The tree of life, one of the iconic concepts of evolution, has turned out to be a figment of our imagination, says **Graham Lawton**

Uprooting Darwin's tree

IN JULY 1837, Charles Darwin had a flash of inspiration. In his study at his house in London, he turned to a new page in his red leather notebook and wrote, "I think". Then he drew a spindly sketch of a tree.

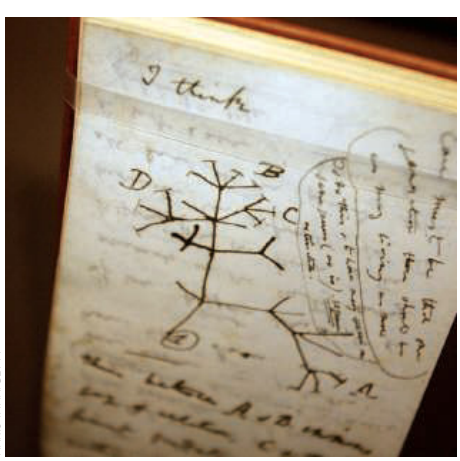
As far as we know, this was the first time Darwin toyed with the concept of a "tree of life" to explain the evolutionary relationships between different species. It was to prove a fruitful idea: by the time he published *On The Origin of Species* 22 years later, Darwin's spindly tree had grown into a mighty oak. The book contains numerous references to the tree and its only diagram is of a branching structure showing how one species can evolve into many.

The tree-of-life concept was absolutely central to Darwin's thinking, equal in importance to natural selection, according to biologist W. Ford Doolittle of Dalhousie University in Halifax, Nova Scotia, Canada. Without it the theory of evolution would never have happened. The tree also helped carry the day for evolution. Darwin argued successfully that the tree of life was a fact of nature, plain for all to see though in need of explanation. The explanation he came up with was evolution by natural selection.

Ever since Darwin the tree has been the unifying principle for understanding the history of life on Earth. At its base is LUCA, the Last Universal Common Ancestor of all living things, and out of LUCA grows a trunk, which splits again and again to create a vast, bifurcating tree. Each branch represents a single species; branching points are where one species becomes two. Most branches eventually come to a dead end as species go extinct, but some reach right to the top – these are living species. The tree is thus a record of how every species that ever lived is related to all others right back to the origin of life.

For much of the past 150 years, biology has largely concerned itself with filling in the details of the tree. "For a long time the holy grail was to build a tree of life," says Eric Bapteste, an evolutionary biologist at the Pierre and Marie Curie University in Paris, France. A few years ago it looked as though the grail was within reach. But today the project lies in tatters, torn to pieces by an onslaught of negative evidence. Many biologists now argue that the tree concept is obsolete and needs to be discarded. "We have no evidence at all that the tree of life is a reality," says Bapteste. That bombshell has even persuaded some that our fundamental view of biology needs to change.

Darwin's first sketch of an evolutionary tree of life



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So what happened? In a nutshell, DNA. The discovery of the structure of DNA in 1953 opened up new vistas for evolutionary biology. Here, at last, was the very stuff of inheritance into which was surely written the history of life, if only we knew how to decode it. Thus was born the field of molecular evolution, and as techniques became available to read DNA sequences and those of other biomolecules such as RNA and proteins, its pioneers came to believe that it would provide proof positive of Darwin's tree of life. The basic idea was simple: the more closely related two species are (or the more recently their branches on the tree split), the more alike their DNA, RNA and protein sequences ought to be.

It started well. The first molecules to be sequenced were RNAs found in ribosomes, the cell's protein-making machines. In the 1970s, by comparing RNA sequences from various plants, animals and microorganisms, molecular biologists began to sketch the outlines of a tree. This led to, among other successes, the unexpected discovery of a previously unknown major branch of the tree of life, the unicellular archaea, which were previously thought to be bacteria.

By the mid-1980s there was great ›

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