Living Fossils: Coelacanths and the Ancestry Debate

Editor's Introduction | Does the discovery of a fish that "walks" and performs headstands confirm a close ancestral relationship between coelacanths and land vertebrates? Coelacanths were long thought to have become extinct with the dinosaurs, but recent underwater studies of the mysterious habitat of the creature has led modern science to dispute this direct connection while acknowledging the existence of a distant link. Peter Forey provides a lively discussion of twentieth-century coelacanth discoveries and the associated political and scientific disputes they generated.

On December 22, 1938, a fishing trawler landed at East London, a port on the east coast of South Africa. It had been fishing for sharks near the mouth of the Chalumna River, with trips into the Indian Ocean. As the trawler came in, the captain radioed to say he had caught a fish of a species he never seen before. The unusual creature was then shown immediately to Marjorie Courtney-Latimer, a curator at the East London Museum, for identification.

The steel-blue-coloured fish measured 1.5 metres in length and weighed around 120 pounds. It was flecked with large white blotches. The curator had no idea what it might be; back at the museum, a local taxidermist took charge of its preservation, using materials from the local morgue. Most of the insides were thrown away, leaving just the carcass. Several features struck Courtney-Latimer as very unusual, in particular the sail-like first dorsal fin, the broad fan-shaped tail with the peculiar tuft at the end, the thick bony plates over the head and the very thick scales. In addition, the paired fins had fleshy bases, unlike most other fishes in existence today. Courtney-Latimer was even more curious, and contacted James Leonard Brierly Smith, professor of chemistry in Grahamstown. He was, at the time, an amateur ichthyologist with a special interest in the identification of South African fishes.

Gordon Howes

Painting of a coelacanth.

The Natural History Museum

Latimeria chalumnae.

In her letter, Courtney-Latimer included basic drawings of the creature, emphasising in particular the sail-like dorsal fin, the peculiar-shaped tail, the thick bony plates covering the head, the thick scales and the fleshy fins. Smith was astonished and realised immediately that he was looking at a fish that belonged to a family thought to have died out 70 million years ago. Here, in essence, was a living fossil, curiously preserved in time. Smith had a scant knowledge of fossil fish, but the sail-like dorsal fin and the shape of the tail were enough to tell him that he was actually looking at a coelacanth, first described back in the 1830s. Smith proceeded to name the living coelacanth Latimeria chalumnae: Latimeria in recognition of Marjorie and chalumnae because it had been found near the mouth of the Chalumna River.

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Coccoderma bavaricum.

Before 1938, coelacanths had been known exclusively as fossils, much like trilobites and dinosaurs. Louis Agassiz, founder of the Museum of Comparative Zoology at Harvard, first described the fossil coelacanth in 1835, roughly 100 years before the living coelacanth was discovered. A coelacanth tail was discovered in rocks 280 million years old, during excavations of a road cutting in northern England. Agassiz was impressed by the fact that the spines which supported the tail fin were hollow and not solid, and so he coined the word "coelacanth": "coela" meaning hollow and "acanth" meaning spine.

Since then, fossil species of coelacanths have been found dating back to the Devonian period (some 360 million years ago) and up to the Upper Cretaceous period (about 70 million years ago). Discoveries have convinced scientists that coelacanths were most numerous in the Lower Triassic period, 230 million years ago.

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Macropoma lewesiensis is one of the last fossil coelacanths restored here swimming in the clear Chalk seas of southern England.

Throughout their history, different species of coelacanths looked, as far the bony skeleton was concerned, virtually identical to one another. Their extreme structural conservatism was important in assisting Smith in identifying the living fish as a coelacanth. It has also been important in telling us more about the ancestry of tetrapods (land-dwelling vertebrates), amphibians, lizards, snakes, crocodiles, birds and mammals, and the relationships between them.

In the 1930s, scientists believed that coelacanths were descended from the same kind of animal that gave rise to land-dwelling vertebrates. Assuming this was the case, scientists attempted to make some important hypotheses. If the skeleton was so conservative, then over time the soft parts and life style was likely to have remained relatively unchanged. And if coelacanths were direct descendants of the ancestors of land-dwelling vertebrates, then studying the coelacanth would enable predictions to be made about the blood system, the reproductive system, the brain and sensory organs of ancestors, which in turn would reveal how they lived, breathed, reproduced and responded to their environment. The living coelacanth thus became the important missing link between water-based fish and land-dwelling vertebrates.

But, by this time, the soft parts of the only known specimen had been thrown away and another had to be found. The search proved fruitless, however, and Smith resorted to producing a "wanted" poster that was distributed widely around the islands in the western Indian Ocean. In the meantime, Dr. Errol White, the pre-eminent palaeoichthylogist in England in the 1940s, dismissed his search as futile, claiming that Latimeria would most certainly be a deep-sea fish, and that hunting the shallow bays would yield nothing. However, none of the physical attributes of deep-sea fish were present in Smith's coelacanth (black colouring, delicate skeleton and thin scales), so he persisted with his search as before.

J.L.B. Smith
Reward Notice.

Fourteen years after the first discovery, the search paid off, and Smith received news on December 22, 1952, that a coelacanth had been found at the island of Anjouan, part of the then French-owned Comores chain, some 1,100 miles to the north of East London, where the original had been found. It was retrieved, but Smith, determined not to let the coelacanth out of his sight, was shocked to discover, on his return to South Africa, that the French were insisting that the fish was theirs. French scientists were called in to analyse the find and Smith retreated disillusioned, to continue his work on descriptions of South African fish.


J.L.B. Smith
Smith pictured with his coelacanth find.

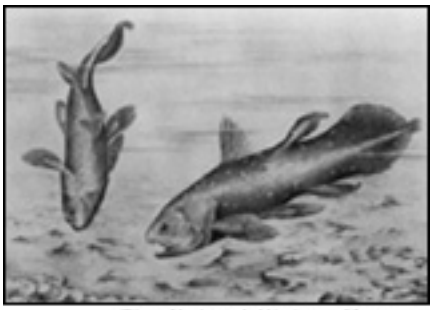
It had now been established that the coelacanth came from the waters of the Comores Islands, and it was assumed that the first specimen had been a stray swept down the east coast by the strong Mozambique current. Interestingly, local Comoran fishermen had been catching coelacanths for some time and knew their habits well. Those caught were thrown back, because they contained foul-tasting and inedible urea and oil. Consequently, they named it the *gombessa*, which means taboo.

Since 1952, around 200 coelacanths have been caught there and analysed intimately. The Comores Islands remained securely in French hands until the mid 1970s, when they gained their independence. Professor Hans Fricke, a professional underwater explorer, then became interested in studying the fish more closely and decided to dive down to examine the coelacanth in its natural habit. At the surface, coelacanths cannot live for more than a few hours, and this had made it difficult to analyse regular patterns of behaviour. From his underwater explorations, Fricke was able to establish that the fish grows up to six feet and weighs up to 180 pounds. Feeding on a diet of other fish and squid, it lives at a depth of about 160 metres (450 feet)--the greatest depth to which light penetrates the waters in this part of the world. This accounts for the large eyes, which have a reflective layer behind the retina. The coelacanth spends most of its time deep inside submarine caves and only emerges at night to feed, the time at which most coelacanth catches have been made.

The reproduction of the coelacanth has caused much controversy. The dissection of a female by the French in the 1970s revealed a few very large eggs in the oviduct. They were the largest fish eggs

known to date, the size of a tennis ball and full of yolk. So the French predicted that the young developed outside the body, using the yolk as the food source.

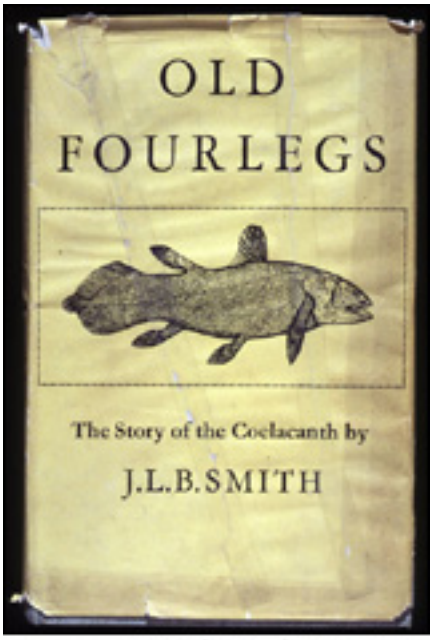
However, in 1975, scientists at the American Museum of Natural History in New York cut open a coelacanth to find five young foetuses, later called pups. Each was a perfectly formed coelacanth with attached yolk sacs, which revealed that the coelacanth actually give birth to live young in the way some sharks do. Unfortunately, little more is known about their reproductive biology, where fertilisation takes place or where the pups are born and mature. So far, only adults have been caught around the Comores; Fricke never saw the young during his numerous diving expeditions, and the mystery surrounding them remains even now.



The Natural History Museum

Latimeria frequently performs 'head-standing' movements. It is possible that it does this to hold the rostral organ close to the seabed.

Fricke witnessed some remarkable behaviour from the coelacanth, noting that it would occasionally stand on its head with its snout held a few feet from the seabed. This behaviour could also be stimulated by placing a weak electric current near the fish. The snout contains a large cavity lined with special cells, similar to those electro-receptive cells found on the undersurface of a shark's snout. In the latter, these are used to detect prey; even the beating of a crab heart will produce a small electrical discharge.



J.L.B. Smith, *Old Four Legs* (Longman, 1957)

The title page of Smith's autobiography "Old Four Legs"

So convinced was Smith of the relationship between the two that he entitled his book *Old Four Legs*, predicting that, when at home in its natural environment, the coelacanth would be found to "walk" on the seabed. In truth, it cannot walk, but it does show one sequence of limb movement that must have been present in tetrapod ancestry: the left pectoral and right pelvic fins move in unison and alternate with the right pectoral and left pelvic. This is like the movement of human arms and legs, and totally unlike the fin movements of other fishes. Another belief was that the tetrapod ancestor should be a freshwater creature, since the most primitive living tetrapods, such as frogs and salamanders, are tied to freshwater. However, *Latimeria* has the fully fledged seagoing physiology of other marine life. Others have suggested that it is a freshwater fish trapped in caves which are really filled with freshwater that percolates down through volcanic rocks, which would explain its difficulty at being away from depth and darkness for more than a short time. This is, however, purely speculation.

Modern science has disputed the close ancestral relationship of coelacanths with tetrapods, but it does acknowledge a distant link. The coelacanth has clearly retained a genetic pool that is at least 360 million years old, and that in itself is of major scientific interest in the study of the origins of species.

The Natural History Museum

Latimeria chalumnae.

In 1949, a woman who owned a gift shop in Tampa, Florida, bought a box of curious-looking scales from a fishermen who claimed they were local. She was intrigued about their identity and sent one to the Smithsonian Institution, where it was identified as a coelacanth scale

In the same year, an ex-voto (an amulet used as a prayer object to give luck or ward off misfortune) was found nailed to a church door in northern Spain. Such ornaments are common and are often used in prayers for local fishermen. The model was made from silver and, when placed alongside a photograph of one of the first whole specimens ever mounted, shows a remarkable similarity and may have been modelled on this. A second ex-voto was purchased in a gift ship in Toledo, in central Spain, and this is much more convincing, even down to the modelling of the white blotches. It is suggested that this was modelled in the eighteenth century, probably in mes-America. Some explanations suggest that the scales and ex-votos arrived in America and Spain through traders moving through the Comores on their journeys between Europe and the Far East.

Nature (1998), Macmillan Magazines Ltd

Map of the Indian Ocean.

In September 1997, 10,000 kilometres to the east of the Comores, an American marine biologist, Mark Erdmann, and his wife, Arnaz, saw an unusual fish being wheeled through a fish market in Manudo, a small fishing town at the northeastern tip of the island of Sulawesi, Indonesia. He recognised it immediately as a coelacanth, but was unable to persuade the fishermen to part with it. The fishermen also considered it a rare find, and Erdmann could not discount the possibility that it had been traded illegally from the Comores. However, a year later another was hauled in behind a boat and it became clear that coelacanths were inhabiting the waters around Sulawesi.

Although very similar to the Comores species, its skin was brown instead of blue, and the scales were flecked with gold. Tissue samples were taken and sent to the University of Texas for analysis. Distinct genetic differences were found, and it was named *Latimeria menadoensis* by Laurent Pouyard, a French molecular biologist. It is predicted that the two species have become separated during the last 1.5 to 4 million years. Geologically, the Comores Islands (which are themselves no more than 5 million years old) and Indonesia are quite distinct; however, one suggestion is that a continuous coelacanth population was possible across the embryonic Indian Ocean about 70 million years ago. When India moved northwards to collide with Asia, this single continuous population was split in two. Another possibility is that the Comores Island populations may have come from Indonesia on the prevailing ocean currents, but the very peculiar habitat and biology of the coelacanth suggest that a journey of this distance was unlikely.

The coelacanth is perhaps more widespread than was previously thought, and there have been anecdotal sightings in Sri Lanka, India, the Seychelles and even South America. Very recent reports have come in of three coelacanths which were filmed swimming outside submarine caves off the coast of northern Natal, South Africa, close to the border of Mozambique. This find almost certainly confirms that a population is living in the western Indian Ocean outside the Comores, and

not just the occasional stray.

Despite the coelacanth being a living fossil of a group that died out 70 million years ago, no records exist during the recent past. Our knowledge of other fish species suggests a species life span of about 5 million years, but this does not explain the absence of the coelacanth lineage for the intervening 65 million years, and it is suggested that they have moved into habitats which leave little trace in the fossil record. The Comores Islands are an oceanic volcanic chain, with Grande Comore itself only three-quarters of a million years old. *Latimeria* appears to live alongside steep volcanic islands, where sediment for fossil preservation simply does not accumulate. The genetic makeup may have changed little over time, in order that they may occupy a variety of habitats. The fact that modern coelacanths live in submarine caves beneath volcanic islands may just signify their incredible ability to adapt, and thus ensure long-term survival.

Books:

Title: History of the Coelacanth Fishes
Format: Hardcover
Author: Forey, Peter L.
Date: 01-JUL-98
ISBN: 0412784807

Title: A Fish Caught in Time: The Search for the Coelacanth
Format: Hardcover
Author: Samantha Weinberg
Date: 01-JUL-00
ISBN: 1857029062

Title: Living Fossil
Format: Paperback
Author: Thomson, Keith Stewart
Date: 01-JUL-92
ISBN: 0393308685

Title: Cranial Nerves of the Coelacanth, Latimeria Chalumnae (Osteichthyes: Sarcopterygii : Actinistia)
Format: Hardcover
Author: Northcutt, R. Glenn / Bemis, William E.
Date: 01-SEP-93
ISBN: 3805558023