Biologists Debate Man's Fishy Ancestors

The lungfish and the coelocanth each has its scientific partisans.

By MALCOLM W. BROWNE

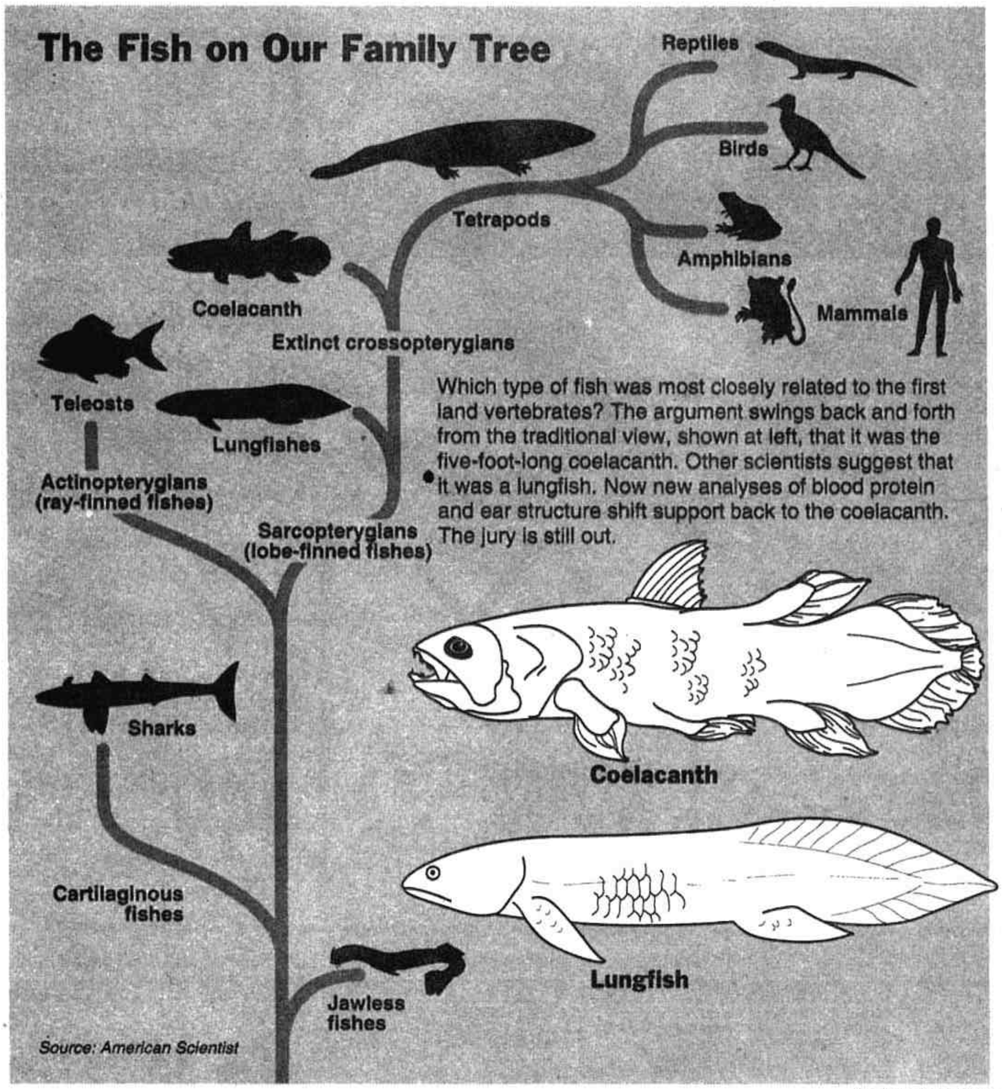
MANY of us forget that our ancestors were fishes, but among biologists the debate over exactly which class of ancient fish was closest to our forebears remains a hotly disputed topic. Was it the coelacanth or the lungfish that was more closely related to the family tree of four-limbed vertebrates that led to human beings? Some new laboratory and fossil evidence seems to favor the coelacanth. Far from settling the controversy, however, the latest discoveries have inflamed it.

In recent years, the preponderance of expert opinion has shifted toward the lungfish as the closest relative of the tetrapods, a group that includes amphibians, reptiles, birds and mammals, including ourselves. But new analyses of blood proteins and ear structures of present-day lungfish and coelacanths have convinced some scientists that the coelacanth is closer.

The first invasion of land by aquatic vertebrates nearly 400 million years ago was a momentous act in evolutionary history. It required the colonists to adopt new modes of locomotion, major changes in their organs of vision and hearing, and a new bellows apparatus for drawing oxygen from air, augmenting or replacing the gill system used by fish to draw oxygen from water.

No one can be certain which group or groups of fishes was the first to make the transition to land, or what their evolutionary pathways may have been. Nevertheless, the lungfish and the coelacanths each have their scientific partisans, while a few other scien-

Continued on Page C7



The New York Times

Biologists Debate Issue of Ancestors From Sea

Continued From Page C1

tists see more affinities between the tetrapod line and such ray-finned fishes as the tuna, carp and herring.

Lungfish are slim, eel-like fish with air-breathing lungs as well as gills, and four filamentary fins they use to feel out their surroundings. Fossil lungfish are found in sediments more than 400 million years old, and modern ones live in fresh-water streams and lakes in South America, Africa and Australia.

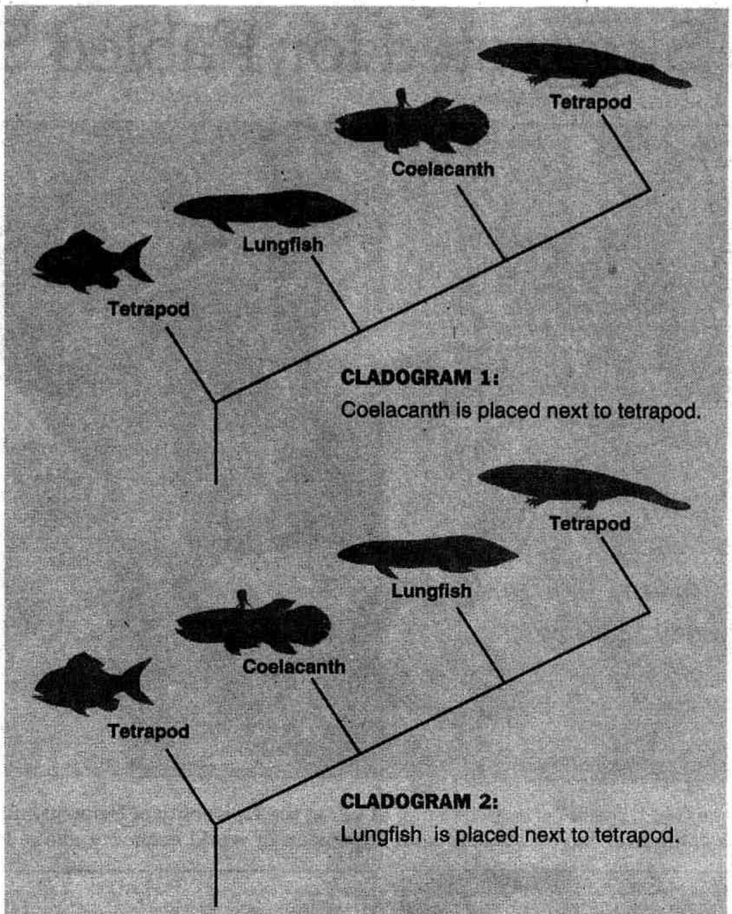
Coelacanths, with a similarly ancient pedigree, were believed to have died out about 80 million years ago, until a living coelacanth was caught off the South African coast in 1938. Its identification as a "living fossil" caused a scientific sensation. Since then, several hundred coelacanths have been caught in waters near the Comoro Islands, although none has survived the experience, and some scientists fear they are about to become truly extinct. These predators, about five feet long, have been photographed maneuvering into peculiar head-down stances with the help of their limb-like fins. They seek their prey on the ocean bottom and rarely, if ever, approach the surface.

In trying to decipher the evolution of tetrapods from fish, scientists face formidable problems. The transition from water to land occurred long ago, and various family trees suggested by the fossil record are so tangled that scientists acknowledge they may never be able to sort them out definitively.

The usual scientific approach is to examine every bony feature of all available fossils and to look for matches between different animals. If two animals share more "characters," or traits, than either animal does with the rest of the group under comparison, they are placed next to each other on a diagram called a cladogram, a tool of the classification system called cladistics, which groups animals and plants according to their similarities to each other. Animals with the fewest common characters are placed farthest apart on this type of diagram.

Cladograms merely show similarities between animal or plant groups and are not intended to portray evolutionary pathways, which are much more complicated. But evolutionary inferences are often drawn from cladograms, and these inferences are a major source of disagreement and contention.

When living animals are involved, comparisons become even more complex. They must take into account detailed features of organs, brains,



Depicting Family Resemblances

A diagram called a cladogram is a classification tool that groups animals and plants according to their similarities; the more similarities, the closer together. Analysis of coelacanth and tadpole hemoglobin places the coelacanth next to the tetrapod, top. Analysis of mitochondrial DNA, cell genetic material, places the lungfish at that position, below.

Source: American Scientist

The New York Times; Illustration by Baden Copeland

the best match was with the lungfish. "This result appears to rule out the possibility that the coelacanth lineage gave rise to land vertebrates," they concluded in a paper published by The Journal of Molecular Evolution in 1990.

In their rebuttal to this, Mr. Gorr and Dr. Kleinschmidt challenge the assertion that mitochondrial DNA is a better indicator of kinship than blood hemoglobin. Mitochondrial DNA evolves relatively rapidly, they say, and although it may be useful in establishing relationships between such recent species as modern elephants and extinct mammoths, it is unreliable for comparing very ancient animals with modern ones.

Dr. Meyer remains unconvinced. "The computer program they used in their analysis was never intended for the use to which they put it," he said in an interview. "Their methodology is wrong, and as far as I can tell, their reanalysis is no closer to the truth than their original work. If anything, it supports my lungfish hypothesis."

Other Lines of Evidence

A different line of evidence supporting coelacanth ancestry has come from Dr. Bernd Fritzsch of Creighton University in Omaha. Dr. Fritzsch, whose research focuses on the evolution of hearing mechanisms,

of Washington at Seattle reported recently that his study showed the oculomotor system of the coelacanth was closer than that of other fish to that of tetrapods.

Still, many if not most scientists remain unconvinced.

Dr. Eugene S. Gaffney, curator of vertebrate paleontology at the American Museum of Natural History in New York, is among the doubters.

"For many years I believed that the coelacanth was closer than the lungfish to the tetrapod line," he said, "but a few years ago I changed my mind. The cumulative evidence finally swayed me to the lungfish, and I haven't changed that view."

"We all must keep an open mind," Dr. Gorr said in reply to criticism by Dr. Meyer. "But why must some of our critics insist that only their own evidence is worth considering? I think scientists can be surprisingly bigoted."

contention.

When living animals are involved, comparisons become even more complex. They must take into account detailed features of organs, brains, nervous systems and such molecular components as DNA and proteins. Controversies have proliferated with each new type of trait that scientists add to their cladistic analyses.

Views differ on which group of fishes first made the transition to land.

Recent debate has focused on the work of two German scientists, Thomas Gorr and Dr. Traute Kleinschmidt, both of the Max Planck Institute for Biochemistry at Martinsried, Germany. They recently recalculated their earlier (and highly controversial) analyses of the blood hemoglobin of 522 marine and land-dwelling animals, and concluded that there is a close chemical match between one component of the coelacanth's blood hemoglobin and its corresponding component in tadpole blood.

The match, they reported, was not nearly as good between the coelacanth and an adult frog, however. The implication of this discovery, Mr. Gorr said in an interview, is that the metamorphosis of a tadpole into a frog not only recapitulates the gross physical changes the fish underwent as they evolved into air-breathing tetrapods, but also recapitulates the molecular changes from fish hemoglobin to tetrapod hemoglobin.

Mr. Gorr and Dr. Kleinschmidt concluded in an article in the February issue of American Scientist that "there is no reason to doubt that the coelacanth is the closest living relative of the tetrapods."

Disputing this view is another group of scientists, led by Dr. Axel Meyer, a biochemist at the State University of New York at Stony Brook. Dr. Meyer and the late Dr. Allan C. Wilson investigated the chemical ancestry of tetrapods from an entirely different direction three years ago. They based their comparisons on analyses of a special form of DNA found in mitochondria, the microscopic components of living cells that supply them with energy. This DNA, unlike ordinary DNA, is believed to be inherited only from the mother, rather than from both parents, and some scientists believe that mitochondrial DNA undergoes evolutionary changes at a steady, clock-like rate.

Dr. Meyer and Dr. Wilson showed that when the mitochondrial DNA of a frog was compared with the mitochondrial DNA of various fishes, including coelacanths and lungfishes,

A different line of evidence supporting coelacanth ancestry has come from Dr. Bernd Fritzsch of Creighton University in Omaha. Dr. Fritzsch, whose research focuses on the evolution of hearing mechanisms, has studied the ears of coelacanths and lungfish, and compared them with those of land-dwelling tetrapods. He concluded that the detailed structure of a coelacanth's middle and inner ear is strikingly similar to that of the tetrapod, while the lungfish ear is like that of a shark.

The hearing mechanisms of all vertebrates must deal with a fundamental problem: the mismatch between the behavior of sound in water and its behavior in air, a phenomenon called impedance mismatch. In land-dwelling tetrapods, the inner ear is a water-filled cavity to which sound arrives from an air-filled middle ear. A structurally similar system, involving a bubble next to the inner ear, had already evolved in coelacanths before marine vertebrates began coming ashore, Dr. Fritzsch said.

Another type of new evidence that suggests coelacanth connections with tetrapods has come from an investigation of the oculomotor system, the brain and neural connections that control movement of the eyes. Dr. Chris von Bartheld of the University