

What could cause major environmental changes, and why would they lead to spurts in evolution? The fossil record shows that drastic environmental changes have occurred very infrequently, separated by quiet periods that often last tens of millions of years. Events such as volcanic eruptions, asteroid impacts, and ice ages have been linked to sudden and drastic changes in climates, both locally and across the entire planet. Such changes have also been linked to the extinction of many groups of organisms. As a result, habitats that were once occupied became vacant and provided opportunities for colonization by species that could rapidly adapt to the new conditions through natural selection.

A prediction that can be made using the punctuated equilibrium model is that the fossil record should be very discontinuous. Is this prediction supported by evidence? There is considerable disagreement among biologists on this point, and the discussion continues. Of course, large gaps in the fossil record exist as a result of erosion and other destructive geologic processes. However, the fossil record seems to provide evidence of both types of evolution. Many groups of organisms appear suddenly in the fossil record. Some of these groups remain virtually unchanged for millions of years, while other groups disappear as suddenly as they appear. Still other groups of organisms change gradually through time, as predicted by the gradualism model. More careful study of the fossil record may reveal additional examples of both types of evolution. □

### □ CAPSULE SUMMARY

*Gradualism is the model of evolution in which change occurs gradually over time. Punctuated equilibrium is the model of evolution in which change occurs in spurts separated by long periods of equilibrium.*

## Section Review

1. How does the fossil record indicate that macroevolution has occurred?
2. What is a common ancestor?
3. What do the similarities in the development of vertebrate embryos indicate about vertebrates?
4. How does the punctuated equilibrium model of evolution differ from the gradualism model?

### Critical Thinking

5. Why do fishes and mammals have more nucleotide sequence differences in their genes for a particular protein than do reptiles and mammals?
6. How are the wings of the flightless cormorant seen in Figure 12-13 homologous to the limbs of other vertebrates? Why are they considered vestigial structures?
7. Does acceptance of the punctuated equilibrium model mean that the gradualism model of evolution must be totally rejected? Why or why not?

## Answers to Section Review

1. Answers will vary but could state that many life-forms that lived in the past have been replaced by those living today. This record also shows a gradual progression in the complexity of life—from the oldest rocks to the youngest rocks—and many examples of transitions from one form to another.
2. A common ancestor is a species from which two or more species diverged.
3. These similarities indicate that all vertebrates had a common ancestor.
4. Punctuated equilibrium states that evolution occurs in spurts; gradualism states that evolution occurs at a slow, even rate.
5. Fishes are more distantly related to mammals than to reptiles, and thus fishes and mammals have more nucleotide sequence differences.
6. The wings are homologous to forelimbs of other vertebrates because they have the same types of bones, and they are vestigial because they are too small to enable the cormorant to fly.
7. No. Evidence suggests that both operate at the same time.

## ✓ RESEARCH Update

### Evolution in Suburban Backyards?

Life is short in the backyard environment. It is the scene of repeated slaughter by both native predators and domestic pets, especially cats. Robert Garrot and P. J. White of the University of Washington and Callie Vanderbilt at the University of California at Davis contend that suburbs are, evolutionarily, new habitats, which tend to quickly become populated by opportunistic species. These ecologists point out that while conservationists bemoan the negative impact of invasions by foreign species on native species, they seem to ignore equally devastating invasions by indigenous species.

According to these concerned scientists, indigenous invaders are more than just pests. Indigenous species that adapt well are often responsible for forcing out species that do not adapt as well. While the construction of suburban areas destroys the habitats of many species, construction of houses, yards, and storm sewers creates new habitats in which adaptable populations thrive. As populations of "tough" species (raccoons, crows, etc.) increase, they prey on or otherwise force out "weaker" or less adaptable species, which may include rare plants or insects on which other rare species feed. This creates a chain reaction that may affect several species. Ecologists wonder what's going to happen as more natural habitats disappear. ✓