Discussions that ensue from thought-provoking questions provide a good way to assess the overall depth of student understanding. The following are some suggested discussion questions.

1. Discuss why evolution occurs so slowly, making sure to mention the fact that genetic mutations occur within individuals of a population and are spread only when those organisms with the mutation successfully reproduce.
2. Talk about why some creatures, like sea urchins and cockroaches, have changed very little over millions of years, while other animals have become extinct or have changed dramatically.
3. Talk about the unique characteristics of DNA molecules that lead scientists to call DNA the "instruction manual" for all known life forms.

Follow-up Activities

- Create an evolutionary time line in the school hallway, giving each student the responsibility of choosing a topic within a certain time period to research and illustrate.
- Assign a hypothetical male and female animal couple a basic dominant and recessive trait. For example, a certain fish species could possess dominant genes for red coloring (R), and recessive genes for blue coloring (r). Explain that the presence of one or two dominant genes will result in a red fish, but that in order to be blue, both genes must be recessive. Have students set up a Punnett square to calculate the probability of colors for offspring of a blue female (rr) and a red male with one red parent and one blue parent (Rr). When finished, ask the students if they can explain the rare appearance of a single purple fish.
- As a group, have students make a list of traits that animals get from their parents, those they do not get from their parents and those that they are unsure about. Have them research some of these traits and continue to refine their list.

Please Note: this activity and the experiment presented in the show both rely on knowledge about the genetic relationship between a child and his or her birth parents. Please be aware of the sensitivity of such activities when choosing to present them in your class.

Internet Resources

- **www.amnh.org/Exhibition/Expedition/Fossils/index.html**
  The American Museum of Natural History presents an online expedition, telling the story of vertebrate evolution through graphic time lines and informative passages.
- **emporium.turnpike.net/~mscott/index.htm**
  "Strange Science" chronicles how modern scientists reached many of the conclusions we have today, while reviewing some of the mistakes made by early scientists.
- **www.terraquest.com/galapagos/**
  "Virtual Galapagos" chronicles an extraordinary exploration of the natural and human history of Ecuador and the Galapagos Islands. ***(Continued)***

- **www.zoomdinosaurs.com/subjects/mammals/Iceagemammals.shtml**
  This Zoom School site is a great place for students to start researching dinosaur and mammal evolution.
- **www.thetech.org/exhibits_events/online/genome/**
  This site, developed by the Electronic Publishing Instructional Curriculum group at UC Santa Cruz is an excellent online exhibit that explains why DNA is the instruction manual for all life.

Suggested Print Resources

- Dal Sasso, Cristiano. *Animals: Origins and Evolution.* Raintree Steck-Vaughn, Austin, TX; 1995.
- Gamlin, Linda. *Evolution.* Dorling Kindersley, New York, NY; 1993.
- Giblin, James. *The Mystery of the Mammoth Bones and How it Was Solved.* HarperCollins, New York, NY; 1999.
- Parker, Steve. *Charles Darwin and Evolution.* Chelsea House, New York, NY; 1995.

TEACHER'S GUIDE CONSULTANT

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TITLES

- AMPHIBIANS
- ANIMAL ADAPTATIONS
- ANIMAL BEHAVIOR & COMMUNICATION
- ANIMAL CLASSIFICATION
- ANIMAL INTERDEPENDENCY
- ANIMAL LIFE CYCLES
- ANIMAL NEEDS
- BIRDS
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- EVOLUTION
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- INSECTS & OTHER ARTHROPODS
- MAMMALS
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ANIMAL LIFE IN ACTION™

Evolution

Grades 5–8

Students in grade 5-8 classrooms possess a wide range of background knowledge. Student response to this video program is sure to be varied, so the teachers for these grades need all the help they can get! This guide has been designed to help science teachers in grades 5-8 by providing a brief synopsis of the program, pre-viewing and follow-up questions, activities, vocabulary and additional resources.

Before Viewing: Extensive research tells how important it is for the teacher to discover what the students know — or think they know — about a topic, before actually starting a new unit. Therefore, after prompting discussion with the pre-viewing questions, lead your class to create a "Everything We Think We Know About…" list. You may also wish to preview key vocabulary words, and have students raise additional questions they hope will be answered.

After Viewing: Have your students share video excerpts that fascinated or surprised them, then challenge your students to prove or disprove the accuracy of the facts they put on their "Everything We Think We Know About…" list. Discuss what else they learned and use the follow-up questions and activities to inspire further discussion. Encourage students to research the topic further with the Internet and reading resources provided.

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Program Summary

According to the theory of evolution, prior to the appearance of bacteria and other simple organisms around four billion years ago, the planet was a chemical slush of floating atoms. Randomly, atoms combined to form molecules and chemical compounds with distinct structures. One of the unique chemical structures that formed is the basic building block for all life as we know it — deoxyribonucleic acid, or DNA. Simple organisms containing DNA had the ability to replicate themselves, and did so in great numbers. Minor changes in DNA led to changes in the structure and behavior of these organisms, and over millions and millions of years, led to new and different life forms. In order to understand the changes that have taken place over the last 4.6 billion years, scientists have organized the Earth's past into an evolutionary time line.

Prior to the Cambrian Period, which began about 600 million years ago, life forms consisted of bacteria and other simple, soft-bodied organisms living in the oceans. The Cambrian Period is known as the Age of Invertebrates, with marine animals like trilobites, sponges and early worms in abundance. Slight changes, or mutations, in the DNA of these animals continued to occur, and the variations that these caused resulted in the evolution of more complex life forms like fish. Ancient fossil evidence shows that by 350 million years ago, during the Carboniferous Period, insects had developed and the first vertebrates had crawled out of the vast oceans and adapted to land. Some of these animals slowly continued to change over millions of years, developing into reptiles that spread rapidly and led to the evolution of dinosaurs and mammals in the Triassic Period. Dinosaurs dominated the Earth through the Jurassic Period from at least 200 million years ago until they disappeared abruptly at the end of the Cretaceous Period, around 67 million years ago.

Scientists believe that the extinction of dinosaurs occurred because they could not adapt to major climate changes that occurred. One group of animals that did have the genetic adaptations to survive such a drastic change was mammals. They thrived without much competition and evolved in great variation. At the start of the Quaternary period, primates appeared, leading eventually to the evolution of humans. The key to this evolution is the DNA that makes up genes, and how these genes are expressed as traits, or characteristics, in a population. Humans receive two sets of genes, one from the father and one from the mother, and sometimes they are not both expressed as traits. There are dominant and recessive genes, and using a chart called a Punnett square, one can figure out the probability of certain traits appearing in the offspring of individuals.

Vocabulary

The following words are included for teacher reference or for use with students. They are listed in the order in which they appear in the video.

evolution — A theory that all types of living organisms have their origin in other preexisting types and that the differences among them are due to small changes in individual animals over many generations.

DNA — (deoxyribonucleic acid) A specialized molecule that contains genetic information and can make exact copies of itself; this property makes DNA molecules the building blocks of life, allowing characteristics to be passed from parents to offspring.

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bacteria — One-celled organisms that have been in existence for three quarters of the Earth's history and have adapted to almost every habitat.

variations — Small differences in characteristics among animals of the same species, brought about by genetic mutations.

Cambrian Period — Known as the Age of Invertebrates, from around 550 to 500 million years ago, when marine organisms such as sponges, early worms and trilobites lived in the Earth's oceans.

trilobites — Extinct three-lobed arthropods that dominated the oceans during the Cambrian Period.

Carboniferous Period — The time period, around 350 million years ago, when insects became dominant and vertebrates such as amphibians moved from the water onto land.

Permian Period — The time period around 300 to 250 million years ago, occurring from the end of the Carboniferous Period until the beginning of the Triassic.

Triassic Period — The period of time during which reptiles and the first mammals evolved, over 200 million years ago.

Jurassic Period — Around 200 to 150 million years ago; the time of the dinosaurs and mammals related to horses and elephants.

Cretaceous Period — The period of time from around 150 million years ago, when dinosaurs dominated the Earth, until 67 million years ago, when they abruptly disappeared.

Quaternary Period — The modern age, dating back one million years when primates, such as apes and humans, evolved.

mutation — The random changes in the pattern of DNA, which changes traits from parents to offspring.

gene — A specific sequence of DNA that contains information which determines a given trait for an organism. Dominant traits, like brown eye color, overcome recessive traits, like blue eye color.

Punnett square — A chart that is used to calculate the probability of certain traits passing from parents to offspring.

Charles Darwin — (1809–1882 CE) The naturalist known as the Father of Evolution, credited with developing the theory of natural selection.

natural selection — The theory that changes, or variations, in an animal's characteristics are caused by mutations. Some of these changes give the animal an advantage in surviving and reproducing, and these changes are passed to offspring. Over time, this leads to the creation of new species.

survival of the fittest — The idea that the animals with the best adaptations for a given environment will survive and reproduce. As the environment changes, the adaptations that are considered "fit" change as well.

Pre-viewing Discussion

Before students generate their list of "Everything We Think We Know About…" for this topic, stimulate and focus their thinking by raising these questions so that their list will better reflect the key ideas in this show:

1. What is evolution?
2. How old is the Earth?

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3. How long have humans been in existence?
4. What is a mutation?

After the class has completed their "Everything We Think We Know About…" list, ask them what other questions they have that they hope will be answered during this program. Have students listen closely to learn if everything on their class list is accurate and to hear if any of their own questions are answered.

Focus Questions

1. How do fossils provide scientists with information?
2. What is the theory of evolution?
3. What was the Earth like four billion years ago?
4. What feature of deoxyribonucleic acid (DNA) makes it important in the reproduction of cells?
5. What are variations? How do they occur?
6. What period is known as the Age of Invertebrates? What are some animals that existed during that time?
7. What types of animals were present in the Carboniferous Period?
8. What kinds of animals evolved from amphibians?
9. When did the first mammals appear?
10. What was unique about the Jurassic Period?
11. What do some scientists think happened to the dinosaurs?
12. Why were mammals able to survive the great extinctions that occurred during the Cretaceous Period?
13. What large mammals had relatives living in the Tertiary Period?
14. What features did animals need to survive in the Quaternary Period?
15. What discoveries can we make by studying fossils?
16. What is paleontology?
17. How does extinction occur?
18. How does DNA mutate? What is the result of these mutations?
19. What are some examples of physical traits? How are these determined by DNA?
20. What is the difference between a dominant and a recessive gene?
21. What is a Punnett square? Why is it useful?
22. Who was Charles Darwin? What concepts did he help develop?

Follow-up Discussion

Research indicates that students will retain their previous misconceptions about a topic, in preference to new information, until they actively recognize and correct their own errors. Therefore, it is important to have your students re-examine the facts/beliefs they put on their "Everything We Think We Know About…" list. It might also be helpful to review the list by marking each entry with a "+" or "-" to show which facts were correct and which were incorrect.

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