demonstration of a lesson that adult societies have yet to embrace — societies prosper and persist best when they figure out ways to keep their soil where it belongs and not treat it as if it were dirt cheap. ■

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Secret life of plants

The Emerald Planet: How Plants Changed Earth's History
by David Beerling
Oxford University Press: 2007. 304 pp. £14.99

Paul Falkowski

Plants are an inextricable part of the human experience. They provide us with food and fibre, drugs and building materials, fuel and fodder, fragrances and shelter. Although we are literally beholden to plants for our very existence, the geological history of plants and their role in transforming Earth's biology and chemistry is a largely unsung tale.

This book tries to capture the stories for a scientifically literate reader. It is not written, nor intended to be, a popular science blockbuster, but rather an accessible monograph, in the modern sense, that examines basic questions that palaeobiologists and geochemists have addressed for decades. When did oxygen-producing organisms evolve? How did they come from the oceans to invade land? Once on land, how did they transform the rocky world in which they found themselves to create soils and environments conducive to terrestrial animals, such as ourselves?

The author, David Beerling, trained in palaeobiology and geochemistry, tells two stories in parallel. One is the history of Earth and how photosynthetic organisms transformed it. The other is the history of humans who sought to understand Earth's history. Both are eloquently and engagingly merged in a scholarly, yet generally accessible book that bespeaks of the author's love for plants, the geological history of Earth and the history of science.

Traditionally, Earth's biological history has been inferred from fossils. The fossil record of plants extends back to about 420 million years, yet the fossil record of animals is at least 200 million years older, and fossils of marine microorganisms extend back several billion years (although the validity of some of the earliest microfossils has been questioned). So when did oxygen-producing organisms first appear on Earth?

We are not certain; molecular fossils (organic remnants of organisms that are physically lost in the fossil record) suggest that the earliest oxygen-producing microbes — cyanobacteria — evolved about 3 billion years ago. Over the past 50 years, geochemists, armed with mass spectrometers and other sophisticated instruments, have been able to piece together isotopic records of carbon and sulphur, from which the oxidation state of Earth can be inferred. These records suggest that the atmosphere of our planet 'flipped' from a mildly reducing, anaerobic condition to a mildly oxidizing, low-oxygen state about 2.3 billion years ago. Subsequently, cyanobacteria responsible for the generation of oxygen were appropriated via a series of symbiotic associations, and spread throughout the oceans as eukaryotic algae.

One clade among these algae successfully garnered a foothold on land and became the progenitor of all higher plants. This book describes how terrestrial plants transformed the surface of the planet, not only by accelerating the oxidation of the atmosphere (a process pioneered by algae), but by accelerating the weathering of rocks to form soils and release nutrients, thereby transforming the terrestrial landscape.

Beerling provides for the reader a fascinating history of the discovery of fossils and the the inferences drawn from them. For example, he describes how the French palaeontologist, Charles Brongniart, described in 1894 the discovery of a fossil dragonfly with a wingspan of 63 cm. Such an enormous insect cannot fly without extraordinarily high levels of oxygen; indeed, such gigantic insects are taken as support for geochemical models that suggest oxygen concentrations during the Carboniferous period were upwards of 30% or more — about 50% higher than current oxygen level of 21%. The discovery of fossil forests and dinosaur remains in polar regions, such as Greenland and Antarctica, clearly suggest that 200 million years ago these environments were much warmer than today, presumably as a consequence of significantly higher concentrations of CO_2 in Earth's atmosphere.

Beerling argues that the long-term changes in atmospheric oxygen and carbon dioxide are driven not only by tectonics and slow chemical reactions, but by plants. Indeed, he develops a set of examples that explore how the evolution of plants and animals altered the history of Earth as much as geological processes did.

The emerald portion of our blue planet — the largely terrestrial photosynthetic world — owes its existence to the oceanic realm. Perhaps ironically, Beerling virtually ignores the lowly cyanobacteria, without which there would be no higher plants.

Be that as it may, this book is a wonderful example of the nascent field of Earth systems science, in which geologists and biochemists try to document changes in Earth's environment throughout the planet's history, and biologists try to understand how the core metabolic processes of life altered the distribution of elements on the planet's surface. Beerling describes how we came to understand the importance of oxygen in the nineteenth century, yet to this day we still do not fully understand the mechanism by which the energy of the Sun is used to split water to form the gas on which all animal life is dependent. ■

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ANIMALS ANIMALS/EARTH SCENES

Deep roots: plants such as this fossil tree have shaped Earth's chemistry and geology.