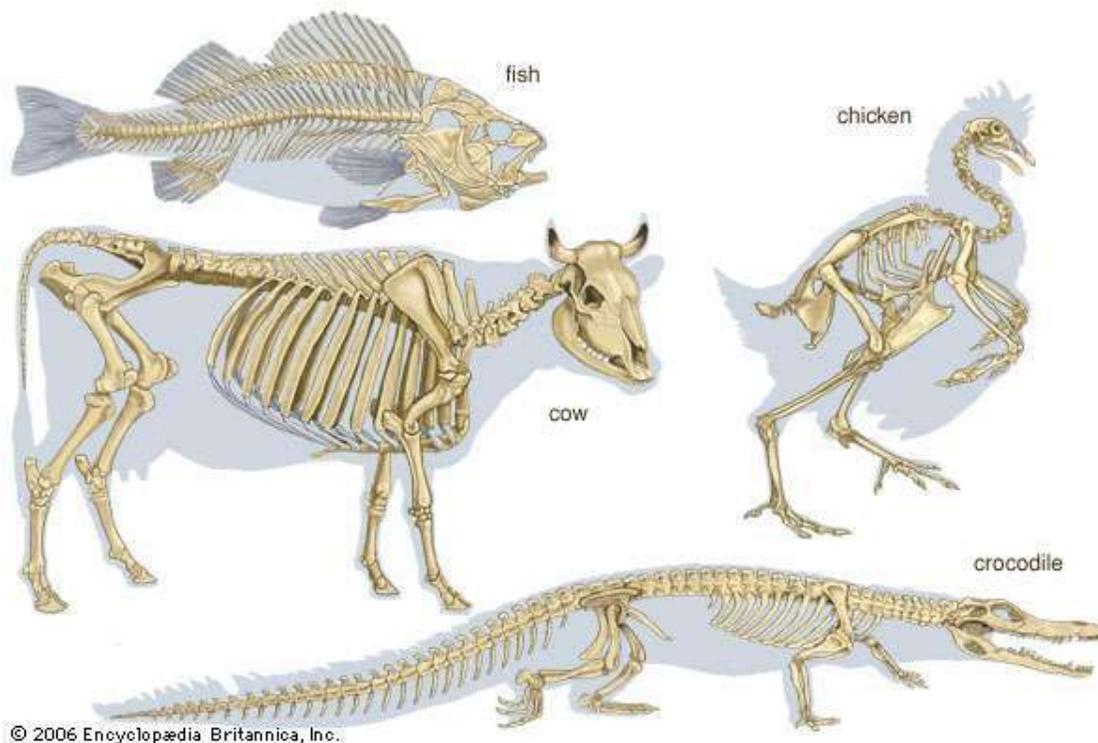


## Overview of axial & appendicular skeleton, Jaw Suspension, visceral arches

### Zoology (Hons.) 2<sup>nd</sup> SEM, DC4 Unit 2

In vertebrates the adult skeleton is usually formed of bone or cartilage—living substances that grow with the animal, in contrast to the many types of invertebrate skeleton that do not grow or are dead secretions, deposits, or crystals. The internal position of bones and their central position in limbs provide firm support for small and large animals. Muscles can be inserted on all surfaces of the skeleton, in contrast to the limitations of the cuticular skeleton of arthropods, in which muscles occur on only one side. Antagonistic muscles are easily placed upon vertebrate bones to allow contrasting movements at the joints between them.



The component parts of the skeletons of vertebrates, although remarkably uniform in basic plan, are subject to wide superficial differences, which are associated with each class and

with adaptations for particular habits or environments. The axial skeleton consists of the skull and the vertebral column. The appendicular skeleton supports the fins in fish and the legs in tetrapods (four-legged animals) and is associated with limb girdles, which become progressively more closely linked with the vertebral column in the higher vertebrates.

An unjointed elastic notochord is present in the protochordate amphioxus, in the tail of larval ascidians (tunicates), and in the adult cyclostomes (lamprey and hagfish), but there are no vertebrae. Segmental series of muscles are present as in fish, and the resultant swimming movements of these muscles, working with the elastic notochord, are similar to those in fish.

The lateral body undulations caused by the trunk musculature, as seen in fish, are the main propulsive agents in amphibians such as the newt. The feet raise the body from the ground but otherwise serve only to anchor the body, while the vertebral musculature allows forward progression by straightening the flank. The same propulsive mechanism serves for locomotion in water and on land.

The **axial skeleton** is the part of the skeleton that consists of the bones of the head and trunk of a vertebrate. In the human skeleton, it consists of 80 bones and is composed of six parts; the skull (22 bones), the ossicles of the middle ear, the hyoid bone, the rib cage, sternum and the vertebral column. The axial skeleton together with the appendicular skeleton form the complete skeleton. Axial skeleton is the bones including the vertebrae, sacrum, coccyx, ribs, and sternum.

The **appendicular skeleton** is the portion of the skeleton of vertebrates consisting of the bones that support the appendages. The appendicular skeleton includes the skeletal elements within the limbs, as well as supporting shoulder girdle pectoral and pelvic girdle.

Of the 206 bones in the human skeleton, the appendicular skeleton comprises 126. Functionally it is involved in locomotion (lower limbs) of the axial skeleton and manipulation of objects in the environment (upper limbs).

The appendicular skeleton forms during development from cartilage, by the process of endochondral ossification.

The appendicular skeleton is divided into six major regions:

1. Shoulder girdles (4 bones) - Left and right clavicle (2) and scapula (2).
2. Arms and forearms (6 bones) - Left and right humerus (2) (arm), ulna (2) and radius (2) (forearm).
3. Hands (54 bones) - Left and right carpals (16) (wrist), metacarpals (10), proximal phalanges (10), intermediate phalanges (8) and distal phalanges (10).
4. Pelvis (6 bones) - Ilium (2), Ischium (2) and Pubis (2).
5. Thighs and legs (8 bones) - Left and right femur (2) (thigh), patella (2) (knee), tibia (2) and fibula (2) (leg).
6. Feet and ankles (52 bones) - Left and right tarsals (14) (ankle), metatarsals (10), proximal phalanges (10), intermediate phalanges (8) and distal phalanges (10).

**Jaw suspension:** It means attachment of the lower jaw with the upper jaw or the skull for efficient biting and chewing. There are different ways in which these attachments are attained depending upon the modifications in visceral arches in vertebrates.

### **AMPHISTYLIC**

In primitive elasmobranchs there is no modification of visceral arches and they are made of cartilage. Pterygoquadrate makes the upper jaw and meckel's cartilage makes lower jaw and they are highly flexible. Hyoid arch is also unchanged. Lower jaw is attached

to both pterygoquadrate and hyoid arch and hence it is called amphistylic.

### **AUTODIASTYLIC**

Upper jaw is attached with the skull and lower jaw is directly attached to the upper jaw. The second arch is a branchial arch and does not take part in jaw suspension.

### **HYOSTYLIC**

In modern sharks, lower jaw is attached to pterygoquadrate which is in turn attached to hyomandibular cartilage of the 2<sup>nd</sup> arch. It is the hyoid arch which braces the jaw by ligament attachment and hence it is called hyostylic.

### **HYOSTYLIC (=METHYSTYLIC)**

In bony fishes pterygoquadrate is broken into epipterygoid, metapterygoid and quadrate, which become part of the skull. Meckel's cartilage is modified as articular bone of the lower jaw, through which the lower jaw articulates with quadrate and then with symplectic bone of the hyoid arch to the skull. This is a modified hyostylic jaw suspension that is more advanced.

### **AUTOSTYLIC (=AUTOSYSTYLIC)**

Pterygoquadrate is modified to form epipterygoid and quadrate, the latter braces the lower jaw with the skull. Hyomandibular of the second arch transforms into columella bone of the middle ear cavity and hence not available for jaw suspension.

### **MONIMOSTYLIC**

This type of suspension is a modification of autosystylic suspension in which quadrate is immovable and not flexible as in amphibia and many reptiles. Hyomandibular is modified as columella bone of the middle ear cavity.

### **STREPTOSTYLIC**

This type is found in snakes, lizards and birds, in which quadrate bone is movable and flexible at both ends making the jaw highly flexible. Columella is single bone in the middle ear cavity and is sometimes called stapes.

**HOLOSTYLIC** type is found in lung fishes and Holocephali. Upper jaw is fused with the skull and the lower jaw is attached directly with it. Hyoid arch does not participate in jaw suspension and is a typical branchial arch. There is no columella bone.

### **AUTOSTYLIC (=CRANIOSTYLIC)**

Found in mammals, in this type of jaw suspension, pterygoquadrate is transformed into alisphenoid and incus, while meckel's cartilage is changed into malleus and not available for jaw suspension. Lower jaw is directly attached to the skull bone called squamosal. Monotremes also possess this type of jaw suspension.

**Visceral arches**: They are pieces of cartilages or bones that support the pharyngeal region of vertebrates and also help attach the jaws with the skull. There are typically 7 pairs of visceral arches in vertebrates which modify in different groups depending upon the presence or absence of gills and type of jaw suspension.

Visceral arches are numbered 1-7, the first arch is known as **mandibular arch** having two cartilaginous pieces called **pterygoquadrate** and **meckel's cartilage**.

Second visceral arch, called hyoid arch, consists of hyomandibular, ceratohyal and basihyal.

From 3<sup>rd</sup> to 7<sup>th</sup> visceral arches are called **branchial larches**, since they support gills and typically consist of 4 pieces of cartilages, namely, pharyngobranchial, epibranchial, certobranchial and hypobranchial.

### **Cyclostomes**

There is no resemblance with the typical pattern but cyclostomes possess a splanchnocranium in which usual cartilages are not identifiable. The whole pharyngeal skeleton fuses to form a branchial basket to support gills.

### **Elasmobranchs**

They contain full set of visceral arches and three unpaired branchial cartilages called basibranchials. The arrangement is close to basic pattern as they have 5 pairs of functional gills and skeleton is all cartilaginous.

### **Bony fishes**

Meckel's cartilage forms articular and becomes part of the lower jaw. Hyoid arch is modified for the movement of operculum and functioning of the lower jaw. **Symplectic** helps in jaw suspension. Last branchial arch shows sign of degeneration as the number of gills is reduced to 4 pairs.

### **Amphibia**

Larval frogs have 6 visceral arches and the last 3 bear gills. In urodeles having gills third, fourth and fifth epibranchials support gills while their basibranchials and ceratobranchials are reduced to two pairs. Hyomandibular modifies as **columella** of the middle ear cavity in frogs and toads. The air breathing hyobranchial apparatus of frogs and toads is made by the fusion of 2<sup>nd</sup>, 3<sup>rd</sup> and 4<sup>th</sup> visceral arches.

## Reptiles

Quadratoquadrate and epipterygoid bones of the skull are modifications of pterygoquadrate, and articular of the lower jaw is a modified meckel's cartilage. Hyoid arch forms a small hyoid plate that also extends forward to support the tongue. One of two ceratobranchials may form the posterior cornu of the hyoid plate.

## Birds

Modification is similar to reptiles except that there is only one cornu of the hyoid plate that is modified from the third visceral arch.

## Mammals

Pterygoquadrate breaks into **alisphenoid** and **incus**, the former becomes part of the skull and the latter joins the ear ossicles. Meckel's cartilage modifies into **malleus** and hyomandibular into **stapes** of the middle ear cavity. Larynx of mammals evolved from the fourth and fifth visceral arches. Thyroid cartilage is a modification of 4<sup>th</sup> and 5<sup>th</sup> visceral arches while **arytenoid** and **cricoid** cartilages are modified fifth visceral arch.

