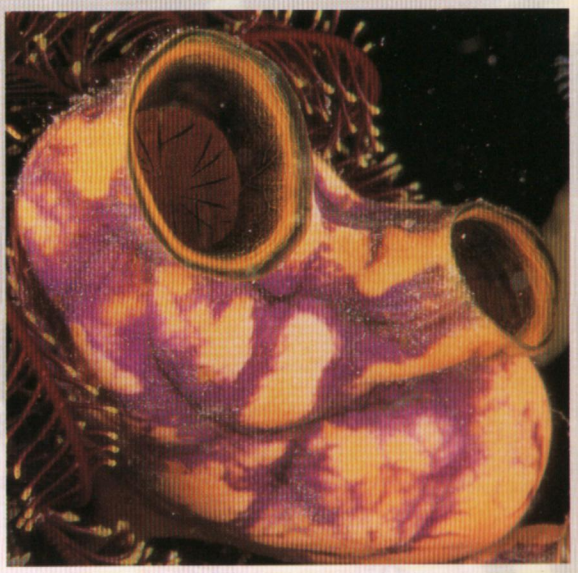
Pikaia – Our Ancestor?

A PRIMITIVE CREATURE WITHOUT A WELL-defined head and less than 2 inches (5 centimetres) long, which swam in the seas during mid-Cambrian times, is close to the ancestor of all backboned animals (vertebrates), from fish to birds to mammals. Called *Pikaia*, it is one of the most interesting of the myriad animal fossils found in the famous Burgess Shale in the mountains of British Columbia.



SEA SQUIRT
The sea squirt, like the lancelet *Branchiostoma* (opposite), is a most unlikely looking close relation to the vertebrates. Adult sea squirts live permanently attached to the seabed and superficially look like sponges. Their free-swimming larvae, which look like tadpoles, have a body structure that relates them to vertebrates. A long stiffening rod allows the tail to flex for swimming. The larvae attach themselves head first to the seabed and transform into adults.

UNLIKELY ANCESTOR

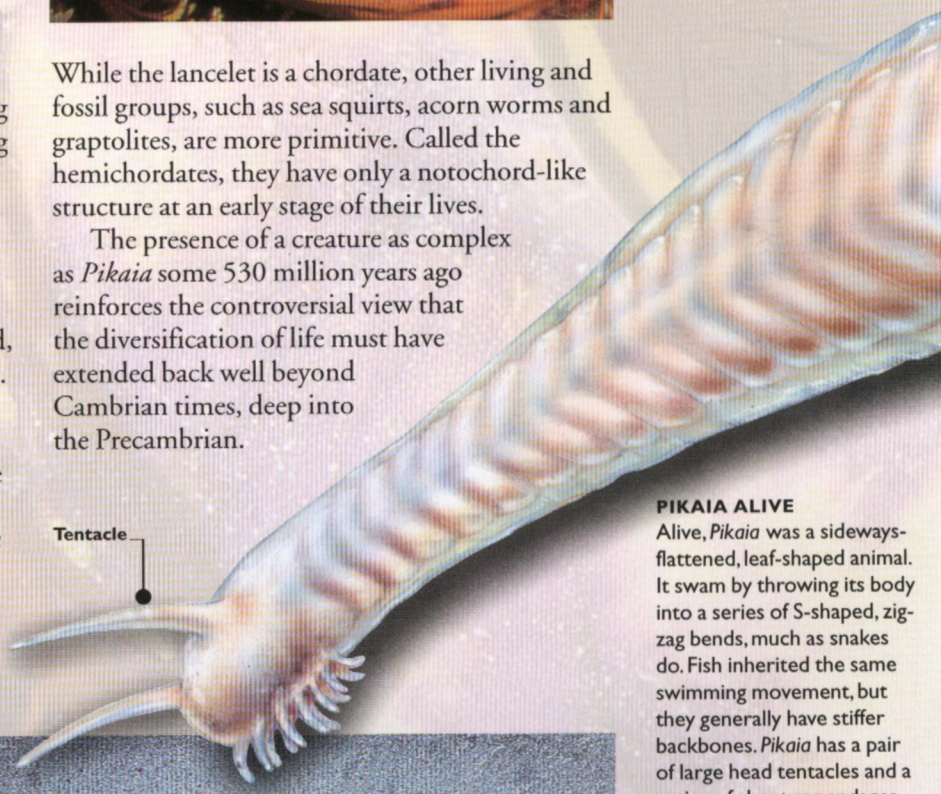
At first glance, *Pikaia* does not seem like a human ancestor. It looks like a worm that has been flattened sideways. But in detail, these fossils compressed within the Burgess Shale clearly show chordate features such as traces of an elongate notochord, dorsal nerve cord and blocks of muscles down either side of the body – all critical features for the evolution of the vertebrates.

The notochord is a flexible rod that runs along the back of the animal, lengthening and stiffening the body so that it can be flexed from side to side by the muscle blocks for swimming. In the fish and all subsequent vertebrates, the notochord forms the backbone (or vertebral column). The backbone strengthens the body, supports strut-like limbs, and protects the vital dorsal nerve cord, while at the same time allowing the body to bend.

Surprisingly, a *Pikaia* lookalike still exists today, the lancelet *Branchiostoma*. This curious little animal was familiar to biologists long before the *Pikaia* fossil was discovered. With notochord and paired muscle blocks, the lancelet and *Pikaia* belong to the chordate group of animals from which the vertebrates have descended. Molecular studies have confirmed the lancelet's status as the closest living relative of the vertebrates.

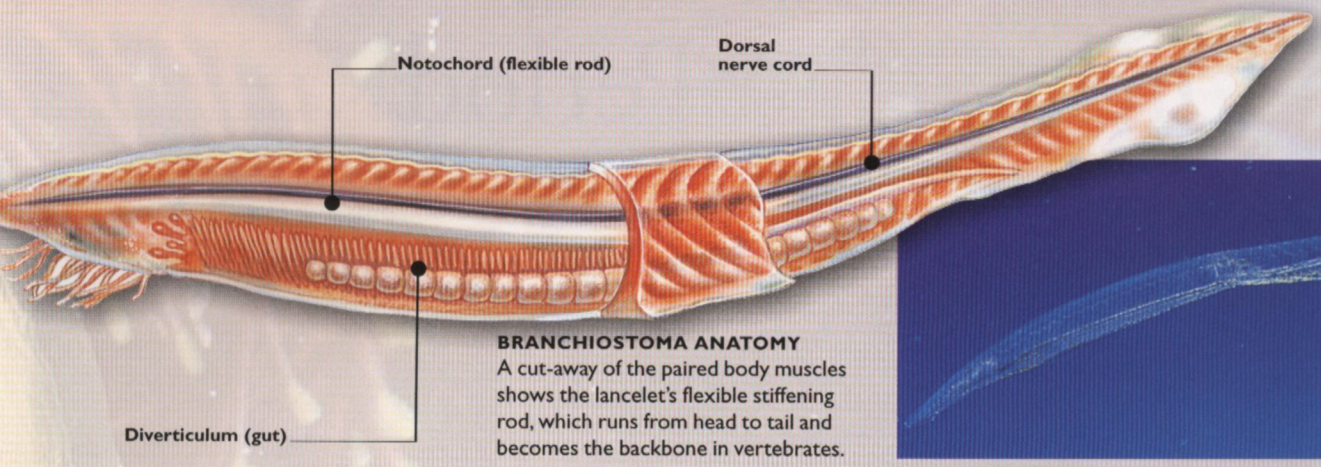
While the lancelet is a chordate, other living and fossil groups, such as sea squirts, acorn worms and graptolites, are more primitive. Called the hemichordates, they have only a notochord-like structure at an early stage of their lives.

The presence of a creature as complex as *Pikaia* some 530 million years ago reinforces the controversial view that the diversification of life must have extended back well beyond Cambrian times, deep into the Precambrian.



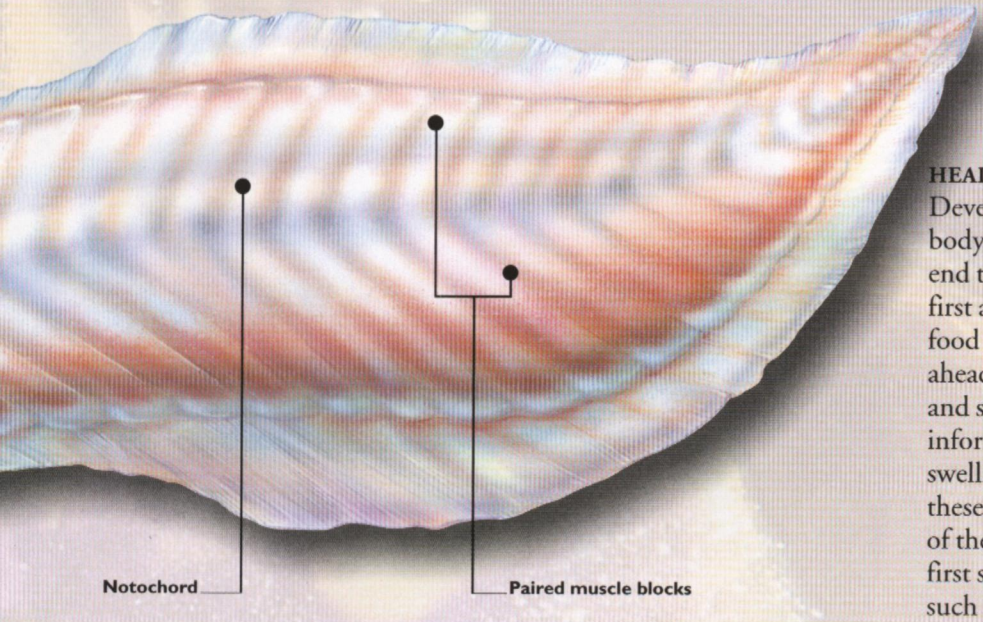
PIKAIA ALIVE
Alive, *Pikaia* was a sideways-flattened, leaf-shaped animal. It swam by throwing its body into a series of S-shaped, zig-zag bends, much as snakes do. Fish inherited the same swimming movement, but they generally have stiffer backbones. *Pikaia* has a pair of large head tentacles and a series of short appendages, which may be linked to gill slits, on either side of its head. In these ways, it differs from the living lancelet. Paleontologists are still researching details of *Pikaia*'s anatomy.

PIKAIA FOSSIL
This primitive marine creature shows the essential prerequisites for making backboned animals. The flattened body is divided into pairs of segmented muscle blocks, seen as faint vertical lines. The muscles lie either side of a flexible rod which runs from the tip of the head (bent round at the left) to the tip of the tail (the larger tapering structure to the right).



BRANCHIOSTOMA ANATOMY
A cut-away of the paired body muscles shows the lancelet's flexible stiffening rod, which runs from head to tail and becomes the backbone in vertebrates.

SEE-THROUGH BODY
The translucent body of a *Branchiostoma* clearly shows its internal anatomy, which closely resembles the internal structure of *Pikaia*.



HEADS FOR VERTEBRATES

Development of the head resulted from a long body shape, swimming habit and a mouth at the end that came into contact with the environment first as the animal swam forwards. The search for food required ways of continually testing what lay ahead. Anatomical structures for seeing, feeling and smelling developed around the mouth. The information they gathered was processed by a swelling of the nerve cord – the brain. Altogether these front-end structures formed the distinct part of the vertebrate body known as the head. The first sign of head development is seen in chordates such as *Branchiostoma* and *Pikaia*.

VERTEBRATE RELATIONSHIPS

Understanding animal biology allows scientists to determine how different creatures are related. There are some surprises. For although the connection seems unlikely, starfish (echinoderms), acorn worms and sea squirts (tunicates) are closely related to all backboned animals (vertebrates), ranging from fish to humans. The embryos and larvae of sea squirts, acorn worms and echinoderms, before they change to their adult forms, have close similarities to those of the vertebrates. On this biological "family tree" of relatedness, those closest to the vertebrates are chordates with a body stiffening rod (notochord) throughout their lives, as represented by the living lancelet. The 530-million-year-old fossil Pikaia *is sufficiently similar to the lancelets to suggest that it, too, is a chordate, and thus our most distant known ancestor.*