1-18
THE CHANGING GLOBE: CONTINENTAL DRIFT

When Darwin experienced earthquakes and volcanos, he recognized that the earth is a dynamic ever-changing powerhouse. Neither he nor his contemporaries could appreciate how extensively continents and oceans have altered over time, and how profoundly those alterations have affected the distribution and evolution of biological species (1-1).

The remarkable jigsaw fit of the continental margins led German meteorologist Alfred Wegener (1915) to suspect that the continents might have once formed a single giant landmass. This notion was dismissed by most geologists, since no mechanism was then known for propelling huge continents like giant battleships over the earth's surface.

From 1950 onwards, Wegener's conjecture was supported by oceanographers who studied the ocean floor using new techniques of drilling cores, magnetic surveys, and echo-soundings to map the submarine mountains and valleys. These studies revealed that rocks in mid-ocean ridges were of relatively recent origin, formed by hot lava from deep within the earth pushing up through faults and spreading out to form the sea floor. Canadian geophysicist Tuzo Wilson deduced that the earth's crust is divided into a series of plates. The continents of lighter rock float on the heavier plates of solidified magma; their movements are known as plate tectonics (tecton, Greek for building).

Begin by coloring the continental positions in the present day. Use these colors for the rest of the plate. Iceland is colored with Greenland; Australia with the surrounding islands.

Next, color the continents at the end of the Triassic when they formed one supercontinent, Pangea ("all lands"), indicated by the solid line. A single ocean surrounded Pangea.

About 200 mya India was close to Africa with Madagascar wedged between them. Plants and animals on this land mass constituted one continuous living system.

Color the land masses of the Cretaceous indicated within the solid lines. Notice that parts of present day continents were submerged, as indicated by the dotted lines.

Pangea separated into two major land groups, Laurasia to the north, and to the south, Gondwana (land of the Gonds, after an Indian province), each moving away from Africa. India "floated" north and collided with mainland Asia, raising the Himalayan mountains. Madagascar became an island (4-6). South America and Africa were apart, but they remained close enough to exchange plants and animals.

Continental drift answers questions that previously baffled zoologists, botanists, and paleontologists. Dinosaur fossils, for example, are found on all major land masses. How did dinosaurs cross the oceans? The answer is that they did not. They evolved during the Triassic on the single continent of Pangea.

Darwin and his contemporary Alfred Russel Wallace wondered about how the ratites, giant flightless birds, came to be widely distributed: ostriches in Africa; elephant birds (now extinct) in Madagascar; rheas in South America; emus and cassowaries in Australia and New Guinea; and kiwis and extinct moas in New Zealand. Some orthnithologists proposed convergent evolution, that each ratite evolved from a different flying ancestor.

The combination of information from plate tectonics and molecular biology renders the idea of convergence incorrect. Using DNA hybridization (2-7), Charles Sibley and Jon Ahlquist demonstrated that the ratite birds are all genetically related and had a common ancestor resembling the South American tinamou, a bird that flies but shares with the ratites a distinctive "paleognathic" palate. Ratites most likely evolved on Gondwana and took separate evolutionary courses when the giant continent broke up into the southern continents of today.

Reptilian and mammalian evolution also followed the changing globe. The Age of Reptiles lasted 200 million years and gave rise to 20 orders (1-21). The Age of Mammals during the last 65 million years (the Cenozoic, 1-22) diversified much faster, giving rise to 35 orders. When reptiles evolved, there were fewer land masses and climates were more uniform than when mammals evolved. These differences account for the more rapid and extensive diversification of mammals, according to Finnish paleontologist Björn Kurtén. The breakup of the Laurasia and Gondwana supercontinents produced more geographic isolation and therefore more possibilities for independent evolution of species, including marsupials and placentals in Australia and North America (1-9), and lemurs in Madagascar (4-6).

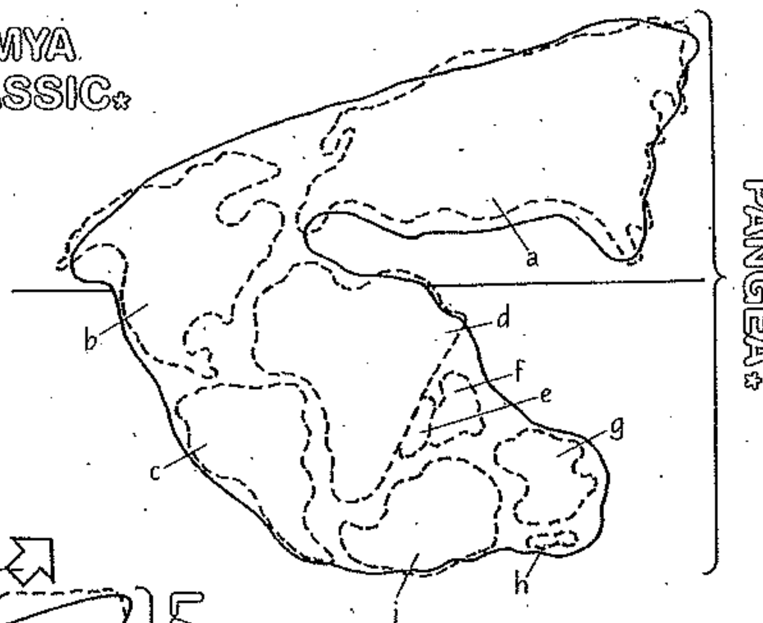
Modern geography is best understood through its geological history. The Mediterranean Sea, separating Africa and Eurasia, is a remnant of the once more widespread Tethys Sea. The Indian Ocean divides India from Africa. The Mid-Atlantic Ridge, a huge submarine mountain chain, separates South America from Africa (4-11). North America and South America became connected only three million years ago through the Isthmus of Panama, permitting interchange of plants and animals between the two continents while isolating the once continuous marine life.

Far from being a fixed monument, our globe has been in flux for more than four billion years. Continents merge, fragment, and sometimes collide with each other. Such movements impact ocean currents, atmospheric circulation, and continental temperature and rainfall patterns. These motions account for how mountains form and why volcanos and earthquakes are most active at the edge of plates. Plate tectonics provide a missing piece of the biogeography puzzle that Darwin tried to solve—the mystery of how innumerable species that have lived on this planet came to be in the particular places where we find them living today or as fossils.

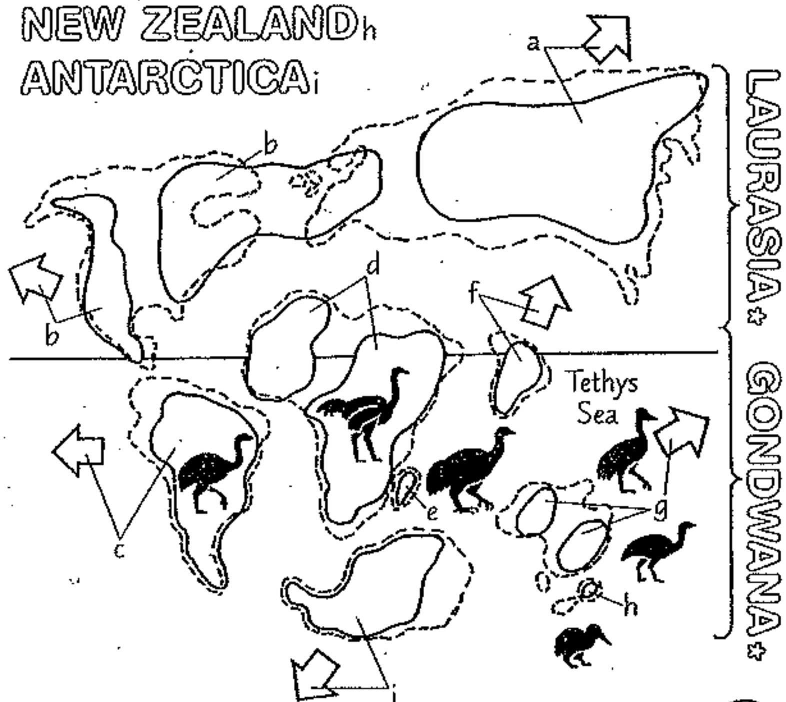
CONTINENTAL DRIFT

EURASIA a
NORTH AMERICA b
GREENLAND b'
SOUTH AMERICA c
AFRICA d
MADAGASCAR e
INDIA f
AUSTRALIA g
NEW ZEALAND h
ANTARCTICA i

200 MYA
TRIASSIC*



100 MYA
CRETACEOUS*



PRESENT DAY*