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Learning Modules – Dinosaurs in Living Color

What is a fossil?
The word *fossil* was first used as we know it in 1736 and originates from the Latin word *fossus,* which means "having been dug up."

A fossil is any preserved evidence (remnant, impression, or trace) of past life on Earth. The branch of geology that studies fossils is known as paleontology (See Learning Module "What is Paleontology?").

The oldest fossils were bacteria that existed 3.8 billion years ago. Invertebrates (animals without backbones) have the longest geological record and occur in the greatest numbers, including in marine sediment. Vertebrates were the most successful large animals to adapt to land, so their fossils provide information on the evolution, distribution, and habits of animals with backbones. The fossil record of plants is not as well known as that of animals, but plant pollen has been extremely useful in the study of past ecosystems. Fossilized feces have given us much information about the digestive systems and dietary habits of past organisms.

Direct Evidence – the remains of a dead animal or plant. Often bone material is replaced by different minerals contained in the sediments that buried it. Permineralization and petrification are two processes that describe the way minerals can replace the original organism.

- Bones, teeth, wood, hair, feathers, shells
- Hardened shells of ancient invertebrates, like a trilobite or an ammonite

Indirect Evidence (trace fossils) – something that was made by the animal while it was living

- Footprints, tracks
- Skin and body impressions or imprints (even if the actual parts are missing)
- Molds or casts of the original organism left in the space where an organism decays
- Burrows
- Coprolite (animal excrement)

Sources:

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What are Dinosaurs?

The word "Dinosauria" and hence, "dinosaur," was coined in 1842 by Sir Richard Owen. In Greek, the term *deinos* means "fearfully great" and *sauros* signifies "lizard." Dinosaurs can generally be described as terrestrial reptiles with limbs held erect beneath the body that existed from the Late Triassic to the Late Cretaceous. This means they existed on Earth for about 165 million years, but went extinct about 65 million years ago.

From a scientific viewpoint, the study of dinosaurs is important both for understanding the causes of past major extinctions of land animals and for understanding the changes in biological diversity caused by previous geological and climatic changes of the Earth. These changes are still occurring today. A wealth of new information about dinosaurs has been learned over the past 30 years, completely turning around science's old ideas of dinosaurs as slow and clumsy beasts.

Approximately 700 species of dinosaurs have been named. However, a recent scientific review suggests that only about half of these are based on fairly complete specimens that can be shown to be unique and separate species. These species are placed in about 300 valid dinosaur genera (*Stegosaurus*, *Diplodocus*, etc.), although about 540 have been named. Most dinosaur genera presently contain only one species, but some have more (for example, *Iguanodon*). Even if all of the roughly 700 published species are valid, their number is still less than one-tenth the number of currently known living bird species, less than one-fifth the number of currently known mammal species, and less than one-third the number of currently known spider species.

Recent estimates suggest that about 700 to 900 *more* dinosaur genera may remain to be discovered. One branch of the dinosaur tree is believed to have given rise to today's birds.

Dinosaurs generally are named after a characteristic body feature, after the place where they were found, or after a person involved in the discovery. Usually the name consists of two Greek or Latin words (or combinations); in order, these are the genus (plural, genera) and the species name. For example, the Greek and Latin combination (binomen) *Tyrannosaurus rex* means "king of the tyrant lizards." Biologists name modern animals exactly the same way. Some examples include humans (*Homo sapiens*), domestic dogs (*Canis familiaris*), box turtles (*Terrapene carolina*), and rattlesnakes (*Crotalus horridus*).

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US Geological Survey

- http://pubs.usgs.gov/gip/dinosaurs/

University of Maryland – Department of Geology

- http://www.geol.umd.edu/~tholtz/G104/lectures/104sci.html

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What is Paleontology?

Paleontology is more than just dinosaurs! Paleontology is the study of the history of life on Earth, as reflected in the fossil record. Fossils are the remains or traces of organisms (plants, animals, fungi, bacteria and other single-cell organisms) that lived in the geologic past and are preserved in the crust of the Earth. Paleontologists are frequently involved in studies of evolutionary biology. There are many subdivisions of the field of paleontology, including:

- Vertebrate paleontology: the study of fossils of animals with backbones
- Invertebrate paleontology: the study of fossils of animals without backbones
- Micropaleontology: the study of fossils of single-cell organisms
- Paleobotany: the study of plant fossils
- Taphonomy: the study of how fossils are formed and preserved
- Biostratigraphy: the study of the vertical distribution of fossils in rocks
- Paleoecology: the study of ancient ecosystems and how they developed.

Source:

- http://www.priweb.org/ed/lol/careers.html
- http://www.fossils-facts-and-finds.com/what_is_a_fossil.html

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Birds of a Feather – On the Origin of Birds and Feathers

There are nearly 10,000 species of modern birds! Is it possible to trace these diverse birds back to one common ancestor? If so, what is it?

One of the major criticisms of Darwin's *Origin of Species* was the apparent lack of any evidence showing the evolution of birds. Then, as luck might have it and only two years after he first published his book, *Archaeopteryx* appeared in a site in Germany. Today there are eight preserved fossils of *Archaeopteryx* in various museums of the world. *Archaeopteryx* was amazing for a few reasons. First, it superficially resembled both a bird and a reptile. In fact, aside from the feathers, the bird-like feet, and the fact that it had a wishbone (*furcula*), it didn't really look like a bird. The jaws had teeth in them (no bird today has teeth), it had a long, bony tail, and it had the ankle bone fused to the shinbone. Clearly this bird had features of dinosaurs AND birds.

Three hypotheses on the origin of birds finally arose:

1. Therapod dinosaur hypothesis: The first was a hypothesis that birds came from the therapod dinosaurs (meat eating dinosaurs such as *Allosaurus).*
2. Crocodile hypothesis: The second hypothesis was that birds came from crocodiles because they had an endolymphatic duct (a canal in the ear). Yet, as more research was conducted, they discovered that there was a tremendous amount of variation in this duct, even among the lizards and other reptiles. Not many people today give much attention to this hypothesis.
3. Neither crocodiles or dinosaurs: The reasoning behind this hypothesis is that several dinosaurs were already very specialized.

Today we can show that birds are related in many ways to dinosaurs. Exceptional dinosaur fossils show the development of early feathers from embryo to adult. The first feathered, but not flying, therapod dinosaur (*Sinosauropteryx*) was discovered in 1996 in China, and since then more discoveries have been made. In 2009, *Tianyulong* was discovered, a bristly-backed dinosaur that is not closely related to therapods, making scientists believe that perhaps the ancestor of all dinosaurs had hair-like feathers, and that perhaps modern reptiles *lost* theirs as they evolved.

Although feathers cover most parts of the body of birds, they arise only from certain well-defined tracts on the skin, known as placodes. Reptile placodes grow horizontally to form scales, bird placodes grow vertically to form feathers. Feathers are made up of slender barbs, each lined with smaller barbules liked with tiny hooks that grasp one another, creating a structure that is light yet strong. The first feathers were slender, hollow filaments. Then different lineages of theropods evolved various kinds of feathers, like the fluffy down on chicks today or stiff ribbons, or broad filaments unlike the feathers on any modern birds.

Currently, scientists do not that that feathers formed initially as an adaptation for flight, but rather, to attract potential mates. *Anchiornis*, more than 150 million years old and about the size of a chicken, was covered from head to tail to toe in extravagant feathers that resembled flight plumage, but may have hindered flight instead of help it.

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- "The long curious extravagant evolution of feathers." By Carl Zimmer. Photographs by Robert Clark. Art by Xing Lida. *National Geographic.* February 2011, pp 32-57.
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Pigmentation in Dinosaurs

Pigmentation is the coloring matter found in certain plant and animal cells and occurs in nearly all living organisms. Coloring is an important adaptation that can help protect plants from UV rays, help animals hide from predators or attract mates, and more.

Almost all plants synthesize their own pigments, such as chlorophylls (green). Animals either derive pigments from their plant foods, or they synthesize them themselves. The major animal pigments are the hemes (red) of blood hemoglobin, the carotenes (reddish orange to yellow), the melanins (black and brown), and guanine (white and iridescent). The latter three produce the surface coloration of most animals. The pigmentation of many animals is adapted to their environment and aids in their survival. In some animals the pigment is even changeable. For example, flounders and squids are capable of changing their color to blend in with their surroundings and thus escaping detection by their enemies.

In her ESI lecture, *Dinosaurs in Living Color*, Dr. Julia Clarke mentions melanosomes. Melanosomes are unique organelles (microscopic pigment sac structures within a cell) where melanin production takes place. Melanin is a pigment produced by melanocytes (specific cells) found in the skin, hair and eyes that determine their color. The major determinant of color is not the number but rather the activity of the melanocytes. Darkly pigmented skin, hair and eyes have melanosomes that contain more melananin. Melanosomes are found in dinosaurs as well as in modern birds.

In 2009, Jakob Vinther and his colleagues discovered melanosomes in the feathers of an extinct bird. "In February 2010, a team of Chinese and British scientists announced that they found melanosomes in individual feathers of several dinosaurs that would have produced black and reddish hues. A week later, Vinther and his colleague decoded the full-body coloration of *Anchiornis:* rusty red crown, dark gray body, and black-and-white striped wings (from "True Colors" cited below)." *Sinosauropteryx*, found in China in 1996, now appears to have had reddish and white stripes on its tail.

Source:

- *Dinosaurs in Living Color*, by Dr. Julia Clarke, as part of the Environmental Science Institute's Hot Science – Cool Talks Lecture Series
- "True Colors." *National Geographic*. February 2011. pp. 51
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