52

Endoskeleton in Vertebrates

What is Skeleton?

The hardened tissues of the body together form the *skeleton* (*sclero* = hard). Organism will remain small and slow moving if there had been no skeleton for support and to serve as levers on which muscles can act. Skeleton of invertebrates is most often secreted on the surface, forming a lifeless or dead *exoskeleton.* Whereas skeleton of vertebrates develops most often underneath the surface forming a living or growing *endoskeleton.*

Types of Vertebrate Skeletons

Three types of skeletons develop in vertebrates :

1. Epidermal horny exoskeleton. These include hard and horny or keratinized derivatives of epidermal layer of skin, such as claws, reptilian scales, bird feathers and mammalian hairs, horns, nails and hoofs, etc. All living amphibians lack an exoskeleton. Epidermal horny exoskeletal structures of vertebrates have already been discussed in Chapter 51.

2. Dermal bony skeleton. Dermal bony skeleton is derived from the dermis of skin. It includes bony *scales* and *plates* or *scutes* (*osteoderms*), *finrays* and *antlers* of fishes, reptiles and mammals. In fishes, dermal scales become exposed due to wearing out of epidermis, and form exoskeleton.

3. Endoskeleton. Greater part of vertebrate skeleton lies more deeply, forming the endoskeleton. It develops from mesenchyme. At early embryonic stage, endoskeleton is composed of *cartilage*, which is replaced by *bone* in most adult vertebrates. Such bones deposited in place of preexisting cartilages, are called *cartilage* or *replacement bones.* Thus, they are distinguished from the *dermal* or *membrane bones* which directly form more superficially in dermis without any preexisting cartilage. Despite this difference in the mode of their development, the two types of bones are similar histologically.

Functions of Endoskeleton

Chief functions of vertebrates can be enumerated as follows :

(1) To provide physically support to body by forming a firm and rigid internal framework.
(2) To give definite body shape and form.
(3) To protect by surrounding delicate internal organs like brain, heart, lungs, etc.
(4) To permit growth of huge body size (whale, elephant, extinct dinosaurs), since it is living and growing.
(5) To provide surface for attachment of muscles.
(6) To serve as levers on which muscles can act.
(7) To manufacture blood corpuscles in bone marrow.
(8) To aid in hearing (ear ossicles).
(9) To help in breathing (tracheal rings, ribs).

Subdivisions of Vertebrate Endoskeleton

For convenience of study, endoskeleton of vertebrates is further subdivided into 3 major categories on the basis of their location in body—axial, appendicular and heterotopic. Each of these categories includes several elements as given in Table 1.

According to another scheme, endoskeleton can be divided first into somatic and visceral skeletons, as follows :

1. Somatic skeleton. Skeleton of body wall.

(a) Axial skeleton. Vertebral column, ribs, sternum and most of the skull (neurocranium and dermatocranium).

(b) Appendicular skeleton. Girdles and limb bones.

2. Visceral skeleton. Skeleton of pharyngeal wall (splanchnocranium).

Skull

The skeletal structure forming the framework of the vertebrate head is called *skull*. It is an important structure which is derived from three

Table 1. **General Divisions of Endoskeleton in a Land Vertebrate.**

I. Axial skeleton (median)			**II. Appendicular skeleton (lateral, paired)**		**Heterotopic bones (miscellaneous)**
Skull	**Vertebral column**	**Thoracic basket**	**Girdles**	**Limb bones**	**Develop in association with certain organs**
A. Neurocranium 1. Cranium or brain box surrounding brain 2. Sense capsules (i) *Olfactory*–nose (ii) *Optic*–eyes (iii) *Auditory* ears **B. Dermatocranium** Membrane or dermal bones of skull **C. Splanchnocranium** Includes visceral arches or pharyngeal skeleton 1. Upper jaw 2. Lower jaw 3. Hyoid 4. Larynx	**Vertebrae** 1. Cervical–neck 2. Thoracic–chest 3 Lumbar–lower back 4. Sacral–hip 5. Caudal–tail	**A. Ribs** Paired; bony or cartilaginous **B. Sternum** Breast bone	**A. Pectoral** Anterior or shoulder girdle. Includes : 1. Scapula–dorsal 2. Clavicle–anterior 3. Coracoid–posterior **B. Pelvic** Posterior or hip girdle. Includes : 1. Ilium-dorsal 2. Pubis-anterior 3. Ischium-posterior	**A. Forelimb** 1. Humerus-upper arm 2. Radius and ulna-forearm 3. Carpals-wrist 4. Metacarpals-palm 5. Phalanges-fingers **B. Hind limb** 1. Femur– thigh 2. Tibia & fibula–shank 3. Tarsals– ankle 4. Metatarsals–sole 5. Phalanges – toes	**1. Os cordis**—Inter ventricular septum of heart in deer and bovines **2. Rostral**– Pig's snout **3. Os penis**–Penis of bats, rodents, marsupials, carnivores, insectivores, whales, lower primates. **4. Os clitoridis**–Clitoris of otters, rabbits, several rodents. **5. Pessulus**–Syrinx of birds. **6. Epipubic**–Ventral abdominal wall of monotremes and marsupials. **7. Sesamoid**–Pisciform in hand, patella (kneecap), etc.

major embryonic components— (i) *neurocrancium* or *chondrocranium*, (ii) *dermatocranium* and (iii) *splanchnocranium*.

1. Neurocranium or chondrocranium. It includes (i) the *cranium* or *brain box* that houses the brain, and (ii) three pairs of *sense capsules* containing special sense organs of smell (*olfactory*), sight (*optic*) and hearing (*otic*).

2. Dermatocranium. It includes membrane or dermal bones attached to neurocranium and splanchnocranium.

3. Splanchnocranium. It includes the visceral or pharyngeal skeleton, originally forming a series of paired arches providing jaws, support for tongue (hyoid), and support for gill region.

Table 2 lists all the different types of bones found in different regions in the skull of vertebrates.

***Table 2.* Types of Bones in Skull of Vertebrates.**

Region of skull	Cartilage or replacement bones	Membrane or dermal bones	Bones of mixed origin
A. Chondrocranium 1. *Occipital*	* Supraoccipital Exoccipital * Basioccipital	Parietal * Interparietal Postparietal	
2. *Parietal*	* Basisphenoid Pleurosphenoid		
3. *Frontal*	Orbitosphenoid * Presphenoid	Frontal Postfrontal Lacrimal	Prefrontal
4. *Olfactory capsule*	* Mesethmoid Turbinals } Ethmoid Cribriform } Ectethmoid	Nasal Vomer Septomaxillary	
5. *Otic capsule*	Epiotic Prootic Opisthotic	Squamosal Supratemporal	Sphenotic Pterotic
6. *Optic capsule*	Sclerotic		
7. *Palate*		* Parasphenoid Vomer (in mammals) Endopterygoid or Pterygoid Ectopterygoid	Palatine
B. Splanchnocranium *1. Upper jaw*	Quadrate (incus) Epipterygoid Alisphenoid Metapterygoid	Premaxilla Maxilla Jugal Quadratojugal	
2. *Lower jaw*	Articular (malleus) Mentomeckelian	Dentary (mandible) Coronoid Splenial Angular Supra angular	
3. Hyoid arch	Hyomandibular Columella (stapes) Symplectic Inter- epi-, hypo-, cerato-, * basihyal		
4. Gill cover		Preopercular Opercular Subopercular Interopercular Gular	

N.B.—All bones are paired. Single bones are marked with an asterisk (*).

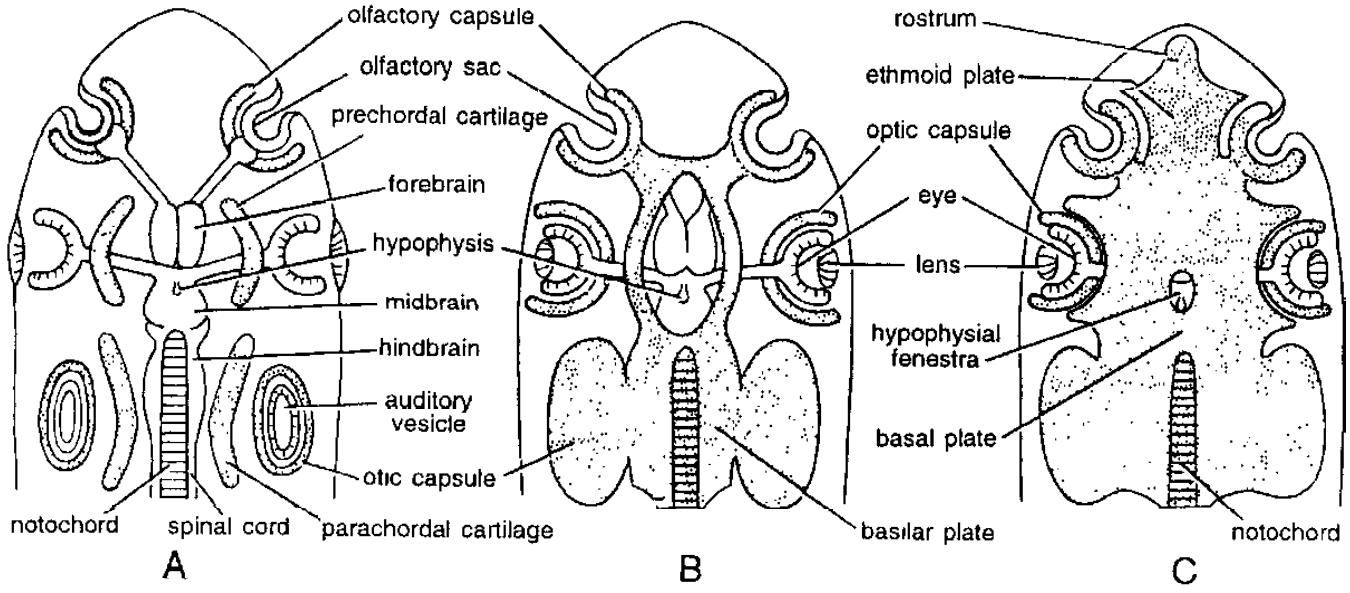

Fig. 1. Stages to show diagrammatic development of chondrocranium or cartilaginous neurocranium in ventral view A—Cartilages appear in head of embryo B—Formation of ethmoid and basilar plates. C—Chondrocranium completed

[I] Morphogenesis (history and development) of skull

1. Development of chondrocranium. Skull formation commences in the embryo soon after the formation of central nervous system and notochord (Fig. 1). A pair of curved cartilaginous plates, called *prechordals*, forms parallel to and below the forebrain. Similarly, another pair of *parachordal cartilages* forms beneath the midbrain and hindbrain, and parallel to the anterior end of notochord. The two prechordals expand towards each other and unite in the midline to form an *ethmoid plate*. Similarly, the two parachordals unite across the midline forming a *basilar plate*. Later, the ethmoid and basilar plates also grow towards each other and fuse to form a single *basal plate*, or floor upon which the brain rests. A large opening in the basal plate, the *hypophyseal fenestra*, lodges the pituitary gland.

Meanwhile, paired capsules of cartilage are also formed around the developing sense organs. The *olfactory capsules* around the nasal epithelium, and *auditory* or *optic capsules* surrounding the membranous labyrinths or internal ears, fuse with the basal plate forming the *neurocranium*. In its cartilaginous stage, the neurocranium is often termed *chondrocranium*, which means 'cartilaginous braincase'. The *optic capsules* or *sclerotic coats* around the eyes do not fuse with the chondrocranium, so that eyeballs can move independently of skull.

Further development involves formation of cartilaginous walls along lateral sides of brain. In lower forms, such as elasmobranches and lower bony fishes (e.g. *Amia*), the sidewalls further grow forming a complete cartilaginous roof over brain. Some openings remain uncovered for cranial nerves and blood vessels. The largest of all is foramen magnum at the posterior end of chondrocranium for spinal cord. In most bony fishes and tetrapods, however, the brain is not roofed over by cartilage except above the foramen magnum. Later membrane or dermal bones form a roof over the brain.

2. Development of splanchnocranium. It develops partly from neural crest cells and from splanchnic mesoderm. It includes visceral or pharyngeal skeleton consisting of a series of horseshoe-shaped paired cartilaginous arches (usually 7 pairs) encircling and supporting the pharynx between gill clefts. The arches remain united and interconnected ventrally, but are free dorsally. In jawed vertebrates or gnathostomes, the *first* or *mandibular arch* on either side is divided

into a dorsal *palatopterygoquadrate cartilage* forming the *upper jaw*, and a ventral *Meckel's cartilage* forming the *lower jaw*. The *second* or *hyoid* arch on either side gives out a dorsal *hyomandibular* cartilage to support and connect jaws to chondrocranium below auditory region, and ventrally forming the *hyoid apparatus* supporting tongue. The remaining or *branchial arches* support the gills or larynx.

[II] Skull in different vertebrates

A comparative study shows that the basic architectural pattern of the three major components of skull (viz., neurocranium, dermatocranium and splanchnocranium) is essentially the same in all the vertebrates. However, there are many differences in general form and detailed structure of skull, including reduction in the number of bones.

1. Cyclostomata. Skull is most primitive (or specialized?) among living cyclostomes. It retains cartilaginous embryonic neurocranium with an imperfect fibrous roof without dermal plates or bones. Visceral skeleton, modified as a branchial basket, is not comparable with that of higher vertebrates.

2. Chondrichthyes. In elasmobranchs, neurocranium is cartilaginous. Brain is completely roofed. Olfactory and otic capsules are fused with the chondrocranium, but optic capsules remain free. Dermal bones are absent.

3. Osteichthyes. In ganoids or primitive bony fishes, such as gar, sturgeon, spoonbill, *Amia*, etc. and earlier crossopterygians, neurocranium is flat,

Table 3. **Major Skeletal Derivatives of Visceral Arches in Representative Vertebrates.**

Visceral arch	Dogfish *(Scoliodon)*	Teleost (Bony fish)	Amphibian *(Necturus)*	Amphibian (Frog)	Reptile & Bird (*Uromastix* & Pigeon)	Mammal (Rat or rabbit)
	Meckel's cartilage	Articular	Articular	Articular Mentomeckelian in some species	Articular	Malleus
I.	Pterygoquadrate	Quadrate Epipterygoid Metapterygoid	Quadrate Cartilage in lateral Roof of mouth	Quadrate Annulus tympanicus	Quadrate Epipterygoid —	Incus Alisphenoid —
	Hyomandibula	Hyomandibula Symplectic	Rudimentary —	Columella —	Columella —	Stapes —
II.	Ceratohyal Basthyal	Interhyal Epihyal Ceratohyal Hypohyal Entoglossal	Ceratohyal — — Hypopyal	Anterior horn — — Body of hyobranchial apparatus	Anterior horn — — Body of hyobranchial apparatus Entoglossus	Anterior horn — — Body of hyoid
III.	Pharyngobranchial Epibranchial Ceratobranchial Hypobranchial	Pharyngobranchial Epibranchial Ceratobranchial Hypobranchial	Epibranchial Ceratobranchial	Body of hyobranchial apparatus	Second horn Body of hyobranchial apparatus	Posterior horn Body of hyoid
IV.	Branchial elements (as in III)	Branchial elements (as in III)	Branchial elements (as in III)	Posterior horn Body of hyobranchial apparatus	Posterior horn	Thyroid cartilage
V.	Branchial elements	Branchial elements	Epibranchial only Homologies of laryngeal cartilages remain in doubt	Not clearly delineated		Thyroid Cricoid Arytenoid
VI.	Branchial elements	Branchial elements	Missing or not clearly delineated			
VII.	Bears no gill Some reduction	Reduced	Missing			

completely roofed, cartilaginous and partially ossified forming many sculptured dermal bones by the fusion of dermal scales. In *Polypterus*, neurocranium is extensively ossified.

In some primitive teleosts (trout, salmon), chondrocranium is mostly cartilaginous. But, in higher teleosts, skull is highly specialized, laterally compressed and well ossified. Dermal bones are smooth, without ganoin, and not scale-like. Cartilaginous visceral arches have been changed to bones or replaced by dermal bones. Palatoquadrate cartilages do not meet anteriorly. Upper jaw is formed by premaxilla and maxilla, which are dermal bones. Lower jaw (Meckel's cartilage) has three bones—dentary, angular and articular-the last hinging on quadrate which attaches to cranium.

4. Amphibia. Modification in skull of Amphibia over that of fishes are correlated with the shift from water to land. There are fewer bones and much more embryonic cartilage in skull of modern amphibians, which is markedly platybasic and flattened. Basioccipital, supraoccipital, basisphenoid and presphenoid are absent. Hyomandibular becomes columella of the middle ear. Ventral wall of otic capsule bears a membrane covered aperture, fenestra ovalis, into which columella articulates for transmitting sound waves. Two occipital condyles, one on each exoccipital, are present. Visceral skeleton is essentially bony fish-like except that the number of gill-bearing arches is reduced.

5. Reptilia. In modern reptiles, neurocranium shows extensive ossification except in naso-ethmoidal region. There is one occipital condyle and more dermal bones than in Amphibia. Skull is tropibasic. One or two temporal fossae occur behind the orbits, except in Chelonia. Pineal foramen is lost, except in *Sphenodon* and many lizards. Prootic, epiotic and opisthotic of otic region remain separate. A quadratojugal is absent. Quadrate is movable at both ends showing streptostylism. There is tendency to form a Turbinal element in nasal passage, and to form a secondary palate. A transverse ectopterygoid and a vertical epiterygoid are present. Hyomandibular is modified into columella of middle ear. Lower jaw exhibits a large toothed dentary, angular, supraangular, splenial, coronoid and articular bones.

6. Aves. Bird skull is essentially reptilian in structure. Neurocranium is well ossified. A single occipital condyle occurs. Modifications are associated with flight and altered feeding habits. Skull is large, penumatic and light, with very thin dermal bones and practically without sutures. Premaxillary and dentary are elongated to form a toothless beak necessary for feeding. Cranium is large and its roof domed to accommodate the larger brain. Orbits are large, separated by a thin interorbital septum, and each with a ring of dermal sclerotic bones. Foramen magnum faces downwards. Like reptiles, there is a columella in the middle ear. Quadrate is streptostylic. Lower jaw has one cartilage bone (articular) and four dermal bones.

7. Mammalia. Mammalian skull has two occipital condyles, a condition inherited from ancestral synapsid reptiles. Prefrontals, postfrontals, transpalatines, supraorbitals, postorbitals, parasphenoid, quadratojugals, quadrates and all lower jaw bones except dentary are absent. Occipital bones fuse into a single piece enclosing foramen magnum. Otic bones become fused into a petrosal or periotic. Middle ear cavity has 3 ear ossicles - malleus (articular), incus (quadrate) and stapes (columella or hyomandibula). A complete secondary palate is present. Teeth are heterodont and present on premaxillae, maxillae and dentaries. Pterygoids are insignificant. Lower jaw on either side is made of a single dentary, there being no trace of Meckel's cartilage. Hyoid arch mainly contributes to hyoid apparatus. Remaining visceral arches contribute to thyroid, epiglottis, arytenoids, cricoid, tracheal rings, etc.

[III] Suspensoria or jaw suspensions

As mentioned earlier, the vertebrate skull has three major parts - neurocranium, dermatocranium and splanchnocranium. The splanchnocranium includes the visceral arches. The first or *mandibular arch* consists of a dorsal *palatopterygoquadrate bar* forming the upper jaw, and a ventral *Meckel's*

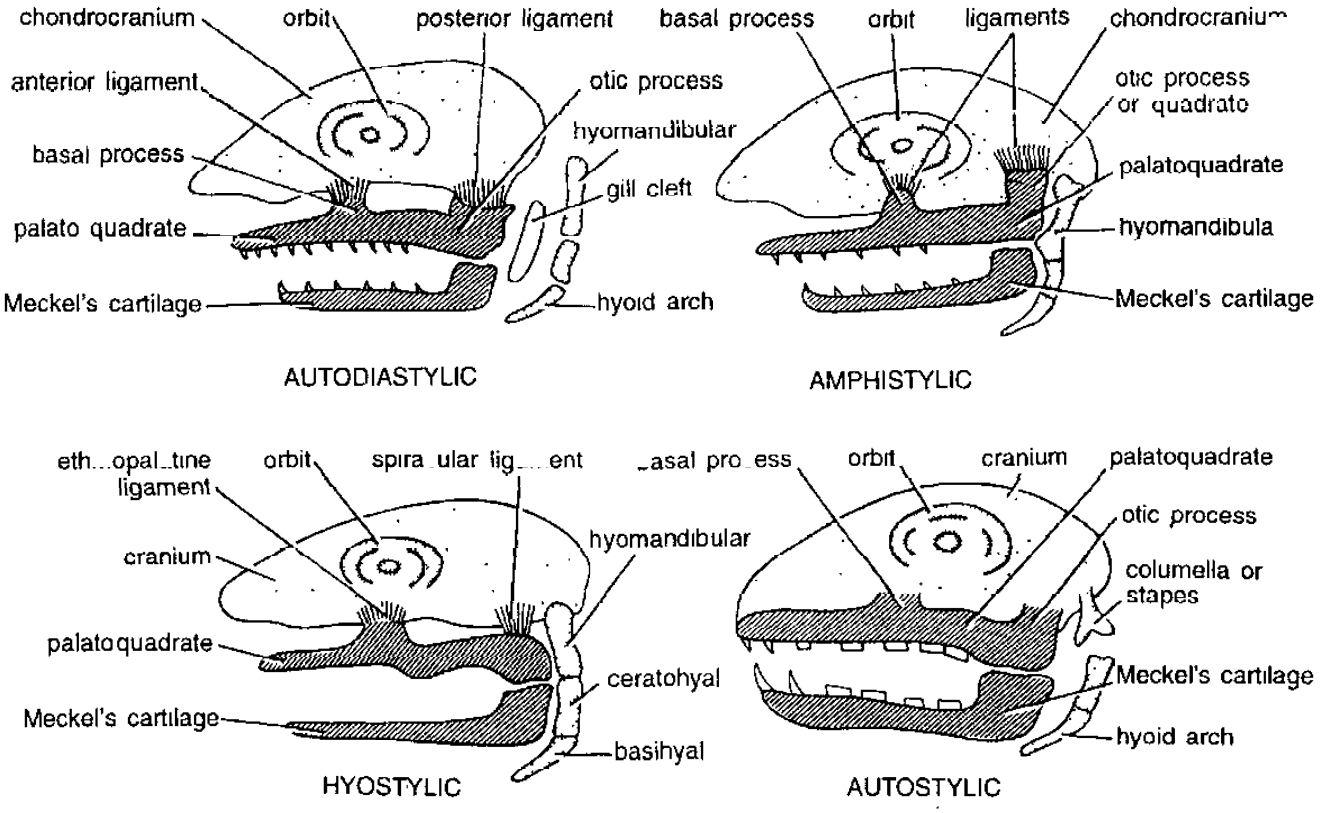

Fig. 2. Types of jaw suspensoria in vertebrates

cartilage forming the lower jaw. The second or *hyoid arch* consists of a dorsal *hyomandibular* which supports and suspends the jaws with the cranium, and a ventral *hyoid proper*. The remaining arches support the gills and are known as branchial arches.

Thus, we find that splanchnocranium plays an important role in the formation of jaws in gnathostomes, and in their suspension with the chondrocranium. The method of attachment or suspension of jaws from the chondrocranium is termed *jaw suspension* or *suspensorium*. There are 5 principal variants or types of suspensoria as follows (Fig. 2) :

1. Autodiastylic. This condition was found in some earliest gnathostomes such as acanthodians. The jaws are attached to the cranium by anterior and posterior ligaments. Hyoid arch remains completely free or independent and does not support the jaws. The gill cleft in front of hyoid arch bears a complete gill and does not form any spiracle.

2. Amphistylic. This is a rather primitive arrangement found in Crossopterygii and some primitive sharks (e.g. *Heptanchus, Hexanchus*). The quadrate or the basal and otic processes of upper jaw (mandibular arch) are attached by ligaments to chondrocranium. Similarly, the upper end of hyomandibula (hyoid arch) is also attached to chondrocranium, while the two jaws are suspended from its other end. This arrangement makes a double suspension (*amphi* = both+*style* = bracing) since both the first and second arches participate in bracing the jaws against the chondrocranium.

3. Hyostylic. It is found in most elasmobranchs and all bony fishes. Upper jaw (palatoquadrate) is loosely attached by anterior ethmopalatine to cranium. Both the jaws are braced against hyomandibular, the upper end of which fits into auditory region of skull. Since only hyoid arch braces or binds the two jaws against cranium, this jaw-suspension is termed *hyostylic*. It provides the jaws a wider movement and helps in swallowing larger preys.

4. Autostylic. This condition is found in extinct placoderms, chimaeras, lung fishes and most tetrapods (amphibians, reptiles and birds). Hyomandibular does not participate but becomes modified into columella or stapes of middle ear for transmitting sound waves. Upper jaw (palatoquadrate) is directly and intimately bound to cranium by investing dermal bones (*auto* = self). The articular of lower jaw articulates with the quadrate of the upper jaw.

Autostylic suspensorium is widespread and has at least 3 variation or subtypes.

(a) Holostylic. In Holocephali (chimaeras), upper jaw is firmly fused with skull and lower jaw suspended form it. Hyoid arch is complete, independent and not attached to skull.

(b) Monimostylic. In many tetrapods, hyomandibular forms columella and articular articulates with quadrate. However, the quadrate remains immovably attached with skull.

(c) Streptostylic. In some reptiles (lizards, snakes) and birds, quadrate is loosely attached and is movable at both ends, a condition known as *streptostylism.*

5. Craniostylic. This type of jaw-suspension is characteristic of mammals and some consider it as a modification of autostylic suspension. Upper jaw fuses throughout its length with cranium, and hyomandibular forms the ear ossicle stapes. But articular and quadrate also become modified into ear ossicles malleus and incus, respectively. Consequently, two dermal bones, dentary of lower jaw and squamosal of skull, provide the articulation between jaw.

Vertebral Column

Notochord. In all chordate embryos, the first axial endoskeleton to appear is a slender, stiff, unsegmented, gelatinous rod, the *notochord.* It is present below the nerve cord and above the digestive tract. Its ancestral predecessor is not known but it probably originated from endoderm. Typically, notochord is covered by inner and outer elastic fibrous connective tissue sheaths, called *elastica interna* and *elastica externa*, respectively.

In protochordates (amphioxus) and cyclostomes (lamprey), notochord persists throughout life and continues to grow with the animal. But in fishes and higher types, notochord is later on surrounded by cartilaginous or bony rings, called *vertebrae.* In most fishes and aquatic amphibians, the adult notochord is constricted within each vertebra. It is not constricted in lungfishes and sturgeon. In tetrapods, it is practically obliterated.

Vertebrae. Backbone or vertebral column of all vertebrates is formed of a metameric series of many small and essentially similar pieces, called *vertebrae.* Thus, a vertebra is the unit of vertebral column. Vertebrae are named after the region of body in which they occur. Vertebral column of fishes comprises only *trunk* (abdomen) and *caudal* (tail) vertebrae (Figs. 3A–B). In tetrapods, vertebral column includes five regions : *cervical,*

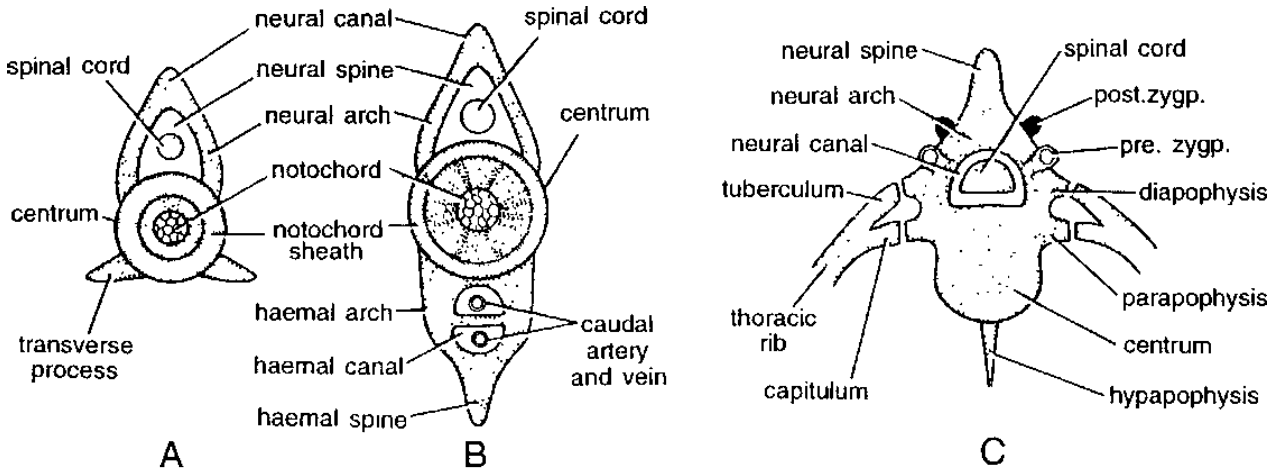

Fig. 3 Structure of a vertebra showing processes in cephalic view. A—Trunk vertebra of shark. B—Caudal vertebra of shark C—Typical tetrapod vertebra

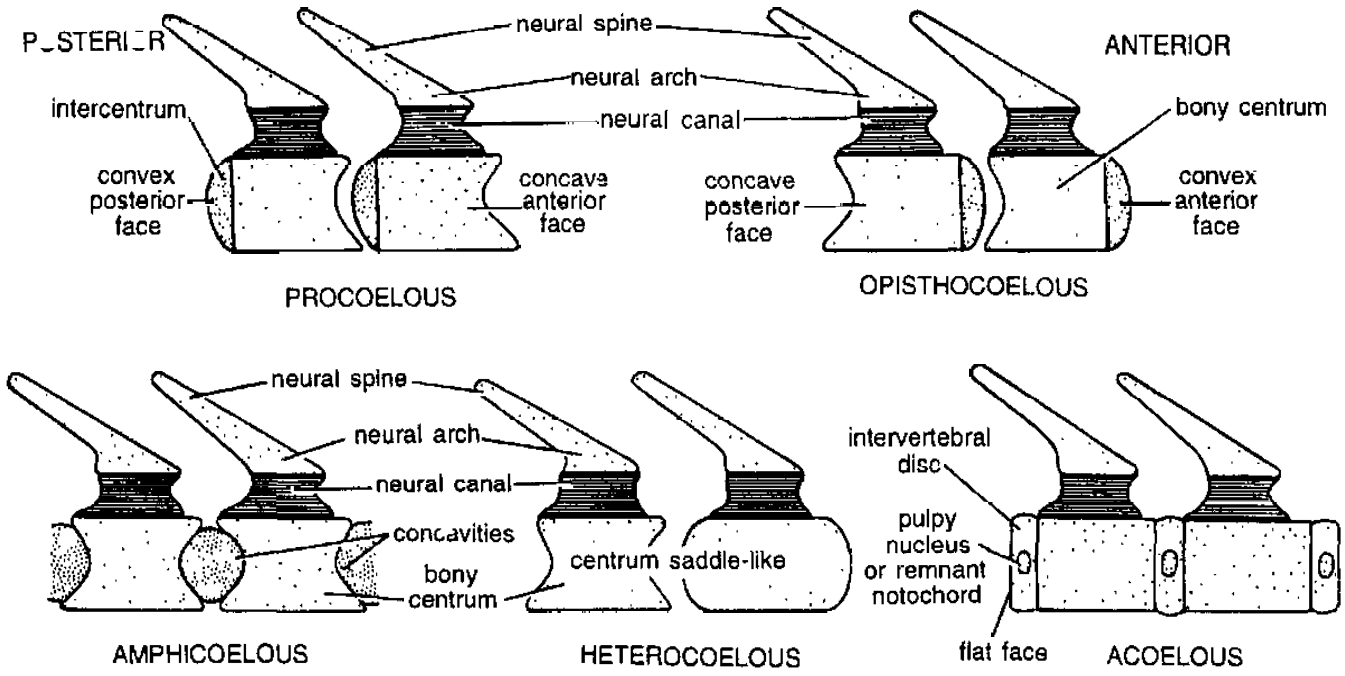

Fig. 4. Types of vertebrae based on shape of centra, in sagittal section.

thoracic, lumbar, sacral and *caudal*, each having usually several vertebrae. Amphibians have a single cervical (atlas) and only one sacral (9th) vertebra. Morphologically, vertebrae differ in different vertebrates or even in different regions of the same vertebrate, but all vertebrae are built according to a similar basic pattern.

Basic structure of a vertebra. Typically, a vertebra has a cylindrical, spool-like body or *centrum*, which encloses or replaces the embryonic notochord (Fig. 3C). Above the *centrum* is a *neural arch* produced dorsally into a *neural spine*. Successive neural arches enclose a *vertebral* or *neural canal* in which the *spinal cord* lies. The caudal vertebra in fishes also has a ventral *haemal arch* enclosing a *haemal canal* through which the caudal artery and vein pass. Haemal arch also carries a ventral *haemal spine*.

Types of processes. Various kinds of processes (*apophyses*) arise from the arches or centra of vertebrae.

(a) ***Zygapophyses.*** In vertebrates, from anterior and posterior faces of neural arch project paired articular facets, the *pre-* and *post- zygapophyses*. These serve for articulation between adjacent vertebrae. Zygapophyses do not occur in fish vertebrae.

(b) ***Transverse processes.*** Lateral transverse processes arise from centrum and serve for attachment of ligaments and muscles.

(c) ***Diapophyses.*** Each projects laterally from centrum or neural arch and articulates with dorsal head (tuberculum) of thoracic rib.

(d) ***Parapophyses.*** Each projects laterally from centrum and articulates with ventral head (capitulum) of rib.

(e) ***Basapophyses.*** These project ventro-laterally from centrum or haemal arch, or meet ventrally to form haemal arch.

(f) ***Pleurapophyses.*** These are lateral transverse processes fused with short ribs at their tips.

(g) ***Hypapophysis.*** It is a single prominent mid-ventral projection of centrum in certain vertebrae.

Types of centra and vertebrae. An intervertebral disc or intercentrum is often present between centra of successive vertebrae in embryo. This may fuse with anterior or posterior end of a centrum changing its shape to convex or flat. On the basis of the particular shape of centra, the following main types of vertebrae occur (Fig. 4) :

(a) ***Procoelous*** (*pro* = in front + *coelous* = hollow). Anterior face of centrum is concave and

posterior face convex. e.g. typical vertebrae of frog and most reptiles.

(b) Opisthocoelous (*opistho* = at the back). Centrum is concave posteriorly and convex anteriorly. e.g. cervical vertebrae of some large ungulates.

(c) Amphicoelous (*amphi* = both). Centrum is concave at both ends. e.g. vertebrae of most fishes and tailed amphibians, 8th vertebra of frog.

(d) Acoelous or amphiplatyan (*a* = absent; *platy* = flat). Centrum is flat at both ends, without a concavity or a convexity. e.g. vertebrae of mammals.

(e) Biconvex (*bi* = two). Centrum is convex at both ends. e.g., sacral or 9th vertebra of frog.

(f) Heterocoelous (*hetero* = asymmetrical). Ends of centra are shaped like a saddle. e.g. vertebrae of modern birds.

IMPORTANT QUESTIONS

» *Long Answer Type Questions*

1. Compare the skull of lizard with bird.
2. Give an account of different types of jaw suspensorium in vertebrates.
3. Describe the pectoral and pelvic girdles of frog, *Varanus*, *Gallus* and rabbit. Show how the structure of girdle is suited to the mode of life in these animals.

» *Short Answer Type Questions*

1. Give a brief account of the following — (i) Basic structure of vertebra, (ii) Jaw suspensorium, (iii) Development of chondrocranium.

» *Multiple Choice Questions*

1. In living amphibians exoskeleton is :
   (a) Hairy (b) Horny
   (c) Nails (d) Absent
2. Which of the following is a pelvic bone?
   (a) Ilium (b) Scapula
   (c) Clavicle (d) Coracoid
3. Cartilage bone :
   (a) Parietal (b) Lacrimal
   (c) Quadrate (d) Prefrontal
4. Cranium is a constituent of :
   (a) Dermatocranium (b) Splanchocranium
   (c) Visceral skeleton (d) Neurocranium
5. Pituitary gland is housed in :
   (a) Hypophyseal fenestra (b) Olfactory capsule
   (c) Ethmoid plate
   (d) Basal plate
6. Skull in cyclostomes is made of :
   (a) Replacing bones (b) Cartilage
   (c) Membrane bones (d) Dermal plate
7. In modern amphibians the collumella of middle ear is modified :
   (a) Basisphenoid (b) Sphenoid
   (c) Hyomandibular (d) Mandibular
8. Foramen magnum in birds faces :
   (a) Upwards (b) Downwards
   (c) Left (d) Right
9. The jaw suspensorium in elasmobranchs :
   (a) Autodiastylic (b) Amphistylic
   (c) Autostylic (d) Hyostylic
10. A single prominent mid-ventral of centrum in vertebrates :
    (a) Hypapophysis (b) Zygapophysis
    (c) Diapophysis (d) Parapophysis

ANSWERS

1. (d) 2. (a) 3. (c) 4. (d) 5. (a) 6. (b) 7. (c) 8. (b) 9. (d) 10. (a).