GEOBROWSER

Charles Darwin and geology

This year marks the bicentenary of Darwin's birth and 150th anniversary of his volume: On the Origin of Species by Means of Natural Selection, which established him as the founding father of modern evolutionary biology. Rather less is known of Darwin the geologist, even though during the Beagle voyage he devoted 1383 pages of notes to geology, and only 368 pages to the wildlife he found. His comprehensive observations included the weathering of rocks; igneous processes and metamorphism; volcanic and seismic activity; uplift of mountain ranges, and the development of oceanic islands and their coral reefs through time (*Geol. Assoc. Rockwatch Magazine, 50, p.32*).

Some indication of Darwin's polymath character is revealed by his rather chequered college career (*The Autobiography of Charles Darwin by Nora Barlow, 1958*). At first he followed his father's example by studying medicine, at Edinburgh University. There he became acquainted with 'several young men fond of natural science' and he also attended lectures on geology; although he deemed those 'incredibly dull'. Leaving Edinburgh before completing his medical degree he went on to Cambridge, but confessed to 'wasting' three years there, even though he did gain a degree in Theology, Euclid and the Classics. His real interest evidently lay in natural sciences, for he attended lectures on botany and enjoyed collecting and describing beetles. Through these activities he met J. S. Henslow, who organised informal discussions covering natural science topics that included geology. It was Henslow who introduced the newly-graduated Darwin to Professor Adam Sedgewick, whom he accompanied to Wales in the summer of 1831. This rather brief field course did not satisfy Darwin's curiosity about geology and landscapes, but it enabled him to acquire many basic geological skills, which he subsequently augmented by avid perusal of Lyell's Principles of Geology.

Darwin's somewhat informal geological training was to prove vital for the Beagle voyage of 1831-36, during which he noted that 'The investigation of the geology of all the places visited was far more important… by recording the stratification and nature of the rocks and fossils at many points, always reasoning and predicting what will be found elsewhere, light soon begins to dawn on the district, and the structure of the whole becomes more or less intelligible'. This might well sum up the analytical approach used by Darwin as he formulated his theory of evolution.

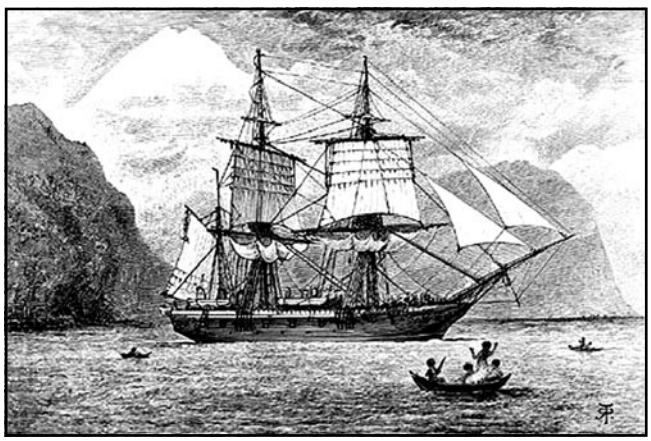
Darwin's tree of life

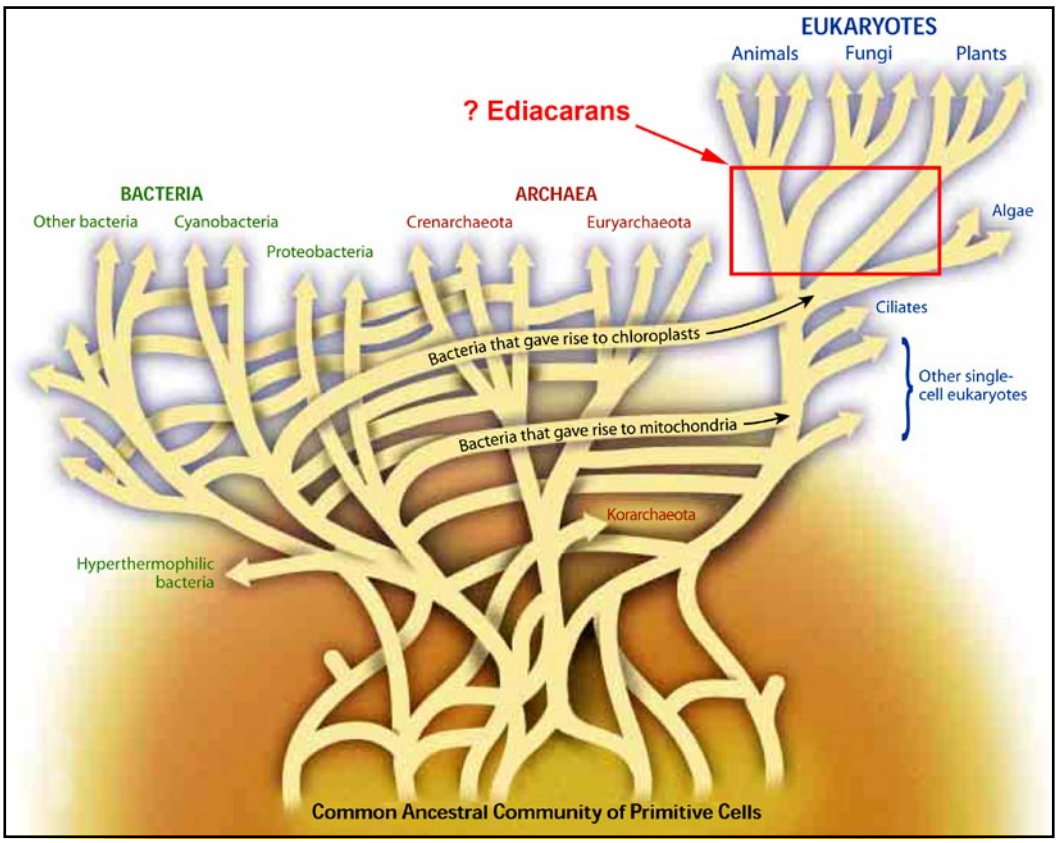
Although much has been made of Darwin's concept of natural selection, his theory of evolution between species had an equally important theme. He compared this to a 'great tree', and it was an elegant depiction of how different species might be related through biological evolution and diversification. Natural selection furnishes the explanation for the Tree, which as Darwin noted provided the 'propinquity of descent' lacking from Carl Linnaeus's hierarchical system for grouping organisms. The Tree of Life has been described as the unifying principle for understanding evolutionary history (*New Scientist, 2009, p.34*). Its base has come to be represented by the LUCA (Last Universal Common Ancestor) and out of this grows the trunk, which bifurcates outwards into branches, some of which continue upwards to end at currently extant species and others, lower down, completed by species now extinct. This tree is typically portrayed in simplified form by modern 'artist-scientists', even though Darwin's most commonly replicated sketch is not particularly tree-like. Moreover, Darwin experimented with ten other tree-variants, indicating an awareness of the complexities of evolution.

For some 150 years biologists have been filling in the various branches of this idealized tree, but since the mid-1960's our perception of evolution has been profoundly modified and greatly improved by the science of molecular phylogenetics, which attempts to determine the rates and patterns of change occurring in DNA and proteins and to reconstruct the evolutionary history of genes and organisms. This new way of thinking followed from the discovery of DNA in 1953, but was given tremendous impetus by the bio-technological advances of the 1990's that enabled the molecular analysis of DNA and RNA protein sequences.

Challenges to Darwin's concepts

At first it was hoped that the new techniques would confirm the tree of life scenario, and fill in more of the gaps. However, they very soon led to the discovery of the archaea (*Proc. National Academy of Science, USA, 1977, p.5088*). These unicellular organisms were previously thought to be bacteria, but are now regarded as an entirely new Third Domain of life, separate from bacteria and eukaryotes (which include animals). Their traces occur in rocks as old as 3.8 billion years, when the planet was hostile to life, and today they include the 'extremophile' organisms, which can exist in very hot, very cold, acidic or anaerobic environments. Importantly, they possess some advanced processes connected with gene transcription and translation, and in evolutionary terms may have an ancestral link





W Ford Doolittle's drawing of the Revised Tree of Life, *to which we have added the possible evolutionary situation at c. 580-542 Ma, when Ediacarans proliferated.*

A chloroplast is the part of a cell that conducts photosynthesis.

A mitochondrion is the part of a cell involved with controlling cell growth and cell functions but with DNA similar to bacterial genomes.

Below left: HMS Beagle

to eukaryotic organisms (*Proc. National Academy of Sciences, USA, Vol. 87, 1990*). Furthermore, the new DNA sequencing databases show that certain bacterial genes also form vital parts of eukaryotic cells, as well as being present in archaea. To paraphrase W. Ford Doolittle (*Scientific American, February 2000, p.90*), this suggests that the pattern of evolution is not as linear or treelike as Darwin imagined it, and although genes do show vertical descent from generation to generation, there is a further process at work, called horizontal gene transfer (HGT). This is facilitated by viruses or 'bacterial conjugation' and must have profoundly affected at least the early course of evolution. There is increasing acceptance that way back in time, all animal life originated through fusion between bacteria and archaea, and HGT is implicated in various evolutionary 'jumps' towards viable, multicellular organisms.

Doolittle's new version of evolution retains the traditional or 'consensus' treelike branching mode at the top for multicellular animals, plants and fungi where both gene transfer and Darwinian natural selection could work. Lower down, however, there is a mesh-like series of linkages, sometimes called a 'web', to symbolize rampant horizontal gene transfer between unicellular organisms. This modified 'tree' also lacks a Universal Common Ancestor, and suggests that the three major domains of life probably originated from a population of primitive cells with different combinations of genes.

Should Darwin's tree be uprooted?

Most scientists agree that Darwin's theory of descent remains valid, and that despite Doolittle's modifications the tree metaphor is still an apt, albeit oversimplified depiction of early evolution. This year, however, a controversy focussed on the biomolecular discoveries of the previous decade has entered the popular media, with attention-grapping headlines such as: 'Darwin was Wrong' (*New Scientist, January 24, 2009*) and 'Darwin was wrong and misleading' (*The Telegraph, January 22, 2009*). These attacks have been repudiated by evolutionary scientists, who maintain that they not only misrepresent the outcomes of biomolecular studies, but also inspire creationists to mislead people into believing that the theory of evolution by common descent is wrong. A succinct riposte to such articles can be found online (*S. Schafersman; February, 2009 'The Death of the Tree of Life has been greatly exaggerated'*). It features a letter to the New Scientist from a panel of experts, including Richard Dawkins, insisting that the tree of life concept is not fundamentally unsound, but it is '…more complicated than was realised before the advent of molecular genetics. It is still true that all of life arose from "a few forms or... one", as Darwin concluded in The Origin of Species. It is still true that it diversified by descent with modification via natural selection and other factors'.

Does this help understand Charnian fossils?

The apparent absence of fossils in Precambrian rocks bothered Darwin, although in Origin of Species he presciently wrote that: 'Traces of life have been detected in the Longmynd beds beneath Barrande's so-called primordial [Cambrian] zone.' He might also have mentioned the organic impressions discovered in Charnwood Forest in 1848 (*Geobrowser, 2008*),

had he known about them. We now appreciate the true richness and diversity of the Ediacaran biota, with 325 Precambrian fossils featured in the glossary of The Rise of Animals (*reviewed in Mercian, 2008, p.67*). Few of these actually survived beyond the Precambrian-Cambrian boundary (542 Ma), so the biological affinities of those that did not can only be guessed at. Doolittle's modified Tree of Life helps here, since it places Ediacarans at a very early stage in multicellular organisation, when processes such as horizontal gene transfer, hybridisation and symbiosis were considerably more fluid. The referral of the more enigmatic Ediacarans to 'failed experiments in life' rings true, though it may be more accurate to say that those particular 'experiments' produced unexpected and bizarre organisms. Suited to environmental niches that existed then, they were unable to evolve further or to compete with the more genetically robust species that went on to become the true ancestors of modern life.

THE RECORD

We welcome new members who have joined the Society during 2008. Our membership now stands at 343 with an additional 40 institutional members.

Indoor Meetings

Many of the indoor meetings this year seem to have had historical as well as geological interest. They began with the members' evening which, under the chairmanship of Gerry Slavin, was held after the AGM in March. The subjects of this series of short talks were Iceland, Faroe Islands and zeolites (Alan Dawn), Ardnamurchan (Robert Gill), The rise of the roddens (Dinah Smith) and Water wheels and geology in the Derwent Gorge, Matlock (Lynn Willies)

Also in March, there was a joint meeting with the Yorkshire Geological Society at Keyworth entitled The Erosion of Northern Britain.

April's lecture was about the Midland Influences on William Smith, given by Peter Banham.

The winter programme began in style October with Geology of the Languedoc, presented by Roger Suthren, complete with wine tasting.

In November, Will Watts spoke about the Rotunda Museum in Scarborough, its role in the beginnings of geology and its recent redevelopment.

December's speaker was Tony Waltham, who gave us the Salt Terrains of Iran, and this was followed by the Christmas buffet.

In January, the Secret of Sherwood Forest was disclosed by Kevin Topham from Dukes Wood Oil Museum.

The Foundation Lecture this year was on Palaeobotany of Antarctica and was given by Professor Jane Francis.

We are grateful to Richard Hamblin for organizing this year's successful programme of speakers, and to Gerry Shaw for organizing the refreshments.

Field Meetings

Once again a varied programme of field excursions was organised by Ian Sutton to whom we give our thanks. Also due thanks to the field trip leaders who share with us their time and their knowledge.

In May, Paul Guion led a trip concerning hydrocarbon reservoirs and the Dukes Wood oil museum.

Evenings in June were to Charnwood Forest with John Carney, and to Middleton Moor for the Hopton Wood Stone led by Ian Thomas.

July saw a whole day visit to the Millstone Grit of Skipton Moor led by Neil Aitkenhead, and also an evening walk to look at the gravels and tills in Charnwood Forest with Keith Ambrose.

The weekend excursion led by Ian Sutton was this year to The Gower in South Wales, for its fossils and its fine structural geology.

Council

Council met formally on six occasions during the year.

As no Treasurer had been elected at the Annual General Meeting, Colin Bagshaw was co-opted to the position in May. Paul Guion and Ian Sutton were also co-opted to Council on the same occasion.

This has been a quieter year for projects. We have given our support to the Ecton Hill Field Study Centre, and have donated £100 to Dukes Wood Oil Museum towards the cost of replacing their stolen notice boards. The Hemlock Stone is currently being researched, and the back copies of the Mercian Geologist are being converted into electronic form both for archive purposes and to make the contents more widely available. The Society continues to support Geodiversity in the East Midlands, with some of our members helping to update the RIGS databases.

Thanks are due to Sue Miles for editing the Society's Circular (which now goes to half the membership via e-mail), to Tony Waltham for editing the Mercian Geologist (including The Geology of Chatsworth which was off-printed to form a special publication), and to Rob Townsend for continuing to maintain the Society's website.

To conclude I would like to thank all those I have not specifically named in my report who work hard to further the aims of the Society.

Janet Slatter, Secretary

Notes for authors

Guidance notes for authors intending to contribute to the ***Mercian Geologist*** may be seen on, and printed from, the Society website (www.emgs.org.uk). Paper copies may also be requested by mail or by telephone from the editor for anyone without web access. Contributions are welcome from both members and non-members.