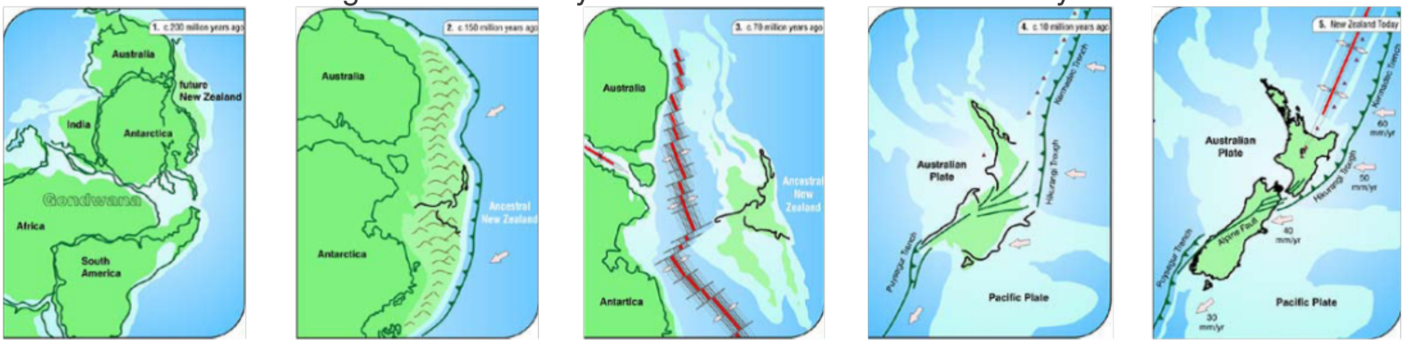
Ancient Tiri Part 7: The first Metazoans (Multicellular Animals)

<u>From the Seas to the Land 2.</u>

To say that the Cambrian Period (650-420Mya) was a “busy” time for life on Earth is somewhat of an understatement! Part 7 is the fifth episode of “Ancient Tiri” looking at this period when many of today’s animal and plant groups appeared in the fossil record.
As we saw in Episode 6, at this time (540 to 360 Mya) a “dry-land” Tiri did not exist yet because “Proto-New Zealand” was in the form of an underwater seabed on the edge of the supercontinent Gondwana. It did not begin to move away from Gondwana until about 70Mya.



The tectonic movement of NZ away from Gondwana. *GNS*

Multicellular animals and plants had evolved, having taken on many and varied forms in order to exploit the marine environment in which they lived.
Now we will look at how animals evolved the necessary adaptations needed to venture out of the sea and onto dry land, and how many of these animals are found on Tiri today
The term “dry land” is a little misleading as there must have been many terrestrial shoreline “niches” that were anything but dry. Examples of these semi-aquatic/terrestrial “half way houses” were marine intertidal mudflats, freshwater creeks, marshes, damp soil, leaf litter as well as moist places beneath rocks and debris. To start with many animals probably spent their lives mostly in water, occasionally crawling about in damp semi-terrestrial places - much like todays ragworms do. Certainly the emergence of plant life onto the dry inhospitable shorelines must have provided shade and a slightly moister atmosphere, and would have provided a veritable oasis for the animals which slowly followed them.
We do not know exactly *when* plants and animals started to invade the terrestrial environment, in fact it was almost certainly a slow process over a considerable period of time. Evolution only happens when there is selective environmental pressure sifting favourable genes which control physical (outward) and physiological (internal/biochemical) features in organisms enabling them to succeed where others fail. Selection pressures at the margins of the land are, and always have been intense.

Lancelet showing myotomes - segmented muscle blocks. *Wikimedia Commons*

Who are the likely candidates for emergence onto land 650-420 Mya? The early **Chordates** – a group to which **Vertebrates** (Amphibians, Reptiles, Birds and Mammals) belong, are nowhere to be seen at this time. Their primitive distant relatives were still in the sea, and today are represented by the NZ lancelet (Puhi) *Epigonichthys hectori* found off most of our sandy coastlines. Puhi are small inconspicuous and transparent chordates, looking like elongated wriggling splinters of glass as they burrow into soft sediments to filter feed. Instead of a backbone they possess a stiffening cartilage rod called a notochord against which its muscles contract to produce swimming undulations. We will have to wait another 165My

before tetrapod vertebrates like amphibians evolve, and another 223Ma before the Reptiles appear. (More on the rise of the Vertebrates in a later episode.)
Before an animal can leave the aquatic environment it must possess several important physical and physiological adaptations.

For example they will need:

1. A gas exchange system that allows O_2 in and CO_2 out of their bodies. Most *small* invertebrates simply rely on gas exchange across the outer surface area of their bodies through their thin skins.

An aquatic mayfly larva with gills. *J.S.*

In larger insects gills were replaced by spiracles allowing air to enter their bodies and diffuse directly to cells.

2. A tough waterproof skin or shell to prevent excessive water loss by evaporation and to act as a shield against harmful UV rays. This would prevent the skin being used as a gas exchange surface so other solutions for this have to be found.

3. A reproductive system that allows sperms to be transferred to the female directly by internal fertilisation. (On land there would be no water present to allow external fertilisation.)

4. A method of locomotion that doesn't rely on the supportive buoyancy of water. (Think of how "heavy" you feel when emerging from the sea after a swim!)
Little wonder then that so many animal groups did not manage a complete transition, and still to this day occupy both worlds, often having to return to water to breed.

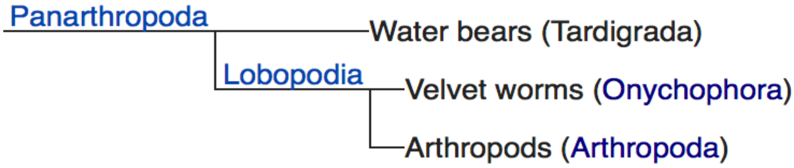
A common Earthworm - an Annelid *J.S.*

The **Annelids** (true worms) are just such animals. The common earthworm found on Tiri lives in damp soil rarely poking its head above ground, and then only to pull dead leaves into its burrow for food.
The animals with the best dry-land adaptations were the **Arthropods** (= "Jointed legged" invertebrates) with "suit of armour" exoskeletons which have to be shed in order to grow. For many years structural evidence suggested they probably evolved from the Annelids and a strange invertebrate called the Velvet Worm or **Peripatus** (Phylum **Onychophora**) was celebrated as the "missing link" between Annelids and Arthropods, but again molecular evidence suggests that the Peripatus is not a direct link but a sister group to the Arthropods. Nevertheless they are strange and primitive creatures. Chris Green our DOC entomologist is sure that the Peripatus is present on Tiri – probably best seen at night in wet conditions in the most undisturbed parts of the original forest, (this would be on the Kawerau Track

Peripatus - no longer thought to be a missing link. *Wikimedia Commons* in the region of the old Pohutukawa tree). Fossils of marine Peripatus date back as far as 513Ma, and they are thought to have adopted a terrestrial lifestyle some 490-340Mya.

Tardigrade showing 8 jointed legs
Wikimedia Commons

Tardigrades (=”slow walkers”) or Water “Bears” were also suggested as another possible candidate for “missing link”



status. These, like the Peripatus also have segments and stubby legs. Modern molecular analysis also shows the Tardigrades to be a “sister” group alongside the Arthropods. Both show Annelid-like segmentation, and also possess stubby legs rather like caterpillars.
The Tardigrades have remained unchanged for 530Ma.They are incredibly resistant to drying out, extremes in temperature and high radiation levels.
They have survived after being exposed to the vacuum and cold of space attached to the outside of the International Space Station for several months. They are between 0.1 and 0.5mm long, and have tiny piercing mouthparts. They appear to feed by sucking the contents out of moss cells. Where can they be found on Tiri? Practically everywhere. The best source is to find a pad of damp moss and squeeze a drop or two of water out of it onto a microscope slide and observe.
So the latest evidence shows that Annelids and Arthropods probably evolved from a common unknown ancestor perhaps 550Mya.
Metamerism (= Segmentation) was a breakthrough as far as the invertebrates were concerned. In its most primitive form, each segment in the animal’s body is virtually a complete self-contained unit containing all the necessary systems needed for life - such as digestion, breathing, excretion and sometimes reproduction etc. Growth is achieved simply by adding more segments. This is why when you see a robin tugging at the tail end of an earthworm and breaking it, the worm may survive provided it does not lose too many segments near its front end where its multiple hearts are located.
Segmentation crops up in most of the invertebrate and vertebrate phyla, and probably evolved independently several times in different animal groups.

The **Crustaceans** are probably the most ancient arthropods, arising some 540Mya. They struggled to colonise the land because their exoskeletons were (and are still are) highly permeable, losing water easily. Tiri’s terrestrial “landhoppers” found in our damp forest leaf litter are Amphipods (= “Different shaped legs”). These crustaceans are almost unchanged in appearance and physiology to those still in the sea. Consequently, they are restricted to living exclusively in damp leaf litter on Tiri. These ancient landhoppers form an important food source for Tiri birds. They illustrate the difficulties of land invasion beautifully as they are virtually identical to their marine cousins and have not had time yet to adapt to the difficulties of life on land. Come back in another 200Ma and see how they have done! Familiar “Slaters” or woodlice have not evolved yet and will not appear for at least another 100Ma. In our next foray into “Deep time” we will look at the other groups of arthropods present on Tiri today that joined the crustaceans on their journey to colonise dry land all those years ago.

"Landhopper" Amphipod crustacean. J.S.