. Try to find six to ten characteristics, or *characters*, that you can describe simply for all of your species, for example “eye color” or “diet.” Include both similarities and differences among your species, for example, two may have red eyes, while one may have brown eyes. Two may be carnivorous and the third may be herbivorous. These *character states* will be the data you use to test your hypothesis.

Use the *phenetic* approach to decide which of your two hypotheses is better supported. How many characters in your table support the grouping of A with B? How many characters support the grouping of B with C? How many characters are useless for your analysis? Look for more characters if you need them.

Use the *cladistic* approach to decide which of your two hypotheses is better supported. You will use only *synapomorphies* to compare your trees. To polarize your characters, or determine which are synapomorphies, you first need to make a “best guess” about the primitive condition of the character. To do this, systematists choose an *outgroup*,

that is one or more species that they believe are closely related to but outside the group of interest, and determine the state of the character in it. Let's pick something else in the same family as your group of interest, but from another genus, since we don't have enough background information to know the best outgroup. Score your characters for the outgroup. That is, add your outgroup species to your table and then fill in the character states for that species. Now, for your outgroup, put a 0 (zero) next to each character state. Look across the table at the character states in each row for the other species. If the character is the same as in your outgroup, also put a 0 next to the character state.

Now you are ready to test your hypotheses. Using only synapomorphies—those character states that DO NOT have zeros next to them, how many characters in your table support the grouping of A with B? How many characters support the grouping of B with C? How many characters are useless for your analysis?

If you don't have enough informative characters to decide between your hypotheses, look for more characters.

Pick a different outgroup and repeat the analysis. Does it make a difference in your results?

#### Discussion questions

1. What problems do you see with how we did all of the above analyses?
2. Did you choose your characters randomly? Did you stop choosing characters when you got the answer you expected?
3. Compare the phenetic method with the cladistic method. Why do cladists use only synapomorphies? Discuss the drawbacks of each method.
4. Consider what happens: When you have more than three species. When you have more than one outgroup. When you are using DNA sequences as your data.
5. Were your synapomorphies really unique? What happens if you have evolutionary convergence?

This problem would also work well with mammals. Students could use skull pictures at this level, but they could also work at family or maybe even ordinal levels by using information in the family and order descriptions (combined with the labeled photos provided for most mammal families).

### Activity 4

Inquiry-learning: Bat feeding adaptations

**Goal:** Learn and practice the scientific method: how to look for interesting patterns, frame hypotheses, and test them.

This exercise is used to accompany lectures about many of the ways in which mammals are adapted to their environments—for example, in their reproduction, physiology, and anatomy. Students are asked to write a brief paragraph or two on their findings and be prepared to discuss them.

We'd like you to do some exploring on the Animal Diversity Web, <http://animaldiversity.ummz.umich.edu>, to discover ways in which the anatomy of bats reflects (is adapted to) their feeding habits. Bats are an especially appropriate group for this study, because they include species with a great variety of diets — insects, fruit, pollen and nectar, meat, fish, and blood.

To do this assignment, you'll need to use the "advanced search" capability of the Animal Diversity Web. Restrict your searches to the order Chiroptera. The first search might, for example, be on diet = (fruit or frugivore). The result will be a list of links to accounts of bats whose diet includes mention of these items. Read the accounts. For example, you'll probably want to consider a species that eats mainly fruit, but also some insects, to be a fruit-eater -- even though it will appear in the diet = insect search as well as diet = fruit). Focus on the pictures of the live bats if available, and especially, any pictures of skulls and teeth. What traits do these fruit-eaters have in common? Then do a second search, this time for order = Chiroptera and diet = (insect or insectivore). Repeat for diet = (carnivore or meat), diet = blood, etc. What elements do you see in common among the insectivores? The fruit-eaters? Blood-drinkers? Pollen and nectar feeders? How do they differ from one another?

How to carry out the assignment: Click on the rhino on the ADW home page, which takes you to the Mammalia page. Scroll down to the list of orders, and click on Chiroptera. At the very top of the Chiroptera page on the left, you'll see "advanced search." Click on it. You'll get a search form with two empty boxes, each followed by a pair of scrolldown fields. In the first box enter "blood", and in the first scrolldown box on the first line go down to "food habits." Make sure that the second scrolldown field reads "and". In the second line enter "Chiroptera", and in the scrolldown field go to "Order". Click "search". You'll get a list of links to bats in the ADW whose "food habits" section mentions "blood." There's only one. Click on it and read about common vampires. At the top of the page, you'll see two "file tabs", one labeled "species account" and the other labeled "media." Click on the media tab to see skulls and teeth. (These images are thumbnails, so clicking on them results in a full-sized picture.) **IMPORTANT:** For queries with more than two lines, the order of the lines is critical. If you do it as described above (first set of lines describing what you're looking for in "food habits," last line specifying the Order Chiroptera), it will work.

Next, repeat the process using "insect", "food habits", and "or" in the relevant boxes on the first line; "insectivore", "food habits", and "and" in the second line, and "chiroptera" and "Order" in the third line (it doesn't matter what's in the third box). This query will give you a list of links to accounts of insect-eating bats, which you can read and scan for pictures.

Continue this search process for diet = (fruit or frugivore) and diet = (carnivore or meat), etc. You'll quickly discover that many species lack pictures of skulls (there may not even be a "media" tab), and that some lack species accounts. Ignore the ones that don't have the information you need. Look at the pictures and synthesize!