The Emerald Planet
David Beerling

A climate change expert who works by gentle persuasion instead of blatant fearmongering

Paleoclimatologists are having quite a run. Projections of what the climate will be in the future are based on our understanding of what it has been in the past, and even more importantly, why it has been what it has been.

Beerling's specialty is the evolution of plants. Plant evolution has always been a topic of much less interest than animal evolution. However, quite obviously, they evolved together. Here is the story in a nutshell:

The first forms of life came into being in the Earth's first billion years, exploiting sources of energy from chemicals already present in the earth. Cyanobacteria developed the ability to perform photosynthesis about 3 billion years ago. It was an easy task in that CO2 was 100 times more abundant than today. One celled plants formed the basis of the marine food chain.

Monticello organisms appeared in the animal and plant kingdoms between 600 and 500 million years ago. Among plants it was simple algaes, Animals developed complexity a bit earlier, as well as a deeper food chain. Carnivorous organisms and scavengers could feed off the primary consumers of plants.

Vascular plants colonized dry land about 425 million years ago. The oldest appears to be one called Cooksonia, descended from freshwater green algae. It consisted of nothing but a vertical stem that could cling to a rock. Good enough; the atmosphere was still rich in CO2. In fact, Beerling hypothesizes, so rich that a plant could not have exploited leaves even had they evolved. Leaves took something like 50 million years to evolve, slow by evolutionary standards. He conjectures that a decrease in CO2 levels, among other things, was needed to encourage their development.

Leaves led quickly to ferns and horsetails, then to conifers. Flowering plants took another 200 million years, until about 140 million years ago. The most efficient photosynthesizers, C4 grasses, became widespread only about 8 million years ago.

That is the broadest overview. Beerling's thesis is that throughout the whole period of their existence plants have both reacted and contributed greatly to changes in the atmosphere. Though CO2 is a major gas, he also speaks to methane, nitrous oxide (family of 7 gases), sulfur, ozone and oxygen itself.

Here are brief notes on Beerling's chapters

2. Leaves, genes, and greenhouse gases

Leaves perform several functions. First they have to be strong enough to hold up and to face the sun. Second is photosynthesis. A third is respiration – give off oxygen, dissipate heat. Their size, shape, thickness and the number of stomata (pores) adapts to fit their environment. Plant genetics are such that they are primed to respond quickly. The rise in CO2 levels from 280 to 400 ppm over the past 200 years has resulted in dramatic changes in leaf structure and the geographic distribution of plant species.

3. Oxygen and the lost world of giants

A question of aerodynamics: how did those two foot long dragonflies stay airborne? How did they get enough oxygen to keep their motors running? Beerling's answer: there was much more oxygen in the air. It rose from 20% to 35% of the atmosphere. Air pressure increased. Denser air made flying slower, but it was easier to stay aloft. And, of course,

easier to breathe enough oxygen, even with organs much less efficient than lungs, to generate the requisite metabolic energy.

Big bugs are just one of many intriguing pieces of evidence that Beerling says have to be fit together into a coherent argument. One of the endearing qualities of the book is his appreciation of paradox and modesty. There are so many things they just don't know. So many competing theories.

4. An ancient ozone catastrophe?

Revisiting the earth's five major mass extinctions. How ozone protects us. Destroy the ozone and pollen ceases to split cleanly into separate particles, rendering plants unable to reproduce. Evidence from ancient forests, Chernobyl and Patagonia under the 1980s ozone depletion is compatible.

5. Global warming ushers in the dinosaur era

Atmospheric conditions brought about the lush forests of the Carboniferous, then the hotter, dryer world of the dinosaurs.

6. The flourishing forests of Antarctica

The Eocene, 50 million years ago, was warmer overall and much warmer at the poles. The climate models do not show how it could have happened through CO2 alone. However, CO2 triggering other mechanisms, such as release of methane cathrates, the decrease of snow cover, increased water vapor and such might explain it. Again, many competing theories.

7. Paradise lost

The cooling of the earth after the Eocene, and the advent of ice ages. What happened.

8. Nature’s green revolution

The first chemical reaction in photosynthesis generates a three carbon chain, C3, which is subsequently transformed into plant sugars via a few more reactions. Just in the last few million years a number of plants, mainly grasses, have emerged that employ physical structures and enhanced reactions to produce a four carbon chain. They can capture more of the sun's energy, and hence outcompete C3 plants when other factors such as temperature, soil and atmosphere are favorable.

Fire plays a major role in the ecology of grasslands. It clears the forests, making the landscape even more favorable for grasses.

9. Through a glass darkly

Beerling knows the history of science, the theories and the personalities, exceptionally well. He does a masterful job of quoting great men on the subject of what they know, what they think they know, and how human knowledge advances through the interplay of their ideas, experiments, technology and good luck.

The take home from this book is that climate is and always has been very dynamic. There are many theories, not all of which can be correct. However, we do know for sure that an increase of greenhouse gases (CO2 up by a third, methane doubling, nitrous oxide going up significantly) has led in the past to significant climate changes. Also, changes in cloud cover, water vapor, and particulate matter change things measurably.

Mankind would be well advised to discontinue, to the extent possible, making changes to the atmosphere. While Beerling nowhere evidences the zealot's religious conviction that CO2 is evil and that we are doomed (per Al Gore) to drown ourselves in rising seas, he makes a strong case that we should cease from making wholesale changes to a system we so patently do not understand.