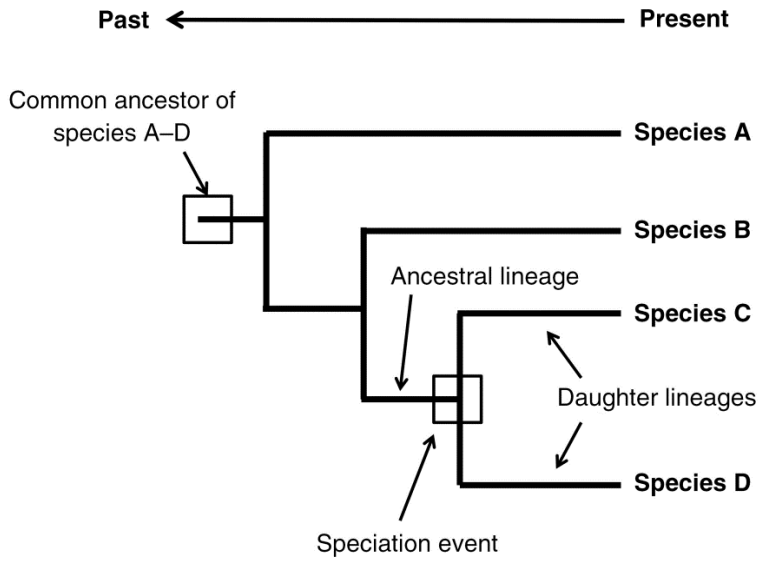
Lab 19. Phylogenetic Trees and the Classification of Fossils: How Should Biologists Classify the Seymouria?

Introduction

Biologists use *phylogenetic trees* to represent evolutionary relationships between species. A phylogenetic tree is a branching diagram that shows how various species are related to each other based on similarities and differences in their physical and/or genetic characteristics. The root of a phylogenetic tree represents a common ancestor, and the tips of the branches represent the descendants (Figure L19.1).

FIGURE L19.1

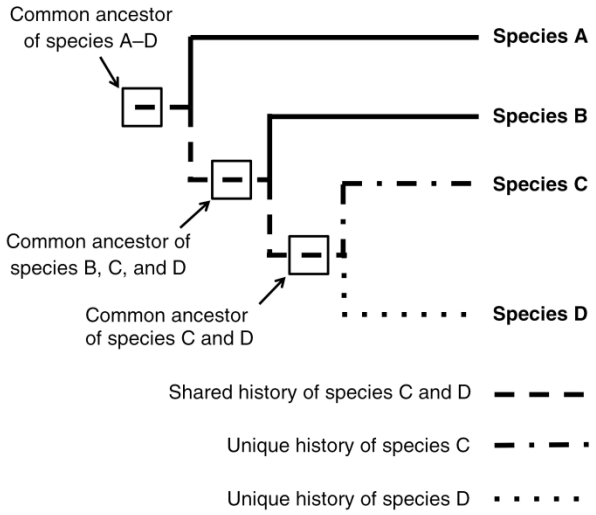
Components of a phylogenetic tree



As you move from the tips to the root of the tree, you are moving backward in time. The forks in the tree represent *speciation events*. When a speciation event occurs, a single species (or an *ancestral lineage*) gives rise to two new species (or two *daughter lineages*). Each species in a phylogenetic tree has a part of its history that is unique to that species and parts that are shared with other species (Figure L19.2, p. 324). Similarly, each species has ancestors that are unique to that species and ancestors that are shared with other species (see species C and D compared with species A and B in Figure L19.2).

FIGURE L19.2

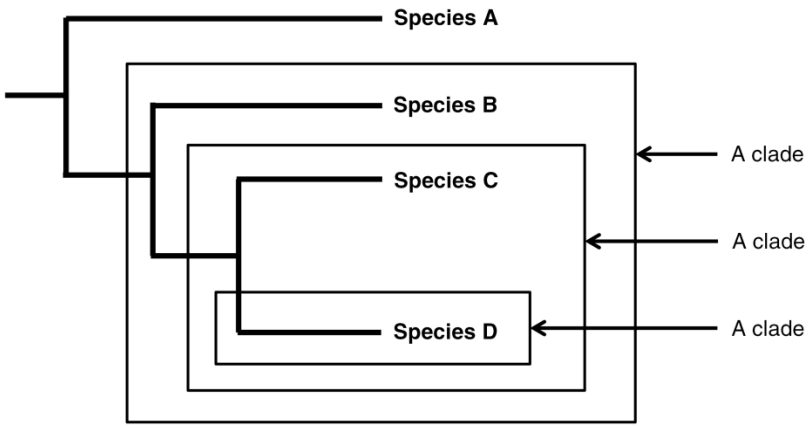
Evolutionary history in a phylogenetic tree



A *clade* is a grouping of species that includes a common ancestor and all the descendants (living and extinct) of that ancestor. Clades are nested within one another—biologists call this a *nested hierarchy*. A clade may include thousands of species or just a few. Some examples of clades at different levels are marked in the phylogenetic tree shown in Figure L19.3. Notice how clades are nested within larger clades.

FIGURE L19.3

Clades with a phylogenetic tree



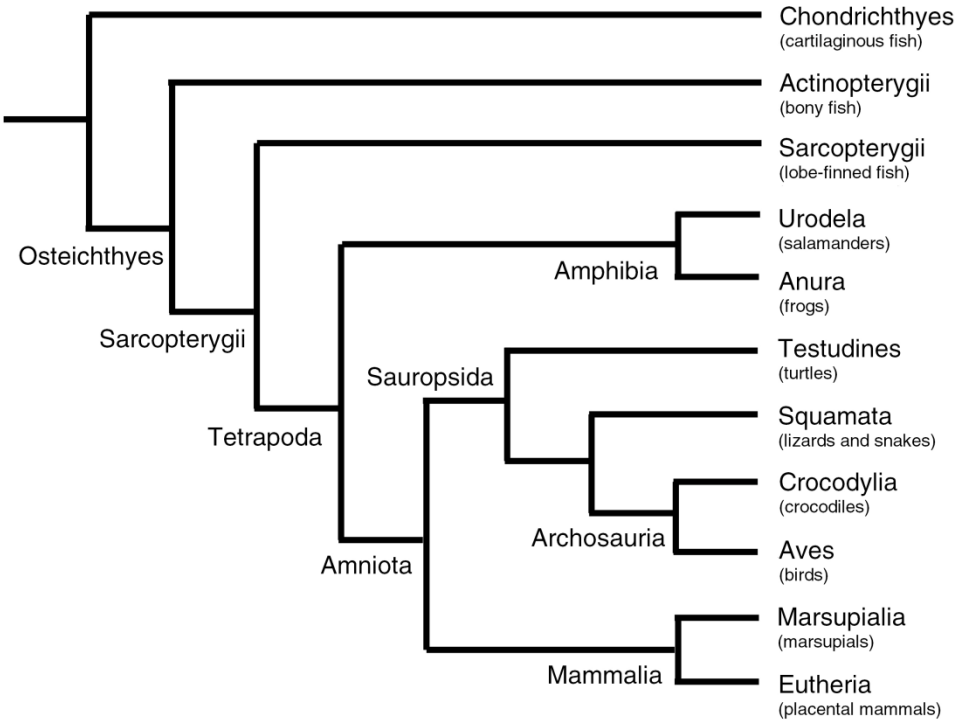
To create a phylogenetic tree, biologists collect data about the characters of organisms. Characters are heritable traits, such as physical features or genetic sequences, which can be compared across organisms. Biologists begin by examining representatives of each lineage to learn about their physical features, and they tend to look for specific features called *shared derived characters* when they create a phylogenetic tree. A shared derived character is one that developed or appeared at some point in the evolutionary history of an

organism and is shared by other closely related organisms but not by distantly related organisms. Biologists then use these features to group the organisms into less and less inclusive clades.

In addition to using phylogenetic trees to represent evolutionary relationships between organisms, biologists also use them as a system of classification. The phylogenetic classification system classifies species by clades rather than assigning every one to a kingdom, phylum, class, order, family, and genus like the Linnaean system of classification. Figure L19.4 provides the evolutionary history of some major types of vertebrates and includes the names of various clades that are used to classify vertebrate species.

FIGURE L19.4

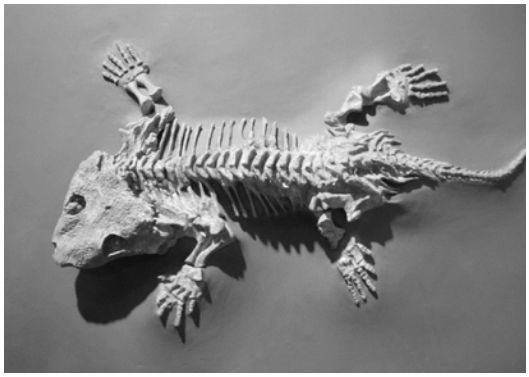
Vertebrate clades



When biologists find a fossil of an extinct organism, they can use phylogenetic trees to understand how it is related to other organisms and to help classify it. The classification of an extinct organism is often difficult, however, because fossils only provide limited information about the characteristics of the organism. To illustrate this point, you will attempt to classify an organism called the Seymouria (*Seymouria baylorensis*; Figure L19.5). The first fossil of the Seymouria was found in the early 1900s in Baylor County, Texas. The Seymouria was about 60 cm long and lived during the Permian Period (between 299 and 251 million years ago) throughout North America and Europe. The Seymouria has many features that make it difficult to classify. In this investigation, you will have a chance to examine the features of the Seymouria and the features of some representative species from different clades and then attempt to classify it.

FIGURE L19.5

Seymouria



Your Task

Use skeletons from vertebrates belonging to four clades (Anura, Squamata, Aves, and Eutheria), what you know about phylogenetic classification, and the characteristics of vertebrate clades to classify the Seymouria.

The guiding question of this investigation is, **How should biologists classify the Seymouria?**

Materials

You may use any of the following materials during your investigation:

- Seymouria fossil
- Frog skeleton (Anura)
- Lizard skeleton (Squamata)
- Pigeon skeleton (Aves)
- Bat skeleton (Eutheria)
- Rat skeleton (Eutheria)

Safety Precautions

Follow all normal lab safety rules. In addition, take the following safety precautions:

- Use caution in handling skeletons. They can have sharp edges, which can cut skin.
- Wash hands with soap and water after completing the lab activity.

Investigation Proposal Required? ☐ Yes ☐ No

Getting Started

To answer the guiding question, you will need to compare and contrast the features of the five modern vertebrate skeletons with the Seymouria fossil. You will be supplied with either actual specimens or images of them. You must determine what type of data you need to collect from these specimens, how you will collect the data, and how you will analyze the data. To determine *what type of data you need to collect*, think about the following questions:

- Which of the modern animals are more closely related to each other?
- What are the characteristics that biologists use to group organisms into vertebrate clades?
- Which characteristics of the specimens will you need to examine?
- How many different characteristics of the specimens will you need to examine?

To determine *how you will collect the data*, think about the following questions:

- How will you quantify differences and similarities in specimens?
- How will you make sure that your data are of high quality?
- What will you do with the data you collect?

To determine *how you will analyze your data*, think about the following questions:

- How will you compare and contrast the various specimens?
- What type of graph or table could you create to help make sense of your data?

Connections to Crosscutting Concepts, the Nature of Science, and the Nature of Scientific Inquiry

As you work through your investigation, be sure to think about

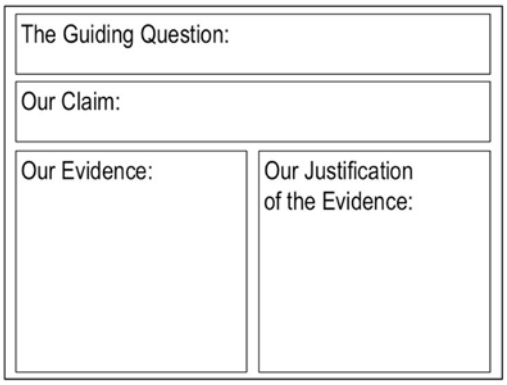
- the importance of looking for patterns in science,
- the relationship between structure and function in nature,
- the difference between observations and inferences in science, and
- how scientific knowledge changes over time.

Initial Argument

Once your group has finished collecting and analyzing your data, you will need to develop an initial argument. Your argument must include a claim, evidence to support your claim, and a justification of the evidence. The claim is your group's answer to the guiding question. The evidence is an analysis and interpretation of your data. Finally, the justification of the evidence is why your group thinks the evidence matters. The justification of the evidence is important because scientists can use different kinds of evidence to support their claims. Your group will create your initial argument on a whiteboard. Your whiteboard should include all the information shown in Figure L19.6.

FIGURE L19.6

Argument presentation on a whiteboard



Argumentation Session

The argumentation session allows all of the groups to share their arguments. One member of each group will stay at the lab station to share that group's argument, while the other members of the group go to the other lab stations one at a time to listen to and critique the arguments developed by their classmates. This is similar to how scientists present their arguments to other scientists at conferences. If you are responsible for critiquing your classmates' arguments, your goal is to look for mistakes so these mistakes can be fixed and they can make their argument better. The argumentation session is also a good time to think about ways you can make your initial argument better. Scientists must share and critique arguments like this to develop new ideas.

To critique an argument, you might need more information than what is included on the whiteboard. You will therefore need to ask the presenter lots of questions. Here are some good questions to ask:

- What did your group do to analyze the data? Why did your group decide to analyze it that way?
- What other ways of analyzing and interpreting the data did your group talk about?
- Why did your group decide to present your evidence in that way?
- Why did your group abandon the other explanations?
- How sure are you that your group's claim is accurate? What could you do to be more certain?

Once the argumentation session is complete, you will have a chance to meet with your group and revise your initial argument. Your group might need to gather more data as part of this process. Remember, your goal at this stage of the investigation is to develop the best argument possible.

Report

Once you have completed your research, you will need to prepare an investigation report that consists of three sections that provide answers to the following questions:

1. What question were you trying to answer and why?
2. What did you do during your investigation and why did you conduct your investigation in this way?
3. What is your argument?

Your report should answer these questions in two pages or less. The report must be typed, and any diagrams, figures, or tables should be embedded into the document. Be sure to write in a persuasive style; you are trying to convince others that your claim is acceptable or valid!