18–2 Modern Evolutionary Classification

In a sense, organisms determine who belongs to their species by choosing with whom they will mate! Taxonomic groups above the level of species are "invented" by researchers who decide how to distinguish between one genus, family, or phylum, and another. Linnaeus and other taxonomists have always tried to group organisms according to biologically important characteristics. Like any taxonomic system, however, Linnaeus's system had limitations and problems.

Which Similarities Are Most Important?

Linnaeus grouped species into larger taxa, such as genus and family, mainly according to visible similarities and differences. But which similarities and differences are most important? If you lived in Linneaus's time, for example, how would you have classified dolphins? Would you have called them fishes because they live in water and have finlike limbs? Or would you call them mammals because they breathe air and feed their young with milk? How about the animals shown in **Figure 18–6**? Adult barnacles and limpets live attached to rocks and have similarly shaped shells with holes in the center. Crabs, on the other hand, have body shapes unlike those of barnacles or limpets. Based on these features, would you place limpets and barnacles together, and crabs in a different group?

Guide for Reading

Key Concepts

- How are evolutionary relationships important in classification?
- How can DNA and RNA help scientists determine evolutionary relationships?

Vocabulary

phylogeny
evolutionary classification
derived character
cladogram
molecular clock

Reading Strategy: Predicting Before you read, preview **Figure 18–7.** Predict how the field of taxonomy has changed since Linnaeus's time. As you read, note whether or not your prediction was correct.

Figure 18–6 Classifying species based on easily observed adult traits can pose problems. Observe the crab (top left), barnacles (bottom left), and limpet (right). Which seem most alike? **Asking Questions** *What additional information might you gather to help inform your decision?*

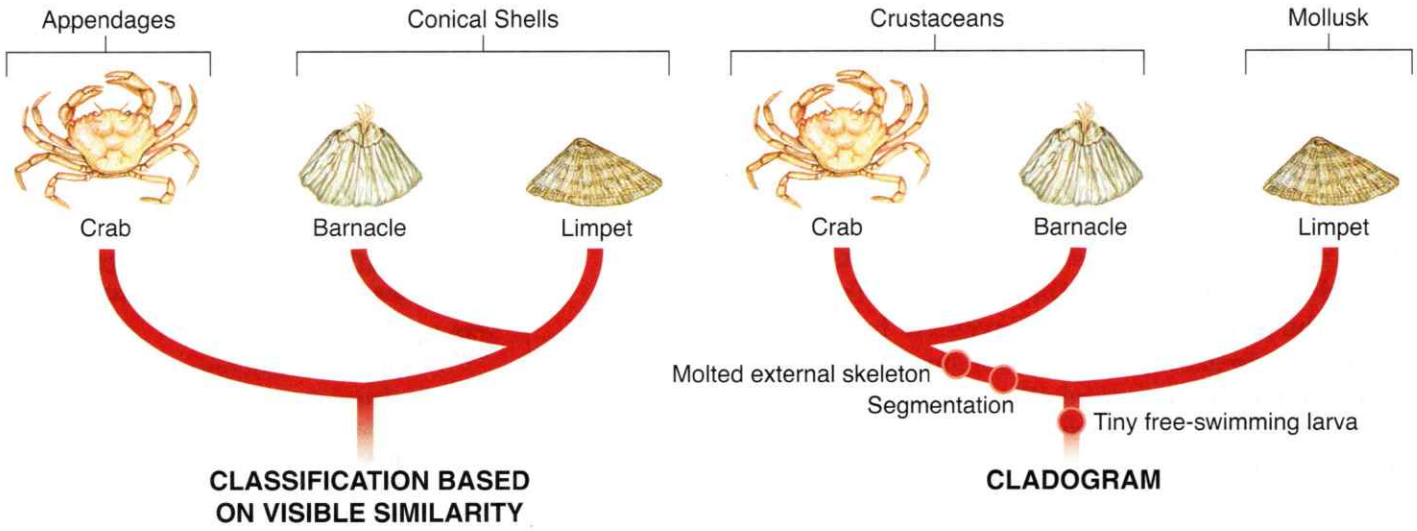

Figure 18–7 Early systems of classification grouped organisms together based on visible similarities. That approach might result in classifying limpets and barnacles together (left). **Biologists now group organisms into categories that represent lines of evolutionary descent, or phylogeny, not just physical similarities.** Crabs and barnacles are now grouped together (right) because they share several characteristics that indicate that they are more closely related to each other than either is to limpets. These characteristics include segmented bodies, jointed limbs, and an external skeleton that is shed during growth.

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Evolutionary Classification

Darwin's ideas about descent with modification have given rise to the study of **phylogeny,** or evolutionary relationships among organisms. **Biologists now group organisms into categories that represent lines of evolutionary descent, or phylogeny, not just physical similarities.** The strategy of grouping organisms together based on their evolutionary history is called **evolutionary classification.**

Species within a genus are more closely related to one another than to species in another genus. According to evolutionary classification, that is because all members of a genus share a recent common ancestor. Similarly, all genera in a family share a common ancestor. This ancestor is further in the past than the ancestor of any genus in the family but more recent than the ancestor of the entire order. The higher the level of the taxon, the further back in time is the common ancestor of all the organisms in the taxon.

Organisms that appear very similar may not share a recent common ancestor. Natural selection, operating on species in similar ecological environments, has often caused convergent evolution. For example, superficial similarities once led barnacles and limpets to be grouped together, as shown on the left in **Figure 18–7.**

However, barnacles and limpets are different in important ways. For example, their free-swimming larvae, or immature forms, are unlike one another. Certain adult characteristics are different too. Adult barnacles have jointed limbs and a body divided into segments. Barnacles periodically shed, or molt, their external skeleton. These characteristics make barnacles more similar to crabs than to limpets. Limpets, in turn, have an internal anatomy that is closer to that of snails, which are mollusks. And like mollusks, limpets do not shed their shells. Because of such characteristics, taxonomists infer that barnacles are more closely related to crabs than to mollusks. In other words, barnacles and crabs share an evolutionary ancestor that is more recent than the ancestor that barnacles share with limpets. Thus, both barnacles and crabs are classified as crustaceans, and limpets are mollusks.

Classification Using Cladograms

To refine the process of evolutionary classification, many biologists now prefer a method called cladistic analysis. Cladistic analysis identifies and considers only those characteristics of organisms that are evolutionary innovations—new characteristics that arise as lineages evolve over time. Characteristics that appear in recent parts of a lineage but not in its older members are called **derived characters.**

Derived characters can be used to construct a **cladogram,** a diagram that shows the evolutionary relationships among a group of organisms. You can see an example of a cladogram on the right-hand side of **Figure 18–7.** Notice how derived characters, such as "free-swimming larva" and "segmentation," appear at certain locations along the branches of the cladogram. These locations are the points at which these characteristics first arose. You can see that crabs and barnacles share some derived characters that barnacles and limpets do not. One such shared derived character is a segmented body. Another is a molted external skeleton. Thus, this cladogram groups crabs and barnacles together as crustaceans and separates them from limpets, which are classified as a type of mollusk.

Cladograms are useful tools that help scientists understand how one lineage branched from another in the course of evolution. Just as a family tree shows the relationships among different lineages within a family, a cladogram represents a type of evolutionary tree, showing evolutionary relationships among a group of organisms.

CHECKPOINT *What is a cladogram?*

Quick Lab

How is a cladogram constructed?

Procedure

1. Identify the organism in the table that is least closely related to the others.
2. Use the information in the table to construct a cladogram of these animals.

Derived Characters in Organisms

Organism	Derived Character		
	Backbone	Legs	Hair
Earthworm	Absent	Absent	Absent
Trout	Present	Absent	Absent
Lizard	Present	Present	Absent
Human	Present	Present	Present

Analyze and Conclude

1. **Using Tables and Graphs** What trait separates the least closely related organism from the other animals?
2. **Classifying** List the animals in your cladogram in order of distance from the least closely related organism.
3. **Drawing Conclusions** Does your cladogram indicate that lizards and humans share a more recent common ancestor than either does with an earthworm? Explain.
4. **Inferring** Where would you insert a frog if you added it to the cladogram? Explain your answer.