EXERCISE 33 OSTEOLOGY OF FROG AND FOWL

Structure

33.1 INTRODUCTION

The skeleton is the frame-work of the animal body, and is so important that on the basis of it, two distinct divisions of the animal kingdom have been recogniscd – **Chordata** (having an axial supporting skeleton) and **Non Chordata.** The internal framc-work of bones and cartilages of the chordates is called endoskeleton is divisible into two main categories:

1. **THE AXIAL SET,** includes skull, vertebral column, ribs and sternum (constituting the long axis of the body).
2. **TIIE APPENDICULAR SET,** consists of girdles and limb bones.

In this unit you will study the skeleton of two chordates – the frog and fowl.

The endoskeleton of frog is made partly of cartilage and partly of bones. In tadpole, the skeleton is solely **cartilaginous,** but in adult frog it is largely replaced by the bones called **cartilage bones.** In some parts of the body where no cartilage was present in the larval stage, certain bones develop from the dermis, called **membrane bones.**

The bii-d's skeleton presents characteristic and indeed unique features. Almost the entire skeleton in birds is so highly specialized that there is hardly a bone except the phalanges of the toes and the free caudal vertebrae, which could possibly be typically similar to that of any other vertebrate class. A further peculiarity in bird skeleton is that many of the bones are light and contain no bone marrow. Such bones are filled with air cavities and are called pneumatic bones, further, there are internally strutted to give them strength.

Objectives

After completing this exercise you will be able to

- identify, distinguish and draw labelled diagrams of the skull of frog and fowl

- identify, distinguish and draw labelled diagrams of bones of axial and appendicular skeleton of frog and fowl
- describe and mention special features of each bone
  explain the interrelationship of bones of girdles' and limbs
- explain the interrelationships of fore and hind-limb bones in frog and fowl.

33.2 MATERIAL REQUIRED

1. Complete articulated skeletons of frog and fowl
2. Skull of frog and fowl
3. Disarticulated bones of axial sets of the skeleton of frog and fowl
4. Disarticulated bones of appendicular sets of both frog and fowl
5. Pencil and eraser
6. Laboratory manual and note book

33.3 OSTEOLOGY OF FROG

Skeleton system of frog comprises axial and appendicular skeletons.

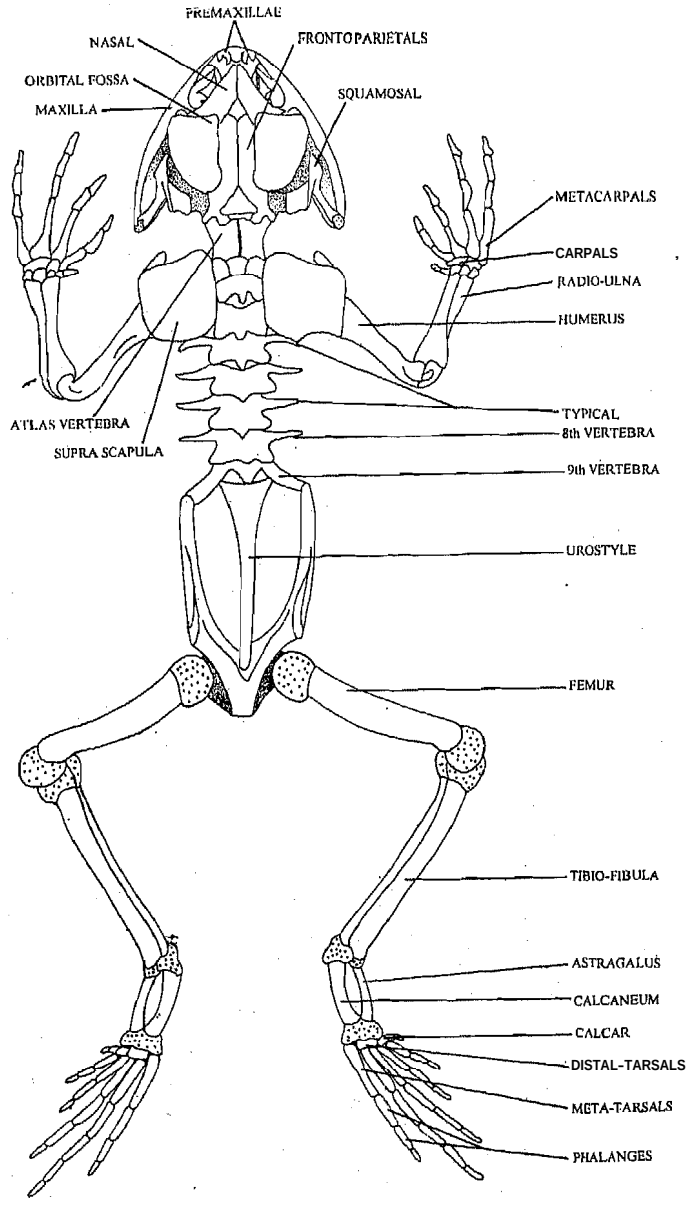


Fig. 33.1: Complete Skeleton of frog (Dorsal view)

33.3.1 The Two Sets-Axial and Appendicular Skeleton

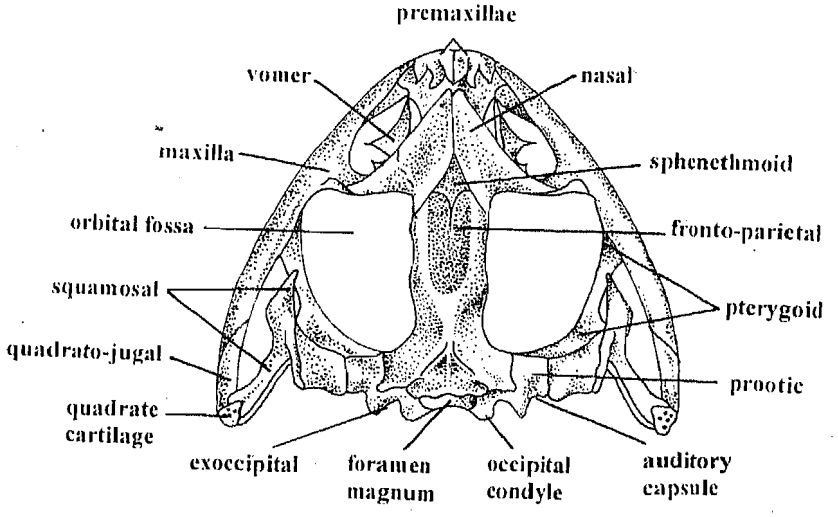
Observe the articulated skeleton of frog and make out the two sets, namely the axial skeleton and appendicular skeleton with the help of figure 33.1 which shows a complete skeleton of frog with the various components. List the parts in sequence, which you can make out in the axial skeleton and similarly, those that constitute the appendicular skeleton.

Next, make detailed observations on the individual parts as listed under subsections 33.3.2 to 33.3.8.

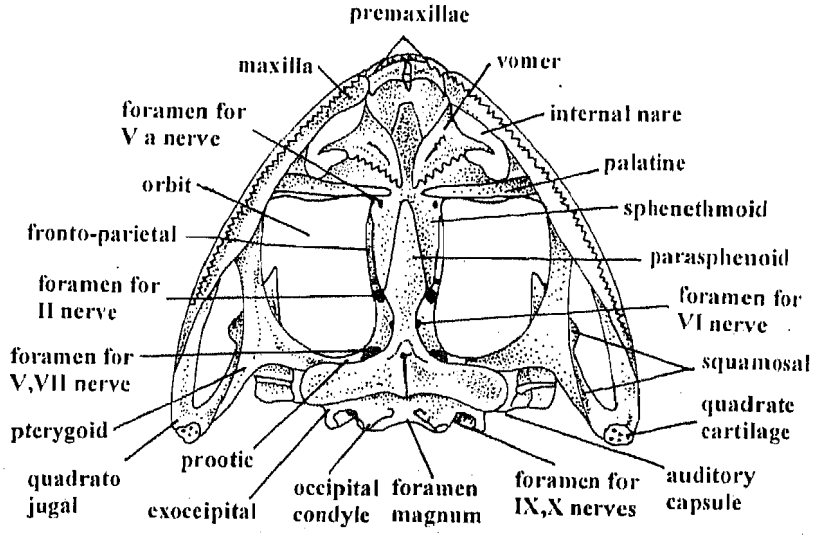
33.3.2 Skull

Observe the skull bones carefully by comparing them with those shown in Fig. 33.2.

(i) In frog the skull is triangular in shape, broad and dorsoventrally flattened.
(ii) It includes three regions i.e. **cranium** (brain box), sense capsules and jaws.
(iii) The cranium or brain box is smaller due to the smaller size of brain.
(iv) Floor of cranium is formed by **paraphenoid** and roof by **frontoparietal** bones.



Skull (Dorsal view)



Skull (Ventral view)

Fig. 33.2: Skull of **Frog.**

(v) Posterior-most part of the cranium is the occipital segment, mainly made of **exoccipitals** because supra and basioccipitals are absent.
(vi) There are two occipital condyles projecting backwardly to articulate with the anterior concavities of atlas vertebra.
(vii) The interorbital septum is absent so the cranium extends beyond eye orbits.
(viii) The orbits are dorsally placed and optic capsule is not fused with the skull.
(ix) A pair of olfactory capsules is made up of the nasal dorsally, vomers ventrally and sphenethmoid posteriorly.
(x) The anterior wall and partly the roof and floor of each auditory capsule are formed by the irregular cartilage bone called pro-otic and squamosal.
(xi) Each half of upper jaw is formed by premaxilla, maxilla and quadratojugal bones.
(xii) The maxilla is provided along its whole length with numerous sharp, pointed and backwardly directed conical teeth (homodont dentition).
(xiii) The lower jaw or mandible is devoid of teeth.
(xiv) Each half of lower jaw consists of a core of Meckel's cartilage surrounded by three bones i.e. Mentomeckelian, angulosplenial and dentary.
(xv) Jaw suspensorium is autostylic in which lower jaw is attached to skull through a rod like cartilaginous quadrate bone.

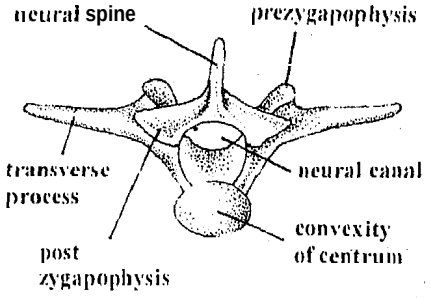
33.3.3 Vertebral Column

The vertebral column of frog is remarkable for its extreme shortness due to its inflexibility and the absence of tail. It consists of only nine vertebrae, the last one followed by a slender bony rod, the urostyle. The 2nd to 7th vertebrae (Fig. 33.3) have similar characters hence are called as typical vertebrae. The Ist, 8th and 9th vertebrae are not typical and also differ from each other. Let us first study the typical vertebrae. (any one out of 2nd to 7th).

Hold the vertebra in hand one by one and verify the features as described below.

(A) **TYPICAL VERTEBRAE (2ND TO 7TH)** (Fig. 33.3)

(i) In frog 2nd to 7th vertebrae are typical in structure.
(ii) Each has a ring-like form with a large passage called neural canal through which the spinal cord passes.
(iii) The centrum is procoelus (*pro*: front, *coelous*: cavity) in all typical vertebrae, its anterior side is concave and posterior face is convex (to fit into the concavity of the centrum of the next vertebra).
(iv) Neural arch bears a small and blunt middorsal neural spine which is obliquely directed backward,



Typical vertebra (Posterior view)

Fig. 33.3: A typical vertebra of frog.

(v) Anteriorly at the base of neural spine on either side the neural arch bears upwardly and inwardly directed articular surfaces called prezygapophyses..

(vi) The **postzygapophyses present** at the posterior margins of neural arch are directed downwards and upwards (to fit into the prezygapophyses on the next vertebra).

(vii) Sideward prominent tapering processes directed sidewards arise from the neural arches, these are called the **transverse processes.**

(viii) Now look at the second and fourth vertebra in particular.

(ix) The second vertebra is like other typical vertebrae except that its **neural spine is short and conical** and **transverse processes are broad and flat.**

(x) The fourth vertebra is also typical in structure except that the **transverse processes are broader.**

(B) ATLAS – THE FIRST VERTEBRA (Fig. 33.4)

(i) This vertebra is simply in the form of a bony ring with reduced centrum and neural spines.

(ii) The transverse processes and prezygapophyses are absent.

(iii) Anteriorly the centrum carries a pair of large concave facets to articulate with the occiptal condyles of the skull.

(iv) Postzygapophyses are present on the posterior margins of the neural arch.

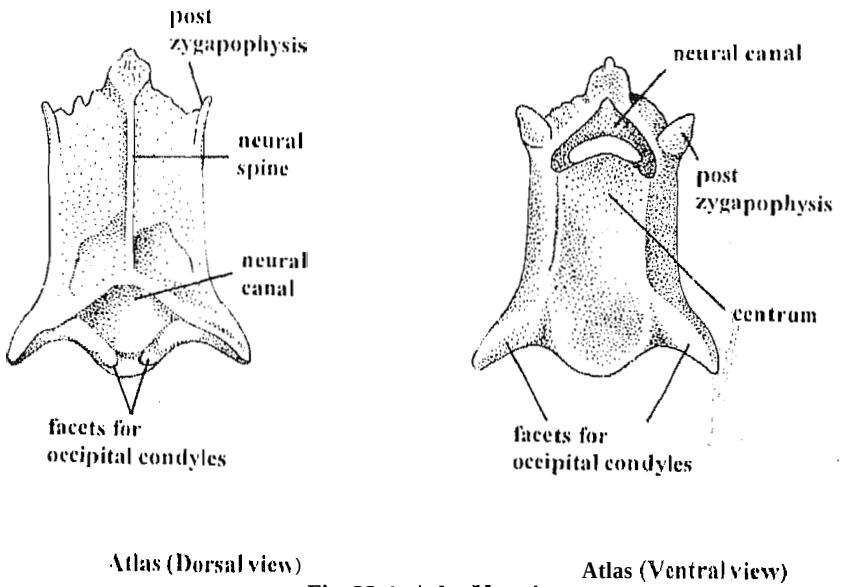
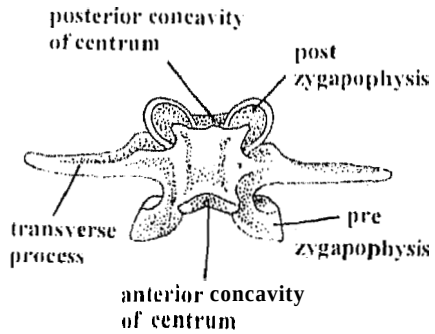


Fig. 33.4: Atlas Vertebra.

(C) EIGHTH VERTEBRA (Fig. 33.5)

(i) It rcsennbles a typical vertebra very much but its centrum is amphicoelus or biconcave.

(ii) The anterior concavity receives the posterior convexity of 7th vertebra while its posterior concavity receives the anterior convexity of the 9th vertebra.



Pig. 33.5: Eighth Vertebra of frog.

(D) NINTH VERTEBRA **(Fig.** 33.6)

(i) This is also called **sacral vertebra** and is different in many respect from the typical structure.

(ii) Its centrum is biconvex, bearing one anterior and two posterior convexities.

(iii) The two posterior convexities fit into the corresponding two anterior concavities of urostyle.

(iv) Large cylindrical and stout transverse processes are directed backwards.

(v) The distal ends of these transverse process support the iliac bones of the pelvic girdle.

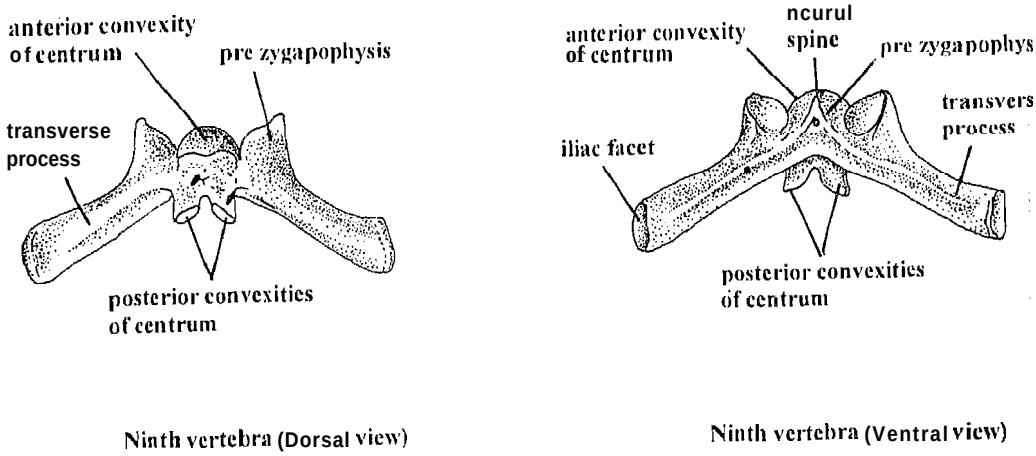


Fig. 33.1: Ninth vertebra of frog.

(E) UROSTYLE **(Fig.** 33.7)

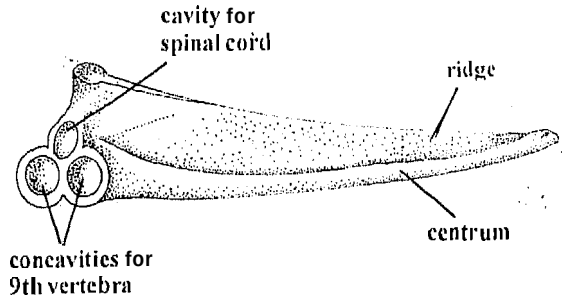
(i) It is the posterior unsegmented part of vertebral column which constitutes approximately half of the total length of vertebral column in frog.

(ii) It is somewhat triangular in outline with the pointed apex directed backwards

(iii) Its centrum is rod-like with a broad anterior face bearing two concavities for articulation with the ninth vertebra.

(iv) The dorsal surface is raised up in the form of a vertical ridge gradually tapering posteriorly.

(v) Anteriorly the ridge contains a short narrow neural canal which encloses the terminal part of spinal cord.



Urostyle (Lateral view)

Fig. 33.7: Urostyle of frog.

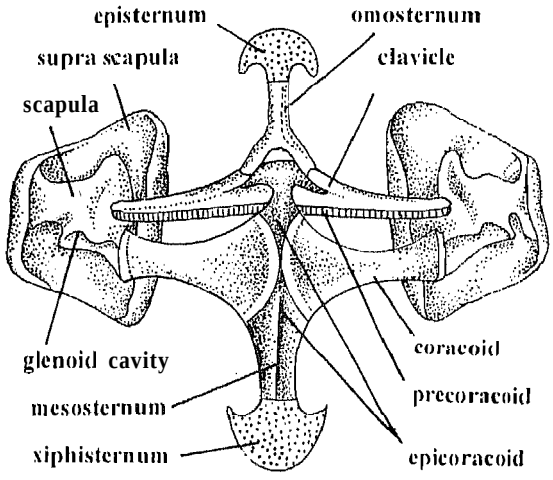
33.3.4 Sternum

(i) The sternum (Fig. 33.8) lies in the midventral line intimately connected between the two halves of the pectoral girdles.

(ii) It includes four parts i.e. the (a) episternum, (b) ornosternum, (c) mesosternu and (d) xiphisternum:

(a) Episternum is a flat circular and cartilaginous disc, anteriormost in position.

(b) **Omosternum** is a bony rod connecting the episternum with the clavicles.
(c) Mesosternum is a cartilaginous rod projecting behind the epicoracoid.
(d) Xiphisternum is the terminal broad cartilaginous plate.



Pectoral girdle and sternum (Ventral view)

Fig. 33.8: Pectoral girdle of frog.

33.3.5 Pectoral Girdle

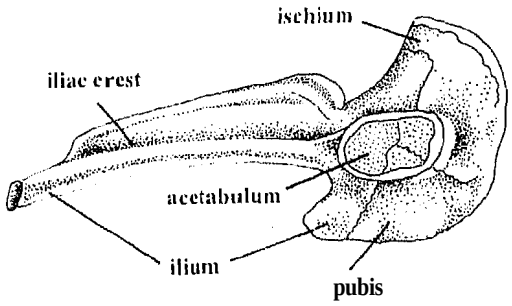
(i) The pectoral girdle (Fig. 33.8) protects the inner softer parts of the chest region as there are no ribs.
(ii) The pectoral girdle also provides support and attachment to the forelimb bones and muscles.
(iii) It is fonncd by the bones and cartilages both,
(iv) The two similar halves of pectoral girdle are united midventrally with the sternum but are separated dorsally.
(v) Each half is made up of four bones – (a) supra-scapula, (b) scapula, (c) coracoid and (d) clavicle bones:
  (a) Supra-scapula is broad, flat, almost rectangular bone whose upper margin is made of calcified cartilage.
  (b) Scapula is a stout fat bone broader towards the ends and constricted in the middle. Posteriorly the scapula forms the upper half of glenoid cavity.
  (c) Clavicles and coracoids of both sides unite midventrally with each other and with sternum through a cartilaginous strip called epicoracoid.
  (d) The clavicle is a slender rod-like bone separated from the coracoid by a wide gap called coracoid foramen.
(vi) A narrow strip of cartilage called precoracoid, lies attached to each clavicle posteriorly.
(vii) The coracoid is a dumb-bell shaped bone with its inner end broader than outer.
(viii) The outer end of coracoid forms the lower half of the glenoid cavity which receives the head of humerus bone of the forelimb.

33.3.6 Pelvic Girdle

(i) In frog pelvic girdle (Fig, **33.9)** is a 'V' shaped structure in the posterior region of the body providing support to pelvic region and hind limbs
(ii) Each half of the pelvic girdle called **innominatum** is composed of – (a) ***ilium,*** (b) *ischium* and (c) ***pubis:***
  (a) The long **ilium** meets with the transverse processes of ninth vertebra. Two ilia meet posteriorly at an iliac symphysis.

(b) Pubis, the reduced calcified cartilage forms the part of acetabulum (The cavity which lodges the head of femur of the hind limb). Pubic cartilages of both sides are completely fused together.

(c) The two ischia give rise to one third of disc and completely fused together at an ischial symphysis.



Pelvic girdle (Lateral view)

Fig. 33.9: Pelvic girdle of frog.

33.3.7 Forelimb Bones

Humerus, radio-ulna and hand bones constitute the **bones of forelimb (Fig. 33.10).**

(A) HUMERUS **(Fig.** 33.10)

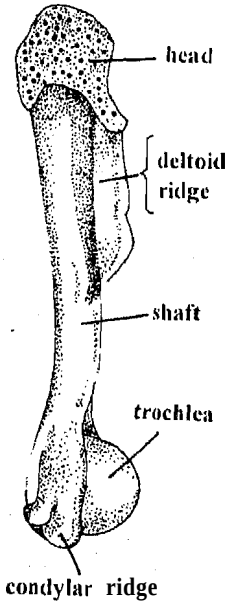
(i) It is a short cylindrical bone of the upper arm.

(ii) The shaft of humerus is slightly curved.

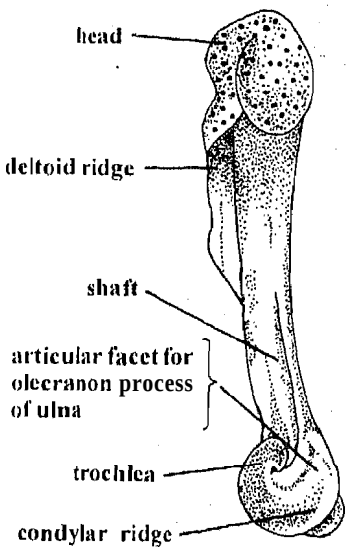
(iii) The round head formed at the proximal end fits into the glenoid cavity of the pectoral girdle.

(iv) The head is covered by calcified cartilage and below the head is present the deltoid ridge for the attachment of muscles,

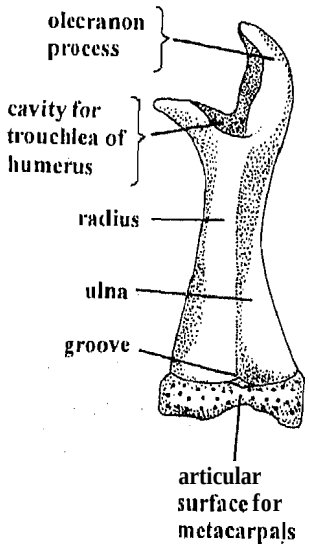
(v) The distal end has a well prominent trochlea or capitulum and a condylar ridge for articulation with radio-ulna.



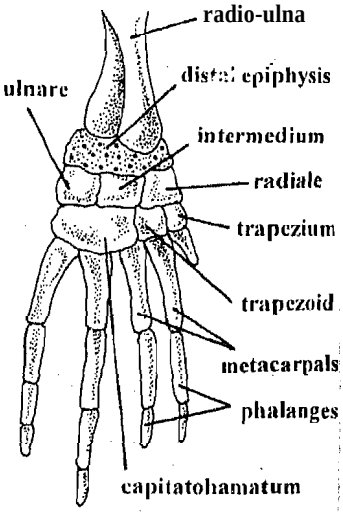
Humerus (Anterior view)



Humerus (Posterior view)



Radio-ulna



Bones of hand

Fig. 33.10: Forelimb bones of frog.

(B) RADIO-ULNA **(Fig.** 33.10)

(i) It is the compound bone of the lower arm, formed by the fusion of two bones i.e radius and ulna.

(ii) At the proximal end of this bones a concavity is present to receive the rounded capitulum of humerus.

(iii) An olecranon process is also found at the same end.

(iv) Distally the division of radio-ulna into radius and ulna is well marked due to the presence of a groove.

(v) Each of these bones terminates distally into a facet to articulate with the carpal bones.

(C) BONES OF THE HAND **(Fig.** 33.10)

(i) Carpals or wrist bones are 6 in number, arranged in two rows

(ii) The proximal row bears the three bones – **radiale**, intermedium and **ulnare**.

(iii) Distal row bears the other tlirce bones called trapezium, **trapezoid** and **capitohematum** which articulate with the metacarpals.

(iv) The hand of frog is supported by five slender, rod-like bones the metacarpals, the first one is rudimentary.

(v) There are only four digits in the hand of frog, (pollex or thumb is absent).

(vi) All the digits arc internally supported by short rod-like bones called phalanges.

(vii) Two phalanges occur in each of the I and II digit and three in each of III and IV digit.

33.3.8 Hind Limb Bones

Femur, tibio-fibula, **astragalus-calcaneum** and foot bones constitute **the hind limb of** the frog **(Fig.** 33.11).

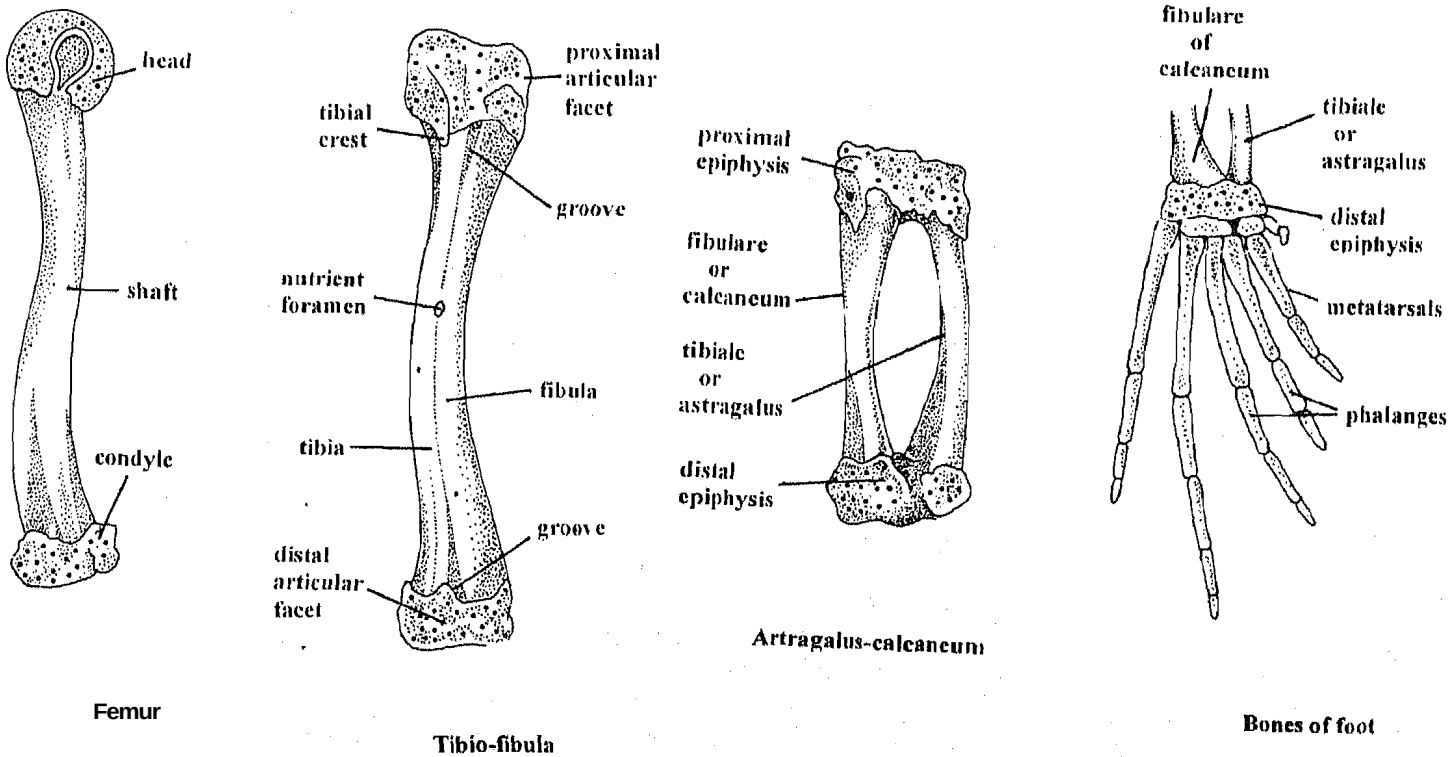


Fig. 33.11: Hind limb bones of frog.

(A) FEMUR (Pig. 33.11)

(i) Feinur or the thigh bone has a slightly curved shaft.

(ii) Both expanded ends of the bone are covered by calcified cartilage.
(iii) Proximal end has rounded head which articulates with acetabular cavity of pelvic girdle and distal end with tibio-fibula.

(B) TIBIO-FIBULA (Fig. 33.11)

(i) This is a large compound bone of shank, and its longest in frog's skeleton.
(ii) Its shaft is slightly curved while two ends are expanded and are covered by cartilage.
(iii) As indicated by the median longitudinal groove, this bone is made up of two bones i.e. inner tibia and outer fibula.
(iv) Proximal end of tibia ,containsa tibia crest.
(v) This bone articulates proximally with femur and distally with astragalus-calcaneum.

(C) ASTGRAGALUS-CALCANEUM (Fig. 33.11)

(i) Astragalus and calcaneum together constitute compound bone.
(ii) These are greatly elongated tarsal bones which represent two rows of tarsals that are fused together at proximal and distal ends but have a wide gap at the middle.
(iii) The outer thicker and straight bone is calcaneum while the inner, thinner and slightly curved bone is astragalus (or tibiale.)
(iv) Both ends are covered by epiphysis or calcified cartilage.
(v) The distal row of tarsals bears two very small bones.

(D) BONES OF FOOT (Pig. 33.11)

(i) Frog's foot is supported by five long slender metartarsals.
(ii) These metartarsals have 5 true digits (toes) and in addition a very small pre-axial sixth toe, present on the inner side of Ist toe or hallux.
(iii) This supplementary toe called calcar or prehallux is made of 2-3 small bones and does not project from the foot.
(iv) The true toes have 2,2,3,4 and 3 phalanges respectively.

33.4 OSTEOLOGY OF FOWL

A complete skeleton of fowl is shown in Figure 33.12 to give you a general idea of a skeleton of bird. Similar to frogs in birds as well the skeleton is composed of two sets – axial skeleton and appendicular skeleton. The former set consists of the skull, vertebral column, the rib cage and the sternum, whereas the latter set consists of the girdles and limb-bones.

33.4.1 Skull

(i) The compact skull (Fig. 33.13) is very light due to pneumatic bones (see also Fig, 33.12 & 33.13).
(ii) Sutures disappear in skull of adult birds as most of the bones become firmly fused together.
(iii) The skull broadly consists of the same usual three parts i.e. the jaws, sense capsules and cranium.
(iv) A toothless beak is formed by the jaw bones.
(v) Each half of the upper jaw is made up of four bones i.e. premaxilla, maxilla, jugal and quadratojugal.
(vi) Similarly each half of lower jaw is made up of five bones i.e. articular, angular, supra-angular sphenoid and dentary.
(vii) All these bones develop around Meckel's cartilage.
(viii) Jaw suspensorium is autostylic.

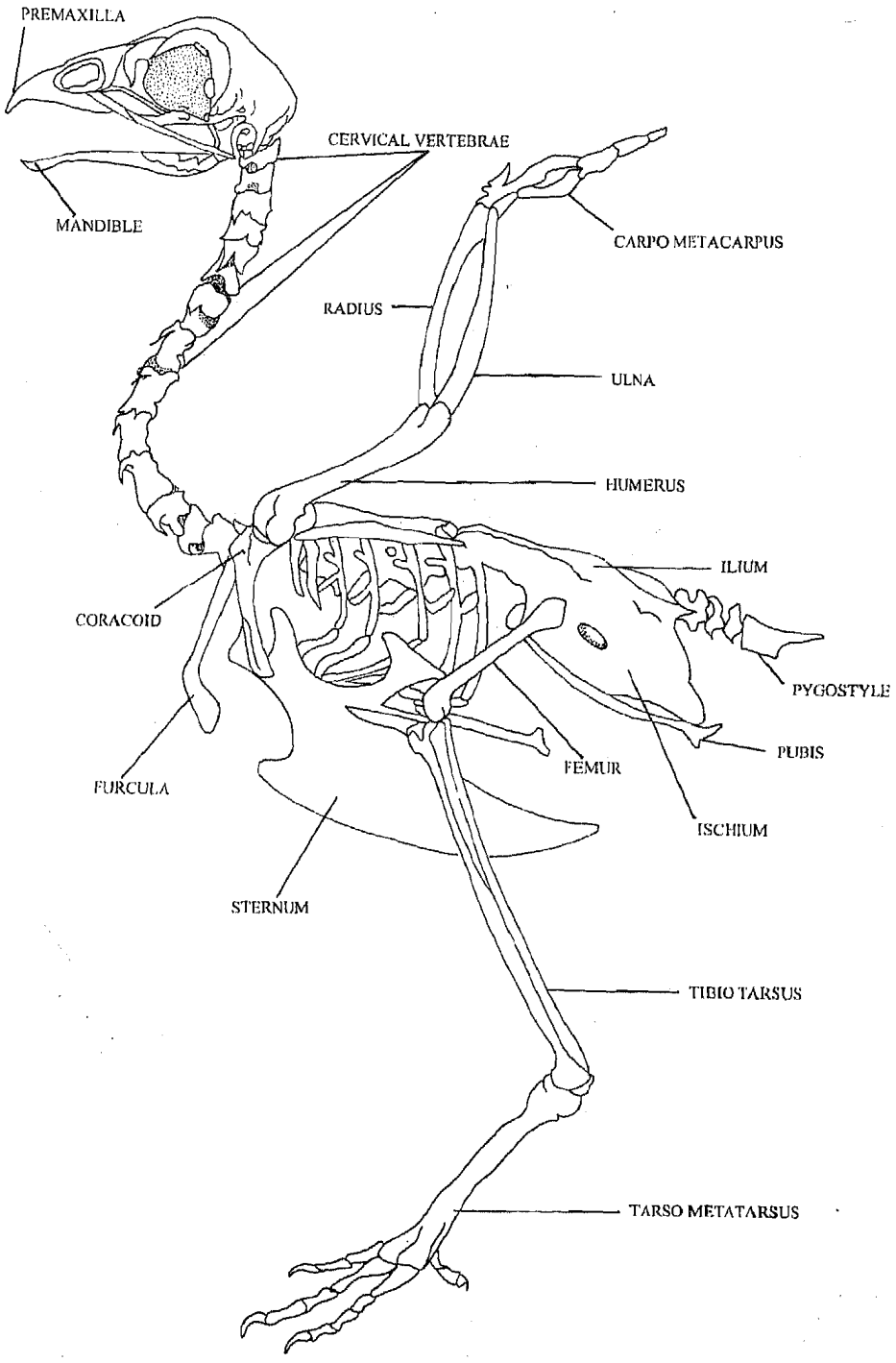


Fig. 33.12: Complete Skeleton of Fowl in Lateral View.

(ix) **Palate** is formed by vomers, palatines, pterygoid and palatal prolongations of maxillae and is **schizognathous** i.e. with short vomers allowing palatines to meet.

(x) Large eye orbits are separated from one another by a narrow **longitudinal interobital** partition formed by **mesethmoid** together with orbito-, **pre-,** and parasphenoids.

(xi) Each orbit is bounded by **frontal** anteriorly, **alisphenoid and postorbital process of frontal** posteriorly.

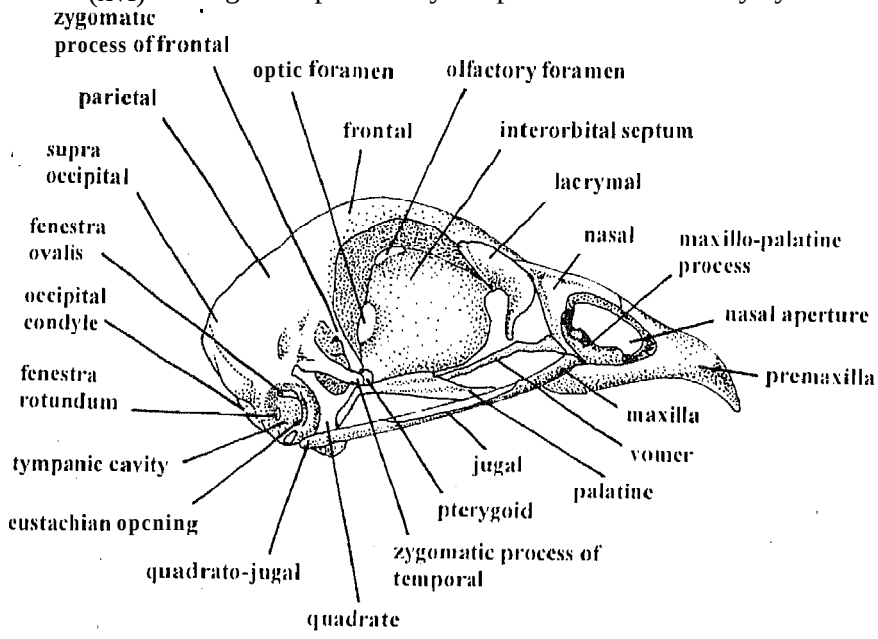
(xii) The auditory capsule mainly formed by pro-otic bone has large cup-like hemispherical tympanic cavity.

(xiii) Three bones are associated with each reduced olfactory capsule, these are nasals, vomers and a small median bone at the base of nasal chamber.

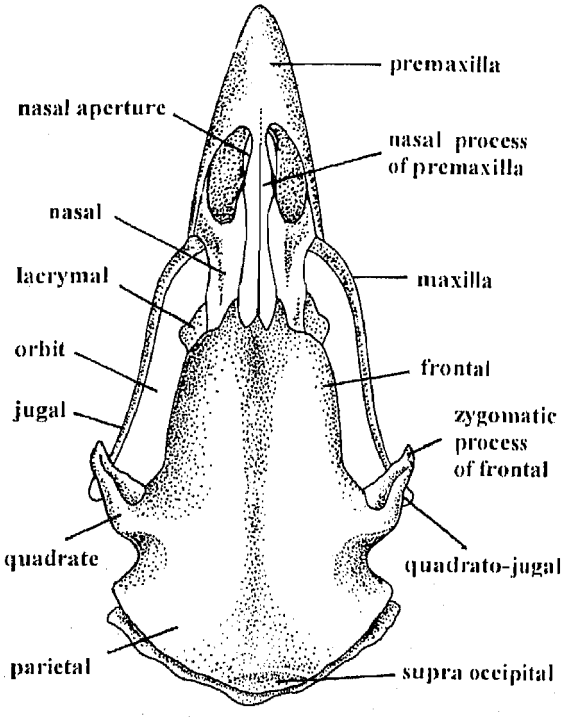
(xiv) Cranium is large and rounded to accommodate the well developed brain.

(xv) Occiptal segment is made up of supra-,basi-and exoccipitals enclosing a downwardly directed foramen magnum.

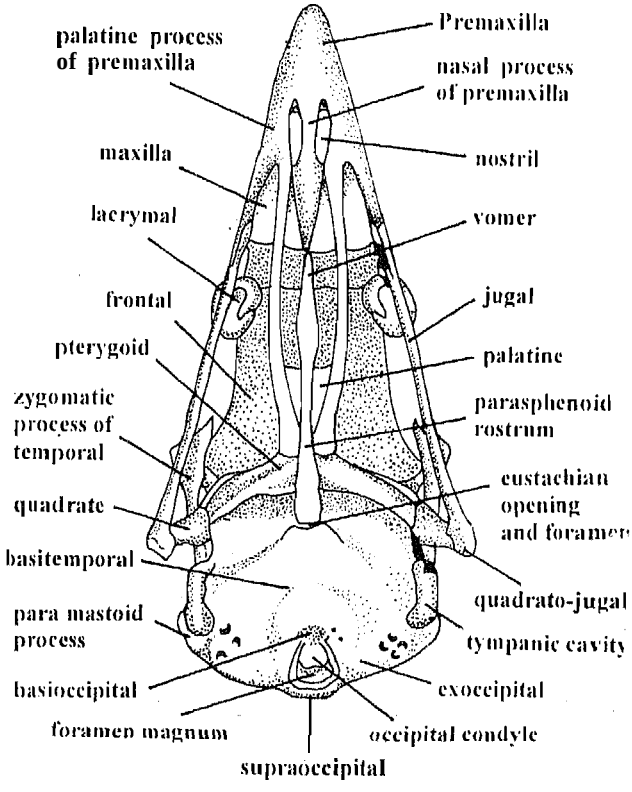
(xvi) Single occipital condyle is present formed mostly by basioccipitals.



A Skull (Lateral view)



B Skull (Dorsal view)



C Skull (Ventral view)

Fig. 33.13: Skull of Fowl. A) Lateral View, B) Dorsal and C) Ventral View.

33.4.2 Vertebral Column

The vertebral column is distinguished by the great length and extreme mobility of the neck, the rigidity of trunk region and shortness of the tail. These features are very advantagenous for flight (Fig. 33.12).

The vertebral column of fowl is differentiated into following regions:

(1) Cervical (2) Thoracic (3) Synsacral and (4) Caudal.

(3) CERVICAL VERTEBRAE

Approxiinately half of the total length of vertebral column in fowl is occupied by 14-16 cervical vertebrae. The cervical vertebrae consist of (a) Atlas vertebra (b) Axis vertebra (c) Typical vertebrae (from 6 – 33 vertebrae) (d) Posterior cervical vertebrae. Special structure and articulation of cervical vertebrae allow greather freedom of movement of the long neck and head. All of these are not similar in structure. The first two vertebrae differ from others.

(a) ATLAS VERTEBRA (Fig. 33.14)

This is first cervical vertebra which is quite small in size and ring-like or roughly triangular in shape.

(ii). The centrum, neural spines, transverse processes, ribs and prezygapophyses are all absent.

(iii) A transverse ligament divides the broad neural canal into two halves.

(iv) The upper half of the neural canal is spinal canal through which spinal cord passes.

(v) The lower one is a notch to receive the odontoid process of axis vertebra.

(vi) Thick ventral portion anteriorly carries a deep concavity to receive the single occipital condyle of skull.

(vii) Small postzygapophyses are present on the posterior side of neural arch to join with the prezygapophyses of axis vertebra.

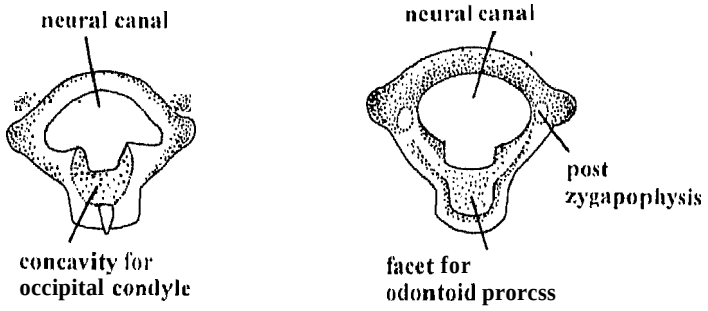


Fig. 33.14: Atlas Vertebrae of Fowl.

(b) AXIS VERTEBRA (Fig. 33.15)

(i) Axis is the second cervical vertebra slightly bigger than atlas.

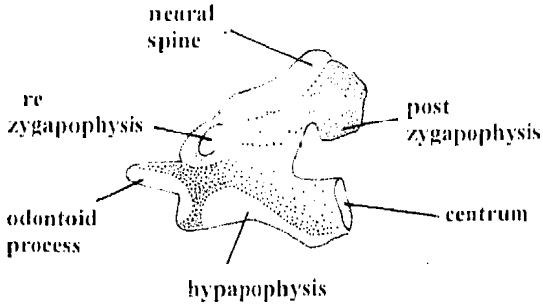
(ii) Axis also lacks transverse processes, ribs and vertebral canal.

(iii) Centrum is heterocoelus and gives rise to an anterior peg-like odontoid process.

(iv) A small and blunt neural spine is present on the dorsal side of neural arch.

(v) Post and prezygapophyses are present.

(vi) Axis forms the pivot on which the atlas vertebra and in turn the head rotates.



Axis vcrtchra (Lateral view)

Pig. 33.15: Axis Vertebra.

(c) TYPICAL CERVICAL VERTEBRA (Fig.: 33.16)

(i) From 6^{th} to 33^{th} cervical vertebrae all are typical in structure.

(ii) The body of a typical vertebra is long but neural arch and neural spine are short.

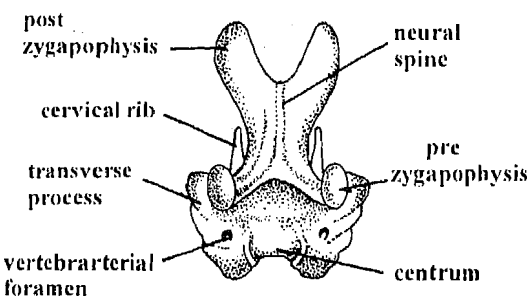
(iii) Centrum is heterocoelous having saddle-shaped articular surfaces.

(iv) Short transverse processes arise laterally at the anterior end.

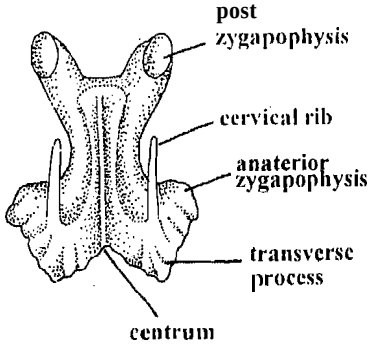
(v) Each process is fused with a backwardly directed thin, spicular rudimentary cervical rib of its side.

(vi) Anterior articulating surfaces called prezygapophyses are flat and oval facing upwards and inwards.

(vii) Post zygapophyses are projecting backwards from the posterior side of the neural arh.



Typical cervical vertebra (Dorsal view)



Typical ccwical vcrtchra (Ventral vicw)

Fig. 33.16: Typical Cervical Vertebra.

(d) POSTERIOR CERVICAL VERTEBRAE .

(i) Four vertebrae (11^{th} to 14^{th}) are included in this category. These are similar in structure to the typical cervical vertebrae differing only slightly in size.

(ii) These are shorter but more massive.

(iii) The neural arch and spine are well developed.

(iv) Transverse processes bear the large double headed ribs in last one or two cervical vertebrae.

(v) Centrum is heterocoelus and bears at its ventral surface a prominent spine like **hypapophyses.**

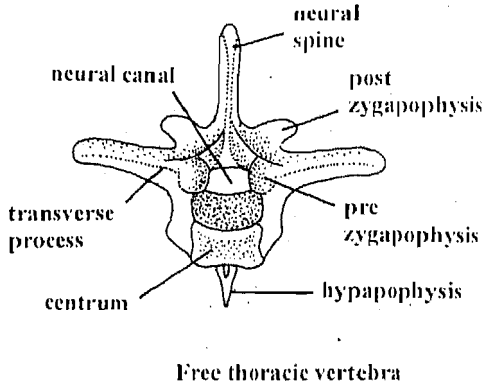
(vi) Pre and post zygapophyses are present on anterior and posterior surfaces respectively.

(2) THORACIC VERTEBRAE (Fig. 33.12)

(i) There are 7 short thoracic (free and fused thoracic) vertebrae present in fowl.
(ii) Second to fifth vertebrae are fused together into a common mass.
(iii) The Ist and 6^{th} vertebrae remain free while the 7^{th} fuses with synsacrum.

(a) FREE THORACIC VERTEBRAE (Fig. 33.17)

(i) The 1" and 6^{th} thoracic vertebrae are slightly smaller than the cervical vertebrae.
(ii) The centrum in free thoracic vertebra is heterocoelus.
(iii) Neural arch well developed and neural spine is long and pointed.
(iv) Long transverse processes are outwardly directed.
(v) Pre and postzygapophyses are present on the anterior and posterior surfaces respectively.
(vi) The centrum at its ventral surface gives rise a well developed hypapophysis for the attachment of flexor muscles of neck.
(vii) The transverse processes and centrum also bear the articular facets for the attachment of tuberculum and capitulum of thoracic ribs.



Pig. 33.17: Free Thoracic Vertebra.

(b) FUSED THORACIC VERTEBRAE (Fig. 33.18)

(i) Most of the structures of four thoracic vertebrae (2^{nd} to 5^{th}) are fused together to make almost a common continuous structure (Fig. 33.18).
(ii) The neural arches and transverse processes of these vertebrae are fused with each other to form continuous dorsolateral ridges.
(iii) The neural spines and hypapophyses are fused to form a dorsal and ventral crest tcspcctively.
(iv) All hctcrocoelus centra are also fused together.
(v) The fused transverse processes and centra possess the tubercular and capitular facets for the thoracic ribs.

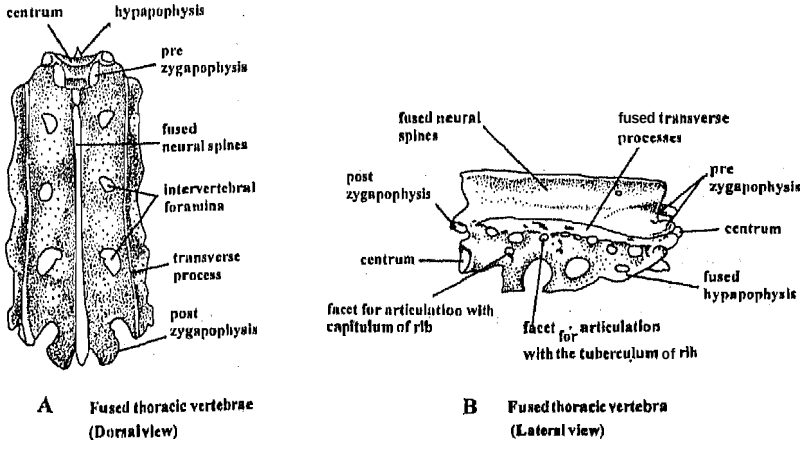


Fig. 33.18: Fused Thoracic Vertebrae. A) Dorsal view, B) Lateral View.

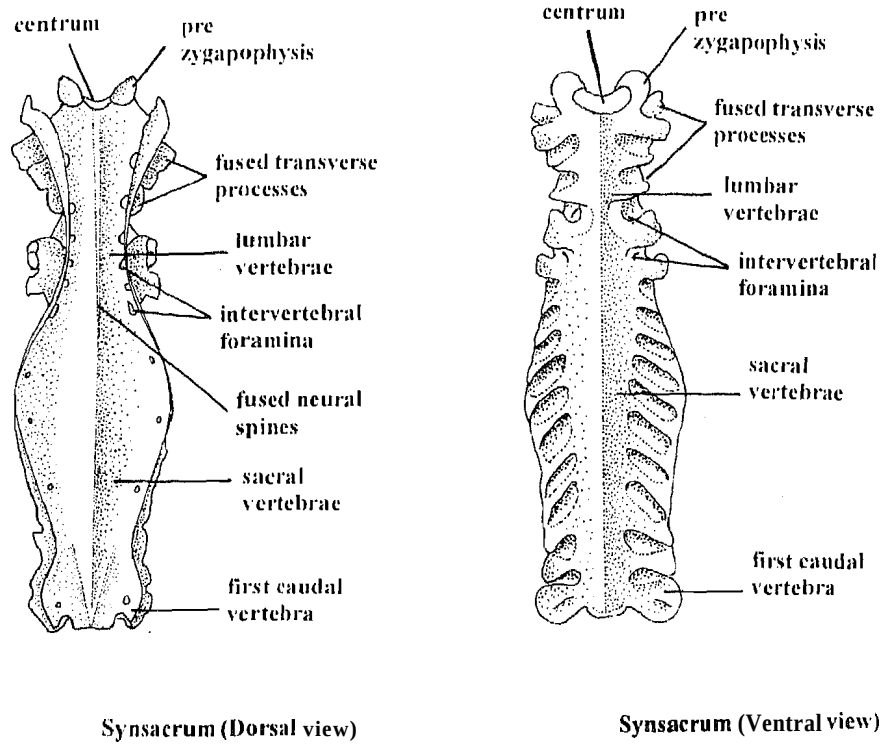
(3) SYNSACRUM (33.19)

(i) It is a compound structure formed by 16 fused vertebrae to support the pelvic region.

(ii) Among these 16 are included the last thoracic, six lumbars, two sacrals and about 7 caudal vertebrae.

(iii) Anteriormost vertebra of synsacrum is the last thoracic vertebra bearing a pair of free thoracic ribs.

(iv) Lumbar vertebrae are firmly fused together with free transverse processes and without hypapophyses.



Synsacrum (Dorsal view) Synsacrum (Ventral view)

Pig. 33.19: Synsacrum of fowl.

(v) The two sacral vertebrae fuse with the lumbar region and their transverse processes are fused to form bony plates.

(vi) Sacral ribs are fused with the transverse processes of these vertebrae.

(vii) Remaining seven vertebrae in synsacrum are anterior caudal vertebrae.

(viii) Their transverse processes except in the last, bifurcated into dorsal and ventral processes.

(ix) The dorsal processes unite to form bony plates.

(x) Free ventral processes represent the ribs, which are rod-like in first 4-5 vertebrae but are smaller in the rest.

(xi) All the components of synsacrum are so intimately fused that it is difficultto distinguish them separately.

(4) CAUDAL REGION

It is a short portion of the bird's vertebral column. In fowl it includes 4 or 5 free vertebrae and a pygostyle (Fig. 33.20).

(a) FREE CAUDAL VERTEBRAE (Fig. 33.20)

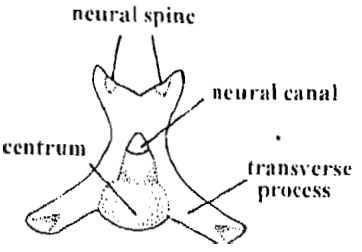
(i) A free caudal vertebra is quite small and rudimentary.

(ii) The centrum is heterocoelous and transverse processes are directed downwards and outwards.

(iii) The small neural spine is bifid.

(iv) Pre- and post-zygapophyses are absent.

(v) Free caudal vertebrae make the movement of tail and tail feathers possible.

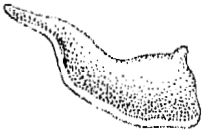


Free caudal vertebra

Fig. 33.20: Free Caudal Vertebrr and Pygostyle of Fowl.

(b) PYGOSTYLE

(i) The last part of caudal region is formed by the fusion of four or more posterior most caudal vertebrae and is called pygostyle (Fig. 33.21).
(ii) It is a large vertical plough-shaped like compound bone.
(iii) It looks like a vertical triangular and laterally compressed plate.
(iv) Centra, neural spines, pre and post zygapophyses, all are absent.
(v) It supports the muscles and large tail feathers.

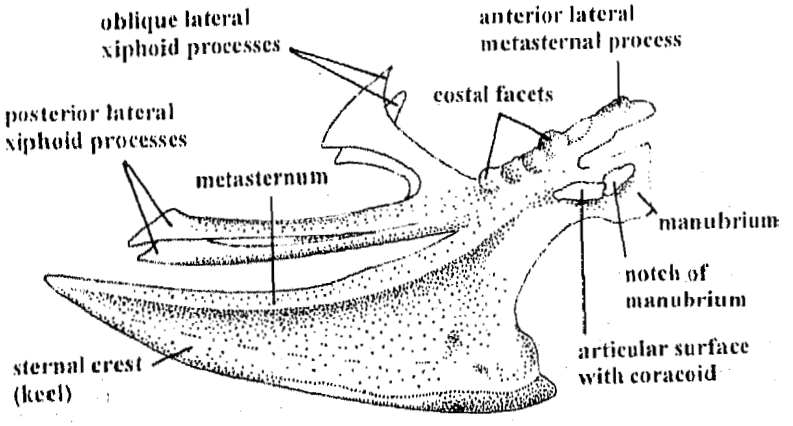


Pygostyle

Fig. 33.21: Pygostyle.

33.4.3 Sternum

(i) The sternum of most flying birds is a broad plate, concave dorsally from side to side and produced anteriorly into an anteroposterior keel (Fig. 33.22).
(ii) The sternum of fowl is well developed and is called breast bone.
(iii) The boat-shaped sternum is composed of 4-5 components.



Sternum (Lateral view)

Fig. 33.22: Sternum of fowl.

(iv) Metastemum is the main component which is concave dorsally and convex ventrally.

(v) Another part called manubrium is the anteroventral vertical process of metastemum, perforated by foramen of manubrium.

(vi) A median sagittal ridge arising from the ventral surface of metasternum is called keel. It provides the attachment surfaces for the pectoral muscles.

(vii) Metasternum gives out from its anterior region, on either side a small anterior costal process and a large posterior metastea or xiphoid process.

(viii) For the attachment of lower ends of sternal ribs, 4-5 costal facets are present in the dorsolateral margins of metasternum.

(ix) At the base of manubrium on either side a groove is present to articulate with the lower end of coracoid bone.

33.4.4 Ribs

(i) Seven pairs of thoracic ribs (Fig. 33.23) are present in fowl.

(ii) One pair of rib articulates with each thoracic vertebra.

(iii) Two distinct parts are present in each thoracic rib.

(iv) A dorsal flat and curved vertebral part remains attached to the vertebral surface.

(v) The other rod-like part is attached to the sternum.

(vi) The 1'' and 2nd and sometimes the 7th rib lacks the sternal part and do not reach the sternum.

(vii) The vertebral end of each rib in turn has two parts, a lower capitulum attached to centrum and upper tuberculum attached to transverse process of vertebra.

(viii) On the vertebral side, each rib (except the first and last pair) carries a backwardly directed uncinate process which overlaps the next rib behind, to provide sufficient strength and rigidity to the thoracic wall.

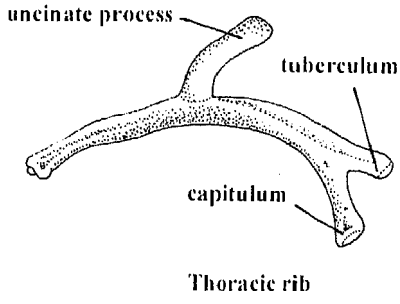


Fig. 33.23: Thoracic ribs of fowl.

33.4.5 Pectoral Girdle

(i) Pectoral girdle (Fig.33.24) is made of the usual three bones i.e., Coracoid; Scapula and Clavicle.

(ii) All these bones are elongated and constitute the two similar halves of pectoral girdle.

(iii) Each half is peculiarly like the inverted "L" in shape.

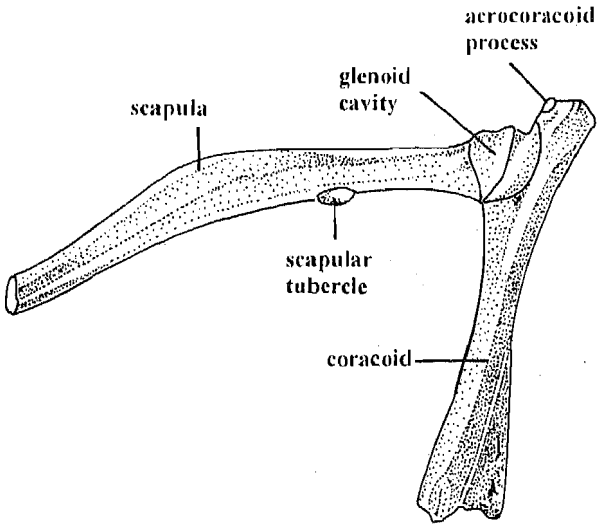
(iv) Coracoid is a large, stout and rod-shaped bone, its inner surface articulates with scapula and outer surface contains the cup shaped glenoid cavity. The head of humerus bone fits into this cavity.

(v) Scapula is also a narrow , elongated sabre like bone.

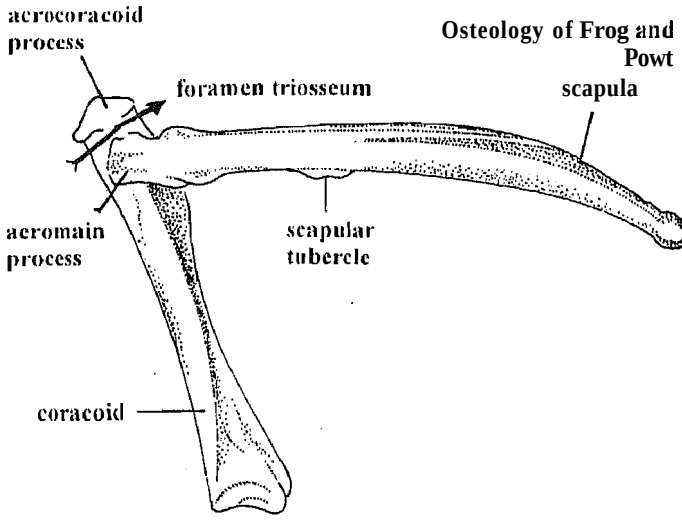
(vi) A depression is present in the anterior part of scapula contributing in the formation of glenoid, cavity and on inner side it has an acromian process.

(vii) The rod shaped clavicles of both sides fuse to form a 'V' shaped furcula or wishbone.

(viii) Ventrally the furcula bears the interclavicle at the region of fusion.



Pectoral girdle (Outer view)



Pectoral girdle (Inner view)

Fig. 33.24: Pectoral girdle of fowl.

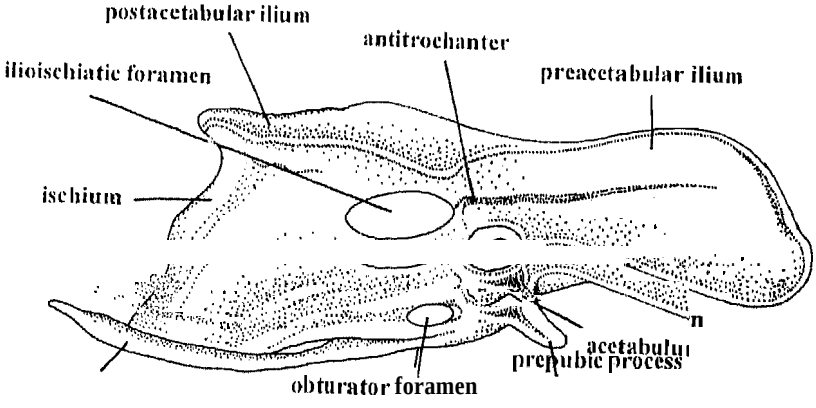
33.4.6 Pelvic Girdle

(i) The pelvic girdle of fowl is made up of usual three bonds i.e. the **Ilium, Ischium** and **Pubis** (Fig.33.25).

(ii) The flat and lamellar **ilium** bone fonns the dorsal part of the acetabulum.

(iii) The outer surface of preacetabular part of ilium is concave while that of postacetabular part is convex.

(iv) **Ischium** is a broad and lamellar bone which extends behind the acetabalum. It fuses with ilium posteriorly and remains separated from it in the anterior region by its ischiatic foramen.



Pelvic girdle (Right half)

Fig. 33.25: Pelvic girdle of fowl.

(v) Pubis forms the ventral part of the acetabulum.

(vi) Just behind the acetabulum the pubis is separated from ischium by an obturator foramen.

(vii) Ventral symphysis is absent in accordance with the laying of relatively large sized eggs.

(viii) Firm and extensive fusion of pelvic girdle with synsacrum provides sufficient strength to the pelvic region in the absence of ventral symphysis.

33.4.7 Forelimb Bones

(i) In birds because the forelimb is adapted for flight and has to support the wings, certain changes have occurred in the number and arrangement of the fore limb bones (Fig. 33.26).

(ii) Forelimb of fowl, like those of other birds is composed of the usual bones i.e. **humerus, radius, ulna**, carpals, **carpometacarpus** and phalanges

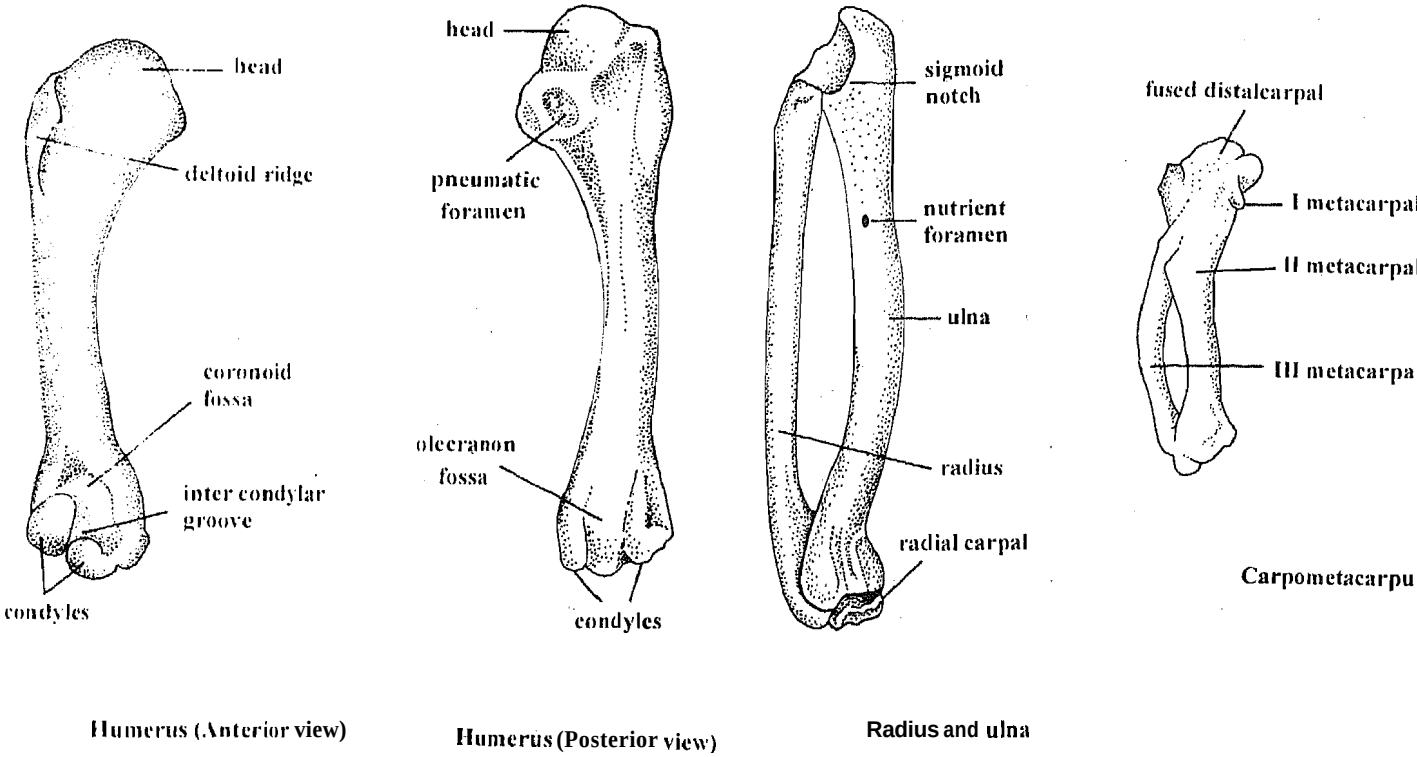


Fig. 33.26: Fore-limb bones of fowl.

(iii) Distal carpal bones fuse with the metacarpals forming carpometacarpus.

(iv) Instead of five only three digits are present in the forelimbs.

(A) HUMERUS

(i) The upper arm bone is stout, elongated, slightly curved and expanded at both ends (Fig.33.26)

(ii) Proximal expanded end bears a head which articulates with the glenoid cavity of pectoral girdle.

(iii) The head bears a small preaxial tubercle with a prominent deltoid ridge for the attachment of pectoral and deltoid muscles.

(iv) A greater tuberosity with a large pneumatic foramen is present on the post-axial side of the head.

(v) The distal end of humerus bears two trochlear articular surface or condyles for radius and ulna.

(B) RADIUS AND ULNA

(i) The forearm has two separate bones i.e. **radius** and **ulna** (Fig. 33.26) which in birds do not move upon each other.

(ii) **Radius** is a short, slender and almost straight bone, Its proximal end has a cup-like depression to receive and articulate with the outer condyle of humerus. A distal knob-like end fits into the radiale carpal.

(iii) **Ulna** is longer, stouter and more curved than radius. Its proximal end contains a facet for inner condyle of humerus and it further projects into small olecranon process.

(iv) Distal end articulates partly with carpals and partly with radius.

(C) CARPALS

(i) There are only two carpal bones present in adult birds (Fig. 33.26).
(ii) The smaller one is called radiale, and articulates with radius and is proximal in position.
(iii) The large, ulnare articulates with distal end of ulna and is post-axial in position.
(iv) These two represent the proximal row of carpals, because all the distal carpals fuse with the metacarpals in adult.

(D) CARPOMETACARPUS

(i) Three metacarpals fuse with distal carpals to form a single elongated compound bone, called carpornetacarpus (Fig. 33.26).
(ii) First **metacarpal** is in the form of a small stumpy projection at the proximal end of carpornetacarpus.
(iii) Second **carpometacarpus** is the strongest and straight bone.
(iv) The third metacarpal is slightly curved and slender than the second with which it is fused nt both ends.

(E) PHALANGES **(Fig.** 33.26)

(i) The three metacarpals bear three clawless fingers.
(ii) First and the third digit consists of single phalanx each.
(iii) The second digit or index finger has three phalanges.

33.4.8 Hind-Limb Bones

(i) Hind-limbs in birds arc modified for bipedal locomotion.
(ii) These arc homologous with forelimbs in general struetural plan.
(iii) Each hind-limb comprises femur, tibio-tarsus, fibula, tarsals, tarsometatarsal and phalanges (Fig. 33.27).

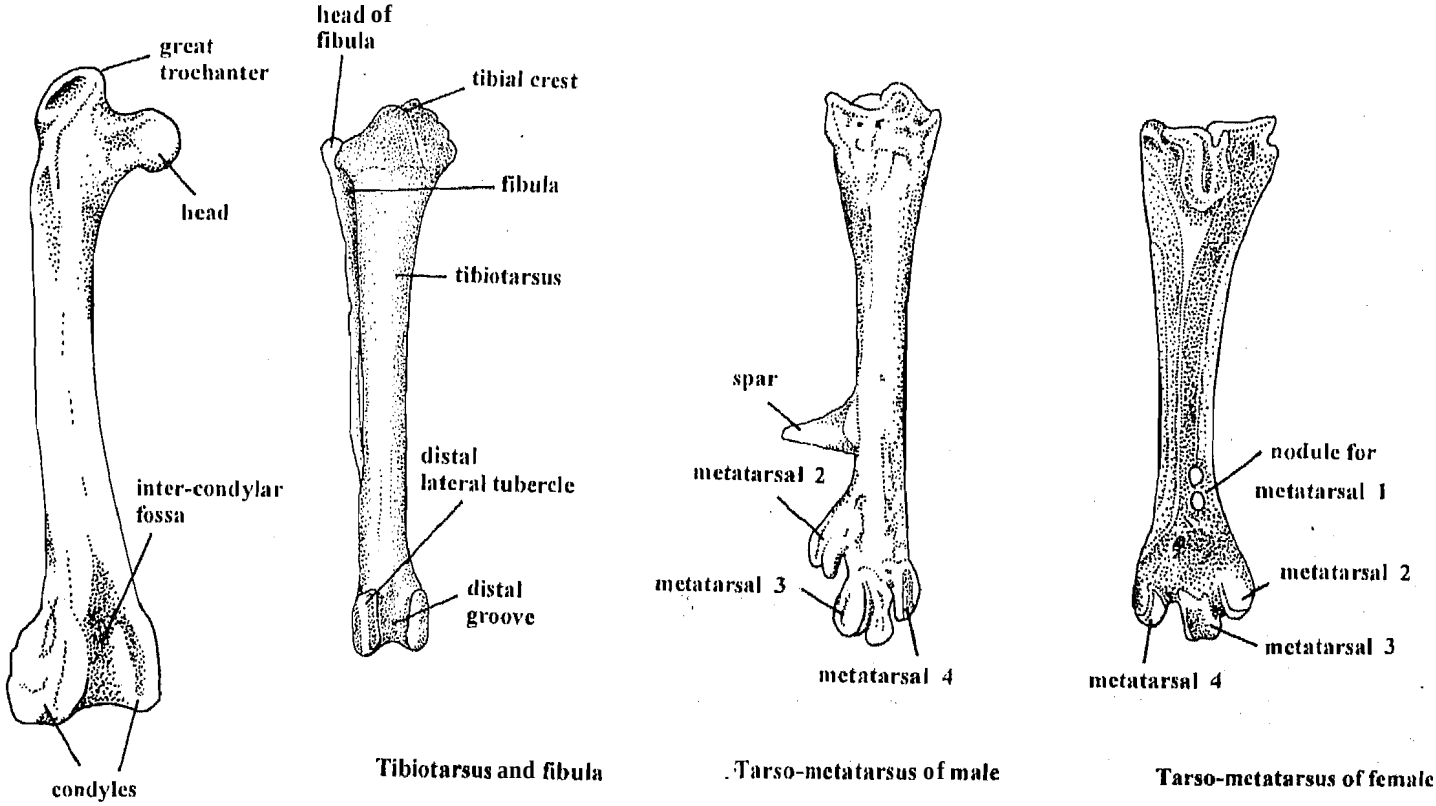


Fig. 33.27: Hind limb bones of; fowl.

(A) FEMUR

(i) It is a single, cylindrical, stout and slightly curved bone with flattened ends (Fig. 33.27).
(ii) On the inner side of the proximal end a rounded head is present which fits int acetabulum of pelvic girdle.
(iii) On the outer side of this end is present a prominent but irregular process called a greater trochanter.
(iv) Distal end of femur has a pulley like structure, consisting of an anterior deep intercondyler groove or fossa.
(v) Two prominent condyles are present on the lateral sides of fossa for the articulation with tibio-tarsus.
(vi) Outer condyle is deeply grooved to articulate with the upper end of fibula.
(vii) In front of femur tibiotarsal joint, a sesamoid bone or patella is found in orde to provide sufficient protection to the joint.

(B) TIBIO-TARSUS AND FIBULA

(i) These are the bones of the shank region.
(ii) Tibio-tarsus is the longest bone in the body, even longer than femur (Fig. 33.27).
(iii) It is a stout nearly straight bone formed by the fusion of tibia with proximal tarsals (astragalus and calcaneum).
(iv) The broad proximal end shows two articular facets to receive two distal condyles of femur
(v) The same end also contains a prominent cnemial crest in front.
(vi) Distal end contains a smooth groove bounded by two condyles to articulate with the tarso-metatarsus.

(C) **FIBULA**

(i) It is markedly reduced to a small slender bone (Fig. 33.27).
(ii) It is attached to the outer surface of tibio-tarsus.
(iii) The proximal end bears a head to articulate with the outer condyle of femur.
(iv) The distal end tapers gradually to a sharp point and does not reach the ankle.

(D) TARSALS

(i) No free tarsals are present in adult fowl.
(ii) The proximal row of these fuses with tibia to form a compound tibio-tarsus bone.
(iii) Their distal row fuses with metatarsals.
(iv) An intertarsal ankle joint is present between the two rows.

(E) TARSO-METATARSUS

(i) It is a single, stout and straight compound bone present in the foot region (Fig. 33.27).
(ii) Second, third and fourth metatarsals fuse with the distal row of tarsals to form this compound bone.
(iii) At the distal end the three metatarsals become free, each forming a pulley like articular surface for the corresponding toe.
(iv) In male fowl the tarsometatarsus bears a stout, conical and slightly curved bony projection ending into a pointed horny fighting spur.

(F) PHALANGES

(i) There are four toes in the foot (Fig. 33.27).
(ii) Only the first toe (hallux) is directed backwards while the remaining three, are directed forwards.

(iii) Each one is made up of small slender bones, the phalanges, whose number varies in the four toes.

(iv) There are 2,3,4 and 5 phalanges in hallux, second third, and fourth toe respectively.

(v) Each toe ends in a horny claw making the feet raptorial.

33.5 TERMINAL QUESTIONS

1. Give two major difference between vertebrae of frog and fowl.

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2. How can you identify the bone of frog from that of fowl.

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3. What is the difference between Urostyle and Pygostyle.

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4. What is very peculiar in the following?

i) Ninth vertebra of frog:

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ii) Ribs of fowl:

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iii) First vertebra of fowl:

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5. Campare the bones of lower jaw of frog with those of the lower jaw of fowl.

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