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Anthony D. Barnosky, Ph.D., is a vertebrate paleontologist and curator of the Museum of Paleontology at the University of California–Berkeley. His current research...

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evolution: species and speciation

Climate Change and Speciation of Mammals

Interview with Anthony D. Barnosky

An ActionBioscience.org original interview

articlehighlights

Although there is a debate about whether climate change is a major factor in speciation, the author explains that:

- *new species of mammals evolve when significant climate change persists over very long periods of time*
- *when mammals can't move to habitats that provide favorable climate, climate change leads to evolutionary changes or extinction*
- *fossils provide clues that can help predict effects on species in the current warming trend*

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Climate Change and Speciation of Mammals

Interview with Anthony D. Barnosky

ActionBioscience.org: *Do changes in the physical environment contribute to the evolution of mammals?*

When climate change is of significant duration, speciation is more likely to occur.

Barnosky: I think they do, but it depends on what scale of change you are talking about. There are many different scales of environmental change. Climate change is an example, Climate changes happen from year to year and decade to decade, over hundreds of years, over thousands of years, in hundred thousand year cycles, and over millions of years. In the work we have been doing it seems that the ones that affect mammal evolution at the population scale are probably very large time scales like the Pleistocene glacial and interglacial cycles, 1.8 million to 10,000 years ago. The mid-Miocene climate optimum, sustained for millions of years rougly 18 million to 14 million years ago, had very pronounced speciation in mammal groups.

ActionBioscience.org: *How does climate change provide conditions for speciation?*

During such times, species either evolve or go extinct.

Barnosky: Basically, when climate changes, species are trying to follow the climate that they are adapted for, so they move around the landscape to stay in the same climate space. When they do that, populations get left behind. These populations might get isolated enough to spur morphological (that is, physical) or genetic changes. You might get a species or population trapped in a place where climate is changing,

which would induce a selective force to make them change or go extinct.

ActionBioscience.org: ***What do fossils tell us about mammalian changes through space and time?***

Changeovers from one set of species to another occur regularly.

Barnosky: One thing they tell us is that as you go through the past 70 million years, there are many times at which we get a changeover from one set of species to a new set of species. Those changeovers are called "faunal turnovers," and the things that contribute to them are both the evolution of new species and the immigration of species from other areas. These turnovers occur regularly throughout time. Mammal fossils also provide clues to the details about their history as they were affected by climate change and evolutionary factors.

Several tools are used to study climate change and evolution.

The history of the planet can be divided into time periods that are defined by the mammalian species alive during these periods. Today we can sequence DNA from many fossil bones, providing us a glimpse into genetic changes that have occurred over time. Other tools include molecular clocks--determining when species diverged using DNA sequence differences--and morphometrics--measuring changes in physical features.

ActionBioscience.org: ***Can fossils help predict potential biotic effects of global warming?***

An important question is whether the changes we see now are within normal bounds.

Barnosky: Fossils are one of the best ways to predict potential effects of today's global warming. When we are looking at a change that's happening within a human lifetime, the first thing we have to figure out is the answer to "Is this within the natural range of variability of what had happened when humans weren't around?" The only way we can do that is to use the fossil records to trace communities back through time. In other words, delimit the bounds of what is normal and compare what is happening today with what is normal in the absence of humans. So that is one way they are essential. The other way to approach this is to study how these changes actually play out over a very long time scale so we can find analogous changes in the fossil record.

ActionBioscience.org: ***Humans are changing climate at unprecedented rates. What possible effect can this have on mammalian evolution?***

There is not enough time for mammals to adapt to the current rate of change.

Barnosky: I think basically most of the information we have about mammal evolution is that the speed at which it takes place is a little bit constrained. How fast can we have genetic mutations and how long can we maintain populations in isolation? These things play out over hundreds of thousands of years on the time scale. The kinds of environmental changes that humans have initiated have been playing out only over a hundred-year scale. I think the bottom line is that humans have changed evolution. The kind of selective pressures that we have put on mammals are so strong there is not going to be time to regenerate biodiversity. Mammal speciation does not occur that fast.

ActionBioscience.org: ***How can scientists arrive at various future***

scenario predictions about climate change effects on mammal species?

Climate models and fossil assemblages provide a context for predictions.

Barnosky: There are a couple of ways you arrive at predictions. One is to basically have models of how climate is going to change. We are beginning to understand the physiological and other constraints on various species relative to climate. Knowing that climate will change by x amount we can surmise that it will affect a species in a certain way. Another way to predict scenarios is to look at the fossil record. The most useful kinds of fossil record for this purpose would be where we can actually take an ecosystem today, obtain fossil deposits to trace history back through thousands and maybe tens of thousands of years, and then observe how those communities have changed and see whether there are more changes at times when there was climate change, and whether those are analogous to today's fast rates.

ActionBioscience.org: ***When population rises or declines during climate change does genetic diversity rise or decline?***

An animal's life history can affect its genetic diversity.

Barnosky: It depends very much on the life history of the animal--what the animal did to survive. If you are an animal who does not disperse very much, like gophers, you would expect that as populations decline, genetic diversity would decline, because the fewer individuals you would have, the fewer genes you have in the gene pool. However, if you are a big disperser, like the voles, then what can be found by some of the studies is that as populations decline, dispersers from other areas join these populations, and that actually increases genetic diversity.

ActionBioscience.org: ***In Earth's history, were there many mammalian speciation events, and if so, was climate a factor in all of them?***

Extended periods of climate change can lead to clusters of speciation events.

Barnosky: There were many different speciation events, certainly just by virtue of the fact that we have about four thousand mammal species on Earth today. Each one of those is a speciation event, and for each one of those, there were almost certainly many more species that evolved but went extinct without making it into the fossil record. Are those speciation events clustered in terms of climate change? My guess is that at certain kinds of climate changes there were clusters of speciation events. What's important is how long the climate change lasted. The climate change 15 million years ago in the western United States is probably a good example of mammal speciation.

ActionBioscience.org: ***What have you learned through your research?***

Different magnitudes of climate change lead to different events

Barnosky: Probably the most important thing is that you have to pay a lot of attention to the scale of climate change and the scale of evolutionary change when you are talking at the population level and species level. Different magnitudes of naturally occurring climate change are key. When you do that you find that the short, less intense climate changes, that is a couple of degrees C, that are not maintained for more

events.

than hundred or a few thousand years will stimulate changes in populations but not necessarily stimulate speciation events. In order to get a speciation event, you have to move to a new climate state and stay there for many hundreds of thousands to millions of years.

Scientists debate the influence of climate change on speciation.

It's important to note, however, that there is an ongoing debate in evolutionary biology about the influence of climatic changes on evolutionary processes. The "Red Queen" hypothesis claims that climatic change is less important than biotic interactions in causing evolutionary change. The "Court Jester" models see climatic change as a very important force in speciation.

About the author: Anthony D. Barnosky, Ph.D., is a vertebrate paleontologist and curator of the Museum of Paleontology at the University of California–Berkeley. His current research projects revolve around understanding how large-scale changes in the environment affect evolution, biogeography, and biodiversity patterns of mammals. Barnosky has written numerous scientific papers and edited and authored several books, including *Biodiversity Response to Climatic Change in the Middle Pleistocene: The Porcupine Cave Fauna from Colorado* (University of California Press, 2004). Barnosky was interviewed at the American Institute of Biological Sciences' symposium "Evolution and the Environment," at the National Association of Biology Teachers convention in 2005.
http://ib.berkeley.edu/labs/barnosky/

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This article summarizes a paper published in Nature. Six biodiversity-rich regions around the world representing 20 percent of the planet's land area were studied.
http://www.leeds.ac.uk/media/current/extinction.htm

Climate Change Drives Widespread Amphibian Extinctions
Science Daily article presents a study claiming warming is enhancing the growth of a fungus fatal to amphibians.
http://www.sciencedaily.com/releases/2006/01/060112035218.htm

Climate Ark: Climate Change and Global Warming Portal
News, views, and alerts can be found here, with an extensive list of links on the subject.
http://www.climateark.org

Questions and answers about global warming
A fact sheet and other information have been assembled by the Worldwatch Institute.
http://www.worldwatch.org/features/climate/questionsanswers/

National Environmental Trust
This is a US source for information on global warming, how you can help prevent it, and international efforts to address global warming.
http://environet.policy.net/warming/

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http://www.iclei.org/index.php?id=800

Global warming and wildlife
The National Wildlife Federation offers information and tips on how you can help to improve wild places and quality of life.
http://www.nwf.org/globalwarming

Rising Tide
A network of groups and individuals in the U.K. dedicated to taking action and building a movement against climate change.
http://risingtide.org.uk/

Sierra Club
Global warming and energy information are available, as well as ways to take action.
http://www.sierraclub.org/globalwarming