

TwoOldGuys™ Study Guides

BI114 Biological Concepts for Teachers

Chapter 4. History of Life

4.3. Fossils

Based on Indiana's Academic Standards, Science, as adopted by the Indiana State Board of Education, Nov 2000.

Numbers refer to the age-appropriate grade-level for the content.

Review

In the previous section of Chapter 4, we have sought to explain how Life may have originated, and then how the earliest life forms could have evolved into a succession of fossil creatures and finally to modern beasts. Two contradictory hypotheses, primordial soup and primordial peanut butter and jelly sandwich, were described to explain how Life may have originated from non-living chemicals. Two examples of evolutionary events, the adaptation from aquatic to land-dwelling by plants and by animals, were considered, with two complementary hypotheses each.

Obviously, the need to explain fossil plants and animals exists only if there are fossil plants and animals. In this section, we shall examine what fossils are, and how we estimate how old they are.

Fossils, Part 1

The Fossil Record

grade 3: to 6:

Prehistoric animals are known from fossils

Fossils are direct evidence of the existence of animals or plants in the past. The presence of a fresh road-kill possum at the side of a road one morning clearly indicates that there was a live possum near that road last night. If you were to observe the same road-kill possum over time, you would see that various scavengers (crows, raccoons, skunks, and vultures) will slowly eat away at the carcass. Less obvious to the sight, but quite clear to the nose, the carcass will be rotting at the same time. Were the carcass not on a busy road, but on a trail rarely walked through a wood, the scavengers and decomposition would eventually leave nothing but a few bones lying on the ground. Thus, the presence of a newly observed deer skull lying at the edge of a woods somewhere clearly indicates that sometime in the recent past there was a live deer in the woods and nearby fields.

We established back in section 3.3. (Selection, artificial & natural) that dust piles up in abandoned houses. It seems perfectly reasonable to presume that dust also piles up outdoors. At 2.54 mm/yr it would take 10 years to accumulate a one inch deep pile of dust; at 0.254 mm/yr it would take a century to accumulate the one inch pile of dust. The point is, if our deer skull from the previous paragraph were under a one inch layer of dust, its presence “clearly” indicates that a live deer passed into the woods sometime within the last century. Generally we cannot determine exactly *when* the deer was there, but it *was* there. By the same argument, if a farmer were to unearth a rather large elephant skull,

with gigantic curved tusks from under about 15,000 years worth of dirt in northeastern Indiana, we would have to conclude that sometime about 15,000 year ago, an elephant (Mastodon or Mammoth) lived in Indiana.

grade 6: to 8:

Study of prehistoric things

Prehistoric time is considered to be any time before historic records are available. For the Americas, history is considered to have begun with the arrival of Europeans – the arrival of Christopher Columbus in A.D. 1492 [not the arrival of Leif Erickson in A.D. 1000]. For most of western Europe, history began with the Roman invasion of Gaul by Julius Caesar in 58 – 50 B.C. (Anon.). In Turkey, historic records go all the way back to Homer’s account of the war for Troy in 700 B.C. (Korfmann). Scientists who study life in prehistoric time are grouped into three different disciplines:

- fossilized artifacts studied by [paleontology](#)
- old buried artifacts studied by [archaeology](#)
- new buried artifacts studied by "[dumpster diving](#)"

Notice that “dumpster diving” is currently being used to verify information about historic events, dating back about two centuries. Archaeology not only studies pre-historic events, but also attempts to confirm historic and legendary events, dating back about one-half to one millennium. There is also overlap between paleontology of humans and archaeology of ancient humans, since human legend claims to go back about 10,000 years.

Fossil formation:

The biggest problem with burying animal parts in dust is that decomposition occurs rather quickly due to the oxygen in the air. On the other hand, if the animal (or plant) remains were buried under mud, the water would exclude the air, slowing the rate of decomposition by limiting the amount of oxygen. Conventional wisdom suggests that as mud is added on top of mud, the buried mud slowly turns to rock [such as slate and shale]. As this argument continues, bones slowly change to rock too, forming fossils. Following the same logic as in the previous sub-section, the depth at which fossils are found indicates the age of the fossil. The age of the fossil is merely the time in the past when we suspect that the living animal occupied the site.

Fossil formation is a very slow process, and not one which proceeds at the same rate at each site. The best example of the slowness of the process is the determination that coal from the Carboniferous [350 – 270 Myr BP] is made of *partially* decomposed plant remains. I, personally, have had the opportunity to conduct microscopic analysis of Pennsylvania coal samples [estimated about 300 Myr BP] to confirm the presence of material not yet decomposed.

The processes by which fossils can form can be grouped into four distinct mechanisms:

- as parts decay, organic material is replaced by mineral crystals
- hard parts (bone, tree trunks) become compressed to rock
- soft parts can leave imprints in mud
- animals may become trapped in amber, tar pits, etc.

grade secondary: to college:

Dating of fossils

In the above discussion, we established the simplistic notion that depth to a fossil (or other artifact) is sufficient to determine its age. However, we also know that some exposed rocks are a different age than other exposed rocks. The Grand Canyon, Arizona, exposes rocks from the pre-Cambrian [1,700 Myr BP] at the Colorado River to the Permian [250 Myr BP] at the canyon rim (www.kaibab.org/geology/gc_layer.htm). The question becomes, for example, the Morrison Formation sandstones of the Garden of the Gods in eastern Colorado (near Colorado Springs) is what age compared to the rocks of the Grand Canyon? Such questions lead to the field now known as stratigraphic dating. The basic premise of stratigraphic dating is that similar fossils imply similar ages, so the Morrison Formation sandstones at the Garden of the Gods east of the Rocky Mountains are the same as the Morrison Formation sandstones of Arches National Monument and of Dinosaur National Monument (both in eastern Utah) west of the Rocky Mountains [and above the elevation of the rim of the Grand Canyon], based on the similarities of the fossils. In between the two sites, the Rocky Mountains include uplifted rocks from the Cambrian.

A second possibility for increasing the 'accuracy' of dating of fossils involves the use of radioactive isotopes. Radioactive elements have a half life, defined as the amount of time required for one half of the remaining material to decompose releasing radioactivity and changing to a different element.

For example, the half-life of ^{14}C is 5,730 yrs

radio-carbon dating	
amt ^{14}C	years
1/2	5,730
1/4	11,460
1/8	17,190
1/16	22,920
1/32	28,650
1/64	34,380

During the radioactive break-down of ^{14}C (carbon-14), it becomes ^{14}N (nitrogen-14). Specifically, the carbon $^{14}_6\text{C}$ has 6 protons and 8 neutrons; then one neutron becomes a proton and a high-speed electron (x-ray), producing an atom with 7 protons and 7 neutrons, that is nitrogen, $^{14}_7\text{N}$. To determine the carbon-14 age, we need only measure the amount of carbon-14 remaining in the material. Living animals and plants are continually adding new carbon at the same ratio of ^{14}C to ^{12}C as for the Earth. As soon as they die, this replacement ceases and the ^{14}C decay reduces the ratio of ^{14}C to ^{12}C .

Any other radioactive element can theoretically be used to date things.

Works Cited

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Korfmann, M. "Was There a Trojan War?" *Archaeology* 57 (2004).

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