

TwoOldGuys™ Study Guides
BI114 Biological Concepts for Teachers
Chapter 3. Inheritance and Evolution
3.5. Evolution, macro-evolution

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

We should know by now that the characteristics or traits of species are inherited by transmitting information from the parents to the offspring. Sometimes, the information of a trait may change by mutation. When mutation occurs, the mutated alleles are inherited as if they were 'normal.' However, the environment will select among the alternative traits which ones to maintain in the population. This natural selection causes greater reproduction in individuals with favored traits, while causing reduced survival in individuals with less favorable traits.

As natural selection works over several to many generations, the description (characteristics) of the species tend to slowly change, a process known as micro-evolution. There are numerous well-documented cases of micro-evolution. One web reference even states that the majority of creationists are willing to accept the concept of micro-evolution.

Macro-Evolution

Environmental variability

grades 3: to 4:

Once upon a time, ...

there were different animals, now known only from fossils. The Ice Age occurred about 2 million years ago, during which some animals not known in the modern world, such as Woolly Mammoths (elephant-like animals) and Saber-tooth Tigers (tiger-like animals) roamed the world. There are a large number of fossils of Mastodons (another elephant-like animal) which have been found along the edge of the Pleistocene glaciers in the Great Lakes region, and Woolly Mammoths along the glacier margins across the Great Plains of North America and across the glacier margins in Siberia. Further back in time, there was the Age of the Dinosaurs (ended 65 million years ago) when the World was tropical, from the Antarctic circle northward to the equator. We do not know what the climate in the northern hemisphere was, because there was no land there then. Some of the strange creatures of the period were:

- T. rex, and other (smaller) raptors
- Triceratops
- Pterodactyl
- Brachiosaurus
- Stegosaurus
- Ichthyosaurs
- Pterosaurs
- Archyopteryx

grades 5: to 8:

The 2nd Age of the Dinosaurs was tropical, but ended with a glacial period 65 million years ago. The 1st Age of the Dinosaurs was also tropical, and also ended with a glacial period 175 million years ago.

This suggests a long-term climate cycle:

start	end	climate
20 Kyr	now	global warming
2 Myr	20 Kyr	ice age
?	2 Myr	warm period
65 Myr	?	ice age
220 Myr	65 Myr	tropical period
220 Myr	?	ice age
270 Myr	220 Myr	warm period

Clearly, there had to be episodes of global warming after each of these ice ages; but also episodes of global cooling before each ice age. The simplest assumption is that the change from global warming to global cooling occurred at or near the middle of the Geological time period:

start	end	duration	climate
20 Kyr	?	?	warming
31 Myr	2 Myr	30 Myr	cooling
65 Myr	31 Myr	30 Myr	warming
140 Myr	65 Myr	75 Myr	cooling
220 Myr	140 Myr	80 Myr	warming
245 Myr	220 Myr	25 Myr	cooling
270 Myr	245 Myr	25 Myr	warming

The average duration of these episodes is about 80 Myr to go from warmest to coolest and back to warmest. Projecting this pattern backwards through Geologic Time, we can predict roughly all known instances of ice ages. Two such predicted ice ages were not previously known when we first tried this, but since then we have confirmed the predicted ice ages from geologic evidence.

grades secondary: to college:

The climate appears to be composed of several overlapping cyclic components. The most obvious short-term cycle is the daily temperature cycle [warm days, cool nights]. Across North America [southern Canada and northern United States], frontal systems bring rain about every week during the spring, and bring snow showers about every week during the winter. The next longer cycle is the annual temperature cycle, with hot summers and cold winters.

Beyond these obvious cycles, there is an 11-year wet – dry cycle which may correlate with sunspot activity. In the spring of A.D. 2004, sunspot activity changed from active to quiet, which should lead to wetter conditions, ending the five-year drought across much of the United States. We now have relatively clear evidence of a 500 (± 200 years) year temperature cycle. The most recent low point of this cycle has been called the “Little Ice Age” of the mid-1600’s with crop failures throughout Europe and snow reported every month of the year in Warsaw, Poland. The most recent high point of this cycle was a forty year drought which ended in A.D. 1300, resulting in the collapse of civilization throughout the Americas [the Anasazi or Ancient Ones of Native American (Hopi) legend; the Pueblo, Inca, Mayan and Aztec civilizations]. References to extremes related to this cycle can be found in Japan, China, Europe, North America, and perhaps in the Middle East. Some evidence suggests that the warming associated with the retreat of the Pleistocene glaciers went too far, producing a ‘hyposithermal’ episode with prairie [less than 30 inches annual precipitation] as far east as western Pennsylvania, that would have matched a hot, dry episode of the 500 or so year cycle. A 1,500 or so year cycle has been proposed, and data is currently being sought to confirm this cycle. The glacial advances and retreats of the

Pleistocene roughly match a 10,000 – 15,000 year cycle. The longest proposed cycle is a 85 million year cycle of Ice Ages dating from the Pleistocene back as far as we have exposed rocks [pre-Cambrian with glacial scratch marks on the rock surfaces].

short term cycles , for example

11 yr	precipitation	
	3-5 yr	dry period
	2 yr	"transition" period
	3-5 yr	wet period
	2 yr	"transition" period

directional component

Numerous studies have suggested the existence of trends which persist for 100's of years. Many of these were of the “end of the world” type predictions. Two examples are (1) the prediction less than a half century ago that the glaciers were returning, and that it should take only about 100 years for a continental glacier to form over Canada and parts of the United States; and (2) the current prediction that global warming, caused by human activity, is going to melt all polar ice, cause a major sea level rise, destroy agriculture, and numerous other disasters appropriate to Hollywood disaster movies. An apparently declining number of scientists are suggesting that these doomsday prediction are misinterpretations of what are probably very-long term cycles. For example, a 150 – 200 year temperature increase may be half of a 500 year cycle.

- 'half' of cycle = increasing trend
- 'half' of cycle = decreasing trend
- transition = steady trend

The following is some recent data to illustrate the potential complexity of the overlapping climate cycles.

Climate cycles in Alaskan Subartic from Hu, et al (2003) <i>Science</i> vol 301:pp.890-1893		
period (yrs)	CL*	half-cycle
135	90	67
170	90	85
195	90	97
435	90	217
590	90	295
950	90	475
1500	80	750

*CL = confidence level

"Residual" (unexplained) component

- random fluctuations around above cycle(s)

Population changes to remain adapted to changing environment

grades secondary: to college:

Natural selection can drive population change as long as genetics allow. If the change continues long enough, the creatures will become so different, that they become a new species:

The usual textbook example is horses:

- dog size, four-toed
- pony size, three-toed
- Arabian horse
- modern breeds: Belgian, Clydesdale, Quarterhorse, Morgan, etc...

Effalumps are another example, based on DNA comparisons:

- Mastodon
- Woolly Mammoth
- Indian Elephant
- African Elephant [now recognized as two species]

Creationism, or Intelligent Design

In 1925, in Dayton, Tennessee, there was a trial: “Tennessee vs. John Thomas Scopes,” in which the state of Tennessee charged that Mr. John Scopes [general science teacher, teaching from the state approved textbook] had violated a state law forbidding the teaching of “any theory that denies the story of divine creation as taught by the Bible and to teach instead that man was descended from a lower order of animals,” argued by Clarence Darrow [for the defense] and William Jennings Bryant [for the prosecution] (www.law.umkc.edu/ftrials/scopes/scopes.htm). Largely due to the coverage of the trial by the press at the time, the case has become known as the “Scopes Monkey Trial.” The controversy between the fundamentalist Protestants and the scientific community over the issue of evolution has not gone away in the decades since 1925, nor do I anticipate that it will go away in the foreseeable future. You need to be aware of this controversy because it will affect your ability to teach your students, along with the parental objections to the concept of sex education and with the anti-cruelty activists’ objections to studying animals. I find it curious that the document cited by the fundamentalists [the King James Version of the Judeo-Christian Bible] does not state that evolution did or did not occur, but it does clearly describe the World as flat, and the Sun as traveling across the sky. My recommendation is that you attempt to avoid the controversy in your

classroom. Regardless of which side you personally believe [evolution or creation], the advocates of the other side will use emotional arguments rather than logic, at least part of the time.

Creation Story

One day, Coyote was out in his canoe. He had been paddling for a long time, and had become tired. He could not stop and rest because there was no place to beach the canoe because the Earth had not been created yet, so he paddled on. Pretty soon, coyote decided he was very tired. He could not beach the canoe to rest because the Earth had not been created yet, so he sent Rabbit diving to get some mud. After a while, Rabbit floated up, dead. So Coyote paddled on. Now Coyote was quite tired, but he could not beach the canoe because the Earth had not been created yet, so he sent Squirrel diving to get some mud. After a long while, Squirrel floated up, dead. So, Coyote paddled on. Now Coyote was very tired, but the Earth had not been created yet, so he sent Muskrat diving for some mud. After a very long time, Muskrat floated up, dead. So Coyote paddled on. He still could not stop because the Earth had not been created yet, so he sent Beaver diving for some mud. Coyote waited and waited for Beaver to return. At last Beaver floated up, almost dead. So Coyote pulled Beaver into the canoe, and began to revive him. Then Coyote noticed some mud under Beaver's fingernails. Coyote took this mud and made the land. Now he could beach the canoe and he laid down to rest.

Pretty soon, Coyote thought, "This is nice, but the sun is bright and it is getting hot. It would be better if I had some shade." So Coyote made trees to cast shade. This was much better, but not very pretty to look at, so Coyote made flowers and scattered them among the trees. Coyote then picked some flowers, threw them into the air and they became butterflies. Then Coyote thought, "It's too quiet here." So he caught some butterflies and taught them to sing, and released them as birds. He then made beasts so that there would be something to hunt. Then he thought, "Now, there is only one thing missing." And that is when Coyote created Human Beings.

The above Creation Story is retold from an Algonquin Indian myth [from *Journal of American Folklore*]. I must apologize to Grandfather and to all of the Algonquin people, both living and those who have died and become legends. I know that stories are supposed to be told correctly, but I come from a culture in which stories are expected to be changed to

match the story-teller, and I have a hard time breaking from that tradition.

An important point is that nearly every culture has a traditional creation story, and they all share several fundamental characteristics. What this means is unclear, it is merely an observation. You may have noticed some similarities between the Algonquin version and the Judeo-Christian version. You need, however, to know that the Algonquins believed in a single God, whom they called Grandfather. Coyote is not considered by the Algonquin tradition to be a god in the pagan sense (such as in Greek and Roman mythology). Although I have used the Algonquin Creation Story in a parochial [Catholic] High School, I am inclined to believe that I was deluding myself when I thought the students understood the point [that all cultures share similar, but subtly different, traditional Creation Stories].