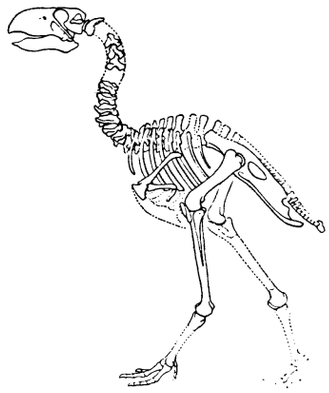
Continental drift and the diversity of species



A. S. Romer, Vertebrate Paleontology (from Matthew and Granger)

Diatryma: Evidence for land bridge.

Continental drift has regulated the evolution and distribution of the earth's creatures

by Louise Purrett

The concept of continental drift has proved to be one of those rare occurrences—a true revolution in scientific thinking. It has produced the order of a comprehensive theory from a chaos of facts, and its effects have reached far beyond pure geology. One of the fields now beginning to feel the touch of continental drift is paleontology.

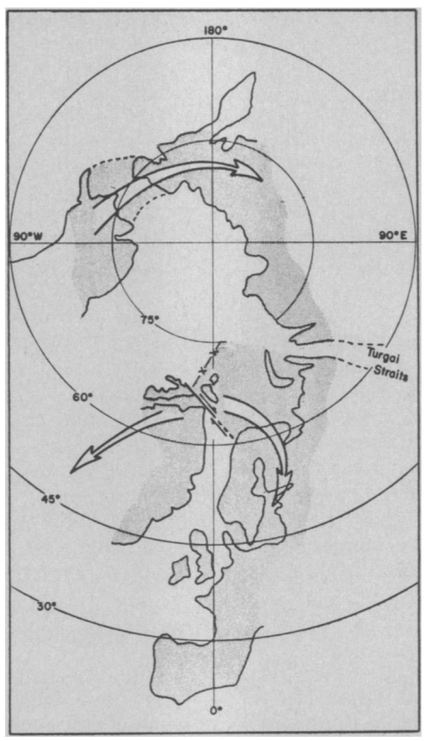
The discovery of similar fossil remains in such places as Antarctica and Africa has provided some of the strongest evidence for the occurrence of continental drift and for confirmation of past plate positions (SN: 12/5/70, p. 428). The reverse argument can as well be made. More and more, biologists and paleontologists are recognizing that continental drift has influenced the evolution and dispersal of species. The program of the latest annual meeting of the Geological Society of America included an entire symposium on Plate Tectonics and Fossil Vertebrate Distribution.

Since the fossil record in many instances is sparse, the course of evolution cannot always be definitely traced. The effects of continental drift can only be inferred by correlating evidence of changes that have occurred in fauna and in geological or climatological conditions.

One fact puzzling to scientists is the great diversity of mammalian species that have developed in a relatively short period of time. In a third of the time, mammals have diversified into half again as many orders as the reptiles. The age of reptiles, which lasted for 200 million years, produced only 20 reptilian orders, while the age of mammals, which began only 65 million years ago, has already given rise to some 30 orders of mammals. During the some 75 million years of the Cretaceous Period, at the height of the age of reptiles, there were only eight or nine orders of land reptiles.

Species diversify by adapting to different conditions—the climate they live in, the amount and type of food available. The reverse process occurs when two originally different species take up similar life modes and come to resemble each other.

Not only have mammals become highly diverse, but also there are many



M. C. McKenna and F. S. Szalay

Ancient animal dispersal routes.

cases of duplication, in which members of different orders perform the same function. For example, Asia, Africa, South America and Australia each has a type of animal that feeds on ants and termites: the ant bear (order Edentata) in South America, pangolins (order Pholidota) in Africa and Asia, aardvarks (Tubulidentata) in Africa, and the spiny anteater (Monotremata) in Australia.

The great diversity, as well as instances of duplication of mammalian groups, is a result of effects of continental drift, the Finnish paleontologist Björn Kurtén believes. During the age of reptiles, there were only the two supercontinents, Gondwanaland and Laurasia. The orders of reptiles that existed during the Cretaceous (about 135 million to 65 million years ago) developed on one or the other of the supercontinents. Three orders of reptiles appear to have originated in Gondwanaland, three in Laurasia, says Kurtén.

The supercontinents may have begun to split as early as the Triassic Period (230 million to 180 million years ago), but the rifts between them did not become effective barriers to the migration of land animals until well into the Cretaceous, when the age of reptiles was ending and mammals were just beginning to diversify. Most geological evidence indicates that South America started to split from Africa about 135 million to 100 million years ago and Australia broke away from Antarctica 45 million years ago.

In addition, says Kurtén, the land areas were further fragmented by high sea levels. High waters formed great inland seas, some of which completely divided the continents. South America was cut in two by water in what is now the Amazon basin, and the Tethys Sea divided Eurasia. At the beginning of the age of mammals there were, in effect, eight separate provinces, each of which could develop its own population of animal species to fill various ecological roles. Where conditions on two separate continents were similar, similar animals would develop.

When drifting continents again collided, previously separate groups mingled, to the extinction of some and proliferation of others. Some African mammals, such as the mastodon, eventually spread over much of the world.

Of course, continental drift, though a major factor, was not the only cause of the greater diversity of mammals over reptiles. For example, the ancient reptiles were larger animals than the mammals that developed later, and smaller animals simply tend to diversify and speciate more than large animals.

The new concept of moving continents has shed light on a number of more limited questions, as well. Joel Cracraft of the University of Illinois has invoked them to explain certain phenomena of bird distribution. It has been the prevailing opinion that continental drift occurred too early to significantly affect the distribution patterns of birds. New evidence that many land masses were still close together as recently as 60 million years ago and that many bird families have older histories than previously thought casts doubt on this assumption, says Cracraft. Many birds probably dispersed throughout the southern part of the world in the Cretaceous and early Cenozoic. Similarly, certain subtypes of gruiformes (the order including cranes, rails and other tropical birds), falconiformes (the order including vultures and hawks) and galliformes (fowl and game birds) that are found in both the Eastern and Western Hemispheres probably dispersed across a North Atlantic land bridge before about 50 million years ago.

A good example, says Cracraft, is the genus *Diatryma*. This giant flightless bird existed in Europe and North America in the Paleocene and Eocene Periods (68 million to 36 million years ago). The only way the bird could have populated two continents that are now separated is by walking across a land bridge. Another example is vultures of the cathartides family. These birds live today in the New World, but fossils of Eocene age have been found in France. Two families of gruiformes, one living in Europe and one in North America, postulates Cracraft, probably have a common ancestor that distributed itself across a now-extinct land bridge. When Europe and North America drifted apart, these two branches became isolated from each other and evolved along different lines.

Malcolm McKenna of the American Museum of Natural History has named this North Atlantic land bridge the De Geer dispersal route. The final separation between North America and Europe, he says, occurred about 49 million years ago. Until that time, this was the main route for animal dispersal between the two continents, and since Asia was separated from Europe by an inland sea in the plains east of the Ural Mountains, animals could travel from Europe to Asia only through North America.

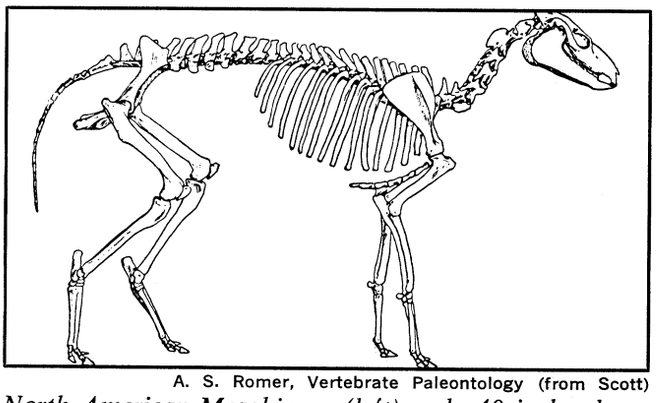
Eohippus, the ancestor of the horse, says McKenna, probably originated in North America and migrated to Europe across the De Geer route. When the continents separated, the North American branch flourished and evolved into the modern horse. The European branch followed a different line of evolution which eventually ended in extinction about 10 million years ago. The European descendants of *Eohippus* became prematurely large and advanced in structure. *Palaeotherium*, for example, reached the size of a rhinoceros. Meanwhile, the Bering dispersal route, which had been so close to the North Pole that climate alone limited migration, moved farther south and became a more important dispersal route. Though the horse died out in North America about 10,000 years ago, its relatives that had migrated to Asia survived.

Continental drift would have influenced vertebrate distribution and evolution in ways other than by simply erasing land connections, Cracraft emphasizes. The drift of continents through different latitudes would have affected climate that prevailed on the continent, and therefore evolution of its fauna. Plate tectonics has also changed the surface features of continents and sizes of oceans and other bodies of water. These changes in turn influenced climate and vegetation, and therefore life forms. For example, the Pacific crustal plate, as it forces its way under the western margin of South America, has raised the Andes Mountains. The uplifting of the Andes prevented westerly winds from reaching eastern South America. The climate has since become drier and the character of the vegetation has changed from subtropical to temperate zone varieties. These changes would obviously influence the types of animals that could survive there, Cracraft says. One group of bird, the phororhacoids, for example, apparently became extinct during uplift.

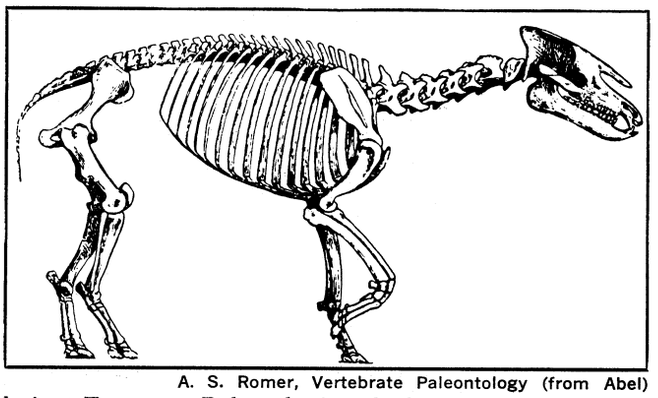
Throughout geological history there have been periods of raising and lowering of the sea level, which some geologists believe may have been caused by uplift of oceanic ridges. Cracraft says that certain evidence suggests that past transgressions and regressions of sea water over what is now southern Argentina may have influenced speciation patterns of penguins that once populated the region.

The effects of drift may not have been limited to land animals. The diversity of marine animals living on continental shelves, says James Valentine (SN: 11/21/70, p. 396), has varied with the latitudes and sizes of continents. High latitudes and large continents have wider seasonal variations, greater fluctuations in food supply, and therefore their shelves support only a few, highly flexible species. The arrangement of continents also influences the number of species, since shelf animals have a small latitudinal range. Long coastlines running north-south would support many different species.

Just as continental drift and plate tectonics have been invoked to explain geological and geophysical phenomena, their possible relation to past and present biota is increasingly being explored and recognized. It could be that the influence of continental drift has been exaggerated, but the test of any comprehensive theory is its compatibility with a wide variety of facts, and so far continental drift has earned high marks. □



A. S. Romer, Vertebrate Paleontology (from Scott)



A. S. Romer, Vertebrate Paleontology (from Abel)

North American Mesohippus (left), only 40 inches long, and giant European Palaeotherium had a common ancestor.