

# Chapter 1

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## INTRODUCTION TO ANATOMY

### Outline

- **What's Anatomy?**
- **Functions of Anatomy**
- **Divisions of Anatomy**
- **Methods to Study Anatomy**
  - **Systemic Study**  
Division of systemic anatomy
  - **Topographic Study**  
Topographic terms
- **Planes of the body**
- **Recumbency Positions**
- **Medical Terms for various species**
- **Common Animal Terms**

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(ANA—apart, TOMY— to cut)

**A** **NATOMY** is that branch of biological sciences which deals with the structure and form of organisms. It includes the study of shape, weight, color, texture, and relative position of various organs and tissues of the organisms when they are in a state of normal health.

### FUNCTIONS OF ANATOMY

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The anatomical knowledge helps a veterinarian, in the discharge of his multifarious duties, in many ways. More important functions of anatomy are:

1. It gives an idea about the form, shape, structure and relative position of various organs and tissues comprising a normal and healthy body.
2. It aids in understanding the functions of various parts, their correlation and coordination, and their physical and functional relationship.
3. When normal shape, structure and function are known, a deviation from this normal can be recognized with great ease. Thus, it helps in the diagnosis and recognition of diseased state.
4. It provides knowledge, which helps in devising the ways and means for the collection of material required for a definite diagnosis.
5. It facilitates the development of more efficient means for the administration of drugs, not to talk of reducing the drug administration hazards.
6. A good grasp of anatomy gives much help and confidence to a surgeon.

### DIVISIONS OF ANATOMY

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#### GROSS ANATOMY

It is the study of structures that can be dissected and observed with the naked eye.

#### HISTOLOGY

It is the study of minute structures too small to be seen without a microscope.

#### CYTOLOGY

It is the study of minute structures in even greater detail, with the help of an electron microscope.

### **MORBID ANATOMY**

It is the study of diseased structures of an organism.

### **APPLIED ANATOMY**

It is the practical application of a normal structural study in relation to diagnosis and treatment of pathology or surgical condition.

### **TERATOLOGY**

It is the study of abnormal development of an individual including their nature and causes of the problem.

### **DEVELOPMENTAL ANATOMY**

It is the study of the development of an individual from the zygote to adult.

### **EMBRYOLOGY**

It is the study of structure from fertilized egg to birth.

### **COMPARATIVE ANATOMY**

It is the study of comparison of the structures of animals and it form the basis of their classification.

### **MORPHOLOGICAL OR PHILOSOPHICAL ANATOMY**

It is the study of generalization made on outer form and inner structure and development of individuals belonging to different species.

### **PHYLOGENY**

It is the study of evolutionary history of specie e.g. the study of changes occurred during process of evolution.

### **SPECIAL ANATOMY**

It is the description of structure & form of a single type or specie e.g. hippotomy(anatomy of horse).

### **VETERINARY ANATOMY**

It is the study of structure and form of domesticated animals e.g. horse, ox, dog, sheep, goat, and poultry birds.

## **METHODS OF STUDY OF ANATOMY**

There are two chief methods of study which are usually employed.

1. Systemic Study
2. Topographic Study

### **1. SYSTEMIC STUDY**

In this approach, the body is regarded as consisting of organs or apparatus which are similar in origin and structure and are associated in the performance of certain functions.

#### **DIVISIONS OF SYSTEMIC ANATOMY**

1. **OSTEOLOGY:**  
The description of the skeleton.
2. **ARTHROLOGY**  
The description of the Joints.
3. **MYOLOGY:**  
The description of the muscles.
4. **SPLANCHNOLOGY:**  
The description of the Viscera. This includes the following subdivisions of the soft organs of the body:-
  - i. Digestive System

- ii. Respiratory System
  - iii. Urinary System
  - iv. Genital System (Reproductive System)
5. **ANGIOLOGY:**  
The description of the organs of circulation.
  6. **NEUROLOGY:**  
The description of the nervous system
  7. **ESTHESIOLOGY:**  
The description of the sense organs and common integument.

**2. TOPOGRAPHIC STUDY**

The term topographic anatomy designates the methods by which the relative positions of various parts of the body are accurately determined.

**TOPOGRAPHIC TERMS**

Following are some special terms which are usually employed in anatomical study. It is assumed that the animal is in a standing position.

..... (See Figure 1.1 and 1.2)

- Dorsal / Superior:** ..... relatively nearer to the top of head, body, back of neck, trunk or tail.
- Ventral / Inferior:** ..... towards or relatively nearer to the underside of the head or body.
- Medial:** ..... toward or relatively nearer to the median plane.
- Lateral:** ..... relatively away from the median plane.
- Cranial / Anterior:** ..... toward or relatively nearer to the head.
- Caudal / Posterior:** ..... toward or relatively nearer to the tail.
- Rostral:** ..... relatively nearer to the nose; applies to the head only.
- Oral:** ..... towards the oral cavity.
- Aboral:** ..... away from the oral cavity.
- Internal / Inner:** ..... close to, or in the direction of, the cavity of a hollow organ.
- External / Outer:** ..... away from the center of a hollow organ.
- Superficial:** ..... relatively nearer to the surface of a body, or a solid organ.
- Deep:** ..... relatively nearer to the center of a body or solid organ.
- Proximal:** ..... relatively nearer to the main mass of the body or trunk.
- Distal:** ..... away from the main mass of the body or trunk.
- Radial and Tibial:** ..... denote the medial sides of the forelimb and hind limb in which the radius and tibial are located respectively.
- Ulnar and Fibular:** ..... denote the lateral sides of the forelimb and hind limb in which the ulna and fibula are located respectively.
- Volar and Palmer:** ..... denote caudal aspect of the forepaw on which the pads are located.
- Planter:** ..... denotes caudal aspect of the hindpaw on which the pads are located.
- Axis:** ..... the central line of a body or any of its parts.
- Axial:** ..... relatively nearer to the axis.
- Abaxial:** ..... away from the axis of a body or part.

**PLANES OF THE BODY**

(See Figure 1-3)

**Plane:**

A surface (real or imaginary) along which any two points can be connected by a straight line.

**Median:**

It refers to the median plane, which divides the body, including the head and tail, into right and left, two symmetrical halves. The term has also been applied to a plane dividing a limb longitudinally into halves.

**Sagittal:**

A plane parallel to the median plane.

**Transverse / Segmental:**

It refers to a plane perpendicular to the long axis of the body or part.

**Dorsal / Oblique / Frontal Plane:**

It runs at right angle to the median and transverse planes and thus divides the body into dorsal and ventral portions.

**RECUMBENCY POSITIONS**

(See Figure 1-4)

- i) Dorsal Recumbency
- ii) Ventral Recumbency
- iii) Lateral Recumbency

**MEDICAL TERMS FOR VARIOUS SPECIES**

In veterinary medicine, there are many different species and many different terms used to describe animal anatomy and diseases.

Reviewing species-specific terms will allow you to communicate effectively with clients.

1. Common Anatomic Terms for Equine Species .....(See Figure 1-6)
2. Common Anatomic Terms for Cattle .....(See Figure 1-7)
3. Common Anatomic Terms for Goat .....(See Figure 1-8)
4. Common Anatomic Terms for Sheep ..... (See Figure 1-9)
5. Common Anatomic Terms for Swine .....(See Figure 1-10)
6. Common Anatomic Terms for Cat ..... ..(See Figure 1-11)
7. Common Anatomic Terms for Dog .....(See Figure 1-12)

**COMMON ANIMAL TERMS**

**DOG**

- Intact male dog
  - dog/stud
- Intact female dog
  - bitch
- Young dog
  - whelp or pup
- Giving birth
  - whelping
- Group of dogs
  - pack
- Multiple offspring born during the same litter
  - litter

**CAT**

- Intact male cat
  - tom
- Intact female cat
  - queen
- Young cat
  - kitten
- Giving birth
  - queening
- Multiple offspring born during the same litter
  - litter

**SWINE**

- Intact male pig

- boar
- Intact female pig
  - sow
- Male pig castrated when young
  - barrow
- Male pig castrated after maturity
  - stag
- Young female pig that has not given birth
  - gilt
- Young pig
  - pig or shoat
- Giving birth
  - farrowing
- Group of pigs
  - herd

**HORSE**

- Intact male horse more than four years old
  - stallion
- Intact male horse less than four years old
  - colt
- Intact female horse more than four years old
  - mare
- Intact female horse less than four years old
  - filly

- Castrated male horse
  - gelding
- Young horse
  - foal
- Giving birth
  - foaling

**CATTLE**

- Intact male bovine
  - bull
- Intact female bovine
  - cow
- Male bovine castrated when young
  - steer
- Young female bovine that has not given birth
  - heifer
- Young bovine
  - calf
- Group of cattle
  - herd
- Giving birth
  - freshening

**SHEEP**

- Intact male sheep
  - ram
- Intact female sheep
  - ewe
- Castrated male sheep
  - wether
- Young sheep
  - lamb
- Group of sheep
  - flock
- Giving birth

- freshening or lambing

**GOAT**

- Intact male goat
  - buck
- Intact female goat
  - doe
- Castrated male goat
  - wether
- Young goat
  - kid
- Group of goats
  - herd
- Giving birth
  - freshening or kidding

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## Chapter 2

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# INTRODUCTION TO SKELETON

### Outline

#### Introduction

#### Classification of Bones

##### Long bones

##### Short bones

##### Flat bones

##### Irregular bones

##### Sesamoid bones

#### Functions of a bone

#### Surface Contour of bone

#### Division of Skeleton

#### Movement terms

#### Bones of Axial Skeleton

#### Bones of Appendicular Skeleton

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**S**keleton is the framework of hard structures, which supports and protects the soft organs of the body. Skeleton of higher animals consists of mainly the bones, supplemented by cartilages in many places, and the binding tissue called the ligament. In the early embryonic development of an animal the skeleton consists largely of cartilages.

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### CLASSIFICATION OF BONES

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The bones of the body are usually classified into five sub-classes.

#### 1. LONG BONES

These are greater in one dimension than the other.

**FUNCTION:** long bones function chiefly as levers and aid in support, locomotion and prehension.

**EXAMPLES:** The bones of the limbs.

#### 2. SHORT BONES

These are somewhat cuboidal or approximately equal in all dimensions.

**FUNCTION:** these function chiefly in absorbing concussion, and are found in complex joints such as knee or hock where a variety of movements as well as absorption of shock are required.

**EXAMPLES:** carpal and tarsal bones.

#### 3. FLAT BONES

These are relatively thin, and expanded in two dimensions.

**FUNCTION:** these bones function chiefly for protection of vital organs e.g. brain, heart, lungs, pelvic viscera but also provide large surface for muscle attachment.

**EXAMPLES:** Scapula, frontal bone and ilium.

#### 4. IRREGULAR BONES

These are unpaired bones located in the median plane of the body.

**FUNCTION:** these are important for protection, support and muscle attachment.

**EXAMPLES:** vertebrae and sternbrae.

## 5. SESAMOID BONES

These resemble a sesame seed and are developed along the course of tendons to reduce friction or change the course of tendons.

**EXAMPLE:** The patella (called knee cap) is the largest sesamoid bone in the body.

## FUNCTIONS OF A BONE

1. It makes the foundation and a proper shape of the shape.
2. It supports and furnishes attachment to the soft organs of the body e.g. muscles and viscera etc.
3. It protects certain soft and delicate tissues of the body e.g. brain enclosed in the cranial cavity.
4. Bones act as levers in various articulations of the body and thus indirectly help in locomotion.
5. Bones of pneumatic type present in the fowl help in flying by reducing in flying by reducing weight of body.
6. It helps in erythropoiesis e.g. red and white blood cell formation.
7. It helps in hearing e.g. ossicles in ear.
8. It acts as storehouse of calcium and phosphorus.
9. They help in respiration e.g. ribs.
10. They help in deglutition e.g. hyoid apparatus.

## SURFACE CONTOUR OF BONE

The surfaces of bones present a great variety of eminences, depressions and perforations which play a specific role in life.

There is a functional, embryological and pathological reason for the existence of every irregularity. The prominences and cavities may be articular or non-articular, serving for the attachment of muscles, fascia, ligaments, and tendons.

### DESCRIPTIVE TERMS

A few of descriptive terms, which are frequently in use, are defined below:-

- Tuberosity (Tuber):** ..... Is a large non-articular rounded projection.
- Tubercle:** ..... Is a smaller tuberosity.
- Process:** ..... Is a vague term generally applied to a projection.
- Trochanter:** ..... Is a term specialized for a tuberosities on the femur.
- Spine:** ..... Is an elongated thin pointed line.
- Crest:** ..... Is a linear sharp ridge.
- Line:** ..... Is a very faint ridge.
- Head:** ..... Is a rounded, smooth, strongly convex articular projecting process, situated at the end of the long bones.
- Neck:** ..... Is a constricted attachment between head and shaft of the bone.
- Condyle:** ..... Is a smooth, convex, articular, large cylindrical, protruding mass situated at the end of the long bones.
- Epicondyle:** ..... Is rough enlarged area, which lies proximal to the condyles.
- Facet:** ..... Is a small articular surface, which may be flat, concave or convex.
- Glenoid Cavity (Cotyloid cavity):** ..... Is a smooth and deep articular depression.
- Trochlea:** ..... Is a large pulley-like articular mass.
- Cochlea:** ..... Is an articular surface reciprocal to that of trochlea.
- Sinus:** ..... Is an air cavity within a bone.
- Foramen:** ..... Is a perforation in a bone.
- Canal:** ..... Is a tunnel through one or more bones.
- Fossa:** ..... Is a large non-articular depression.
- Fovea:** ..... Is a small non-articular depression.

## MOVEMENT TERMS

Where two or more bones unite with each other, a joint or articulation is formed.

The uniting medium may be fibrous tissue or cartilage. The various kinds of movements are as under:-

- Flexion:** ..... When the angle between the uniting bones is reduced.  
The muscles which are responsible for such movements are called flexors.
- Extension:** ..... This is opposite to the flexion and it tends to bring the segments forming the joints in line with each other. The effecting muscles are called extensors.
- Adduction:** ..... It is the movement of a limb towards the medial plane.  
Effected muscles are called adductors.
- Abduction:** ..... It is the movement of a limb away from the medial plane.  
Effected muscles are called abductors.
- Rotation:** ..... It is the rotation of one bone around the other longitudinal axis of the other segment forming the joint.
- Circumduction:** ..... It refers to the movement in which distal end of limb describing a cir-cular path whereas proximal end remains fixed. E.g. arm extended drawing a circle.
- Supination:** ..... It is the lateral rotation of the appendages so that the palmer surface of the paw faces radially or dorsally.
- Pronation:** ..... It is the medial rotation of the appendages from the spine position, so that palmer/planter surface is facing ventrally.

## **DIVISION OF SKELETON**

The skeleton may be divided primarily into following three subdivisions.

1. **Axial Skeleton:**  
It comprises the vertebral column, ribs, sternum, and skull.
2. **Appendicular Skelton:**  
It includes the bones of the limbs.
3. **Splanchnic / Visceral / Heterotopic Skeleton:**  
It consists of certain bones developed in the substance of some of the viscera or soft organs e.g. *os penis* of the dog and *os cordis* of the ox.

## **BONES OF AXIAL SKELETON**

<b>SKULL</b>				
<b>Cranial part</b>	<b>Facial part</b>	<b>Veretbrae</b>	<b>Ribs</b>	<b>Sternum</b>
Ethmoid	Incisive	Cervical	True (joined to	Sternebrae
Frontal	Lacrimal	Thoracic	sternum by	Manubrium
Interparietal	Mandible	Lumbar	cartilages)	Xiphoid
			False (not directly	process
Occipital	Maxilla	Sacral	connected to	
Parietal	Palatine	Coccygeal	sternum)	
Pterygoid	Nasal		Floating (fixed only	
Sphenoid	Turbinates		at vertebrae, last 1	
	(conchae)		pair)	
Temporal	Zygomatic			
Vomer	Hyoid apparatus			

## **BONES OF APPENDICULAR SKELETON**

<b>THORACIC LIMB</b>		<b>PELVIC LIMB</b>	
<b>Part of Limb</b>	<b>Bones</b>	<b>Part of Limb</b>	<b>Bones</b>
Thoracic (shoulder) girdle	Scapula, clavicle, coracoid	Pelvic girdle	Sacrum, os coxae, few coccygeal vertebrae
Brachium (arm)	Humerus	Thigh	Femur
Antebrachium (forearm)	Radius, ulna	Crus (true leg)	Tibia, fibula
Carpus (knee)	Carpal bones	Tarsus (hock)	Tarsal bones
Metacarpus (cannon and splint bones)	Metacarpal bones	Metacarpus (cannon and splint bones)	Metatarsal bones
Phalanges (digits)	Proximal, middle, and distal phalanges Proximal and distal sesamoid bones	Phalanges (digits)	Proximal, middle, and distal phalanges Proximal and distal sesamoid bones

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## Chapter 3

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# AXIAL SKELETON

### Outline

#### **Vertebral Column**

- Vertebral formula
- Characteristics of a vertebra

#### **Vertebral Canal**

#### **Cervical Vertebrae**

#### **Thoracic Vertebrae**

#### **Lumbar Vertebrae**

#### **Sacrum**

- Sacral Canal

#### **Coccygeal Vertebrae**

#### **Ribs (Costae)**

#### **Costal Cartilages**

#### **Sternum**

#### **Thorax**

#### **Skull of the Goat**

- Dorsal surface
- Lateral surface
- Ventral surface
- Occipital surface

#### **Mandible of the Goat**

#### **Vomer and Hyoid Bone**

**A**xial skeleton consists of the skull, vertebrae, ribs, and the sternum.

SKULL		Vertebrae	Ribs	Sternum
Cranial part	Facial part			
Ethmoid	Incisive	Cervical	True (joined to sternum by cartilages)	Sternebrae
Frontal	Lacrimial	Thoracic		Manubrium
Interparietal	Mandible	Lumbar	False (not directly connected to sternum)	Xiphoid process
Occipital	Maxilla	Sacral		
Parietal	Palatine	Coccygeal	Floating (fixed only at vertebrae, last 1 pair)	
Pterygoid	Nasal			
Sphenoid	Turbinates (conchae)			
Temporal	Zygomatic			

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## VERTEBRAL COLUMN

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### INTRODUCTION

The vertebral column is the fundamental part of the skeleton. It consists of a chain of median, unpaired, irregular bones which extends from the skull to the end of the tail.

The column is subdivided for description into five regions, following letters are typically used to designate the respective region:

<b>C</b>	Cervical vertebrae, neck region
<b>T</b>	Thoracic, chest
<b>L</b>	Lumber, loin
<b>S</b>	Sacral, fused vertebrae
<b>Cy</b>	Coccygeal (caudal), tail

### VERTEBRAL FORMULA

A vertebral formula for a given species consists of the letter symbol for each region followed by the number of vertebrae in that region in the given species.

The vertebral formula (for goat) is ..... **C<sub>7</sub> T<sub>13</sub> L<sub>6-7</sub> S<sub>4</sub> Cy<sub>16-18</sub>**

### CHARACTERS OF A VERTEBRA

All typical vertebrae have a common plan of structure, which must be understood. The parts of which a vertebrae consists are; (1) the body (2) the arch and (3) the processes (i) articular processes (ii) spinous processes (iii) transverse processes (iv) Mammillary processes (v) accessory processes

#### THE BODY

- It is more or less cylindrical mass on which the other parts are constructed.
- The anterior and posterior extremities of the body are attached to the adjacent vertebrae, and are usually convex and concave respectively.
- The dorsal surface is flattened and enters into the formation of the vertebral canal.

#### THE ARCH

- It is constructed on the dorsal aspect of the body. It consists originally of two lateral halves, each of which is considered to consist of a pedicle and a lamina.
- The **PEDICLE** forms the lateral part of the arch, and is cut into in front and behind by the vertebral notches.
- The **LAMINAE** are plates which complete the arch dorsally, uniting with each other medially at the root of the spinous process.

The body and the arch form a bony ring which encloses the **VERTEBRAL FORAMEN**; the series of vertebral rings which in turn enclose the **VERTEBRAL CANAL**, which contains the spinal cord and its covering and vessels.

#### THE PROCESSES

##### (i) ARTICULAR PROCESSES

The articular processes, two anterior and two posterior, project from the borders of the arch. They present articular surfaces adapted to those of adjacent vertebrae.

##### (ii) SPINOUS PROCESS

The spinous process or spine is single, and projects dorsally from the middle of the arch. It varies greatly in form, size and direction in different vertebrae.

##### (iii) TRANSVERSE PROCESSES

These are two in number and project laterally from the sides of the arch or from the junction of the arch & body.

##### (iv) MAMMILLARY PROCESSES

These are found on the last few thoracic vertebrae. They are present between the transverse and anterior articular processes or on the latter.

**(v) ACCESSORY PROCESSES**

These when present, are situated between the transverse and posterior articular processes.

## **VERTEBRAL CANAL**

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- The vertebral canal corresponds in its curvature to that of the bodies.
- Its caliber varies greatly at different points; the greatest diameter is in the atlas; where it contains the dens of the axis, in addition to the spinal cord. It is very smaller in the axis.
- It widens considerably at the junction of the cervical and thoracic regions than at any preceding point.
- Beyond the middle to the lumbar region it again enlarges considerably to contain the lumbar enlargement of the spinal cord.
- The caliber diminishes very rapidly from the second sacral segment caudally, and the canal ceases to be complete at the fourth coccygeal vertebrae.

## **CERVICAL VERTEBRAE**

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**PECULIARITIES**

- The cervical vertebrae are seven in number.
- The first (atlas) and second (axis) cervical vertebrae are highly modified in conformity with the special functions of support and movements of the head.
- The sixth and seventh present special characters, but do not differ greatly from the type.
- With the exception of the first, they are quadrangular, massive and longer than the vertebrae of other regions.

**FIRST CERVICAL VERTEBRAE (ATLAS)**

- This vertebra is decidedly atypical in form & structure.
- The body and spinous process are absent.
- The transverse processes are modified into curved plates, the *wings* which project laterally.
- Two foramina, alar (cranial one) and intervertebral, perforate each wing.
- The lateral masses present two deep and oval cranial articular cavities, which receive the occipital condyles but the caudal articular surfaces are somewhat saddle-shaped.
- The dorsal arch presents a median dorsal tubercle and is flat ventrally.
- The ventral arch is thick, narrow and more curved than the dorsal. The dorsal face, on the caudal end presents a transversally concave articular surface, the *fovia dentis* (where dens of axis rests)

**SECOND CERVICAL VERTEBRA (AXIS)**

- The second cervical vertebra is named as axis.
- The cranial extremity of body presents centrally the dens or odontoid process and the cranial articular processes present cranial articular surface.
- The caudal extremity has a usual cotyloid cavity & the caudal articular processes are typical.
- The arch presents a notch on each side of its cranial border (in young subject) which is converted into lateral vertebral foramen later by mean of a ligament.
- The transverse processes are small, single, and projects caudally.
- The spinous process projects a little cranially and increases in height and thickness caudally.

**THIRD, FOURTH AND FIFTH CERVICAL VERTEBRAE**

The three vertebrae, third, fourth and fifth are also called typical cervical vertebrae.

### **Distinct Characteristics**

- The body is long as compared to those of other vertebrae.
- The ventral surface presents a prominent “median ventral crest”.
- The **CRANIAL EXTREMITY** or head has quadrangular convex articular surface, which faces cranially.
- The **CAUDAL EXTREMITY** is larger and has nearly circular cotyloid cavity.
- The **ARCH** is large and strong. It consists of two parts; (i) dorsal wall or roof is formed by the lamina and the (ii) lateral walls by the pedicles. It is perforated on either side by a foramen which communicates with the transverse foramen. The **VERTEBRAL NOTCHES** on the pedicles are large.
- The **ARTICULAR SURFACES** are flat and much extensive; (i) cranial ones are directed dorso-medially, and the (ii) caudal ones ventro-laterally.
- The **TRANSVERSE PROCESSES** are large and plate-like which arises from the body. Between these is a transverse foramen through which the vertebral vessels and nerve pass. The processes divide laterally into cranial and caudal branches for muscular attachment.
- The **SPINOUS PROCESS** is well-developed and increase in height cranio-caudally. They are directed dorsally and cranially with the exception of the last, which is nearly vertical.

### **SIXTH CERVICAL VERTEBRA**

- It is shorter and wider than the fifth.
- The arch is large, especially caudally.
- The cranial articular processes are further apart.
- The spinous process is less rudimentary; its summit is flattened from before backward.
- The transverse processes have two braches; the dorsal branch projects laterally and is short and stout, the ventral one is a thick and sagittal plate, which forms with its fellow of the opposite side.

### **SEVENTH CERVICAL VERTEBRA**

- It is shorter and wider than the others.
- The body is flattened dorso-ventrally and wide caudally.
- The cranial articular processes are wider and longer than the caudal pair.
- The spinous process is about 3cm in height.
- The transverse process is undivided and usually has no transverse foramen.
- The ventral crest is absent.

## **THORACIC VERTEBRAE**

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### **Peculiarities**

- The thoracic vertebrae are about 13 in number.
- The bodies are short but their ends are expanded have articular surfaces.
- The arches are small and their caudal notches are relatively notches.
- The articular processes are small; the cranial processes are represented by two oval facets on the cranial part of the arch, the caudal ones spring from the base of the spinous process.
- The transverse processes are short, thick, and tuberos at the free end. Each has a facet for articulation with the tubercle of the corresponding rib.
- The spinous process is large and narrow. It is directed dorso-caudally. The cranial border is thin, the caudal one is wider and grooved.

### **FIRST THORACIC VERTEBRA**

- **The** body is wide and flattened dorso-ventrally.
- The cranial extremity presents a head which resemble to that of the cervical vertebrae.
- The caudal extremity presents a cavity somewhat deeper than any other thoracic vertebrae and two large costal facets are found on either side.
- The articular processes are much larger than those of other thoracic vertebrae and resemble a good deal those of the seventh cervical.

- The transverse processes are short and each has on its ventral aspect, a large concave facet for articulation with the tubercle of the first rib.
- The spinous process is inclined caudally.

#### **LAST THORACIC VERTEBRA**

- Absence of the caudal pair of costal facets and the confluence of the cranial pair with those on the transverse processes.

#### **SERIAL POSITION**

- ❖ The bodies gradually diminish in length and width to the middle of the region and then increase slightly.
  - The costal facets become smaller and less concave from first to the last.
  - The ventral crest is distinct on last three or four vertebrae of this region.
- ❖ The transverse processes diminish in size and are placed more ventrally as they are traced caudally.
  - The costal facets become smaller and lower in position; on the last it fuses with the costal facet of the body.

### **LUMBER VERTEBRAE**

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#### **Peculiarities**

- The lumbar vertebrae are usually six in number; five lumbar vertebrae have also been reported in the domestic goat.
- They are characterized by the size and form of their transverse processes.
- The **ARCHES** of the first three are semi-elliptical on cross section and present a distinct ventral crest. These (arches) are about equal in size and similar to that of the last thoracic.
- The **ARCHES** of last three increase in breadth and height.
- The **CAUDAL NOTCHES** on the pedicles are much deeper than the cranial ones.
- The **CRANIAL ARTICULAR PROCESSES** are fused with the mammillary processes and present medially a large concave and more strongly curved surfaces for articulation with the caudal pair of preceding vertebra.
- The **CAUDAL ARTICULAR PROCESSES** project distinctly from arch at the base of the spinous process.
- The **TRANSVERSE PROCESSES** are elongated plates, flattened dorso-ventrally which project laterally and all inclines cranial and ventral. Their length increases to the fifth, and then diminishes to the last.
- The **SPINOUS PROCESSES** are relatively low and wide, the last being the smallest. Their summits are moderate thickened.

### **SACRUM**

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#### **Peculiarities**

The sacrum is usually formed by the fusion of four vertebrae and conveniently described as a single bone.

The sacrum is triangular in form and is wedged in between the ilia, with it articulates very firmly on each side.

Its long axis is gently curved and slightly oblique, so that the casual end is a little higher than the cranial.

#### **DESCRIPTION**

The sacrum presents:

Two surfaces, Two borders, a base and an Apex

#### **THE SURFACES**

**DORSAL SURFACE:** presents centrally four sacral spines, which are directed dorsal and caudal and have thick summits. On either wide of the spines there is a groove in which are the three

dorsal sacral foramina; the dorsal branches of the sacral spines, nerves emerge through them.

On the lateral side of the dorsal sacral foramina are a series of tubercles representing the fused transverse processes of the sacral vertebrae, which form the lateral sacral crest. In older goats the dorsal spines may fuse to form the median sacral crest.

**PELVIC SURFACE:** is concave in its length, and is wide cranially, and narrow caudally. It is marked by three more or less distinct transverse lines, which indicate the demarcation of the bodies of the vertebrae. At the ends of these lines are the pelvic sacral foramina, which are larger than the dorsal series and diminish in size from first to last; they transmit the ventral branches of the sacral spinal nerves. The dorsal and pelvic sacral foramina communicate with the sacral canal and are together equivalent to the usual inter-vertebral foramina.

### **THE BORDERS**

**LATERAL BORDERS:** are rough, and thin, the base is directed cranial and is relatively very wide. It presents centrally the body of the first sacral segment which is wide transversally, flattened dorso-ventrally, and has a rounded surface, which articulates with the last lumbar vertebrae by means of an inter-vertebral disc.

The ventral margin projects slightly, forming the promontory.

Dorsal to the body is the entrance to the sacral canal, flanked by a pair of cranial articular processes, which project dorsal and cranial from the arch and have concave surfaces medially for articulation with those of the last lumbar vertebrae.

### **THE BASE**

The lateral parts of the base, the alae or wings, are compressed and strongly curved masses. Caudally there is an elongated oval area, which faces dorso- laterally; this is the auricular surface, which articulates with the ilium; it is slightly concave in its length and somewhat rough and irregular. The rest of the ventral surface of the wing is roughened for ligamentous attachment.

### **THE APEX**

It is the caudal aspect of the last sacral vertebrae and is quite small. It presents flattened caudal surface of the body, dorsal to which is the triangular caudal opening of the sacral canal, surrounded by the last sacral spine.

There is a pair of narrow notches between the arch and the body, dorsal to which rudiments of caudal articular process may occur.

### **SACRAL CANAL**

The name applies to that part of the vertebral canal, which traverses the sacrum.

Its **CRANIAL PART** is large and has the form of a triangle with angles rounded off; its width is nearly twice its height.

Traced **CAUDALLY** it is seen to diminish in size rapidly, and the caudal opening is small and also triangle.

## **COCCYGEAL VERTEBRAE**

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### **Peculiarities**

- The coccygeal (=caudal) vertebrae vary considerably in number, but 18 may be taken as an average.
- From first to last gradually become reduced in size and, with the exception of a few at the beginning of the series, consist of bodies only.
- The **FIRST THREE** have bodies, which are somewhat flattened dorso-ventrally, constricted in the middle and have at both ends convex, elliptical articular surfaces.

### **CHARACTERISTICS**

- The **VENTRAL SURFACE** has a median groove for the median coccygeal artery.
- The **ARCH** is small and triangular; it is formed of two flat plates, which are prolonged to form a short spinous process with a thickened and often double summit.
- The **CRANIAL NOTCHES** are absent.
- Functional **ARTICULAR PROCESSES** are not present but small processes are relatively large plates, which project horizontally laterad. Further caudal the arch becomes incomplete

dorsally and soon disappears; the transverse processes gradually fade out and the vertebrae are reduced to cylindrical rods of diminishing size.

- The **LAST ONE** has a pointed end.

## **RIBS (COSTAE)**

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**CLASSIFICATION:** Modified long bones

**LOCATION:** between the thoracic vertebrae and the sternum.

### **DESCRIPTION**

- The ribs are elongated curved bones, which form the skeleton of the lateral thoracic wall.
- They are arranged serially in pairs, which correspond in number to the thoracic vertebrae.
- They are usually 13 pairs of ribs, but a 14<sup>th</sup> rib on one side or both is not uncommon.
- Each rib articulates dorsally with two contiguous vertebrae and is continued ventrally by a costal cartilage.

**TRUE OR STERNAL RIBS** are those, which articulate with the sternum by means of their cartilages, are termed as true or sternal ribs. The remainder is **FALSE OR ASTERNAL RIBS**.

At the end of the series, which have their ventral ends free and not attached to an adjacent cartilage are named as **FLOATING RIBS**.

<b>Total Pair of Ribs</b>	<b>Sternal</b>	<b>Asternal</b>	<b>Sternebrae</b>
13	8	5	7

- The intervals between the ribs are termed “Intercostal spaces”.
- Ribs from different parts of the series vary greatly in length, curvature and other characteristics.

### **CHARACTERISTICS OF A TYPICAL RIB**

The rib consists of a body and two extremities;

#### **THE BODY**

The body or shaft is band like and varies in length, breadth and curvature in different ribs. The *curvature* is not uniform but is accentuated at a certain point, termed the *angle of the rib*, which is most pronounced in the dorsal third and marked by a rough ridge.

#### **THE SURFACES**

The **Lateral surface** is convex in its length and also transversely; its cranial part is, however, grooved longitudinally.

The **Medial surface** is smooth, concave in its length, and rounded from side to side. The costal groove; situated caudally, is very distinct dorsally and fades out about the middle; it contains the dorsal intercostal vessels and intercostal nerve.

#### **THE BORDERS**

The **cranial** and **caudal** borders are thin and sharp on some ribs, rounded on other.

#### **THE EXTREMITIES**

The **vertebral extremity** consists of the head, neck and tubercle.

The **HEAD** ..... is actual end of the rib and is rounded and somewhat enlarged. It presents two convex facets, cranial and caudal, for articulation with the bodies of two adjacent thoracic vertebrae, except the first, which articulates with the seventh cervical and first thoracic.

The **NECK** ..... joins the head to the body and is roughened dorsally and cranially and varies in length and diameter. Its lateral surface is ..... rough and medial is ..... smooth.

The **TUBERCLE** ..... projects caudally at the junction of the neck and body. It has a facet for articulation with the transverse process. The tubercle gradually approaches the head in the caudal ribs and eventually fuses with it.

The **ventral extremity** is commonly slightly enlarged and is roughened at the junction with the costal cartilage (costo-chondral junction).

### **FIRST RIB**

- It is easily distinguished.
- It is the shortest and the shaft widens greatly toward the ventral end.
- The costal groove is absent.
- The head is large and has two facets of unequal extent, which meet at an acute angle cranially; the smaller one faces cranial and articulates with the last cervical vertebra; the large one is directed medially and articulates with the first thoracic vertebra.
- The neck is thick and very short.
- The tubercle is larger than that of any other rib and has an extensive articular surface, which is convex in its length.
- The ventral end is larger than that of any other rib; it is thick and very wide and is turned a little cranial.

#### **LAST RIB**

- It is the most slender and regularly curved.
- It is usually equal but little longer than the second.
- The facet on the tubercle is confluent with that of the head.

#### **SERIAL POSITION OF THE RIBS**

The serial position of the ribs may be determined approximately by the following consideration:

- ▶ The length increases from the first to the fifth and eighth and then diminishes.
- ▶ The width increases somewhat to the seventh and then diminishes.
- ▶ The groove of the lateral surface is distinct on the fourth to the tenth inclusive.
- ▶ The curvature increases in degree rapidly from the second to the eighth and then decreases very noticeably.
- ▶ In regard to dorso-ventral direction, the first rib inclines a little cranial and the second is about vertical; caudal to this they slope caudal in increasing degree so that a transverse plane tangent to the ventral ends of the last pair cuts the third lumbar vertebrae.
- ▶ The head and tubercle diminish in size from first to last. The relative positions change, in that the tubercle of the first rib is almost directly lateral to the head, further caudal it gradually comes to lie caudal to it.
- ▶ The neck is longest on the longest rib and is absent on the last two or three.

### **COSTAL CARTILAGES**

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The costal cartilages are bars of hyaline cartilage, which continue the ribs.

Those of **TRUE RIBS** articulate with the sternum and those of **FALSE RIBS** overlap and are attached to each other by elastic tissue to form the costal arch.

#### **COSTAL CARTILAGES OF STERNAL RIBS**

The first costal cartilage is 2.5 to 3cm in length. The **DORSAL END** is very wide and thick. The sternal end is small. The two articulate with each other as well as with the sternum.

The cartilages of the other sternal ribs are more rounded. The **STERNAL END** is enlarged and has an elliptical convex facet for articulation with sternum.

#### **COSTAL CARTILAGES OF ASTERNAL RIBS**

The costal cartilages of asternal ribs are long, slender and pointed. They overlap and are attached to each other by elastic tissue, forming the costal arch, as indicated above.

The seventh is very firmly attached to the eighth; it and the next two are the longest. Caudal to this they diminish progressively in size.

- ▶ Except in case of the first, the cartilage does not continue the direction of the rib but form with the latter an angle, which is open cranially and increases in size from second to last.

### **STERNUM**

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The sternum is composed of six unpaired segments; the *sternebrae*.

Consecutive sternbrae are joined by the inter-sternbral cartilage.

**FIRST STERNEBRA**

It is also known as *manubrium*, ends cranially in a club-like enlargement.

**LAST STERNEBRA**

It is flattened dorso-ventrally and is called the *xiphoid process*. The caudal end of this process is continued by a thin plate of the cartilage.

**COSTAL NOTCHES**

There are six to seven costal notches, with which the sternal ends of the second to the seventh costal cartilages, inclusive articulate. These notches are situated in series at the inter-sternbral junctions. They are separated by considerable regular intervals. The area ventral to these notches gives attachment to the pectoral muscles.

**THORAX**

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The bony thorax is remarkably compressed laterally in its cranial part but widens greatly caudally.

**CRANIAL/THORACIC APERTURE OR THORACIC INLET**

It is oval and very narrow. In a goat of medium size; its greatest width is ..... 10cm and its height is ..... 18cm to 20cm.

The VENTRAL WALL or ROOF is about 40cm long and the DORSAL WALL or ROOF about 95 to 100cm long.

The height of the last segment of sternum is about 45cm more than twice that of the cranial aperture; this is due to obliquely and divergence of roof and floor.

- The greatest width of the caudal aperture is about 50 to 60cm.
- The intercostal spaces (measured in their middle) averages about 30cm in width. The first is narrow and they widens to the fourth of fifth. Further caudal they gradually diminish to the last two or three, where they again increase.

**THE SKULL OF GOAT**

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**CLASSIFICATION:** A group of flat and irregular bones.

**LOCATION:** At the cranial extremity of the vertebral column.

**DESCRIPTION**

The skull is divided into two parts, viz. the cranium and the face.

**CRANIUM**

The cranium is composed of the bones of the skull which immediately surround the brain and which are incorporated into the floor and vault of the brain cavity.

**FACE**

The face consists of the bones of the skull which are not the part of the cranium.

**BONES OF THE CRANIUM**

**BONES OF THE FACE**

<b>BONES OF THE CRANIUM</b>		<b>BONES OF THE FACE</b>	
<i>Single Bones</i>	<i>Paired Bones</i>	<i>Single Bones</i>	<i>Paired Bones</i>
Occipital	Frontal	Vomer	Maxilla
Sphenoid	Temporal	Hyoid	Premaxilla (incisive)
Ethmoid	Parietal		Palatine
	Interparietal		Pterygoid
			Nasal
			Lacrimal
			Malar (zygomatic)
			Turbinates (conchae)
			Mandible

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### **GENERAL SHAPE AND FORM**

The skull of the goat, as a whole, is in the form of a long, four sided pyramid, the base of which is caudal. It is convenient to exclude the mandible and hyoid from present consideration.

### **DORSAL (FRONTAL) SURFACE**

It is formed by the Interparietal, parietal, frontal, nasal and incisive bones. It may be divided into parietal, frontal, nasal, and incisive regions.

#### **Parietal region**

It extends from the nuchal crest to the parieto-frontal suture. In most breeds, the sagittal crest is replaced by a pair of paramedian curved temporal lines

#### **Frontal region**

It is smooth and widest part of the surface. This surface is divided by a "V" shaped frontal ridge into two areas. At the caudal end of these ridges are the *cornual processes* for support of the horn. In the polled breeds, these processes are absent. The frontal region is bounded rostrally by the fronto-nasal suture.

#### **Nasal region**

It is convex from side to side, wide posteriorly and narrow rostrally. Thus, its profile is convex. The rostral end is divided by a deep notch.

#### **Incisive region**

It presents the osseous nasal aperture and the inter-incisive fissure.

### **LATERAL SURFACE**

It may be divided into cranial, orbital and maxillary regions.

#### **Cranial region:**

It presents the temporal fossa, zygomatic arch and the outer part of the petrous part of the temporal bone.

##### **Temporal fossa:**

It is bounded medially by the temporal lines, laterally by the temporal crest and the zygomatic arch, and caudally by the nuchal crest. The fossa is continuous rostrally with the orbital cavity.

##### **Zygomatic arch:**

The zygomatic arch is formed by the zygomatic processes of the temporal and zygomatic bone. Its ventral face presents the articular tubercle and mandibular fossa for articulation with the lower jaw.

##### **External acoustic meatus:**

It projects outward through a deep notch in the ventral margin of the squamous part of the temporal bone ventral to the temporal crest.

##### **Mastoid process**

They are located a little caudal to the external acoustic meatus.

#### **Orbital region:**

It comprises the orbit and the pterygopalatine fossa.

##### **Orbit:**

The orbit is a cavity which encloses the eyeball(globe), with the muscles, vessels, and nerves associated with it. It is directly continuous caudally with the temporal fossa.

The **medial wall** is complete and extensive. It is concave and smooth, and is formed by the frontal, lacrimal and the wing of the presphenoid.

The **dorsal wall** is formed by the frontal and to a small extent, by a small part of lacrimal bone.

The **ventral wall** is very incomplete, and is formed by the zygomatic bone and the zygomatic process of the temporal.

The **lateral wall** is the zygomatic process.

#### **Orbital group of foramina:**

The orbital group of foramina is located at the extreme caudal part of this region.

Four are situated rostral to the pterygoid crest.

- (i) **Ethmoid foramen:** is the most dorsal one which transmits the ethmoid vessels and nerves.
- (ii) **Optic foramen:** is situated a little more ventrad and further caudad. It transmits the optic nerve.
- (iii) **Foramen orbitotendinum:** is located just ventral to the optic.
- (iv) **Foramen oval:** is situated caudal and ventral to the preceding one. It opens into the cranial cavity.

#### **Pterygopalatine fossa:**

Ventral to the orbital cavity is the pterygopalatine fossa. Its wall is formed by the pterygoid process, the perpendicular part of the palatine bone and the maxillary tuber. Its deep rostral recess contains three foramina;

- (i) The dorsal one ..... **Maxillary foramen** is the entrance of the infra-orbital canal: which transmits the infra-orbital nerve and vessels.
- (ii) The **spheno-palatine foramen** perforates the medial wall of the recess and transmits vessels and nerves of like name to the nasal cavity.
- (iii) The ventral foramen ..... **Major palatine**, transmits the major palatine artery and nerve. The dorsal part of the fossa is smooth, the ventral part is chiefly roughened for the attachment of the pterygoideus lateralis.

#### **Maxillary region:**

The maxillary region is chiefly formed by the maxilla, but also by the incisive (premaxilla) and the facial parts of the lacrimal and zygomatic bones.

Its contour is approximately triangular, the base being caudal. It offers two principal features:

- (i) **Facial crest:** extends rostrad from the middle of the rostral margin of the orbit, and ends abruptly at a point about 3 to 3.5 cm dorsal to the 3<sup>rd</sup> or 4<sup>th</sup> cheek tooth; its ventral aspect is rough for the attachment of the masseter muscle.
- (ii) **Facial tubercle:** is present about 1 cm above the 3<sup>rd</sup> and 4<sup>th</sup> cheek tooth.

#### **Infra-orbital foramen:**

It is situated about 2 to 3 cm rostral to the end of the facial tubercle. The foramen opens rostrad, and via it, the infra-orbital artery and nerve emerge.

### **VENTRAL (BASAL) SURFACE**

The ventral or basal surface, exclusive of the mandible consists of cranial, choanal, and palatine regions.

#### **Cranial region:**

It extends rostrally to the vomer and pterygoid processes.

#### **Foramen magnum and Condylloid fossa:**

At its caudal end is the foramen magnum, flanked by the occipital condyles. Lateral to these is the condylloid fossa, in which the hypoglossal canal, which transmits the hypoglossal nerve and condylloid vein. Further laterad are the jugular processes of the occipital bone. Extending rostrad centrally is a plate, formed by the basilar part of the occipital and the body of the basi-sphenoid bone; at the junction of these parts are tubercles for the attachment of the rectus capitis ventralis and logus capitis muscles.

Laterally the basilar part of the occipital bone is bounded by the petroccipital fissure and the foramen lacerum rostrally. Rostral to these, the region becomes very wide in account of the lateral extension of the zygomatic processes, which present ventrally the articular tubercle and mandibular fossa for articulation with the mandible. Beyond this, the process turns rostrad and joins the temporal process of the zygomatic bone, completing the zygomatic arch and the surface for the attachment of masseter muscle.

On either side of the body of the basi-sphenoid is the **infratemporal fossa**, formed by the wing and the root of the pterygoid process of the basi-sphenoid bone. It is bounded

rostrally by the *pterygoid crest*, which separates it from the orbit and *pterygopalatine fossa*. Just ventral is the entrance to the *pterygoid canal*.

### **Choanal region:**

The choanal region presents the pharyngeal orifice of the nasal cavity. This region is divided in its depth (i) **medially** by the vomer into two narrow choanae. It is bounded (ii) rostrally and (iii) laterally by the palatine and pterygid bones, (iv) caudally by the vomer. It is flanked by the *hamulus process* of the pterygoid bone. The plane of the opening is nearly horizontal, and the length is about twice the width.

### **Palatine region**

It comprises a little less than half of the entire length of the base of the skull. The hard palate is concave from side to side, and in its length also in the rostral part. It is formed by the palatine processes of the incisive and maxillae, and the horizontal plates of the palatine bones.

It is circumscribed rostrally and laterally by the alveolar parts of the maxillae and incisive.

**Inter-alveolar space:** is that part of the arch in which alveoli are not present. Caudal to the last alveolus is a tuberosity. On the midline is the *median palatine suture*. The palatine fissure is the narrow interval along the lateral margin of the palatine process of the incisive; it is closed in the fresh state by the vomeronasal cartilage.

The transverse palatine suture is about 1.5 cm from the caudal border. The latter is opposite to the fourth or fifth cheek tooth in the adult.

### **OCCIPITAL (NUCHAL) SURFACE**

The occipital or nuchal surface is formed by the occipital bone. It is pentagonal in outline, wider dorsally and convex transversally. It is separated from the dorsal surface by the nuchal crest. Ventral to the crest are two rough areas for the attachment of the semispinalis capitis. A little more ventral is a central eminence, the external occipital protuberance. On which the nuchal ligament is attached. At the most ventral part centrally is the foramen magnum. This is bounded laterally by the occipital condyles, lateral to which is the *jugular process*.

- The apex of the skull is formed by the bodies of the incisive and mandible.

## **MANDIBLE OF GOAT**

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The mandible is the largest bone of the face and forms the lower jaw.

### **FORMATION**

It is composed of two halves which fuse cranially at the symphysis mandibulae and is considered as a single bone. It contains the lower teeth and articulates with the squamous temporal at the condyloid fossa.

### **DESCRIPTION**

The mandible consists of a body and two rami (singular: ramus) and possesses two pair of major foramina, the mental and the mandibular.

### **THE FORAMINA**

The mental foramina are located laterally on the body midway between the first premolars and the canine teeth.

The mandibular foramina are located medially about halfway of the rami. These foramina are the caudal opening of the mandibular canal.

### **MANDIBULAR CANAL**

The mandibular canal is located in the ramus and body of the mandible. It transmits the mandibular artery and veins and the mandibular alveolar nerve. The mandibular foramen is the caudal opening of the mandibular canal whereas it opens rostral at the mental foramen.

## **VOMER & HYOID BONE**

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**VOMER BONE**

The vomer is the medial bone which enters into the formation of the ventral part of the septum nasi. It is grooved to receive the perpendicular plate of the ethmoid bone and the septal cartilage. The cranial extremity lies above the palatine process of the premaxilla (incisive).

**HYOID BONE**

**LOCATION**

The hyoid bone lies mainly between the rami of the mandible.

**ATTACHMENTS**

Caudally it is attached by cartilaginous rods, the tympanohyoids, to the styloid process of the petrous part of the temporal bones. Rostrally it is associated with the tongue, pharynx and larynx.

**DESCRIPTION**

The hyoid bone is composed of number of parts; some single and other are paired.

- 1) The **basihyoid** is short and flattened and lies in a transverse plane.
- 2) A short **lingual process** is situated centrally on the rostral.
- 3) The paired **thyrohyoid** is not firmly attached to the basihyoid. They are long (2.5 to 3 cm) and narrow and articulate caudally with the rostral cornua of the thyroid cartilage of the larynx.
- 4) The **ceratohyoid** and 5) **epihyoid** are small rounded bones situated on each side between the basihyoid and the stylohyoid.
- 6) The **stylohyoid** articulates rostrally with the epihyoid and caudally with the styloid process of the temporal bone. The bone is elongated, flattened and about 6cm long and 5mm wide. The rostral end is slightly expanded, while the caudal end bifurcates.
- 7) The dorsal part of the caudal end articulates with the styloid process of the temporal bone by the **temporohyoid**, 8) and the ventral part is the **muscular process**.

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