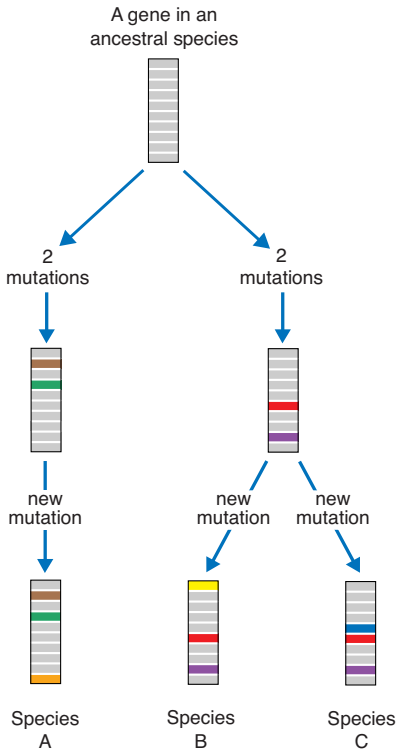
Molecular Clocks

Comparisons of DNA can also be used to mark the passage of evolutionary time. A model known as a **molecular clock** uses DNA comparisons to estimate the length of time that two species have been evolving independently. To understand molecular clocks, think about a pendulum clock. It marks time with a periodically swinging pendulum. A molecular clock also relies on a repeating process to mark time—mutation.

Simple mutations occur all the time, causing slight changes in the structure of DNA, as shown in **Figure 18–9.** Some mutations have a major positive or negative effect on an organism's phenotype. These mutations are under powerful pressure from natural selection. Other mutations have no effects on phenotype. These neutral mutations accumulate in the DNA of different species at about the same rate. A comparison of such DNA sequences in two species can reveal how dissimilar the genes are. The degree of dissimilarity is, in turn, an indication of how long ago the two species shared a common ancestor.

The use of molecular clocks is not simple, however, because there is not just one molecular clock in a genome. Instead, there are many, each of which "ticks" at a different rate. This is because some genes accumulate mutations faster than others. These different clocks allow researchers to time different kinds of evolutionary events. Think of a conventional clock. If you want to time a brief event, you pay attention to the second hand. To time an event that lasts longer, you use the minute hand or the hour hand. In the same way, researchers would use a different molecular clock to compare modern bird species than they would to estimate the age of the common ancestor of yeasts and humans.



▲ **Figure 18–9** By comparing the DNA sequences of two or more species, biologists estimate how long the species have been separated. **Analyzing Data** ***What evidence indicates that species C is more closely related to species B than to species A?***

18–2 Section Assessment

1. **Key Concept** How is information about evolutionary, or phylogenetic, relationships useful in classification?
2. **Key Concept** How are genes used to help scientists classify organisms?
3. What is the principle behind cladistic analysis?
4. What gene indicates that yeasts and humans share a common ancestor?
5. Describe the relationship between evolutionary time and the similarity of genes in two species.
6. **Critical Thinking** **Inferring** Would a barnacle's DNA be more similar to the DNA of a crab or that of a limpet? Explain.

Thinking Visually

Constructing a Chart

Draw a cladogram of a manufactured item, such as an automobile or a household item, that has changed over the years. Label derived characters that appeared as new models arose. For example, automobiles came to have electronic fuel injection and antilock brakes.

18–2 Section Assessment

1. Organisms are placed in various taxonomic groups based on evolutionary descent.
2. Scientists compare the DNA of different organisms to establish similarities between them and reconstruct possible evolutionary relationships.
3. Cladistic analysis traces the process of evolution in a group of organisms by focusing on unique features that appear in some organisms but not in others.
4. A gene that codes for the protein myosin
5. The longer it has been since two species descended from a common ancestor, the more different their genes are likely to be.
6. It would be more similar to the DNA of a crab, because barnacles and crabs have a closer evolutionary relationship.

Molecular Clocks

Use Visuals

Figure 18–9 Have students examine the figure. Then, ask: **Why do biologists study mutations in genes that do not code for essential proteins?** *(Those mutations occur in different species at about the same rate, and they can be used as a basis for comparison.)* L1 L2

3 ASSESS

Evaluate Understanding

Have students make a Venn diagram to show similarities and differences between traditional classification diagrams and cladograms.

Reteach

Call on students to explain in their own words what molecular clocks are, how they are used, and why some molecular clocks "tick" at different rates. Correct any errors or misunderstandings.

Thinking Visually

Students should draw a cladogram based on several derived characteristics of a type of manufactured item. Instead of the automobile, they might choose the television, video game, or camera. Their diagrams should show the order in which innovations were developed in the item they chose. For example, a cladogram for the television might show that this item first acquired colored pictures, then solid-state circuitry, and then remote controls.

Interactive Textbook

If your class subscribes to the iText, use it to review the Key Concepts in Section 18–2.

Answer to . . .

Figure 18–9 *The DNA molecules in species B and C show two common mutations that do not appear in the DNA in species A.*