Beneath the great divide

What was life on Earth like before the Cambrian explosion?

Life on a Young Planet: The First Three Billion Years of Evolution on Earth
by Andrew H. Knoll
Princeton University Press: 2003. 304 pp. $29.95, £19.95

Stefan Bengtson

Hot springs eternal: cyanobacteria exist in conditions that may not have changed for billions of years.

There is a 'great divide' in the fossil record, known as the Cambrian explosion. Above it is a plethora of creatures large and small; below it are mostly microbes and slime. Palaeontologists spend 99% of their efforts working on fossils above it — but what do we know about what's below? Is the great divide what we think it is?

The prominent Harvard palaeontologist–geobiologist Andrew Knoll is an ideal guide through this early phase of life's history on the Earth. ('Early' is a relative term here, for when his narrative ends, the 'young' planet is four billion years old and has 'only' half a billion years to go before the *Beagle* sets sail from Devonport.)

Knoll starts and ends (barring a final trip into astrobiological space and a pleasing philosophical epilogue) with the Cambrian period. The reason is pedagogic: first introduce the reader to a world that is at least vaguely familiar, then plunge into deep time to find the beginnings of things, gradually returning to the more familiar territories. Just as the subject is broad and varied, so too are the demands on the reader: the text moves between impressionistic images of fieldwork and technical accounts and explanations. The reader has to be prepared to change gear, and if you don't know what a Rube Goldberg machine is, you could always try the Internet.

The dearth of data in Precambrian palaeobiology has inspired lateral thinking and multidisciplinary approaches — but it has also made the field vulnerable to speculation and wishful thinking. Even though the number and quality of Precambrian fossil sites have grown significantly during the past half-century, the available information is still scanty and scattered compared with that above the great divide. How representative is it?

Science is the art of not fooling yourself (as Richard Feynman put it), but the lure to present a coherent story by connecting dots is strong. None of us is immune to this, and one of the strengths of Knoll's book is that it presents science as the open-ended endeavour that it is. In one of the final chapters he writes: "the absence of a definitive punch line … is why I get up in the morning." Ah, yes, what could be more depressing than knowing that all of the problems are solved! Knoll sees the beauty of science as a never-ending story, and transmits his vision well to the reader.

So, despite the remarkable progress of the past 50 years, some of the most crucial questions in Precambrian palaeobiology are still unanswered. When, where and how did life begin? The evidence for a very early establishment of life on Earth is currently under heavy fire; whether life started hot or cold, in soup or stone, on Earth or beyond, is undecided. Two other long-standing enigmas are why it took a billion years or more for eukaryotes to start making their mark after the prokaryotes appeared, and why another billion or two passed before multicellular life finally erupted in the Cambrian explosion. Did evolution really need so long to build complex creatures, or was something keeping the lid on those cans of worms during eons of enforced tranquility?

The Knoll hypotheses regarding evolution's dallying and rallying are 'oxygen' and 'permissive ecology'. The ideas are not new, but Knoll has been instrumental in developing them. The first great oxygenation event in the Earth's atmosphere identified by geochemists took place about 2.2 billion years ago, with a second just less than 1 billion years ago. Knoll believes that the latter event fuelled the Cambrian explosion .

A prerequisite is permissive ecology — an initial lack of fierce competition, allowing for rampant diversification before developmental pathways and tightening ecological interactions restricted the possibilities. Although Knoll believes that preceding extinctions thus paved the way for the Cambrian explosion, he is lukewarm about the Snowball Earth hypothesis (the idea that the whole Earth froze over), which would otherwise be a pretty good extinguisher in this scenario. Slushball, yes; snowball, no.

What did the earlier oxygenation event result in? Knoll argues that this, too, led to an expansion of the ecology, where oxygen-dependent organisms, including eukaryotes, caught the whiff of a grander future. Eukaryotic evolution after this event seems remarkably lethargic, however. Maybe the reason for this is what Knoll calls the 'Canfield' ocean — the global Black Sea that geochemist Don Canfield has proposed to be the result of moderately low ambient oxygen levels following on from the earlier boost. If so, life for the early eukaryotes may have been a harsh struggle against limiting conditions for more than a billion years. And if organisms and rocks are scarce, we need to search long and hard to acquire a data set that we can trust to give us a complete picture of the Precambrian biotas.

The mark of a healthy research field is that there is never a good time to write a book about it. Like other attempts to spell out the history of early life on Earth, *Life on a Young Planet* is a time document, but it expresses better than most the bumptious vitality and sheer fun of open-minded research. ■

Stefan Bengtson is in the Department of Palaeozoology, Swedish Museum of Natural History, Box 50007, SE-104 05 Stockholm, Sweden.

More on the Cambrian explosion

In the Blink of an Eye
by Andrew Parker
Perseus, $24.95, Can$ 38.95; Free Press, £18.99

The journey to Enlightenment

The Man Who Flattened the Earth: Maupertuis and the Sciences in the Enlightenment
by Mary Terrall
University of Chicago Press: 2002. 408 pp. $39, £27.50

Steven Shapin

Being Pierre-Louis Moreau de Maupertuis was hard work. Some of that work was deciding what kind of man of science he wanted to be. Starting out in mathematics and mechanics, he eventually made notable contributions to the study of heredity, and ended his career swept up in a series of metaphysical disputes. Some of the hard work was physical: his most notable scientific research in geodesy called for courage and a willingness to suffer for science. In 1736, he led an expedition to Lapland to establish the precise measure of a degree of latitude. Heavy astronomical instruments had to be lugged up mountains at the northern end of the Gulf of Bothnia, and measuring rods were laid end-to-end for miles over frozen rivers. In winter the cold was so cruel that the intrepid group's cups of eau-de-vie froze to their lips, and when summer came, swarms of mosquitoes drove them to the brink of madness.

The expedition to Lapland was a display of manly fortitude as much as an exercise in state-funded scientific rationality. When Maupertuis returned to Paris, he ensured that the world properly appreciated his achievements by publishing a vivid account, imaginatively combining the genres of travelogue, 'boy's own' adventure story and popular science.

Maupertuis had survived the rigours of Lapland, but now he had to make credible the precision knowledge brought back from the Arctic. What was at issue in the measure of equatorial and Arctic degrees of latitude was the bitterly contested question of whether the shape of the Earth was oblate (flattened at the poles), as Maupertuis maintained, or prolate (elongated at the poles), as was claimed by his local enemies in the Paris Academy of Sciences, the Cassini dynasty of astronomers. The problem of the Earth's exact shape was pertinent to practical cartography and navigation, but it was also connected in complicated ways to preferences for newtonian or cartesian theories of gravitation in particular, and philosophies of nature in general.

For Enlightenment men of science working in absolutist political settings, the question of the credibility of scientific knowledge was always linked to the security of their scientific careers. Science played to the sovereign and his courtiers, and without their approval there were limited resources to do research, few institutional stipends to sustain them, and only weak or marginalized cultural allies to support scientific positions. Part of Maupertuis' genius lay in the deft way that he kept audiences of scientific experts and polite society both in play. As Mary Terrall writes, after many years, Maupertuis refined "an identity as a public figure equally at home in academy and salon".

MARY EVANS PICTURE LIBRARY

Snow easy life: Maupertuis endured the Arctic winter in his quest to determine the shape of the Earth.

When he returned from Lapland, Maupertuis was celebrated by both the court and the salons, falling into the arms of a series of married aristocratic literary ladies, whom he serenaded on his guitar, and securing a pension from the crown for his services to the state. He had his portrait painted dressed in exotic Lapp costume, with his left hand flattening the North Pole of a globe, just so no one could possibly miss the point. He never forgot the importance of amusing as well as instructing, and his literary merits were certified in 1743 by election to the Académie française, thus becoming an 'immortal', and one of the very few French men of science honoured by the élite academies of both of the 'two cultures'.

Having achieved all he could in Paris, Maupertuis was now tempted by Louis XV's absolutist rival, Frederick the Great, who wished his court in Berlin to be furnished and burnished by the best Enlightenment literati that money could buy. Frederick wanted Maupertuis to take charge of the Berlin Academy of Sciences, but the Prussian king's first approaches were rebuffed. Maupertuis eventually succumbed in 1745, seduced by the opportunity for dinner-table intimacy with a monarch, by the offer of total authority over the academy's affairs, by piles of cash, and possibly by Frederick's arrangement of a posh German wife for

New in paperback

Dr Tatiana's Sex Advice to All Creation: The Definitive Guide to the Evolutionary Biology of Sex
by Olivia Judson
Owl/Metropolitan/Henry Holt, $14; Vintage, £7.99
"Judson's text is both wonderfully entertaining and authoritative. All in all this is a stimulating feast of extraordinary sexual practices." Tim Birkhead, *Nature* **418,** 483 (2002).

Shoemaker by Levy: The Man Who Made an Impact
by David H. Levy
Princeton University Press, $16.95, £11.95
"Levy writes well, and his pacey style keeps his personal story bubbling along superbly. The book is everything a 'good read' should be." David W. Hughes, *Nature* **409,** 133–135 (2001).

The Secret Life of Dust: From the Cosmos to the Kitchen Counter, The Big Consequences of Little Things
by Hannah Holmes
Wiley, US$14.95, Can$23.50
Shortlisted for the Aventis Prize for Science Books 2002.