

Earliest Vertebrates

The earliest vertebrates were fish-like animals without jaws (Agnatha) which persist today as the cyclostomes (hagfish, lamprey). Most ancient of the fish-like creatures were the Ostracoderms found in sediments of late Silurian and early Devonian age. Modern groups of fish descended from these animals. Together with the Ostracoderms lived another group of strange fish, the Placodermi which are now totally extinct. Close, (and also extinct) relatives of the modern bony fish were also present at this time, the Acanthodii. Because of the varied fish life in the Devonian, this age has become termed the "Age of Fish".

Modern Fish

- There are three groups of living fish:
1. Ray-fins (Actinopterygii)
 2. Cartilaginous sharks, skates, rays (Chondrichthyes)
 3. Lobe-fins (Choanichthyes)

Pleuronectiformes

The Pleuronectiformes are advanced spiny-finned teleosts which are analogous to skates in that they have become flattened bottom dwellers. The flattening of these fish has resulted in them having an unusual asymmetrical body form. As young a planktonic fish their body form is like that of a typical fish. However, as they develop prior to adopting the bottom dwelling habit, they become asymmetrical. This asymmetry is the structure of the vertebral column, the position of the mouth in relation to the eye, and the position of the gills.

Perciformes

The Perciformes or spiny-finned fish are the largest group of bony fish and number approximately eight thousand species. These fish are characterized by the thickening of some of the leading rays of the dorsal and anal fins. These rays are uniserial and often sharply pointed. The pelvic fins have migrated forward to lie under the pectorals, and there is a ligamentary connection between the pelvic and pectoral girdles giving rigidity to the front end of the fish. The pectoral fins are situated high on the sides of the body in contrast to their almost ventral position in more primitive fish. The bones of the jaws are characteristically arranged with protrusive premaxilla, the maxilla being included from the pipe. Most of the perciform fish have scales with tooth-like projections on their upper, free edges. Scales like these are called "canal" scales. Examples of this group include bass, perch, darters, sun fish, snappers, porgies, croakers, rockfish, butterfly fish, honey, goby, dragnet, mackerel.

Beryciformes

The Beryciformes are a group of teleosts, most of which are found in the later Permian and Triassic periods. They are characterized by the presence of a large, bony, tooth-like structure in the tail region. Examples include squirrel and wood fish.

Actinopterygii

In contrast to the other two fish groups the ray-finned fish have not become reduced in numbers in more recent geological times, but have become increasingly important. They have become the dominant vertebrates of both marine and fresh-water habitats. Actinopterygians are characterized by having a bony skeleton, the absence of a skeletal axis in the paired fins (the lack of an opening between the nostril and mouth and the presence of a skeletal axis in the paired fins). The group was freshwater until the late Permian when the sea was exploited. The group is divided into three subgroups:

1. Chondrostei
2. Holostei
3. Teleostei

A primitive group with specialized rays, the ray-finned fish, Actinopterygii, although once numerous in the Paleozoic, became reduced in the Mesozoic, eg the bow-fin, *Amia*. The dominant fish group since the Cretaceous, that includes all fish of today, some 20,000 species. The ganoid covering of the scales found in other ray-finned fish is lost in the teleosts which possess bony scales.

Lophiformes

Lophiformes, like the Gasterosteiformes, have a bony covering the head of the head-water fish. These fish are some of the most primitive teleosts, characterized by a dorsal fin type that is a bar in progressive form. Examples include the stickleback.

The Development of Modern Teleosts

Modern teleosts or spiny-finned fish, develop from primitive types belonging to a group called the Leptocephaliformes. From this group three branches gave rise to the eels and herring-like (Anguilliformes, Clupeiformes), Gymnarchus (Mormoniformes) and the salmon-type fish (Salmoniformes). This latter group of fish form the main stem of further fish development, giving rise to the majority of the living teleosts.

Salmoniformes

The Salmoniformes form a primitive group of fish which are on the main evolutionary line of teleost development. A key character of the group is the presence of an adipose fin behind the dorsal and anal fins. They show various features in common with the Clupeiformes (including the relative positions of the pelvic and pectoral fins). Examples include salmon and trout.

Gasterosteiformes

The Gasterosteiformes include the stickleback, *Gasterosteus aculeatus*, and the three-spined stickleback, *Gasterosteus aculeatus*. They are characterized by a dorsal fin type that is a bar in progressive form. Examples include the stickleback.

Cypriniformes

The Cypriniformes belong to the large group of teleosts which are the second largest group of primitive bony fish. This large group is characterized by the following features: The fish are compressed laterally or flattened or pointed ends. They are present in water line of a species. There are usually present two dorsal fins. In some species the presence of a chain of small bones between the lower jaw and lower shoulder. Various species, which are present in warm regions. Examples include carp, goldfish, minnow, dace, tench, loach, roach, bream, etc.

Clupeiformes

The Clupeiformes, of which the herring is a typical example, are very primitive fish. They are characterized by the following features: The fish are compressed laterally or flattened or pointed ends. They are present in water line of a species. There are usually present two dorsal fins. In some species the presence of a chain of small bones between the lower jaw and lower shoulder. Various species, which are present in warm regions. Examples include herring, mackerel, etc.

Anguilliformes

The Anguilliformes comprise the eel-like fish. They are characterized by the following features: The fish are elongated and eel-like. They are present in water line of a species. There are usually present two dorsal fins. In some species the presence of a chain of small bones between the lower jaw and lower shoulder. Various species, which are present in warm regions. Examples include eel, etc.

Leptocephaliformes

The Leptocephaliformes are teleost-like fish that are considered to be the most primitive teleosts. They are characterized by the following features: The fish are elongated and eel-like. They are present in water line of a species. There are usually present two dorsal fins. In some species the presence of a chain of small bones between the lower jaw and lower shoulder. Various species, which are present in warm regions. Examples include leptocephaliforms, etc.

Family Tree of the Lower Fishes

The diagram shows the evolutionary relationships between various groups of fish. It starts with the earliest vertebrates (Agnatha) and branches into Ostracoderms, Placoderms, and Acanthodii. From Acanthodii, it branches into Leptocephaliformes, which further divides into Gasterosteiformes, Cypriniformes, Clupeiformes, Anguilliformes, and Salmoniformes. Salmoniformes leads to Beryciformes, which then leads to Perciformes and Actinopterygii. Actinopterygii branches into Lophiformes and other groups.

Rays, grinders

Rays have developed a bottom dwelling existence. They are flat bodied with large pectoral fins and feed in mudflats, crabs and echinoderms. Their diet is reflected in their teeth which form a mosaic of flat or ridged "grinding stones", usually used for crushing their food. Other fish groups have similar teeth for dealing with hard shelled prey, including the Port Jackson shark (skate-like in appearance) and teleosts like *Pseudis*.

Sharks, cutters

The teeth of sharks are very variable in size and shape and are adapted for catching different types of prey. Sharks are streamlined, active predators, and feed on fish, porpoises, sea birds, turtles, crabs, sea lions and other sharks. The wide gaping jaws and many sharp pointed piercing or triangular cutting teeth provide the shark with an efficient food gathering mechanism. Teeth are continuously replaced from behind and there may be more than one set of functional teeth.

Chondrichthyes

The Chondrichthyes are fish that have a skeleton made of cartilage and their skin is covered with small enamel-covered plates called placoid scales. They evolved in many ways modified in the mid-Permian period which followed they rapidly diversified and produced types that have continued relatively little changed through to the present day. The little fish or chimaeras are an early offshoot from the main line of shark evolution.

Family Tree of the Lower Fishes

The diagram shows the evolutionary relationships between various groups of fish. It starts with the earliest vertebrates (Agnatha) and branches into Ostracoderms, Placoderms, and Acanthodii. From Acanthodii, it branches into Leptocephaliformes, which further divides into Gasterosteiformes, Cypriniformes, Clupeiformes, Anguilliformes, and Salmoniformes. Salmoniformes leads to Beryciformes, which then leads to Perciformes and Actinopterygii. Actinopterygii branches into Lophiformes and other groups.

Chondrichthyes (shark)

Chondrichthyes (shark)

Chondrichthyes (shark)

Chondrichthyes (shark)

Chondrichthyes (shark)

Chondrichthyes (shark)

Chondrichthyes (shark)

Chondrichthyes (shark)

Chondrichthyes (shark)

Chondrichthyes (shark)

Chondrichthyes (shark)

Chondrichthyes (shark)

Chondrichthyes (shark)

Chondrichthyes (shark)

Chondrichthyes (shark)

Chondrichthyes (shark)

Chondrichthyes (shark)

Chondrichthyes (shark)

Chondrichthyes (shark)

Chondrichthyes (shark)

Chondrichthyes (shark)

Chondrichthyes (shark)

Chondrichthyes (shark)

Chondrichthyes (shark)

Chondrichthyes (shark)

Chondrichthyes (shark)

Chondrichthyes (shark)

Chondrichthyes (shark)

Chondrichthyes (shark)

Chondrichthyes (shark)

Chondrichthyes (shark)

Chondrichthyes (shark)

Chondrichthyes (shark)

Chondrichthyes (shark)

Chondrichthyes (shark)