

FISH SKELETON

Fish are [vertebrates](#). All vertebrates are built along the basic [chordate body plan](#): a stiff rod running through the length of the animal ([vertebral column](#) or [notochord](#)),^[4] with a hollow tube of nervous tissue (the [spinal cord](#)) above it and the [gastrointestinal tract](#) below. In all vertebrates, the mouth is found at, or right below, the anterior end of the animal, while the [anus](#) opens to the exterior before the end of the body. The remaining part of the body continuing aft of the anus forms a [tail](#) with vertebrae and spinal cord, but no gut.

The defining characteristic of a vertebrate is the [vertebral column](#), in which the [notochord](#) (a stiff rod of uniform composition) found in all [chordates](#) has been replaced by a segmented series of stiffer elements (vertebrae) separated by mobile joints (intervertebral discs, derived embryonically and evolutionarily from the notochord). However, a few fish have secondarily lost this anatomy, retaining the notochord into adulthood, such as the [sturgeon](#).

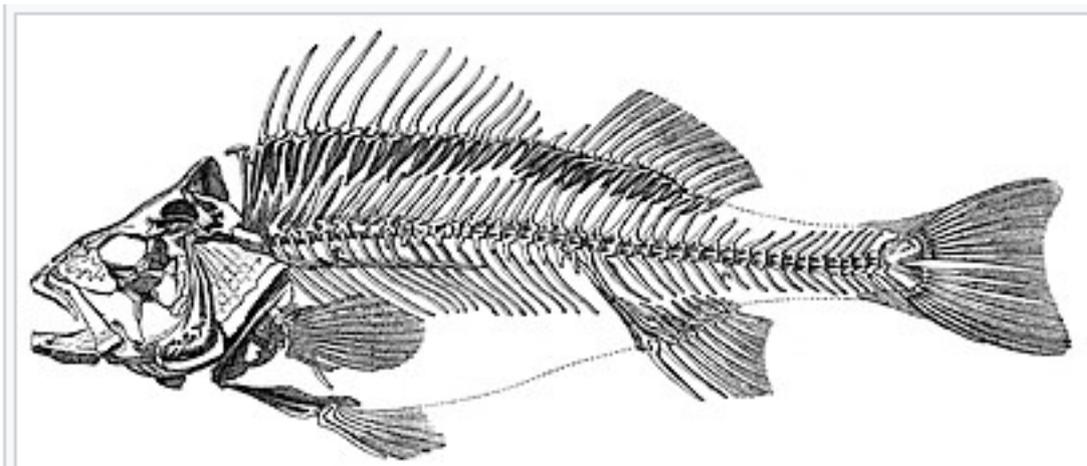
The [vertebral column](#) consists of a [centrum](#) (the central body or spine of the vertebra), [vertebral arches](#) which protrude from the top and bottom of the centrum, and various processes which project from the centrum or arches. An arch extending from the top of the centrum is called a neural arch, while the [hemal arch](#) or [chevron](#) is found underneath the centrum in the [caudal](#) (tail) vertebrae of fish. The centrum of a fish is usually concave at each end (amphicoelous), which limits the motion of the fish. This can be contrasted with the centrum of a mammal, which is flat at each end (acoelous), shaped in a manner that can support and distribute compressive forces.

The vertebrae of [lobe-finned fishes](#) consist of three discrete bony elements. The vertebral arch surrounds the spinal cord, and is of broadly similar form to that found in most other vertebrates. Just beneath the arch lies a small plate-like *pleurocentrum*, which protects the upper surface of the [notochord](#), and below that, a larger arch-shaped *intercentrum* to protect the lower border. Both of these structures are embedded within a single cylindrical mass of cartilage. A similar arrangement was found in primitive [tetrapods](#), but, in the evolutionary line that led to reptiles (and hence, also to mammals and birds), the intercentrum became partially or wholly replaced by an enlarged pleurocentrum, which in turn became the bony vertebral body.

In most [ray-finned fishes](#), including all [teleosts](#), these two structures are fused with, and embedded within, a solid piece of bone superficially resembling the vertebral body of mammals. In living [amphibians](#), there is simply a cylindrical piece of bone below the vertebral arch, with no trace of the separate elements present in the early tetrapods.

In [cartilaginous fish](#), such as [sharks](#), the vertebrae consist of two cartilagenous tubes. The upper tube is formed from the vertebral arches, but also includes additional cartilagenous structures filling in the gaps between the vertebrae, and so enclosing the spinal cord in an essentially continuous sheath. The lower tube surrounds the notochord, and has a complex structure, often including multiple layers of [calcification](#).^[10]

[Lampreys](#) have vertebral arches, but nothing resembling the vertebral bodies found in all [higher vertebrates](#). Even the arches are discontinuous, consisting of separate pieces of arch-shaped cartilage around the spinal cord in most parts of the body, changing to long strips of cartilage above and below in the tail region. [Hagfishes](#) lack a true vertebral column, and are therefore not properly considered vertebrates, but a few tiny neural arches are present in the tail.^{[10][11]} Hagfishes do, however, possess a [cranium](#). For this reason, the vertebrate subphylum is sometimes referred to as "[Craniata](#)" when discussing morphology. Molecular analysis since 1992 has suggested that the hagfishes are most closely related to lampreys,^[12] and so also are vertebrates in a [monophyletic](#) sense. Others consider them a sister group of vertebrates in the common taxon of Craniata.



Skeletal structure of a [bass](#) showing the vertebral column running from the head to the tail

