So, could Ida be the true missing link?

As a 47-million-year-old makes her television debut, Norman MacLeod and Angela Milner assess the significance of her discovery.

Tonight, the world's most famous fossil will go prime-time: Ida, a 47-million-year-old lemur-like creature whose existence was revealed last week, will be the subject of a BBC documentary arguing that this early primate is a potential ancestor of mankind.

The tropical creature, more properly known as *Darwinius masillae*, was found in the lake bed of a volcanic crater in Messel, near Frankfurt, and was so exquisitely preserved that we could see such intimate details as its furry coat, sex (female) and stomach contents. But what does Ida really tell us about our evolutionary past – and can she truly qualify as a "missing link"? The story begins up to 3.8 billion years ago, when the first fossils were laid down. These remains of long-dead organisms, preserved in mud, silt and sand, are the working tools of palaeontologists. The oldest fossils are microscopic bacteria, or bacteria-like organisms, which dominated the first 85 percent of the history of life on Earth.

About 1.2 billion years ago, simple algae evolved; then the "Cambrian explosion", around 525-520 million years ago, saw the first appearance in the fossil record of the patterns and body-plans that would later form the basis of modern animals – including the vertebrates, or backboned creatures, to which we can trace our own ancestry. The fossil record tells us that the dinosaurs were the top predators on land through the Mesozoic Era, 228-65 million years ago, and that the earliest, shrew-sized mammals appeared about 200 million years before the present day, diversifying and becoming dominant after the last of the non-avian dinosaurs became extinct.

Taken together, these species, and countless others, form what is known as the "tree of life" – most commonly presented as a branching diagram containing all the creatures that have ever existed. Many branches of the tree are shrouded in shadow; most that we know of are dead ends, comprised of creatures that became extinct, but left no descendants. In a few cases a seemingly inconspicuous species gave rise to one or more daughter species, that in turn gave rise to other successful species, and so forth until a great and diverse branch of the tree of life had been established, over tens or hundreds of millions of years.

Because we seek to understand why some evolutionary lineages diversified and flourished while others did not, there is intense scientific interest in the ancestors of these massive branches of the tree of life, the single species from which entire categories of today's creatures grew. We want to know everything about these "missing links" – but in the absence of the relevant fossil, the actual body of evidence, none of our questions can be answered definitively.

This absence of firm evidence has been a perennial problem for researchers. Even before modern theories of evolution arose, we still used the concept of a "missing link" as a reference to the pre-Christian idea of Great Chain of Being, or Scala Naturae, in which all possible aggregations of matter, from simple, inanimate materials to the most complex, self-aware biological structures (in other words, human beings), were thought to exist in a smooth gradation of increasing complexity.

Apparent gaps in this sequence – the missing links in the chain – could, these early researchers thought, be filled by plants and animals that existed somewhere on Earth, but had yet to be discovered. After all, new

evidence was turning up continually in the course of human migrations and explorations, in the form of unexpected creatures from remote regions, such as kangaroos and platypuses. So long as much of the Earth's surface remained unexplored, a possibility existed that all the apparent gaps in the classical *Scala Naturae* would be filled.

Yet as explorations proceeded, it became apparent that not everything in this system could be accounted for. Darwin and others proposed a rival theory, of common descent: the great tree of life. With evolution as the driving mechanism, this rapidly became an orthodoxy – yet creationists constantly badger scientists about the supposed absence of the ancestral forms that linked the major evolutionary groups together: the "missing links" that would explain how one creature could evolve into something so vastly different in appearance.

The weary answer of the scientists has been twofold: that this absence of evidence was often a simple consequence of an incomplete fossil record, and that there is now overwhelming evidence for evolution in the way that common features such as hair, milk teeth, feathers, limbs and gill slits appear across so many species. But transitional fossils retained their fascination. And gradually, as the digs and excavations continued, we were able to use them to document the evolutionary transitions between primitive fish and sharks, amphibians and reptiles, reptiles and mammals, and many more.

Consider, for example, *Tiktaalik*. This creature, halfway between a fish and an amphibian, was discovered in Late Devonian river sediments between 375 and 365 million years old. Its fins have become limbs, complete with the same bones we have in our arms, wrists and fingers, and it has developed a robust ribcage able to support its body when out of water. This water-to-land transition is what Donald Rumsfeld might have called an "unknown known": scientists came up with the theory that four-legged animals could have evolved from a certain kind of fish, and went looking in rocks of the right age and type. Sure enough, animals with the appropriate hybrid features were found.

The most famous example of a transitional fossil, however, is *Archaeopteryx*, discovered in 1861 in a quarry in Germany. Coming just two years after Darwin published *On The Origin of Species*, it provoked a sensation far greater even than Ida: here was a small, meat-eating dinosaur that bore the clear imprints of wings and flight feathers, almost exactly like those of modern birds. It seemed to demonstrate conclusively how, as Darwin had suggested, two major and diverse groups of creatures could be linked by an evolutionary transition. More recent brain scans, carried out by one of the authors on the skull of the *A*rchaeopteryx belonging to the Natural History Museum, have revealed that its brain pattern was bird-like and "flight-ready", and its inner ear, crucial for balance and orientation in the air, was as well-developed as in modern birds.

So is Ida another of these great "missing links"? Perhaps – but there is a problem. In order to be recognised as a true ancestor, a fossil must have no truly unique aspects: it must have passed all of its characteristics on to its daughter species, albeit in an altered form. Species do not interbreed (or at least, do so very rarely), so all characteristics must be inherited. For example, while birds do not have the teeth of their dinosaur ancestors, they retain the necessary developmental infrastructure to make them (so if you wanted to make hen's teeth slightly less rare, you could simply switch the dormant gene back on in a laboratory).

On this qualification, the *Tiktaalik* and *A*rchaeopteryx both fall down as true missing links: both have unique features that have not been passed on to any living creatures. In other words, despite their enormous importance, they are not true ancestors, but belong to small branches of the tree of life whose form is close to that of the true ancestor.

Is the same true of Ida? Well, her fossil's status as a missing link is controversial in a slightly different way. Ida lacks some of the features common to modern lemurs, but does not appear to possess any features unique to our own lineage of anthropoid primates. This renders Ida's evolutionary status ambiguous, at best.

Yet whatever the conclusions scientists reach, she is a welcome reminder of the kind of discoveries that make palaeontology so exciting and fascinating. In 1983, for example, an entirely new fish-eating dinosaur, *Baryonyx*, was discovered by an amateur collector just 30 miles south of London. Who knows what other fossils are out there that could help us draw up new branches and new linkages along that great tree of life?

•Prof Norman MacLeod and Dr Angela Milner are Keeper and Associate Keeper of Palaeontology at the Natural History Museum, where a cast of Ida will be on display from tomorrow. The story of Ida's discovery will be told by David Attenborough in 'The Link: Uncovering Our Earliest Ancestor', on BBC One at 9pm on Tuesday May 26 2009.

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