Origin of Tetrapoda

The first tetrapods were amphibians that evolved from the Devonian crossopterygian fishes which lived in shallow marshy locations and already possessed lungs for respiration and lobed fins to support their bodies on muddy banks of ponds, rivers and marshland. The anatomical changes that took place during transformation from fishes to amphibia were as follows:

- A tetrapod limb evolved to support the body out of water as on land the entire body weight fell on the four limbs, whereas in fishes body weight is supported by water and fins have to just propel it forward.
- Gills were lost in the adult stage as lungs became more and more efficient air breathing organs and air contained more oxygen as compared to water.
- The hyomandibular bone of the second visceral arch transformed into columella to transmit sound vibrations from air to the inner ear.
- Loss of scales permitted cutaneous respiration which evolved as an alternative method of respiration in the absence of gills while the animal lived and swam in water.
- The skull developed two occipital condyles that fitted in an atlas vertebra so that skull could move upward and downward for locomotion as well as for better visibility.
- In terrestrial environment vertebral column must be strong to support the body weight and hence centra of vertebrae transformed from amphicoelous to procoelous type.
- The lateral line system that was not useful in terrestrial environment simply disappeared.
- Adipose tissue that stores fat and provides insulation developed under the skin to stop loss of water by evaporation on land.

FOSSIL ANCESTORS OF TETRAPODS

Labyrinthodonts were ancestors of all tetrapods and they had evolved from crossopterygian fishes. These ancestors had large teeth with labyrinthine folds on enamel that traversed deep into dentine. They still carried dermal scales on body and functional lateral line system. They had strong girdles and limbs. They diversified from Devonian to Permian periods and were dominant predators on land.

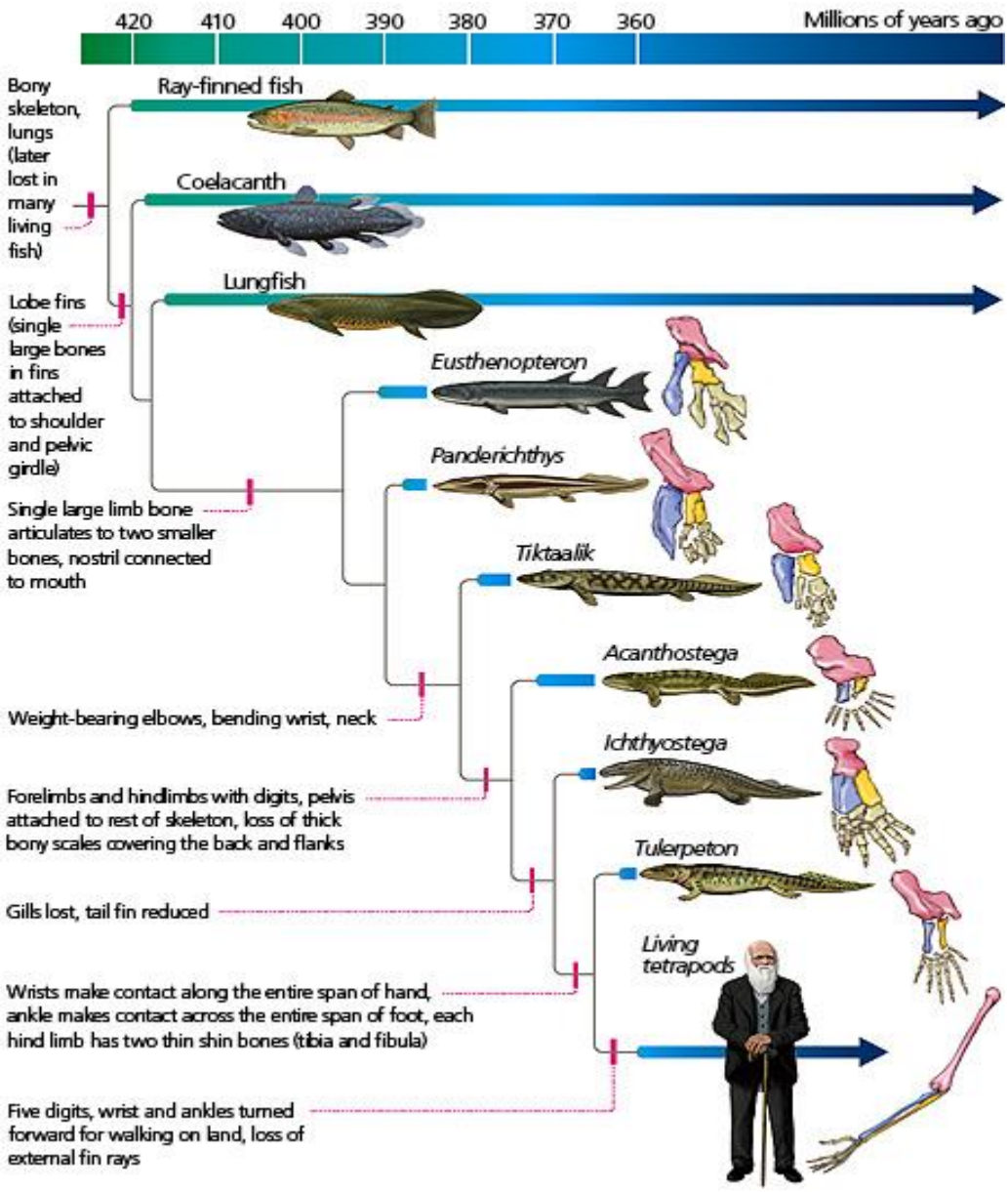
Osteolepis. It was a lobed-finned fish belonging to Crossopterygii that lived about 375 million years ago and breathed with gills as well as lungs. Fins had bony elements homologous to humerus, radius, ulna and digits of tetrapod limbs.

Eusthanopteron. This was another crossopterygian fish of Devonian period with lobed fins having bones arranged in the pattern of a tetrapod limb, even though the fish was completely aquatic.

Tiktaalik roseae (Order **Ichthyostegalia).** The fossils of this labyrinthodont from Devonian (375 million years) were discovered from the river delta on Ellesmere Islands in Arctic Canada by Edward Daeschler of the Academy of Natural Sciences and Neil Shubin of the University of Chicago in 2006, who nicknamed it as “fishapod”.

It had 2.75 m long, scaly body with broad, 20 cm long skull and a flexible neck. Snout was long and flat with nostrils located near the base that suggests that it breathed air by sticking

its head out of water and probably also caught terrestrial prey by hauling itself onto land. It had a big interlocking rib-cage to protect lungs while it dragged its body on muddy shores. Limb bones had typical tetrapod arrangement with 5 digits and primitive wrist bones. But the limb bones were wrapped in a fish-like fin which enabled it to swim and walk in shallow waters but incapable to confer locomotion on land.



Acanthostega (Order **Ichthyostegalia).** It is more aquatic and better known animal than ***Ichthyostega*** and anatomically intermediate between fish and tetrapods.Fore limbs were more paddle-like with 8 digits, and hind limbs had 6 digits but the elbow and knee joints did not bend and could not support animal's body on land and definitely were not capable of carrying out an effective terrestrial locomotion. Vertebrae were less ossified and ribs were short and straight and not overlapping and incapable to prevent collapse of the chest cavity out of water.

Ichthyostega (Order **Ichthyostegalia).** The earliest fossils were discovered in 1932 from Greenland from the late Devonian (360 mya) deposits. Skull was flat and fish-like. Teeth had labyrinthine folds around dentine. Body was covered with dermal scales and lateral line system was present. Although tail carried fin rays, there is no indication of the presence of gills and respiration was carried entirely through lungs. Limbs were paddle-like, suggesting aquatic mode of life and were probably also used to drag the body on land. Digits were 5 or 6 in the hind limb but in fore limb the hand part is missing in fossil.

Eryops, Cacops & Amphibamous (Suborder **Rhachitomi**). They are also called stem animals that evolved from stegocephalians, developed terrestrial adaptations, grew to become giants and became dominant terrestrial carnivores of Carboniferous and Permian. They had massive bodies and some reached a length of five feet and had strong limbs with four digits in the front leg and five in the hind leg. Tail was massive that contained a chevron bone in vertebrae and perhaps assisted in locomotion on land. Body was covered with dermal scales for protection.

Buettneria (Suborder **Stereospondyli**). They were aquatic animals having secondarily simplified vertebral column in which intercentra expanded and became ring-like. They were the largest amphibians of their time that attained a length of up to 6 feet and were perhaps aquatic as suggested by the flattened tail and came on land briefly to feed or escape from predators.

Eogyrinus (Suborder **Embolomeri**). They were small lizard-like, pentadactyle labyrinthodonts that had 5 digits in each limb. Each vertebra had two disc-shaped centra. They were ancestors of Anthracosauria which later evolved into reptiles.

Microbrachis & Sauropleura (Subclass **Lepospondyli**). They were ancestral to limbless caecilians and lived from Carboniferous to Permian periods. Vertebrae were ossified around the notochord and neural arch was continuous with centrum.

Branchiosaurus (Subclass **Phyllospondyli**). They were small amphibians with large flat head and short tail and are believed to be ancestors of urodeles and anurans. The transverse process of the vertebrae and ribs were stout. Pectoral girdle was made of coracoid, scapula, cleithrum and clavicle. Limbs had four fingers and five toes.

ORIGIN OF AMPHIBIANS

Amphibians evolved in specialized situations during Devonian period, just after the Devonian mass extinction when climate became warm and humid, and huge swamps and marshlands appeared on land. By Carboniferous period there were dense gymnosperm forests all over the land areas. Advancement of forests on land attracted insects, worms and molluscs that had already achieved the capability to inhabit terrestrial forests and which were part of fish and amphibian diet.

Swamps of Devonian period were inhabited by highly specialized lobe-finned fishes that were already equipped with lungs to obtain oxygen from air as the marshland water was low in oxygen content. These fishes also had lobed fins with strong bony elements to support the body in muddy water or on submerged vegetation.

Perfection of these two anatomical features, that is, lungs and lobed fins transforming into tetrapod limbs must have taken place in marshy conditions, which later proved to be

important adaptations to conquer land, as seen in labyrinthodonts, such as ***Tiktaalik, Acanthostega*** and ***Ichthyostega.***

As forests started invading land, followed by invertebrates, these primitive labyrinthodonts also tried to venture on land in pursuit of abundant prey or to escape predators. They soon mastered terrestrial living and became the dominant predators on land in Carboniferous and Permian periods, e.g. ***Cacops, Eryops*** and ***Buettneria.*** Large amphibians were wiped out by the Permian mass extinction, when over 70% of tetrapod families and almost 90% of species vanished.