

One and only Earth

Reports from the Kepler mission have raised hopes for finding an Earth-like planet. Nevertheless, our Earth is probably unique — not just because of its distance from the Sun, but also because it has co-evolved with the life forms it has hosted.

Seekers of Earth-like exoplanets in our Galaxy and neighbouring ones have been rewarded. The ongoing identification of planets that are roughly comparable to Earth in mass and distance from their suns has renewed hope for finding kindred worlds (*Nature* <http://dx.doi.org/10.1038/nature.2012.9786>; 2012). But whatever suitable candidates the search will bring up, they are unlikely to look like our home planet: as we delve deeper into the Earth's past, it becomes clear that many of its apparently original environmental features appeared relatively late, and were brought about by the evolution of life. In this Focus issue, we explore some of the complex interactions between terrestrial life and its host planet.

Perhaps the most obvious effect of the advent of life is seen in the composition of the atmosphere. Soon after the earliest forms of life appeared, photosynthesizing organisms evolved. Eventually, they oxygenated the atmosphere, paving the way for the eventual emergence of animals. But the onward march of photosynthesis, from microbes to more complex cells and finally to plants, had other impacts on a planetary scale.

The widespread formation of soil, often rich in organic carbon, is attributed to the arrival of the first photosynthetic microbes and eukaryotes on land — probably about 850 million years ago. Some of the soil material, along with the terrestrial forms of carbon it contained, was washed back into the oceans, changing the composition and balance of marine organic matter (L. P. Knauth and M. J. Kennedy *Nature* **460**, 728–732; 2009).

The subsequent evolution of vascular plants, some 400 million years later, led to another biogeochemical revolution. These plants facilitated the cycling of nutrients by breaking down minerals previously locked in soils and rocks, and soaked up vast quantities of atmospheric carbon dioxide. As a result, the climate cooled dramatically, perhaps even to the point of glaciation.

Vascular plants, with their complex root systems and associated root fungi, are often given the most credit for altering biogeochemical cycles. But the role of non-vascular plants may have been important too, as suggested in the Feature on page 86. The colonization of the Earth's surface by



moss and lichen-like plants some 470 million years ago was broadly coincident with the deposition of nutrient-rich sediments in the ocean and the onset of the Ordovician glaciations — short-lived cold spells in a generally warm climate. It turns out — at least in lab experiments with modern species — that non-vascular mosses can affect the weathering of nutrients from minerals on a similar scale to vascular plants.

The influence of plants on Earth systems goes beyond geochemistry. Plants have an important role in shaping today's rivers; root systems often control the shape and stability of river banks, and the presence of organic matter in sediments can affect the shape taken by the rivers' deltas (D. A. Edmonds and R. L. Slingerland *Nature Geosci.* **3**, 105–109; 2010). Logs and other large pieces of wood also shape fluvial systems. As Gurnell discusses on page 93, large pieces of woody debris carried by rivers often form or reinforce hard points along banks and in small islands, providing a surface for more tree and plant growth.

Similar effects of plants on river shape can also be seen in the sedimentary record.

Before extensive plant life covered the Earth, its surface looked very different from what we see today. Instead of forming rivers with defined channels and extensive floodplains, water flowed towards the ocean in broad sheets with no clearly defined boundaries. A Review Article on page 99 documents the co-evolution of plants and fluvial systems since the first plants spread across the Earth.

Without the workings of life, the Earth would not be the planet it is today. Even if there are a number of planets that could support tectonics, running water and the chemical cycles that are essential for life as we know it, it seems unlikely that any of them would look like Earth. Even if evolution follows a predictable path, filling all available niches in a reproducible and consistent way, the niches on any Earth analogue could be different if the composition of its surface and atmosphere are not identical to those of Earth. And if evolution is random, the differences would be expected to be even larger. Either way, a glimpse of the surface of an exoplanet — if we ever get one — may give us a whole new perspective on biogeochemical cycling and geomorphology. □