Salamander Fish

The last of its tribe

Reg Morrison

A FISH OUT OF WATER ...

In the clear, cold creeks that slide out of the eucalyptus forests of south-western Australia there lives a little-known fish of extraordinary evolutionary significance. Embedded in its ancient genetic code is a talent for survival that sets it among evolution's elite. Even in Australia, where genetic antiquities abound, it has few peers. This seasoned campaigner shares its key feature with the greatest survivor of all back-boned animals, the lungfish. Both can breathe air, but unlike the lungfish, the little Salamander Fish can survive without water, not just for an hour or so but for many weeks, sometimes even months. During the droughts that occasionally ravage the continent's south-west this archaic fish burrows into its creekbed, exudes a mucous sleeping bag, breathes air and switches its metabolism into an 'idle' mode known as aestivation. It is a level that barely maintains life and is fuelled essentially by a special-purpose fat reserve that runs like a keel along its underside. The moment its home pool fills once more, the Salamander Fish sheds its mucous sheath, wriggles out of the sand, and resumes its normal aquatic life. The transition from air-breathing aestivator to gill-breathing aquatic predator takes little more than a minute.

This unique talent for survival out of water has given the Salamander Fish its common name—a reference to the four-legged amphibian salamanders of Eurasia and the Americas. Bearing the resplendant title *Lepidogalaxias salamandroides* this 'living fossil' seems to be the lone survivor of an archaic family whose range may once have spanned half the world.

The home of the Salamander Fish

Lepidogalaxias salamandroides

Distribution

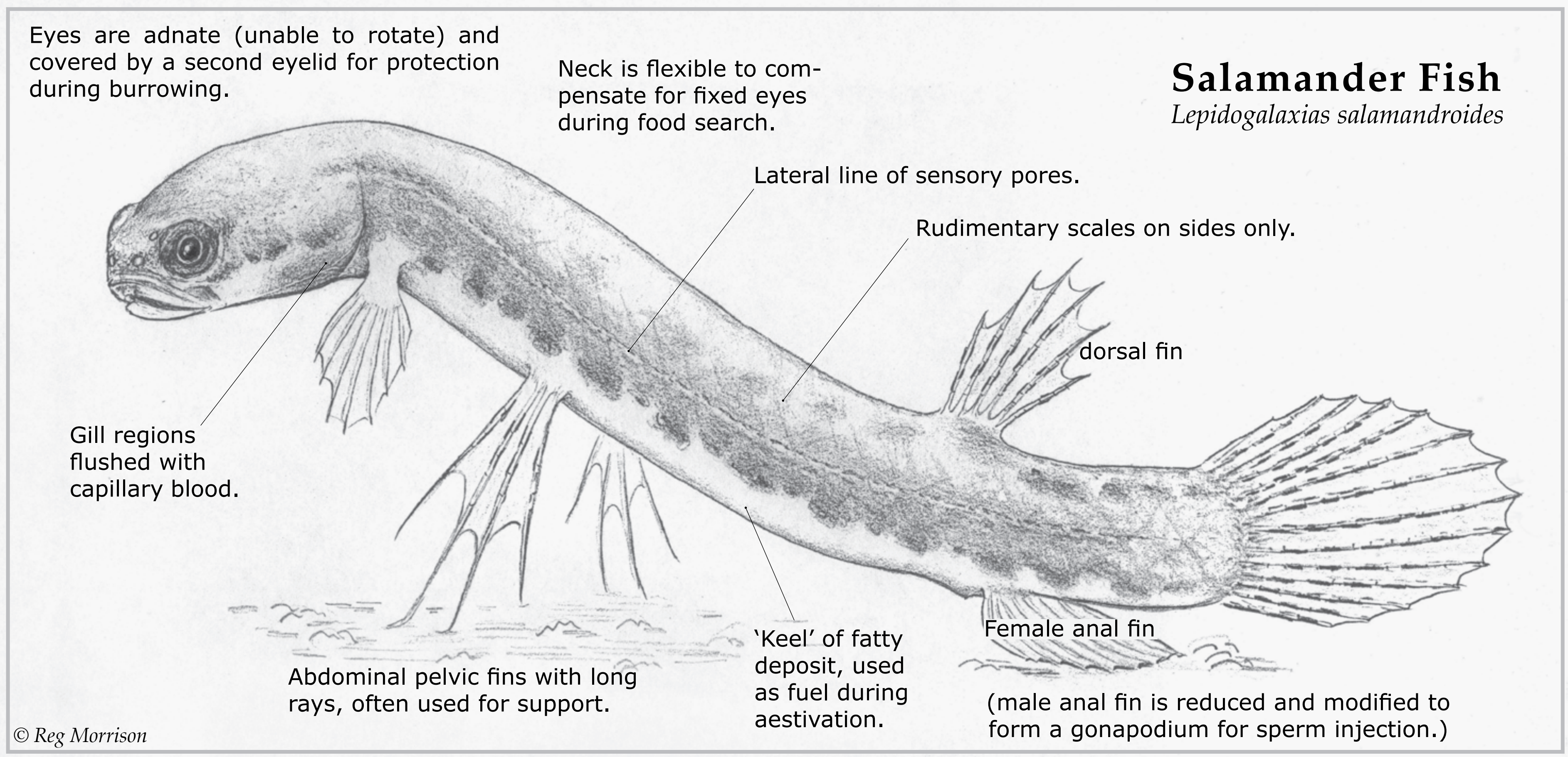
Salamander Fish live in the acidic, ephemeral creeks that originate in the forests of giant Karri and Jarrah trees in South-Western Australia.

A Salamander-Fish habitat, near Northcliffe, WA.

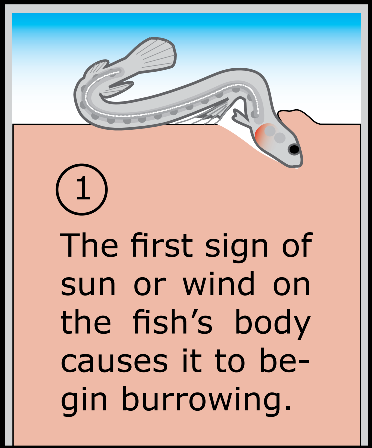
A Karri forest near Northcliffe, WA.

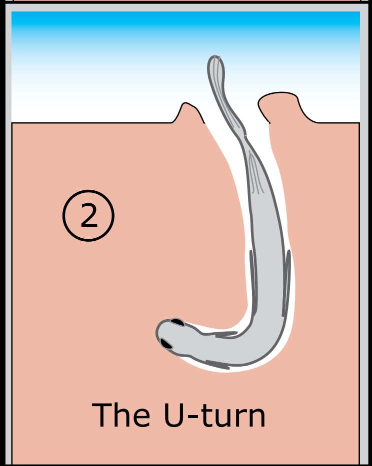
Sex and the Salamander Fish

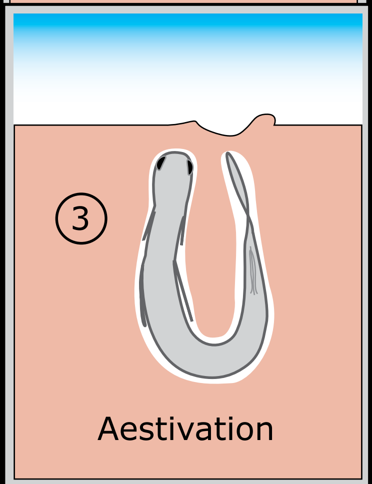
The eel-like body, the fleshy, flipper-like front fins, rudimentary scales, lack of eye muscles, and a form of reproductive fertilisation that involves internal fertilisation and the intromissive introduction of sperm via a modified anal fin, sets the Salamander Fish apart from all others. This broad spectrum of unique characteristics confirms that the lineage of the Salamander Fish is an ancient one indeed, and yet it is also one that incorporates an extraordinarily 'advanced' form of reproduction.



Like the lungfish, the Salamander Fish breathes air only as a secondary option, and it resorts to this when its creeks dry up during Western Australia’s long, hot summers. Unlike the lungfish however, it has evolved the capacity to live for long periods without any standing water at all. It does this by burrowing, sometimes beneath leaf litter, fallen branches or rocks, but more often by burrowing vertically downward into the sandy bed of its creek. As the water level drops and sun and wind begin to dry its exposed back, the enlarged air sack in its gill region swells and flushes with blood as it begins to switch over from gill breathing to air breathing in readiness for aestivation.







BURROWING FOR SURVIVAL

By arching its back and thrashing its tail the Salamander Fish chisels aside the leaf litter and surface sand with its wedge-shaped snout, and then tunnels vertically downwards, almost the full length of its body. Next, it executes a sharp U-turn, aided by its very flexible neck, and works its way upward once again. When its head draws level with its tail all movement stops, leaving it in a U-shape with its head and tail beside each other anywhere from 2cm. to 60cm. below the surface. The burrowing process is made much easier by a sleeve of mucous that exudes through its skin, and this briefly continues to accumulate after the burrowing stops. As this mucous sleeve dries it forms a protective 'sleeping bag' that inhibits any further loss of the body's precious reserves of water. When this stage is complete the fish's metabolism slows and aestivation begins.

Aestivation is the summer-time equivalent of winter hibernation, in which the animal's metabolism slows right down and an energy-saving torpor envelops the body. When the fish's immediate reserves of energy are almost exhausted it begins to draw upon a keel of fatty tissue that has been built up along the underside of its body during the preceding winter. The return of water to its home pool triggers a very fast awakening. The fish digs its way out and resumes its normal gill-breathing, fully aquatic life within several minutes.

Another remarkable feature is the Salamander Fish's system of fertilisation. The anal fin of the male becomes modified into a vehicle for sperm delivery known as a gonopodium. In conjunction with a modified anal scale, the Salamander fish regularly achieves the fishy equivalent of modern penis-based intromissive reproduction.

WHEN THE RAINS RETURN

Awakened from aestivation by a fresh flow of water to its home pool this Salamander Fish begins to wriggle free and resume aquatic life. The survival of this ancient fish in drought-prone south-western Australia shows that it can easily withstand many weeks of waterless air-breathing.

Having just emerged from air-breathing aestivation the blood-flushed gill regions of these fish remain suffused with capillary blood.

Origins and Relationships

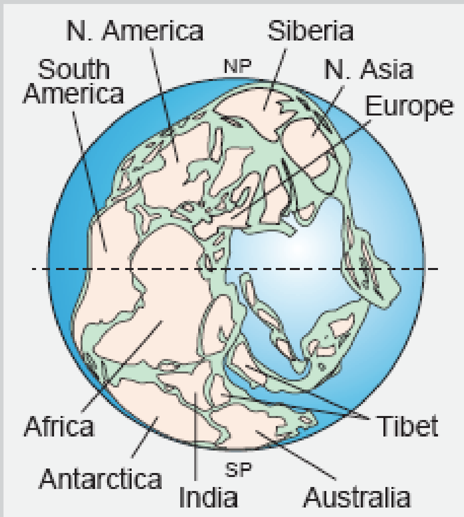
When the Salamander Fish was first scientifically described in 1961 it was assigned to a relatively common southern hemisphere family of freshwater fish, the galaxiids. However, according to some later researchers, *Lepidogalaxias* displayed certain physiological characterisics that suggested a genetic connection with either the large, voracious pike family of the northern America and Europe, or with their close relatives, the salmon family. In addition, they display several primitive characteristics that imply a very long and stable evolutionary history—a history that goes back to the time of Pangaea, the supercontinent to which almost all the world's landmasses were once linked.

If indeed these diminutive fish are members of the pike family (the esocoids), then a Pangaean origin and subsequent continental drift provide the only possible explanation for their modern distribution. The vast network of rivers, lakes and waterways that characterised the supercontinent would have enabled their ancestral family to disperse widely throughout the supercontinent. When it disintegrated the divergent drift of its component continents would have carved the family into numerous isolated branches, most of which failed to survive. Many thousands of kilometres of inhospitable saltwater and innumerable land barriers now separate the little Salamander Fish from its erstwhile relatives in the northern hemisphere.

There is also a possibility that its closest relatives are the southerm hemisphere galaxids. This scenario too, depends to some extent on the rafting of continents to explain their distribution among the southern continents that once formed the supercontinent of Gondwana.

PANGAEA, the supercontinent

A little more than 300 million years ago all the world's major landmasses appear to have congregated into a single gigantic supercontinent that stretched almost from pole to pole down one side of the planet. This extraordinary conjunction of landmasses lasted for almost 100 million years and enabled all aquatic species to gain a broad distribution very swiftly via the vast interlinked system of rivers and inland waterways.



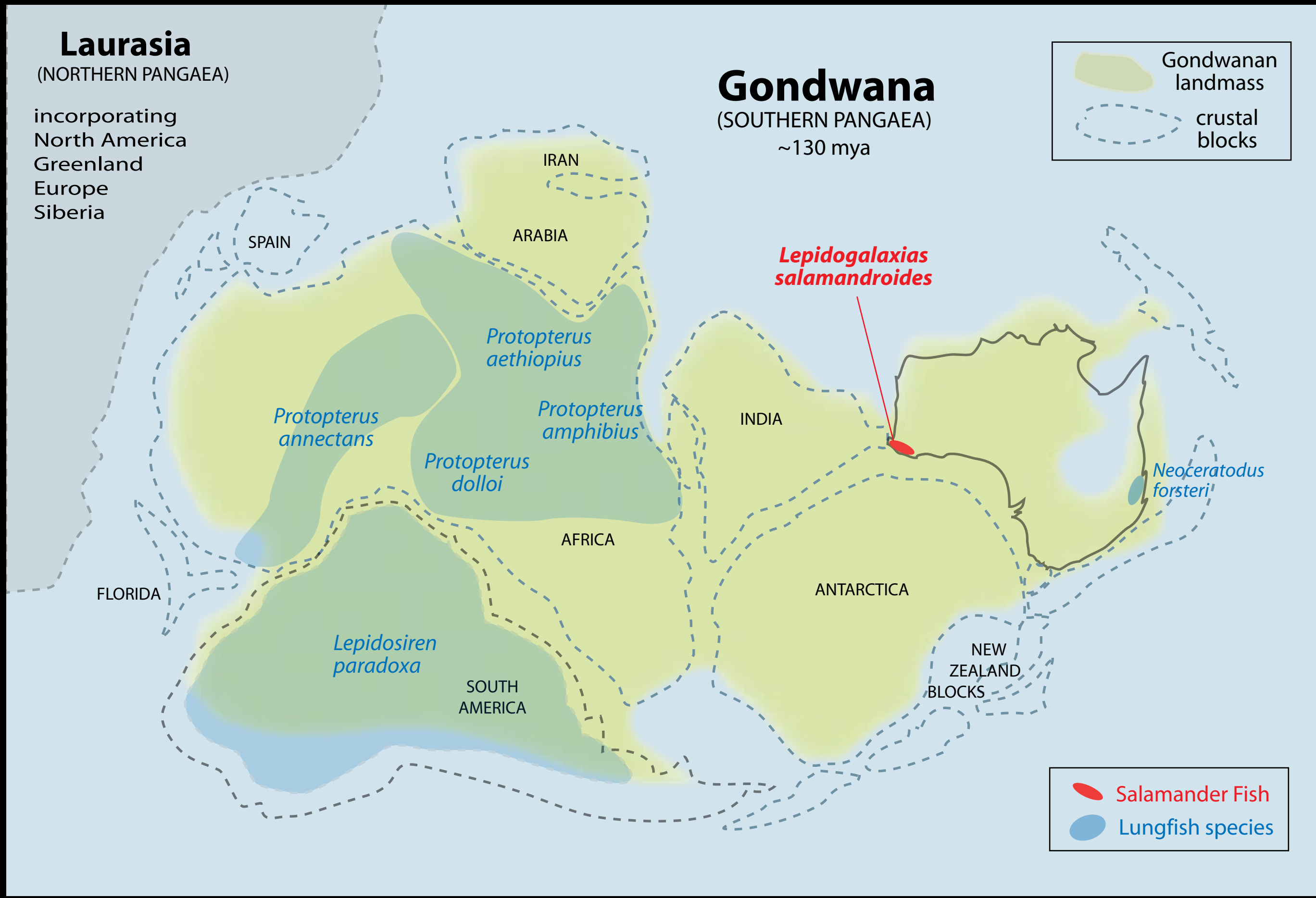
GONDWANA

Life's southern cradle

The southern supercontinent of Gondwana formed long before the Pangaean conjunction occurred, and it then reappeared as a unit when the northern half of Pangaea tore away about 180 million years ago. After the split, the twin supercontinents, Laurasia and Gondwana, remained biologically isolated from each other for almost 100 million years, and this effectively divided the planet's biota into two distinct evolutionary streams.

Judging by the distribution of the world's six modern lungfish and the isolation of Australia's archaic Salamander Fish, the evolutionary birthplace of both of these ancient groups was probably somewhere in Pangaea's southern half—Gondwana.

This would have meant that their ancestors would have had to survive a period of massive continental drift that sent Gondwana right across the South Pole from one side of the planet to the other. During this time they would also have had to cope with an ice age that lasted some 50 million years. Only the best equipped and most resourceful species would have survived the savage environmental traumas of such a polar passage.



These traumas and the subsequent breakup of Gondwana fragmented most of its widespread ancient families such as the lungfish group, and wiped out many of their intermediate populations.

Pivotal events in this culling process were the detachment of Africa and India by about 100 million years ago, and the separation of the New Zealand blocks and the Lord Howe-Norfolk Rise some 20 million years later.

The final act in the disintegration of Gondwana was the breaking of Australia's billion-year bonds with Antarctica around 40 million years ago. This would have ensured total isolation for living 'fossils', such as the Salamander Fish, the Queensland Lungfish, the Tasmanian Mountain Shrimp and the Tasmanian Cave Spider.

Queensland Lungfish (Neoceratodus forsteri)

Like the Salamander Fish the Queensland Lungfish can also breath air, but unlike the Salamander Fish its single subsidiary lung doesn't allow it to live long out of water. Neither does lungfish fertilisation occur internally. The eggs are fertilised outside the mother's body and become attached to water plants (LEFT). She doesn't appear to nurture her young in any direct sense but tends to linger in their vicinity (ABOVE). The Queensland Lungfish displays the most primitive characteristics of the the world's three extant species.

THE DIARY of 'YOU'

This illustrated High School science resource outlines the four-billion-year evolution of our species by presenting, in diary form, the evolutionary milestones that are embodied in the cell structures and chemical pathways that define our bodies today. The book is scheduled for release in October 2008.*

* Publisher: Sainty & Associates http://www.sainty.com.au/
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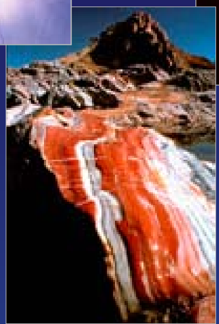

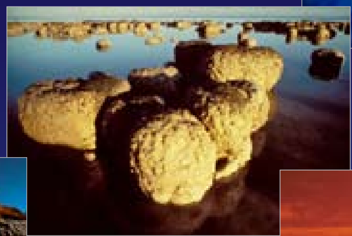

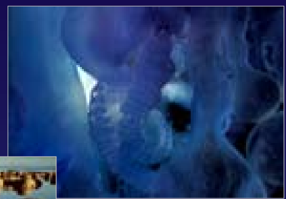

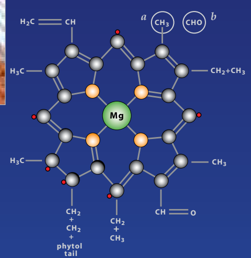

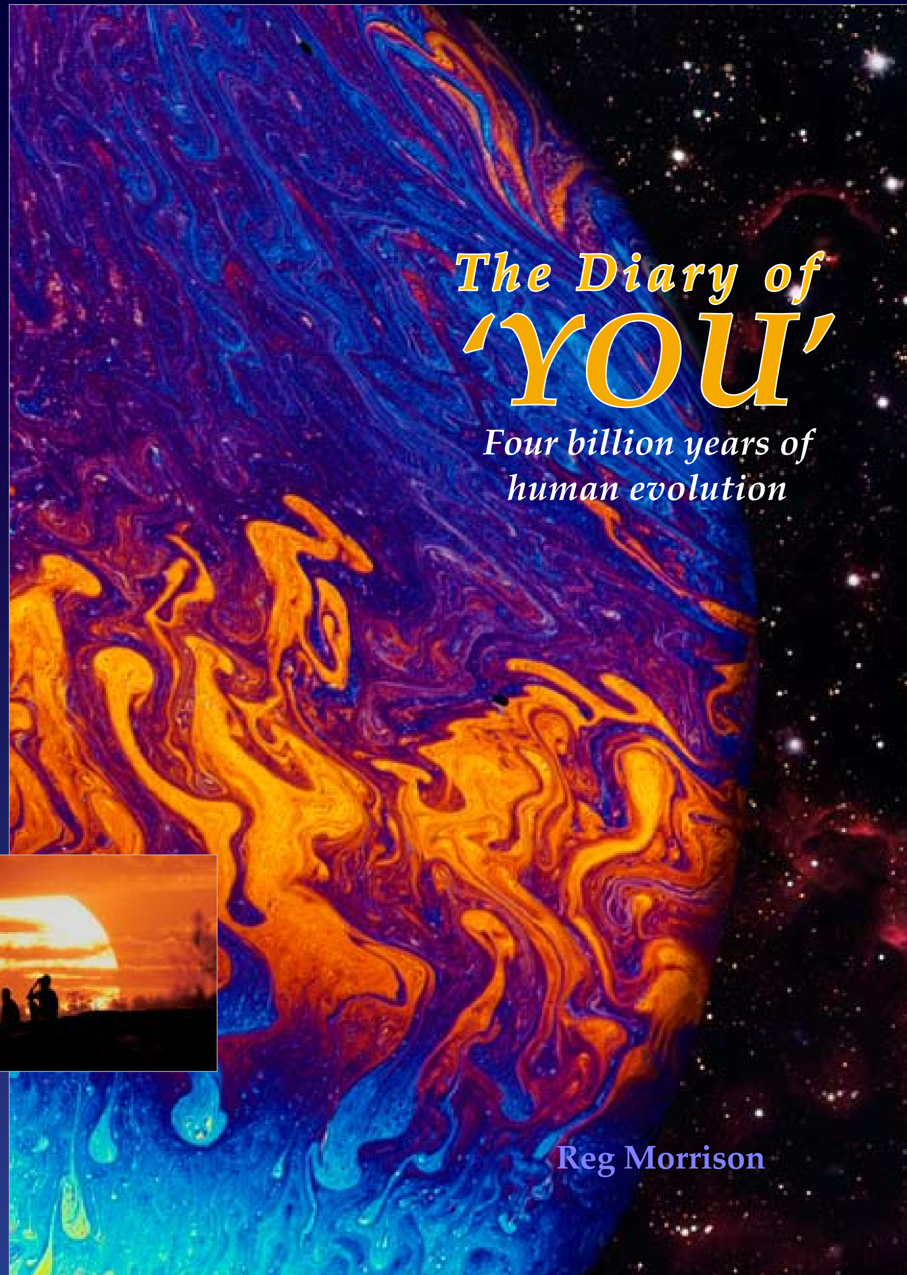

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