1

The Head, Neck, and Vertebral Column

Learning Objectives

- Identify the main bones and some of their palpable features on the bovine skull. Examples of important features include the temporal line, lacrimal bulla, zygomatic arch, facial tuberosity, nasoincisive notch, foramen orbitorotundum, optic canal, supraorbital foramen, infraorbital foramen, mandibular foramen, mental foramen, and body of the mandible.
- Identify the features of the most clinically important frontal and maxillary sinuses. Know the compartments of the frontal sinus (2–3 rostral and 1 caudal). Study the diverticuli of the caudal compartment of the frontal sinus (cornual, nuchal, and postorbital). Note the dividing thin bony septa of the frontal sinus (transverse oblique and median septum). Identify the lacrimal bulla, the most caudal extent of the maxillary sinus. In dehorning operations in goats, you should keep in mind the superficial location and shallow depth of the frontal sinus at the base of the horn.
- Be able to recall the dental formula and methods for estimating age of cattle and goats using eruption times and changes in the occlusal surface of lower incisor teeth.

Guide to Ruminant Anatomy: Dissection and Clinical Aspects, First Edition. Mahmoud Mansour, Ray Wilhite, and Joe Rowe.

Companion Website: www.wiley.com/go/mansour/dissection

Know that the incisor and canine teeth in the upper jaw are absent and are replaced by a fibrous structure known as the dental pad.

- Identify clinically important superficial structures on lateral head views (cornual nerve, supraorbital nerve, infraorbital nerve, mental nerve, dorsal and ventral buccal and auriculopalpebral branches of the facial nerve). Clinically important vessels include the frontal vein, the facial artery (pulse in cattle), and transverse facial artery (pulse in goats). In the neck, identify the external jugular vein, superficial cervical lymph nodes, accessory and great auricular nerves, and parts of the nuchal ligament.
- Identify nerve and blood supply to the horns. You should know the difference in nerve supply of the horn in small and large ruminants, and which nerve or nerves to block in dehorning operations. Note the differences in location and direction of the horn in small and large ruminants. Understand that dehorning is best carried out when the animal is 1–2 weeks of age. Know the meaning of the term epiceras.
- Identify clinically important structures on a paramedian section of the head (lingual torus and lingual fossa, nasal conchae, medial retropharyngeal lymph node, and other oral, pharyngeal, and laryngeal structures on your laboratory ID list).
- Describe some of the methods and structures associated with enucleation (removal) of the eye that has cancer (i.e., retrobulbar and Peterson's nerve blocks).
- Identify lymph nodes of the head (parotid, mandibular, and lateral and medial retropharyngeal lymph nodes). In the neck, identify the superficial and deep cervical lymph nodes. Know that the lateral retropharyngeal lymph node is the major collection center for lymph from the ruminant head. Understand that the medial and lateral retropharyngeal lymph nodes are incised and examined in meat inspection. You should also know the drainage area for each node.
- Identify major salivary glands of the head (parotid, mandibular, and sublingual).
- Identify neck muscles that form the dorsal and ventral boundaries for the jugular groove (or furrow). Know the difference between jugular groove muscular boundaries in cattle, goat, and sheep. Sheep have a less distinct jugular furrow because of the absence of the sternomandibularis muscle. This muscle forms the ventral boundary in cattle and goats. It is also called sternozygomaticus muscle in goats.
- Recall the vertebral formula for large and small ruminants. Know vertebral locations for epidural anesthesia in cattle.

1.1 Skull

Goal: With the help of Figures 1.1–1.9, study the main features of the bovine and caprine skulls on dorsal, lateral, caudal, and ventral views. You should place emphasis on the main paranasal sinuses and bony landmarks for blocking clinically important nerves of the head (e.g., temporal line [corneal nerve], zygomatic arch [auriculopalpebral nerve], infraorbital and mental foramina [infraorbital and mental nerves, respectively], and foramen orbitorotundum [oculomotor, trochlear, ophthalmic, and abducent nerves]).

Before you start your dissection of the head, study the bovine skull. Make comparisons with goat and sheep skulls whenever indicated.

The skull is part of the axial skeleton. In addition to the skull, the **axial skeleton** includes bones of the **vertebral column, ribs,** and the **sternum**.

The functions of the skull include protection of the brain, sensory organs, and the upper gastrointestinal and respiratory tracts.

The mandibles and the hyoid apparatus articulate with the skull but are technically not part of the skull. However, they will be studied with the bones of the skull.

The most striking features of the adult bovine skull is the flattened dorsum (frontal bone), the presence of the **cornual process** (the bony part of the horn), **facial tuberosity** (a bony prominence on the lateral surface of the maxilla), and the lack of upper incisor teeth and their replacement with the **dental pad** in the live animal.

The dorsum of the skull in goats and sheep is slightly dome-shaped compared with the flat frontal bone in adult cattle. However, in young calves the skull is dome-shaped, similar to the skull in small ruminants.

Look at the dorsal view of the bovine skull and, with the help of Figures 1.1 and 1.2, study

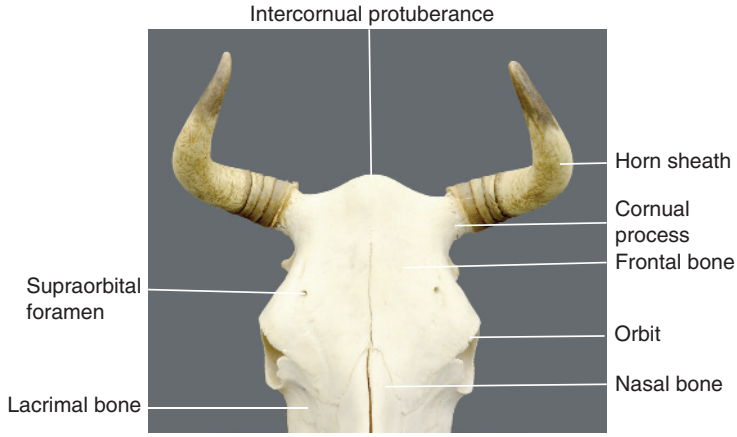


Figure 1.1 Bovine skull: caudodorsal view. The epidermal part of the horn (horn sheath or capsule) and the bony part (cornual process) form the horn. Akin to the hoof, the horn sheath and the cornual process are glued together by dermal tissue that contains blood vessels and nerve endings of the corneal nerve and artery. The cornual process and the horn capsule are sawed in dehorning operations.

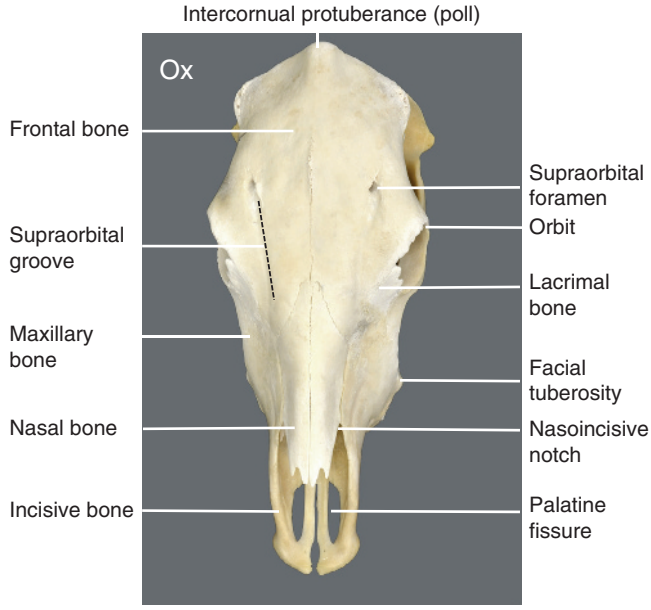


Figure 1.2 A polled (no horns present) bovine skull: dorsal view. Dotted line shows the location of right supraorbital groove. In the live animal, the supraorbital groove houses the supraorbital vein (called the frontal vein after passing through the supraorbital foramen). The ox may have multiple supraorbital foramina (single in small ruminants).

the following bones and features: **frontal bone, cornual process** of the frontal bone (if present in your specimen), **lacrimal bone, nasal bone, incisive bone, nasoincisive notch, intercornual protuberance, supraorbital groove,** and **supraorbital foramen**.

Study the nerves passing through some of the foramina listed on your laboratory ID list (Table 1.1).

Note that the **cornual process** in cattle lies several centimeters caudal to the eye or bony orbit. It extends in lateral and dorsal directions (Figure 1.1). In goats, it lies relatively close to the caudal border of the eye and extends in a caudal rather than lateral direction (Figure 1.3).

The cornual process grows from the frontal bone. Much like the hoof structures, the horn has a bony part (cornual process), dermal and epidermal (horn sheath) parts layered on the cornual process.

The epidermal **horn sheath** and the cornual process form the horn. If the horn sheath is not separated from the corneal process, you should be able to identify both the cornual process and horn sheath on the skull as shown in Figure 1.1.

Table 1.1 Major foramina of the bovine skull and nerves passing through them. Understand that there are vessels that accompany these nerves (not listed). CN V-1, ophthalmic subdivision of CN V; CN V2, maxillary subdivision of CN V.

Foramen/canal	Nerve
Supraorbital foramen	Supraorbital nerve (continuation of frontal nerve, a branch of the ophthalmic division of the trigeminal nerve)
Maxillary foramen–infraorbital canal–infraorbital foramen	Infraorbital nerve (continuation of the maxillary subdivision of the trigeminal nerve)
Mandibular foramen–mandibular canal–mental foramen	Inferior alveolar nerve, mental nerve (continuation of the inferior alveolar), branches of the mandibular subdivision of the trigeminal nerve
Foramen orbitorotundum	Oculomotor nerve (CN III), trochlear nerve (CN IV), ophthalmic (CN V-1) subdivision of the trigeminal nerve, maxillary (CN V-2) nerve subdivision of the trigeminal nerve, and abducent nerve (CN VI)
Optic canal	Optic nerve (CN II)
Caudal palatine foramen–major palatine foramen	Major palatine nerve, a branch of the maxillary nerve subdivision of the trigeminal nerve
Sphenopalatine foramen–nasal cavity	Caudal nasal nerve, branch of the maxillary nerve, a subdivision of the trigeminal nerve

Box 1.1

Drilling a circular hole in the skull or other bones is known as trephination. This hole is generally made to drain inflammatory exudate and flush sinuses in the skull with antiseptic solution. Diseases of the frontal sinus result from microbial infections mostly from dehorning operations in cattle.

Box 1.2

In the ox, the supraorbital groove is palpable. It houses the supraorbital or **frontal vein**. In rostral frontal sinus surgery (i.e., trephination), the frontal vein must be avoided.

Turn the skull so that the lateral surface is facing you. With the help of Figures 1.3 and 1.4, identify the **facial tuberosity, maxilla, body of the mandible, infraorbital foramen, temporal line,** and **the bony rim of the orbit.** Identify the **zygomatic arch** and note that it is formed by two bones, the **zygomatic bone rostrally,** and the **zygomatic process of the temporal bone caudally** (Figure 1.4). The caudal part of the zygomatic bone is called the **temporal process of the zygomatic bone**.

On the lateral facial surface of the skull, ruminants have a circumscribed **facial tuberosity**

Box 1.3

In dehorning operations in cattle, the **temporal line** is used as palpable landmark to block the **cornual nerve** which innervates the horn in cattle. The cornual nerve emerges from the orbit and courses toward the base of the horn along the temporal line. The **cornual artery,** which supplies the horn, must also be ligated or its branches cauterized (for more details of the nerves that supply the horn see Box 1.18)

In adult goats, three nerves must be blocked to anesthetize the horn:

1) The **cornual nerve:** block is between the lateral canthus of the eye and lateral part of the base of the horn.
2) The cornual branches of the **infratrochlear nerve:** block is more medial than that of the cornual nerve between medial canthus of the eye and medial edge of the base of the horn.
3) Cornual branches of the **caudal auricular nerve:** at the back of the ear.

Additionally, a ring nerve block is sometimes performed by depositing a local anesthetic around the base of the horn to achieve maximal pain suppression.

In goats, general anesthesia is sometimes used as better alternative than local anesthesia.

The horn can then be sawed off using a hacksaw or obstetrical wire.

Horn buds (called horn buttons) are typically eliminated in young animals to prevent horn growth. Several procedures, including chemical or heat cautery, are used to prevent growth of the horn buds. Several dehorner devices such as tube or spoon dehorners, lever-type dehorners, and surgical saws are used to remove horns when they are very small.

In dehorning of adult goats, care must be taken not to expose the brain cavity because of the proximity of the cornual process and parietal bone.

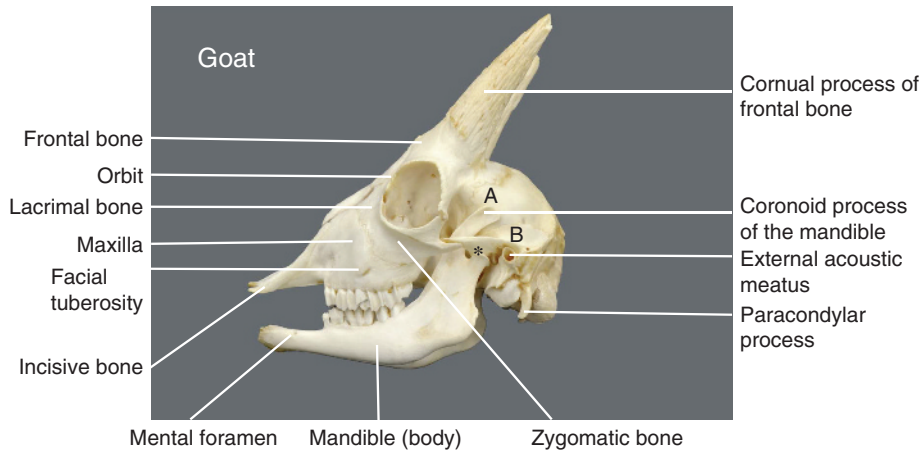


Figure 1.3 Goat skull: lateral view. The horn sheath (epidermal part) is removed. * Temporomandibular joint (TMJ). A, parietal bone; B, temporal bone. Note the proximity of the cornual process to the parietal bone. In dehorning of mature goats, the cut must not be made too far caudally to avoid exposure of the brain.

(Figure 1.4) compared with a longitudinal long bony ridge known as the facial crest in the horse.

Identify the **infraorbital foramen** on the lateral surface of the maxilla (Figure 1.4). The infraorbital nerve (terminal branch of the maxillary nerve) emerges on the face through this foramen.

Note that the bony orbit is complete in ruminants by fusion of the **zygomatic process of the frontal bone** (ZF) and the **frontal process**

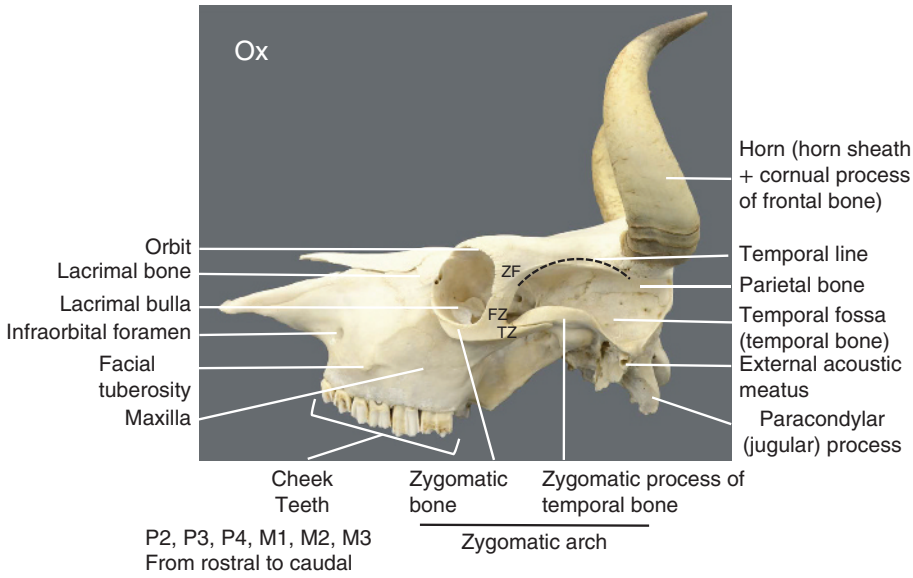


Figure 1.4 Bovine skull: lateral view. The bony orbit is complete where the frontal process of the zygomatic bone (FZ) and the zygomatic process of the frontal bone (ZF) meet. The FZ is not present in the horse. The zygomatic arch is palpable in the live animal and is formed by two bones: the zygomatic bone rostrally and zygomatic process of the temporal bone caudally. **Temporal line** (dotted) is used as a landmark for blocking the cornual nerve in dehorning operations in adult cattle. M, molar; P, premolar. P1 is not present in upper or lower jaws. TZ, temporal process of the zygomatic bone.

Box 1.4

The infraorbital nerve passes out of the skull through the infraorbital foramen. Infraorbital nerve block is sometimes used in cattle to repair nasal laceration and/or to place nasal rings in bulls.

of the zygomatic bone (FZ) (Figures 1.4 and 1.5). This is also true for the horse skull.

In the dog, the orbit is incomplete, and the gap on the orbital rim is bridged by a rigid fibrous structure known as the orbital ligament.

Note the prominent but very thin **lacrimal bulla** within the rostral confinement of the orbit (Figure 1.4). The maxillary sinus extends caudally into the lacrimal bulla.

The angle between the temporal process of the zygomatic bone and the frontal process of the zygomatic bone (FZ) is used as landmark for needle insertion when anesthetizing nerves emerging from the **foramen orbitorotundum** that course to the eye (Figure 1.5).

In ruminants, the foramen orbitorotundum represents the combination of the orbital fissure and round foramen present in other species (e.g., dog). The ophthalmic, oculomotor, trochlear, and abducent nerves pass from the brainstem to the orbital space through the foramen orbitorotundum to supply various structures of the eye.

Box 1.5

The lacrimal bulla is vulnerable to puncture in enucleation (removal) of the eye by the retrobulbar technique. Read more about the retrobulbar technique in the nerve block section (Box 1.6).

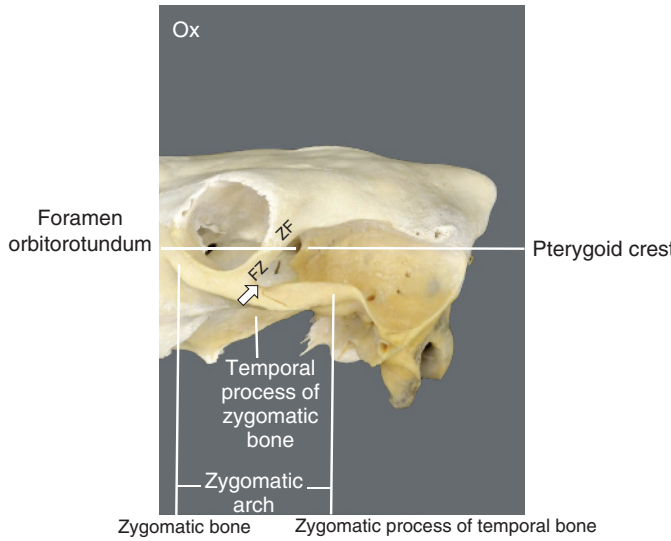


Figure 1.5 The bovine skull showing the bony land marks for Peterson's nerve block: caudolateral view. The white arrow points to the angle where the needle is inserted to deposit an anesthetic close to the foramen orbitorotundum. The pterygoid crest and coronoid process of the mandible are encountered and avoided as a long curved needle is advanced toward the foramen. FZ, frontal process of the zygomatic bone; ZF, zygomatic process of the frontal bone.

Box 1.6

Anesthesia for enucleation of the eye can be performed by two standardized techniques known as retrobulbar (or modified retrobulbar) technique or by Peterson's nerve block.

In Peterson's nerve block, the angle between the frontal process of the zygomatic bone and the zygomatic bone is used for needle insertion where an anesthetic is deposited close to the foramen orbitorotundum to block several nerves coursing to the eye. The coronoid process of the mandible and the pterygoid crest should be avoided.

Because Peterson's nerve block requires advanced technical skill, the retrobulbar technique is considered as an easier alternative. The medial and lateral canthi of the eye and upper (superior) and lower (inferior) eyelids are used as landmarks for anesthetic injection at four points. In this procedure, care should be taken to avoid damaging the thin lacrimal bulla, a caudal extension of the maxillary sinus (Figure 1.4).

Look at the caudal aspect of the skull and, with the help of Figure 1.6, identify the **occipital condyles** and the large **foramen magnum** between the occipital condyles. The spinal cord exits the cranium through foramen magnum. The **paracondylar processes** (also called jugular processes) run parallel to the occipital condyles. The digastricus muscle that opens the jaw originates from the paracondylar process. Identify the **external occipital protuberance** on the caudal aspect of the skull ventral to the **intercornual protuberance**. The funicular part of the nuchal ligament attaches to the external occipital protuberance. The intercornual protuberance, located between the horns, forms the highest point of the bovine skull

In small ruminants, the nuchal crest (or poll) forms the highest point. The nuchal crest is not present in cattle but they instead have a nuchal line (Figure 1.6).

On the ventral aspect of the skull and with the help of Figure 1.7, identify the basilar part of the occipital bone (basiooccipital), palatine

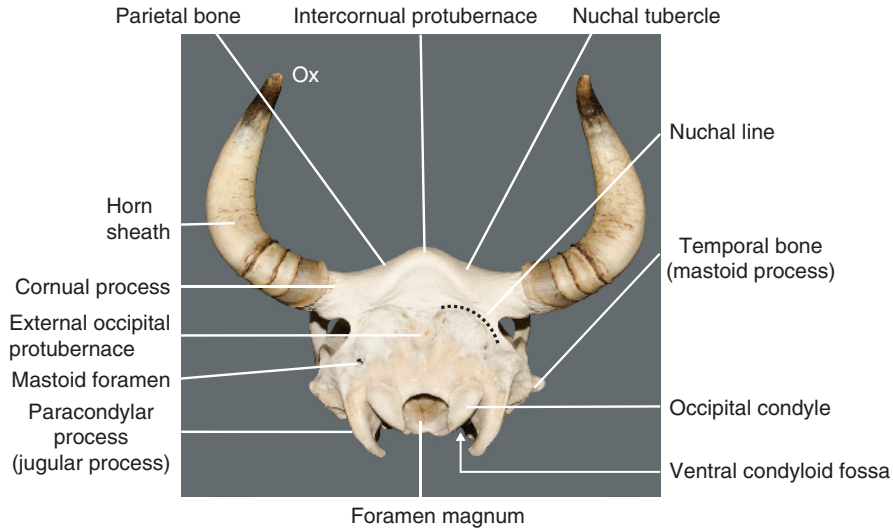


Figure 1.6 Bovine skull showing caudal parts of the occipital bone: caudal view. The foramen magnum is the exit pathway for the spinal cord. The external occipital protuberance is the attachment site for the funicular part of the nuchal ligament. In small ruminants, the nuchal crest (poll) forms the highest point of the skull. The nuchal crest is not present in the ox.

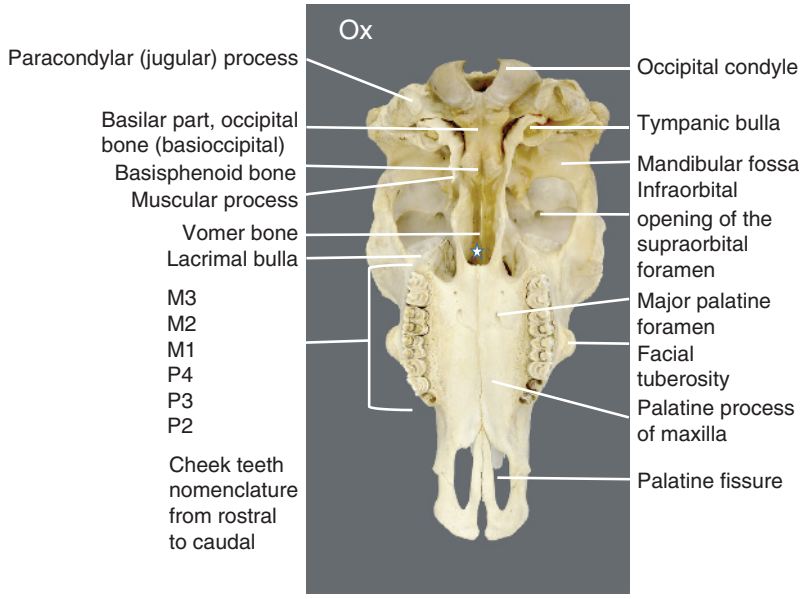


Figure 1.7 The bovine skull: ventral view. * Choanal region, caudal opening of the nasal cavity into the nasopharynx in the live animal. M, molar; P, premolar. The premolar teeth start with P2 in both the upper and lower jaws (the upper P2 are removed to show the shallow alveolar sinuses [teeth sockets in lay terms]). The upper and lower P1 are considered absent in ruminants (see lower P2 in Figure 1.8a). The roots of the cheek teeth in ruminants are shallow compared with horses and it is possible to remove upper cheek teeth without entering the maxillary sinus.

fissure, tympanic bulla, and the choana (plural choanae), a funnel-shaped caudal opening of the nasal cavities into the nasopharynx. Because of time constrains and lack of clinical relevance, most of the structures on the ventral aspect of the skull may not be part of your identification list. Ask your instructor for advice.

1.2 Mandible

Goal: Identify the regions of the mandible, and vessels and nerves passing through the mandibular and mental foramen.

The mandible has horizontal (**body**) and vertical (**ramus**) parts (Figure 1.8). The junction of the ramus and body forms the **angle** of the mandible.

On the proximal aspect of the ramus, identify the caudally pointing **coronoid process**. The **condylar process** extends caudally from the ramus where it articulates with the mandibular fossa of the skull to form the **temporomandibular joint** (TMJ). A **mandibular notch** separates the coronoid and condylar processes.

The coronoid process in the horse is vertically oriented.

On the medial side of the ramus, identify the **mandibular foramen** (Figure 1.8b), the point of entry to the mandibular canal within the body of the mandible. The inferior alveolar nerve enters the mandibular foramen and traverses the mandibular canal giving alveolar branches to the mandibular teeth (Table 1.1). It emerges on the lateral surface as the mental nerve through the mental foramen.

On the rostrolateral surface of the body, identify the **mental foramen**. The mental nerve (sensory) passes out of the mandibular canal as a continuation of the inferior alveolar nerve. It conveys sensation from the skin and mucosa of the lower lips.

Find the mandibular symphysis on the medial side of the mandible (Figure 1.8b). This is a fibrous joint that connect the left and right mandibles. The mandibular symphysis in cattle is weaker than that of the horse and ossifies late in life. Fracture of the mandible is rare in cattle but can occur in young calves following manipulation of the head with a snare.

1.3 Paranasal Sinuses

Goal: Identify the maxillary sinus, the rostral and caudal frontal sinuses, and the diverticuli associated with the caudal frontal sinus on the bovine skull (Figure 1.9). Other paranasal sinuses (Figure 1.10) are minor spaces with less clinical significance. Compare and contrast the cavities of the frontal and maxillary sinuses in the ox with those of small ruminants. At the end of this section watch **video 1.**

Adult ruminants possess a complex set of paranasal sinuses (empty spaces between the external and internal plates of the bones of the cranium and bones of the face). Not all of them are of clinical interest. In young calves, the paranasal sinuses are poorly developed.

Sinus infections with mucoid or purulent discharge or blockage of normal drainage through the nasal cavity represent important clinical issues in bovine medicine.

Small ruminants have the same set of sinuses present in cattle, but they are relatively shallow and lack some of the communications present in cattle.

The following is a complete list of all the sinuses that are present in the adult ox.

1) **Frontal sinus,** divided into:
   - Rostral compartment: forms minor part of the frontal sinus and has 2–3 small chambers (lateral, intermediate, and medial compartments)
   - Caudal compartment: forms the major part of the frontal sinus.

   The caudal compartment of the frontal sinus has three diverticuli **cornual, nuchal,** and **postorbital diverticuli.**
2) Sphenoid sinus: lies in the rostral part of the floor of the cranium and extends into the orbital wing of the sphenoid bone. It

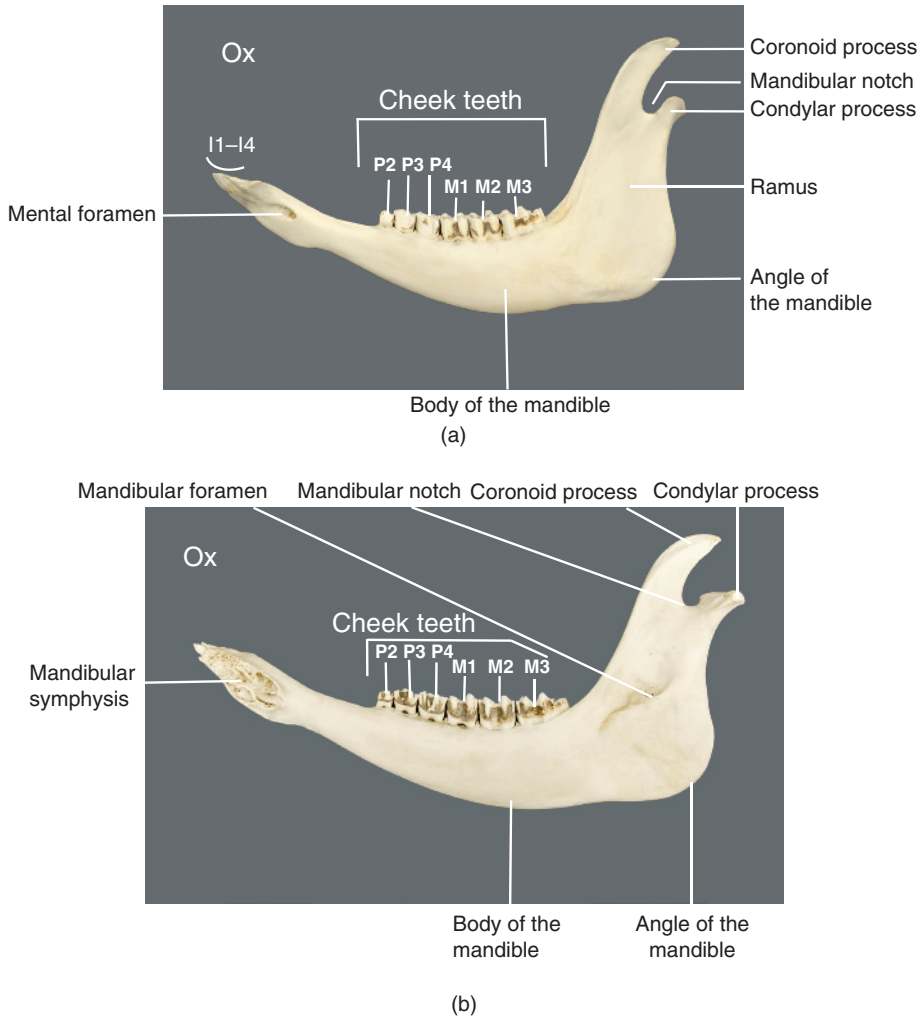


Figure 1.8 (a) Bovine mandible: lateral view. I, incisor; M, molar; P, premolar. The coronoid process in the horse is vertically oriented compared with caudally inclined coronoid processes in ruminants. (b) Bovine mandible: medial view.

communicates with the middle nasal meatus via ethmoidal meatuses.

3) Ethmoid sinus: multiple spaces within the turbinates of the ethmoid bone.
4) Conchal sinuses: dorsal, middle, and ventral conchal sinuses. In the horse, the dorsal conchal sinus communicates with the frontal sinus forming the frontochoncal sinus.
5) **Maxillary sinus:** the cavity medial to the maxilla and dorsal to the upper cheek teeth. It extends into the lacrimal sinus and lacrimal bulla.
6) Palatine sinus: the cavity within the hard palate. It is present in ruminants and pigs.
7) Lacrimal sinus: excavation of the lacrimal bone. It is present in ruminants and pigs.

The **maxillary sinus** is a large space predominately medial to the maxilla and above the upper cheek teeth (Figure 1.9c). It extends into the lacrimal bulla within the bony orbit and communicates with the lacrimal sinus dorsally, and the palatine sinus medially. Unlike the horse, the maxillary sinus in cattle

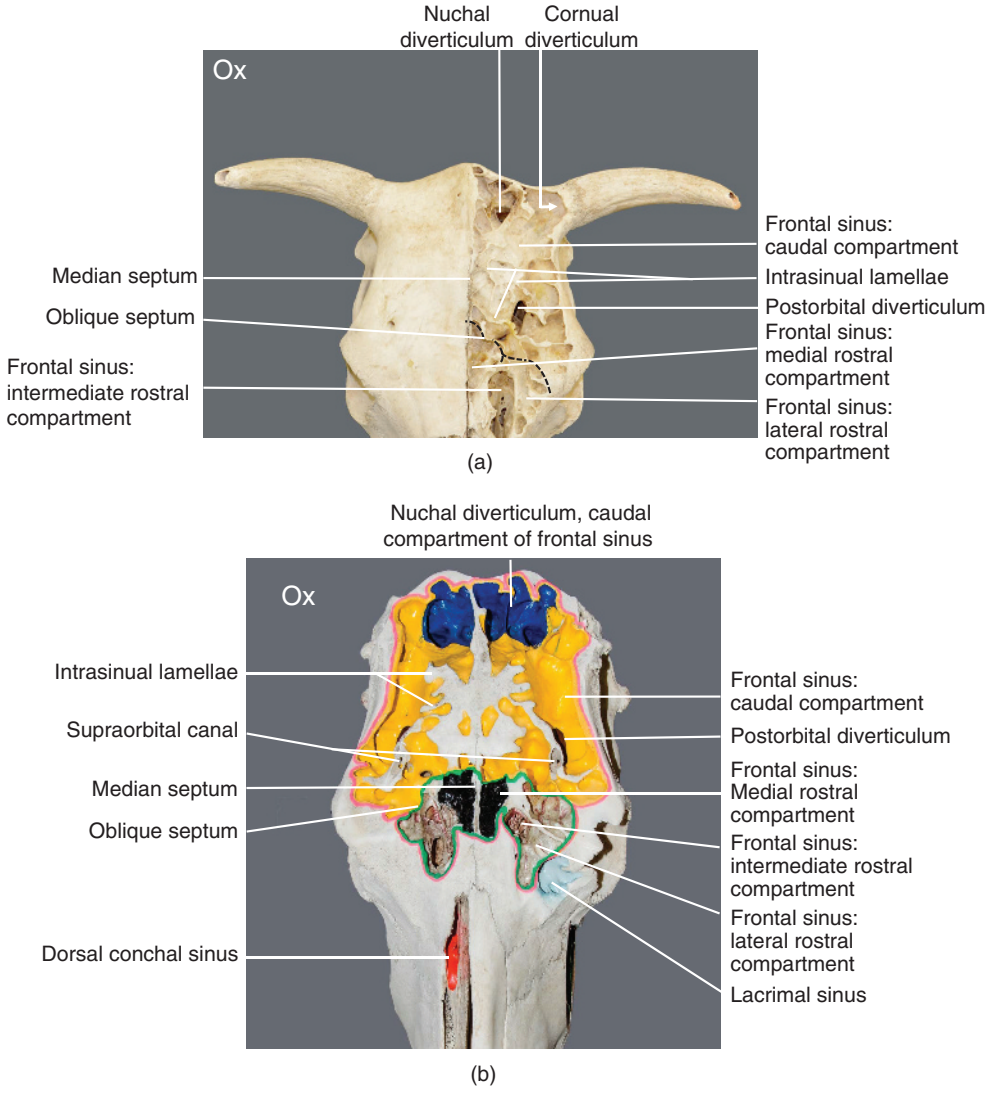
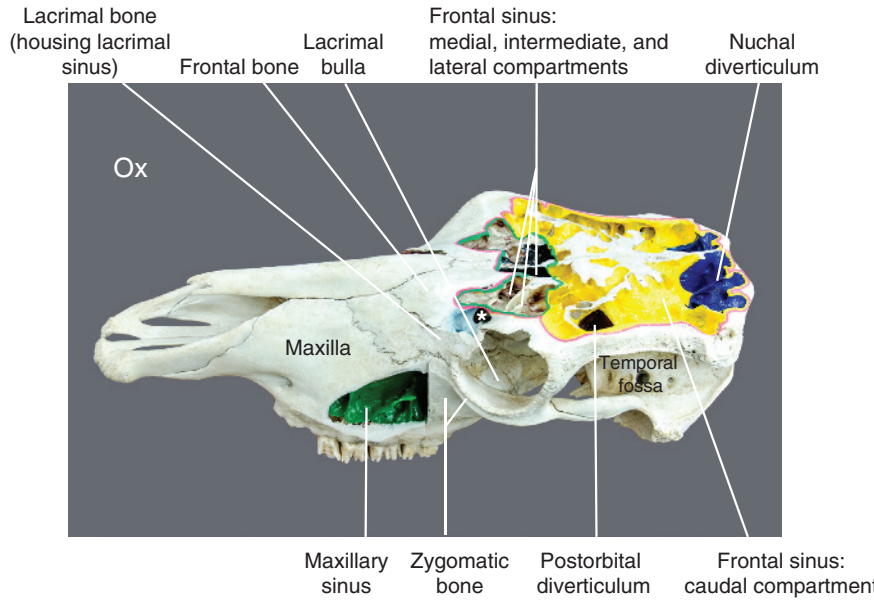
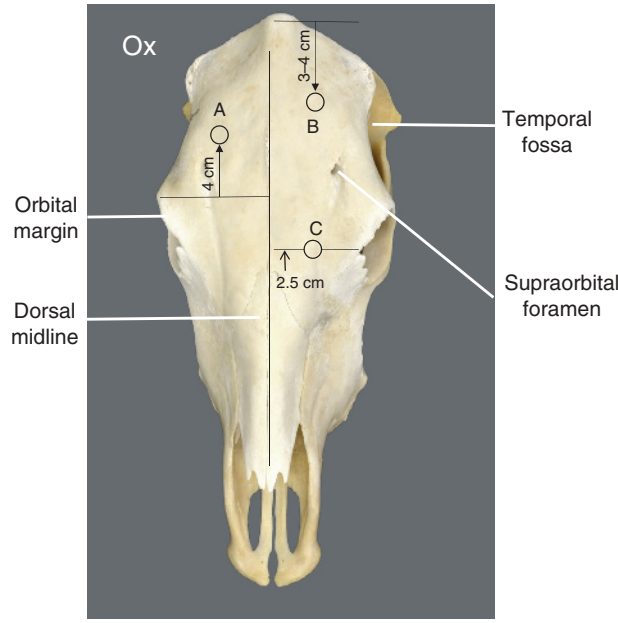


Figure 1.9 (a) Bovine skull with sculptured frontal sinus: dorsal view. An oblique transverse septum (dotted line) divides the frontal sinus into rostral and caudal compartments. The line extends obliquely from the mid-dorsal border of the orbit to the median septum. The median septum separates the left and right frontal sinuses. The caudal compartment of the frontal sinus has three diverticuli the cornual (within the cornual process), nuchal (rostral to the nuchal tubercle), and postorbital (caudal to the orbit) diverticuli. The bony supraorbital canal, which houses the supraorbital vein, passes through the caudal compartment of the frontal sinus. (b) Compartments of the bovine left and right frontal sinus. Bovine skull showing caudal (yellow and blue) and rostral (multiple colors) compartments and diverticuli of the frontal sinus: dorsal view. The caudal compartment of the frontal sinus is larger than the rostral compartment and has three diverticuli (postorbital, nuchal, and cornual). The cornual diverticulum is absent in this skull (no horns present; Figure 1.9a). The rostral compartment of the frontal sinus is divided into three smaller spaces (lateral, intermediate, and medial parts). The rostral and caudal compartments of the frontal sinus communicate with ethmoidal meatuses (not visible). Another major paranasal sinus in cattle is the maxillary sinus (Figure 1.9c). Minor sinuses of less clinical significance include the lacrimal, palatine, sphenoid, and conchal sinuses (Figure 1.10).



(c)



(d)

Figure 1.9 (Continued) (c) Bovine skull showing the maxillary and frontal sinuses: dorsolateral view. The lacrimal bulla is a very thin and excavated bony structure. It represents the caudal extent of the maxillary sinus. The maxillary sinus communicates with the lacrimal sinus (at the junction of frontal and lacrimal bone) and with the nasal cavity through the middle nasal meatus. * Lacrimal sinus. (d) Selected trephination sites of the frontal sinus (small circles). Site A: postorbital diverticulum, located about 4 cm caudal to the caudal edge of the orbit and above the temporal fossa. Site B: caudal part of frontal sinus (major part of frontal sinus), drilled 4 cm rostral from topmost of the head and midway between the base of the horn and the dorsal midline. Site C: rostral frontal sinus, drilled 2.5 cm laterally from the dorsal midline on a perpendicular midline line passing through the center of the orbit.

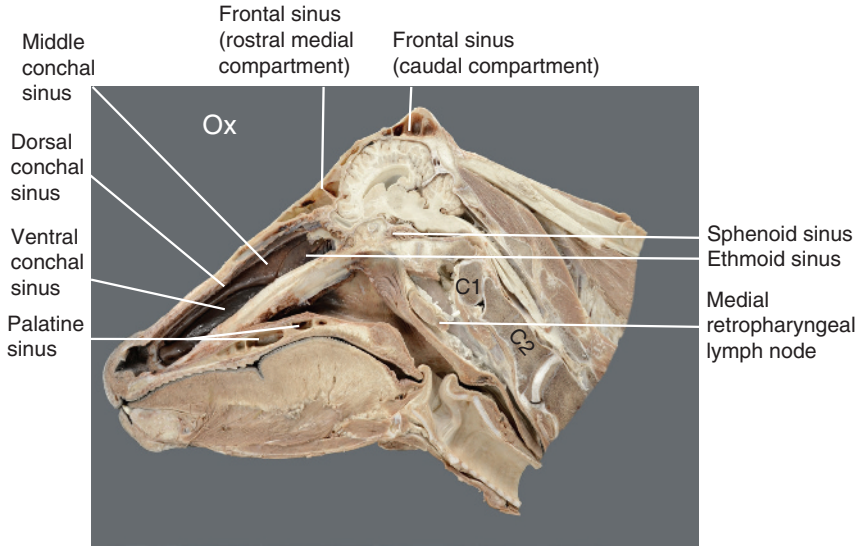


Figure 1.10 Bovine head: sagittal section. The figure shows the location of the conchal sinuses within the nasal conchae. The frontal, sphenoid, ethmoid, and middle conchal sinuses open into the ethmoid meatuses at the caudal aspect of the nasal cavity. The palatine sinus is the space within the caudal part of the hard palate. C1, atlas; C2, axis.

is not divided by a septum into caudal and rostral compartments.

The maxillary, palatine, ventral conchal, and lacrimal sinuses drain into the **middle nasal meatus**. The frontal, sphenoid, ethmoid, and middle conchal sinuses have individual openings into the **ethmoid meatuses** at the most caudal part of the nasal cavity (Figure 1.10).

The palatine sinus is not present in carnivores (dogs and cats). In the horse, the palatine and sphenoid sinuses merge together forming the sphenopalatine sinus.

The **frontal sinus** has multiple compartments (Figure 1.9a,b,c). Using a bovine skull with the sinuses exposed, study the maxillary sinus and the caudal and rostral compartments of the frontal sinus (Figures 1.9a,c and 1.10).

In cattle, the frontal sinus is more elaborate compared with the shallow frontal sinus in goats (Figures 1.9a,b,c and 1.11). On the bovine skull where the dorsal plate of the frontal bone is removed, note that the frontal sinus is divided by an **oblique transverse septum** into two or three relatively small **rostral compartments** and one large **caudal compartment** (Figure 1.9a,b). The frontal sinus extends within a cavity involving the frontal, parietal, occipital, and temporal bones.

A **median septum** separates the left and right frontal sinuses (Figure 1.9a,b). The 2–3 compartments of the rostral frontal sinus vary with age but include lateral, intermediate, and medial parts. The caudal compartment of the frontal sinus represents the major component of the frontal sinus and is well developed in older animals.

Note that the interior of the frontal sinus is variably divided by very shallow and irregular spongy bony partitions (**intrasinual lamellae**) which can be seen forming incomplete septa in the dry skull (Figure 1.9a,b,c). One of these septa forms the bony wall for the **supraorbital canal** in the rostral part of the caudal compartment of the frontal sinus (Figure 1.9b). The canal carries the frontal vein which should be kept in mind in trephination procedures.

The **caudal compartment of the frontal sinus** covers most of the brain area and extends laterally into the horn and squamous part of the temporal bone and caudally into the occipital bone, forming three distinct diverticuli (extensions) for this compartment. These diverticuli

include the **cornual diverticulum** extending into the cornual process of the horn; the **nuchal diverticulum** extending caudally in the area close to the interparietal bone and rostral to the nuchal tubercle; and the **postorbital diverticulum** located caudal to the orbit spanning a space within the parietal bone and squamous part of the temporal bone (Figure 1.9a,b). In dehorning operations, opening of the cornual diverticulum exposes the frontal sinus to bacterial and parasitic infections.

In goats, the lateral part of the rostral frontal sinus communicates with the horn and not the caudal compartment.

On lateral view of opened bovine skull (Figure 1.9c), identify the **maxillary sinus** located predominantly deep to the body of the maxilla and dorsal to the upper cheek teeth. Note that it communicates with lacrimal sinus dorsocaudally, and with the palatine sinus over the infraorbital canal along the caudal surface of the hard palate. It also extends caudally into the lacrimal bulla within the bony orbit. Rostrally, it may extend to the level of the facial tuberosity. The maxillary sinus drains into the nasal cavity through the nasomaxillary opening into the **middle nasal meatus**.

Note that the roots of the last 3–4 cheek teeth may project into the maxillary sinus. But, unlike in the horse, the roots of the cheek teeth are shallower in ruminants and it is possible to remove these teeth without entering the maxillary sinus.

Identify the palatine sinus on sagittal section of the bovine head (Figure 1.10).

Small ruminants have the same sets of paranasal sinuses present in the ox but differ in some of the compartments and their communications. For example, the frontal sinus is composed only of lateral and medial compartments that open into the middle nasal meatus of the nasal cavity. The lateral compartment is similar to the caudal compartment of the frontal sinus in the ox (Figure 1.11). Additionally, the maxillary sinus is divided by the infraorbital canal into medial and lateral compartments. The lateral compartment communicates with the lacrimal bulla while the medial compartment communicates with the palatine sinus.

The maxillary sinus drains into middle nasal meatus of the nasal cavity and does not communicate with the lacrimal sinus which opens separately into the middle nasal meatus.

Details of other sinuses (palatine, sphenoid, and conchal) are less important and are not discussed here.

1.4 Vertebral Column

Goal: Know regional differences in the shape of the vertebrae, the vertebral formula in small and large ruminants, and the sites for epidural anesthesia and collection of cerebrospinal fluid (CSF).

Box 1.7

Trephination of the frontal sinus (Figure 1.9d) is the most commonly performed surgery. This surgery is usually performed in a standing animal restrained in a squeeze chute. Light sedation and local anesthesia is used at predetermined sites.

The main trephination sites for draining the diverticuli of the frontal sinus are shown on Figure 1.9(b):

1) Main part of the caudal frontal sinus (at a point 3–4 cm rostral from topmost of the head and midway between the base of the horn and the dorsal midline.
2) The postorbital diverticulum (at a point 4 cm caudal to the caudal edge of the orbit above the temporal fossa).
3) The rostral part of the frontal sinus (at a point 2.5 cm laterally off the dorsal midline on a perpendicular line passing through the center of the orbit).

Extension of caudal frontal sinus into the horn (cornual diverticulum) may carry the risk of sinus infection when adult cattle or goats are dehorned.

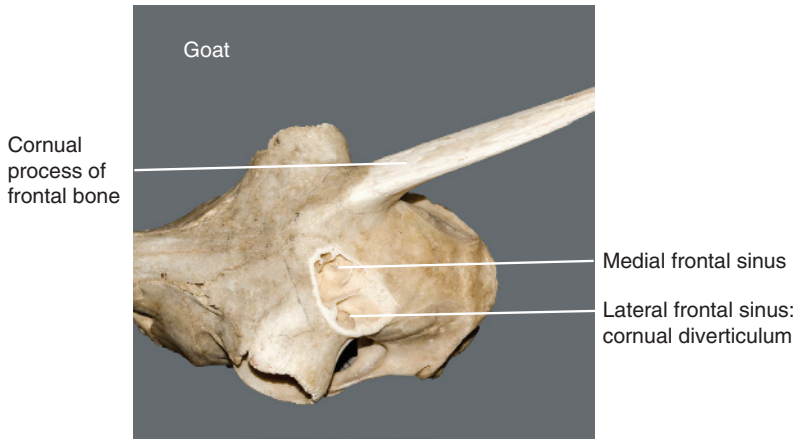


Figure 1.11 Goat skull excavated to show the medial and lateral parts of the frontal sinus: dorsal view. The left horn is removed to show cornual diverticulum from the lateral frontal sinus. In small ruminants, the frontal sinus is composed of lateral (relatively large) and medial (small) frontal sinus. The lateral frontal sinus is equivalent to the caudal frontal sinus in the ox. Note that the compartments of the frontal sinus are shallower compared with cattle.

Understand that degenerative changes in vertebral articulations may lead to retiring of bulls from breeding services.

The vertebral formula for cattle and small ruminants is similar in the cervical (C) and thoracic (T) regions but differs slightly in the lumbar (L), sacral (S), and caudal (Cd) regions.

The vertebral formula is C7, T13, L6, S5, Cd 18–20 in **cattle**; C7, T13, L6 (7), S5, Cd 16–18 in **goats**; and C7, T13, L6 (7), S4, Cd 16–18 in **sheep**.

Box 1.8

1) In addition to the external jugular vein in the neck region, the **median caudal or "tail" vein** is one of the common locations where blood can be collected from cattle. When the tail is raised, the median caudal vein can be accessed in proximal ventral third of the tail between two adjacent tail vertebrae. In this location the caudal vertebrae have hemal arches that should be avoided.
2) Site for collection of cerebrospinal fluid (CSF) is similar to other species and can be conveniently performed at the atlantooccipital (AO) joint.
3) Degenerative changes could occur in the articulation between L6 and S1 region in bulls. This could lead to failure of the bull to serve.
4) Access to the epidural space for induction of epidural anesthesia can be performed at three interarcuate sites depending on area of interest: (i) L1–L2, (ii) L6 (7)–S1, and (iii) Cd1–Cd2. Epidural punctures should be carried out cautiously as they carry the risk of hemorrhage if the internal vertebral venous plexus is punctured.
5) In situations where the caudal vena cava is blocked by an enlarged rumen (gas tympany) or liver displacement, venous blood could pass through intervertebral veins that join the internal vertebral venous plexus within the vertebral canal.

The anatomy of the vertebrae (see Figures 2.1, 2.2, and 3.1) and joint articulations is similar among cattle, goats, and sheep. In the articulated skeleton, the summation of the vertebral foramina forms the vertebral canal. The vertebral canal contains the spinal cord and its coverings and the clinically important internal vertebral venous plexus. Review some of the clinical aspects associated with the vertebral column in Box 1.8.

1.5 Teeth and Age Estimation of Cattle and Small Ruminants (Goats and Sheep)

> **Goal:** Understand basic ruminant dental anatomy and be able to approximate the age of cattle and small ruminants. Be familiar with the teeth surfaces (outer vestibular, inner lingual, contact [mesial and distal], and occlusal or masticating).

Ruminants have brachydont (incisors) and hypsodont (cheek) teeth. Ask your instructor for an explanation of the difference between brachydont and hypsodont teeth.

Estimating age of beef, breeding, or dairy cattle adds value to producers and ranchers when selling their stock. Age determination is also important for buyers of cattle (e.g., when buying animals in cattle shows or exhibitions).

You should understand that documenting birth records (e.g., by year branding or ear tags) is a reliable way of determining age. In the absence of that, a veterinarian may be asked to estimate the age of a cow by the looking at the teeth on the lower jaw (especially the lower incisor teeth).

Age estimation depends on determining eruption times for the type of teeth present (deciduous or permanent) and on identifying the degree of wear on the lingual surface of the lower incisors (by a process called leveling, which will be discussed shortly).

Before you can practice estimating age, we suggest that you read all of the following sections on teeth and watch **videos 2, 3, 4, and 5**. A thorough understanding of type of incisor teeth present (deciduous and/or permanent) and the degree of wear on their lingual surfaces is essential.

1) Teeth can be grouped according to form, function, and whether they have been developmentally preceded by deciduous teeth. The four groups are **incisors** (**I**), **canines** (**C**), **premolars** (**P**), and **molars** (**M**). The premolars and molars collectively are called the **cheek teeth.** The cheek teeth are located in the caudal part of the mouth and are present in both the upper and lower jaws. They are called upper (or maxillary) and lower (or mandibular) cheek teeth (Figures 1.4, 1.7, and 1.8).
2) In calves, there are 20 **deciduous** teeth (also called **temporary, milk,** or **baby teeth**), 8 of which are incisors and 12 are premolars. There are no deciduous molars. Adult ruminants have 32 **permanent** teeth. Of these, 8 are incisors, 12 are premolars, and 12 are molars.
3) The deciduous teeth will be lost as an animal matures and will be replaced sequentially

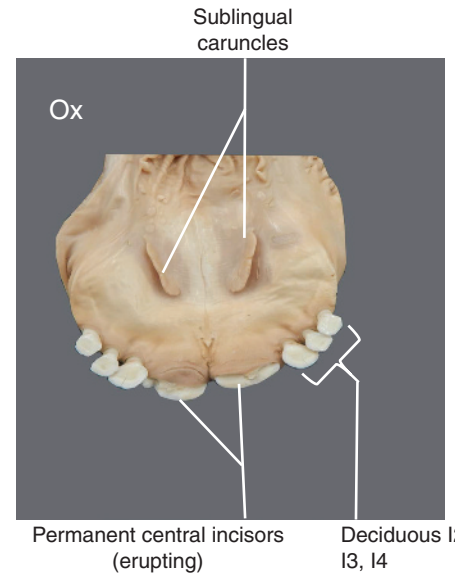


Figure 1.12 Bovine lower jaw showing the permanent central incisors (I1) just erupting while the rest of the incisor teeth (2– 4) are still decidous. This suggests an 18-month-old cow.

by permanent teeth starting with central incisors erupting at approximately 18 months of age in cattle (Figure 1.12).

4) A dental formula is an abbreviated statement of the number and types of teeth Generally, placental mammals typically have up to four upper and four lower premolar teeth (in both deciduous and permanent formulas). When a species has fewer premolars, the reduction occurs in the more rostral members of the group. Because the first premolar (**P1**) is absent in both the upper and lower jaws, the first rostral cheek tooth is designated as premolar two (**P2**) in young and adult ruminants (Figures 1.4, 1.7, and 1.8).
5) The most striking feature of dentition in ruminants is the lack of incisors and canines in the upper jaw. Their place is occupied by a cornified elastic fibrous structure known as the **dental pad** (Figure 1.13).
6) The canines of the lower jaw have the appearance of incisors and are assimilated with the true incisors to form a continuous arched arcade of four pairs of lower incisors (three true incisors plus one functional incisor [or adapted canine] on each half of the jaw). The four pairs of incisors are named as **I1** (**central or pincher**), **I2** (**first intermediate**), **I3** (**second intermediate**), **I4** (**corner**) incisors from rostral (front) to caudal (back), respectively (Figure 1.13a).
7) The incisors have a spatula or shovel-like appearance (Figures 1.14 and 1.15a). As in other species, each tooth has a **crown, neck,** and **root**. The crown and the relatively narrow neck are visible above the gum (Figure 1.13b). The peg-like neck (especially in very young or old cattle) joins the root which is invisible below the gum. The crown is composed of a thin, white, outer **enamel** and inner core of **dentin**. The root contains blood vessels and nerves within a pulp cavity and is encased by a layer of **cement**. Grossly, permanent incisors are relatively larger than deciduous incisors (Figure 1.14).
8) The anchoring of incisor teeth within their alveoli is not as rigid in cattle as is found in other species and there may normally be slight movement of these teeth.
9) Because the canine teeth are similar in shape to incisor teeth, authors differ when representing them in the dental formula. Some identify them as canines while others include them with the incisors. Any of the following formats for the dental formula is acceptable:
   - **Permanent teeth dental formula:**

$$2\times(\mathbf{I}0/3,\ \mathbf{C}0/1,\ \mathbf{P}3/3,\ \mathbf{M}3/3)=32$$

or

$$2\times(\mathbf{I}0/4,\ \mathbf{P}3/3,\ \mathbf{M}3/3)=32$$

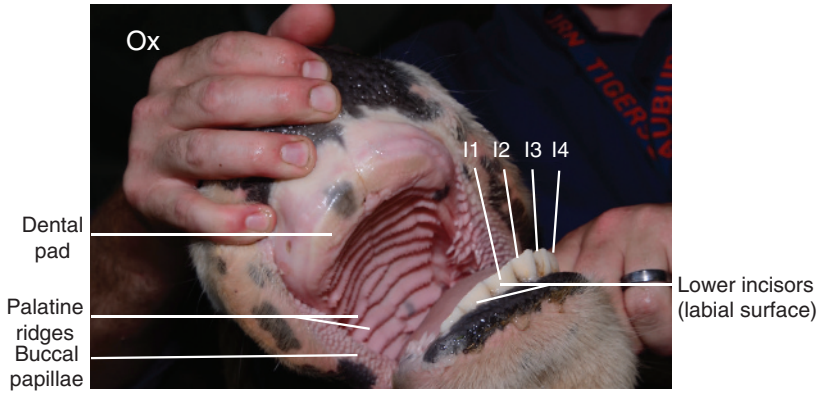
   - **Temporary (deciduous, milk** or **baby) teeth dental formula:**

$$2\times(\mathbf{DI}0/3,\ \mathbf{DC}0/1,\mathbf{DP}3/3)=20$$

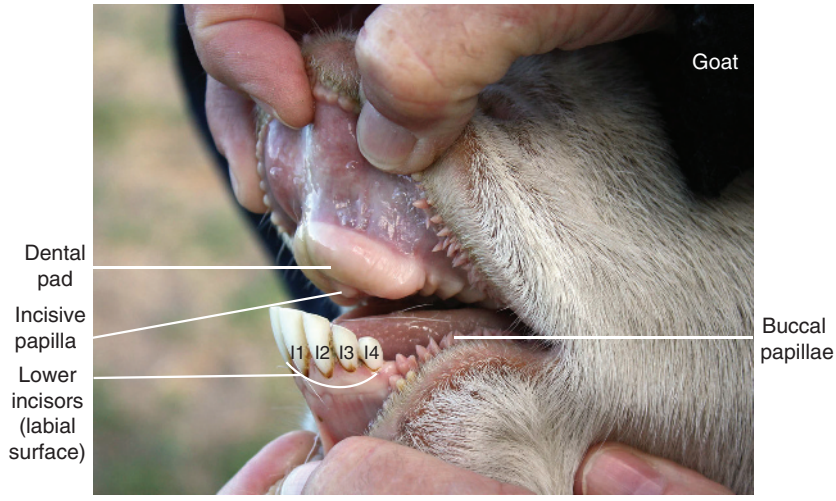
or

$$2\times(\mathbf{DI}0/4,\ \mathbf{DP}3/3)=20.$$

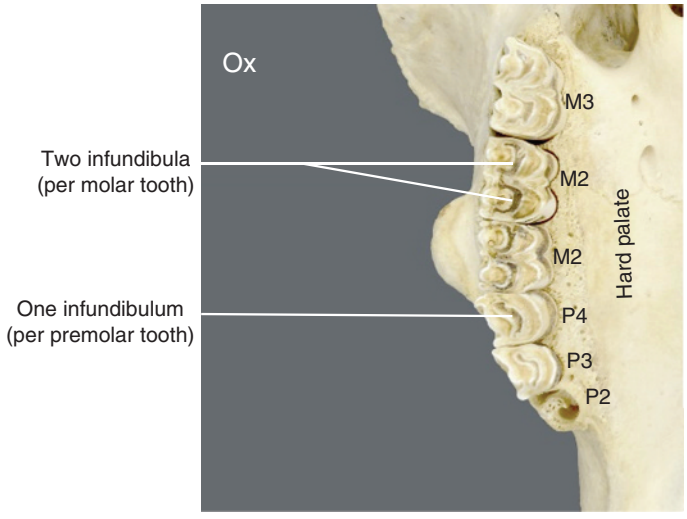
10) Teeth have several surfaces including the **labial surface** (toward the lips; Figure 1.13), the **lingual surface** (toward the tongue; Figure 1.15a), the **occlusal surface** (contact surface between an upper and lower tooth), the **mesial surface** (nearer the center line of the dental arch; Figure 1.15b), and the **distal surface** (further away from the center line of the dental arch; Figure 1.15b). The labial surface is mostly convex and the lingual surface is concave (Figure 1.16).
11) The space that separates the incisors from the cheek teeth is called the **diastema.**
12) The anatomy of ruminant cheek teeth is similar to that found in horses. Both premolars and molars have a complex, infolded arrangement of enamel and cementum. In addition, they have one or two infundibula. This composition results in an occlusal surface that can withstand the intense grinding of plant material to which they will be subjected. To account for the inevitable wear, the cheek teeth are hypsodont in that they continue to grow in length after eruption.


Ox
I1 I2 I3 I4
Dental pad
Palatine ridges
Buccal papillae
Lower incisors (labial surface)

(a)


Goat
Dental pad
Incisive papilla
Lower incisors (labial surface)
I1 I2 I3 I4
Buccal papillae

(b)


Ox
M3
M2
M2
Hard palate
P4
P3
P2
Two infundibula (per molar tooth)
One infundibulum (per premolar tooth)

(c)

Figure 1.13 (a) Bovine mouth showing internal structures that include the **dental pad** on the upper jaw and **lower incisor teeth**. The dental pad replaces the upper incisors and canine teeth in ruminants. I1 (central or pincher), I2 (first intermediate), I3 (second intermediate), and I4 (corner incisor) on the left side of the mandible. (b) Opened mouth of small ruminant showing the dental pad (replaces upper incisors and canines) and deciduous lower incisors (I1–I4): left lateral view. The incisive papilla is a small projection located caudal to the dental pad where the incisive ducts open on either sides of the papilla. The incisive ducts connect dorsally with paired vomeronasal organs located above the hard plate on the floor of the nasal cavity. The vomeronasal organs are olfactory tubular structures that transmit sexual stimuli (pheromones) to the brain. They are associated with what is known as the Flehmen response. Image modified from free source (wikipedia.org) by Helena Bowen and Richard Bowen. (c) Occlusal surface of upper premolar and molar teeth. Note that the upper premolar teeth have a single infundibulum while the molar teeth each have two.

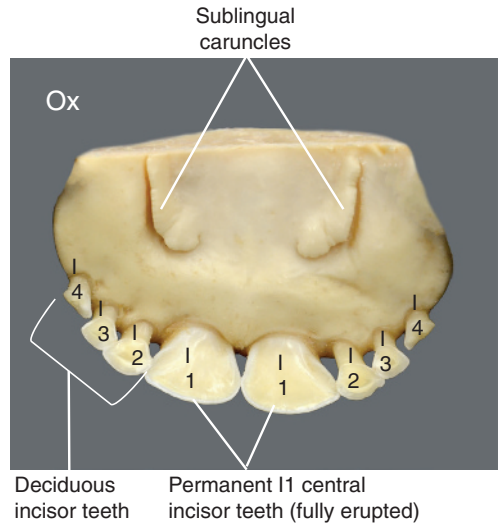
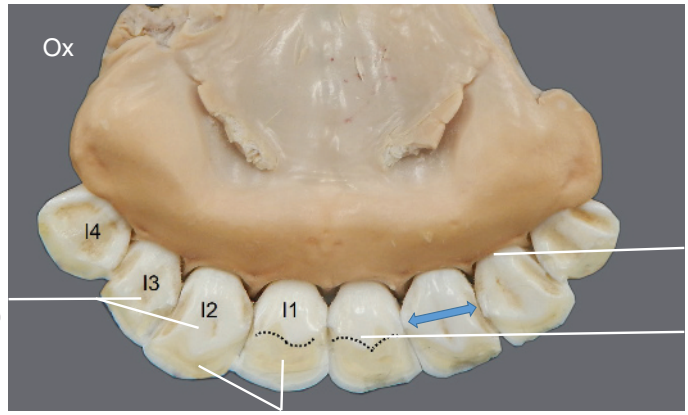


Figure 1.14 Lower bovine jaw showing permanent central incisors (I1) that are fully erupted but not in wear. The remaining set of incisors (first intermediate [I2], second intermdiate [I3], and corner [I4] incisors) are deciduous. Estimated age of this cow is 24 months (2 years). Note the **small size** and **peg-shaped** appearance of decidous I2–I4 compared to the **broad-shaped** appearance of the fully erupted permanent central incisors (I1).

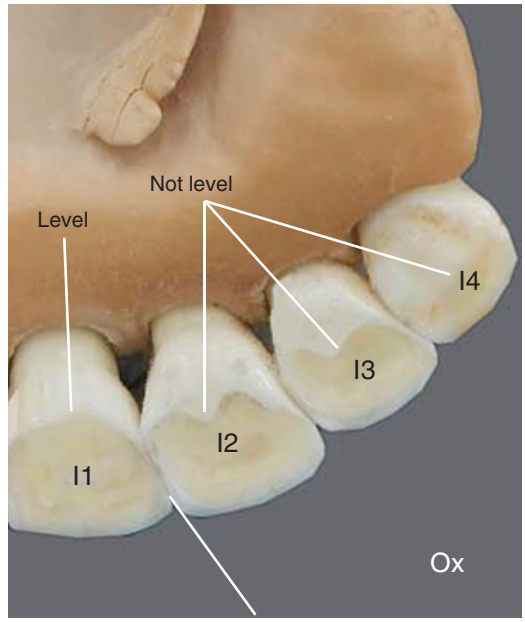
This growth does not last as long in cattle as in horses, but after growth stops, the cheek teeth are somewhat pushed from their alveoli. The upper premolar teeth have a single infundibulum and the molar teeth each have two. Only the lower molars have infundibula with each molar having two. As with horses, there is extensive cement found above the gum. These features result in the occlusal surface having cement, enamel, and dentine arranged in intricate patterns. The occlusal surface, when viewed laterally, appears to have an interlocking serrated pattern.

Box 1.9

The cheek teeth arcade of the upper jaw is wider than that of the lower jaw (this is called anisognathia). Engagement of the occlusal surfaces of the upper and lower cheek teeth during feed grinding creates sharp edges over time. The sharp edges will be located on the lingual surface of lower teeth and on the labial surface of the upper teeth. Floating (leveling) of teeth sharp edges is performed in equine practice.



(a)



(b)

Box 1.10

The **diastema** offers a space to make it easy to pry open the mouth, grasp the tongue, and pull it sideways for clinical examination of the teeth or for drenching an animal with drugs. (Figure 1.13a).

1.5.1 Definitions and Criteria for Estimating the Age of Ruminants

The general criterion for age estimation in ruminants depends on knowing the approximate eruption times of deciduous and permanent incisor teeth, and on recognition of wear changes on the occlusal surfaces of the lower

Figure 1.15 (a) Bovine lower mandible showing permanent lower incisors that are all fully erupted and in **wear** but **not level** yet. Note the shovel-like appearance of teeth charactersitic of ruminant incisors. The enamel–dentin junction line on the lingual surface of incisors is serrated or **wavy** (i.e., not level; see dotted wavy line on I1). Estimated age of this cow is 5 years. The corner incisors (I4) mandibular canines have fully developed and their shapes is similar to the other true incisors. Blue arrow denotes the lingual surface. (b) Permanent incisors in the left half of a lower bovine jaw. All permanent incisors in this mouth are in wear with I1 level**.** Note the round lingual surface of the central incisor (I1) that indicates leveling. I2–I4 are not level and have wavy or serrated lingual surfaces. The approximate age of this cow is 6 years.

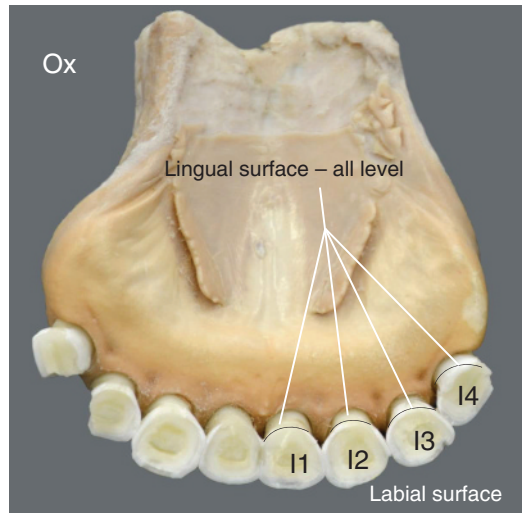


Figure 1.16 Lower bovine jaw showing all 8 incisors are **permanent** and **level.** Note the round and smooth arc lines at the enamel–dentin junctions of the lingual surfaces. Estimated age of this cow is above 9 years of age.

permanent incisors (i.e., level and nonlevel incisor teeth).

The determination of age is not an exact science. The criteria used for age estimation depends on expected dates for eruption (typically, a range for each pair of incisors), and on the state of **wear** (level or not level) of the lower incisors. The types of fodder (soft or harsh diet), breed (genetics), rate of maturation, and geographic location where an animal is raised could individually or collectively influence eruption dates and types of changes on the occlusal surfaces of incisors.

Before you can successfully estimate cattle age, you need to understand the meaning of the terms **eruption, wear,** and **level** as applied to dentition of ruminants.

Eruption means that a tooth has pierced the gum and is visible above the gum line. For example, the central permanent incisors (I1) are typically erupted at 18 months of age (Figure 1.12).

Wear means that the encasing thin enamel wears out over time causing visible exposure of the underlying dentin on the occlusal surface. Initially, the enamel–dentin junction of the occlusal surface creates a wavy outline on the caudal (lingual) surface of an incisor tooth (Figure 1.15a). A permanent tooth with a wavy appearance on the lingual surface is described as being **not level** (Figure 1.15a).

An incisor pair is described as being **level** when the enamel–dentin junction of the **lingual surface** has turned from jagged (**serrated** or **wavy**) appearance to a smooth, round, or arc appearance (Figures 1.15b and 1.16).

The meaning of the term **level** in dentition of ruminants is different from that used in equine dentition. In equine dentition, the term level means that the enamel of the

infundibulum (cup) and surface enamel are separated by dentin.

The dentition of small ruminants generally resembles that of cattle. The teeth of sheep are often exposed to very rough wear.

Several "lay" terms are used to described old cattle. For example, a cow that has lost some incisors is described as "**broken mouth.**" An animal with a significant teeth wear in which the incisor teeth became shorter and smoother than when fully erupted is described as "**short mouth.**" Additionally, an animal with all of the incisors missing or completely worn down smooth to the gum line is described as "**smooth mouth.**" Usually by 15 years some teeth may have fallen out and the rest may stand out as thin **rods** or **pegs.**

An animal that lacks noticeable teeth problems, with no broken or missing teeth is described as "**solid mouth.**"

1.5.2 Steps for Estimating the Age of Cattle

Read the following section and study features of the teeth on Figures 1.12, 1.14, 1.15, and 1.16. Use the information in Tables 1.2, 1.3, 1.4, and 1.5 to practice the art of aging in ruminants.

1) First, decide if the incisor teeth present are all deciduous, all permanent, or a combination of permanent and deciduous. **Deciduous incisors** are generally smaller, whiter, narrower, and more triangular than permanent incisors (Figure 1.12)**. Permanent incisors** are larger, less triangular, and darker in color, with varying shades of yellow (stained) than deciduous teeth (Figure 1.14).
2) When only deciduous incisors are present, the eruption of deciduous incisor teeth generally varies. According to the US Food Safety and Inspection Service (FSIS), about 75% of well-bred calves have all deciduous incisors erupted at birth. On average, deciduous incisors erupt between **birth** to **2 weeks** of age (Figure 1.12). Replacement of deciduous incisors with permanent teeth typically begins at about **18 months** of age when the central

Table 1.2 Eruption times and wear of **permanent teeth in cattle**. Use eruption times, wear, and leveling of incisors for age estimation. I1–I4 are said to be "level" at 6, 7, 8, and 9 years, respectively (Table 1.3). The lower range in eruption times represents the earliest period for eruption to happen while the upper range represents the latest time for eruption to occur. Table 1.5 shows a schema on how to remember eruption times of permanent incisors.

Teeth	Eruption times	Wear (but not level) times
Permanent incisors		
I1 (central)	18–24 months (1½–2 years)	24–30 months (2–2½ years)
I2 (first intermediate)	24–30 months (2–2½ years)	30–36 months (2½–3 years)
I3 (second intermediate)	36–42 months (3–3½ years)	42 months (3½ years)
I4 (corner incisor or canine)	42–48 months (3½–4 years)	60 months (5 years)
Permanent premolars		Not applicable
P2 (premolar 2)	24–30 months (2–2½ years)	
P3 (premolar 3)	18–30 months (1½–2½ years)	
P4 (premolar 4)	30–36 months (2½–3 years)	
Permanent molars		
M1 (molar 1)	6 months	
M2 (molar 2)	12–18 months (1–1½ years)	
M3 (molar 3)	24–30 months (2–2½ years)	

Table 1.3 Leveling times of permanent incisors in cattle starts from central (I1) out to the corner (I4) incisors, respectively.

Incisor pair that are level	Leveling in years
I1 (central)	6
I2 (first intermediate)	7
I3 (second intermediate)	8
I4 (C) (corner incisor or canine	9

permanent incisors (I1) erupt. Cattle having only erupted and fully developed deciduous teeth are estimated to be **less** than 18 months of age.

3) Cattle with **permanent** incisors. As an animal ages, permanent incisors erupt sequentially from rostral to caudal replacing their corresponding deciduous incisors (I1–I4, centrals out to the corners; see eruption times in Table 1.2). The latest eruption time

Table 1.4 Eruption of **permanent** and **deciduous teeth** in **goats** and **sheep**. As a general rule, estimation of eruption times of permanent incisors in small ruminants is derived by subtraction of 6 months from the eruption times of permanent incisors in cattle except for I1 (Table 1.2). The eruption time for I1 is similar in cattle and small ruminants (i.e., 18 months).

Teeth	Eruption times of permanent teeth	Eruption times of deciduous teeth
Permanent incisors		
I1 (central)	12–18 months (1–1½ years)	At birth
I2 (first intermediate)	18–24 months (1½–2years)	At birth
I3 (second intermediate)	30–36 months (2½–3 years)	At birth
I4 (corner incisor or canine)	36–48 months (3–4 years)	Birth or (1–3 weeks)
Permanent premolars		
P2 (premolar 2)	18–24 months (1½–2 years)	Birth–4 weeks (3 weeks)
P3 (premolar 3)	18–24 months (1½–2 years)	Birth–4 weeks (3 weeks)
P 4 (premolar 4)	18–24 months (1½–2 years)	Birth–4 weeks (3 weeks)
Permanent molars		
M1 (molar 1)	3 (3–4) months	Not present
M2 (molar 2)	9 (8–10) months	Not present
M3 (molar 3)	18 (18–24) months (1½–2 years)	Not present

Table 1.5 Schema for remembering eruption times of permanent incisors in cattle and small ruminants in months. List incisors (I1–I4) in column A. Next, write the numbers 1 to 4 (from top to bottom) in the left half of column B. In the right half of column B, write the numbers 5 to 8 (from bottom to top). The two-digit numbers created across the rows in column B translates into eruption times for I1, I2, I3, and I4 in cattle, respectively. For estimation of age in small ruminants, subtract 6 months from cattle numbers except for I1. The eruption time for I1 is similar in cattle and small ruminants (i.e., 18 months). C, canine; I, incisor.

A. Incisor number and name	B. Bovine: eruption times of permanent incisors (months)		C. Goat and sheep: eruption times of permanent incisors (months)
I1 (central)	↓1	8	18
I2 (first intermediate)	2	7	27 – 6 = 21
I3 (second intermediate)	3	6	36 – 6 = 30
I4 (C) (corner incisor or canine)	4	↑5	45 – 6 = 39

for eruption of permanent I4 (corner incisors) is 48 months (~4 years). It may take an additional 12 months for cattle to have fully erupted, fully developed, permanent incisors that have some type of wear but not level (Figure 1.15a). Therefore, an animal with all fully erupted permanent but non-level incisors (i.e., adult teeth) should be estimated at around 5 years of age (Figure 1.15a). Beyond 5 years of age, the degree of wear on the occlusal surface of incisors (leveling) can be used as guidance for age estimation. Leveling is bound to occur at mostly predictable times for I1, I2, I3, and I4, respectively (Table 1.3).

4) At 4 years of age, all permanent teeth (incisors, premolars, and molars) are erupted. When these teeth are fully erupted and fully developed the animal is referred to as having a "**full mouth.**"
5) Estimation of age in cattle beyond 5 years of age depends on **leveling** criteria, as defined earlier. In a scenario where you have decided that the animal age is over 5 years of age (fully erupted permanent incisors with visible wear on all of the occlusal surfaces), then you should determine if any of the permanent incisors are **level.**
6) **I1, I2, I3,** and **I4** are said to be level at **approximately 6, 7, 8,** and **9 years**, respectively (Figure 1.16 and Table 1.3). As defined earlier, leveling means that an incisor pair is worn down so that the enamel–dentin junction line on lingual surface is smoothly curved.
7) Estimation of age in cattle beyond leveling (i.e., over 9 years of age) is guesswork. The following information can be used as a rough guide but it is less reliable.

   I1, I2, I3 are "pegs" and I4 is level 10–12 years ("**short mouth**")

   All incisors are small and rounded pegs 15 years

   Mixture of missing and small rounded pegs More than 15 years
8) Age estimation of goats and sheep with permanent incisors. Generally, eruption of permanent incisors in goats is 6 months earlier than the eruption dates for cattle (Table 1.4).
9) Suggestion of how to remember eruption times of permanent incisors. A relatively easy way to remember approximate eruption dates in "months" is presented in **Table 1.5**.

1.6 Joints of the Head

Goal: Identify the bony components for each joint using an articulated skeleton. You do not need to dissect the joints of the head on your specimen.

The joints of the head include the temporomandibular joint (TMJ) (Figure 1.3), the atlanto-occipital (AO) and mandibular symphysis (Figure 1.8b). The TMJ and AO are condylar synovial joints. The mandibular symphysis is fibrous. Review the features of these joints on the skeleton.

1.6.1 Temporomandibular Joint

The TMJ is a synovial articulation between the obliquely oriented **condylar process** of the mandible and the **mandibular fossa** of the squamous temporal bone (Figure 1.3). The joint has a fibrocartilaginous disc that compensates for irregularities of articular surfaces. The **articular disc** divides the joint cavity into dorsal and ventral compartments. The general location of the joint in the live animal can be estimated as mid-way point on an imaginary line between the base of ear and the ipsilateral lateral canthus of the eye.

1.6.2 Atlantooccipital Joint

The AO is a synovial joint between the cranial articular foveae of the **atlas** (C1 vertebra) and the **occipital condyles** on the skull.

1.6.3 Mandibular Symphysis

The mandibular symphysis is a fibrous joint between the rostral ends of the contralateral mandibles (Figure 1.8b). In cattle, this joint ossifies later in life and is much weaker than that of the horse.

Box 1.11

The atlantooccipital (AO) joint capsule is a site for collection of CSF. The joint is punctured between the dorsal arch of the atlas and dorsal aspect of foramen magnum using a long spinal needle.

1.6.4 Vertebral Joints

For most vertebral articulations caudal to the axis (C2), there are two types of joints: (i) **fibrocartilaginous joint** between two successive vertebral bodies, and (ii) **plane (flat) synovial joint** between cranial and caudal articular processes of two successive vertebrae.

An intervertebral disc bridges the gaps between vertebral bodies. The intervertebral disc is composed of two parts: an outer **annulus** (or anulus) **fibrosus** and a central **nucleus pulpous**.

Box 1.12

The term spinal (vertebral) spondylopathy is defined as any vertebral disease such as osteomyelitis, spinal abscessation, and ankyloses (spondylosis). Trauma in young calves could cause intervertebral disease in the thoracolumbar region.

1.7 Muscles of the Head

Goal: Identify major muscle groups based on their function (e.g., muscles of facial expression or muscles of mastication). Know the innervation of each muscle group and the clinical signs associated with motor nerve damage to any of the specific muscle groups.

Understand that the muscles of the head receive more attention in the dog and horse than in ruminants. It may be sufficient to identify the superficial muscles of the head in ruminants and understand the major groups and their innervation.

Based on your prior knowledge, your instructor will decide which head muscles you would need to dissect. In our program at Auburn College of Veterinary Medicine, we require that students identify only two head muscles. The first is the **sternomandibularis muscle** in the ox, which is also known as **sternozygomaticus** in the goat. This is a neck muscle that originates from the manubrium of the sternum and attaches on the mandible (bovine) or the zygomatic arch (goat) (Figures 1.17 and 1.18). The sternomandibularis is absent in sheep.

The second muscle is the **masseter,** a muscle of mastication (Figure 1.17).

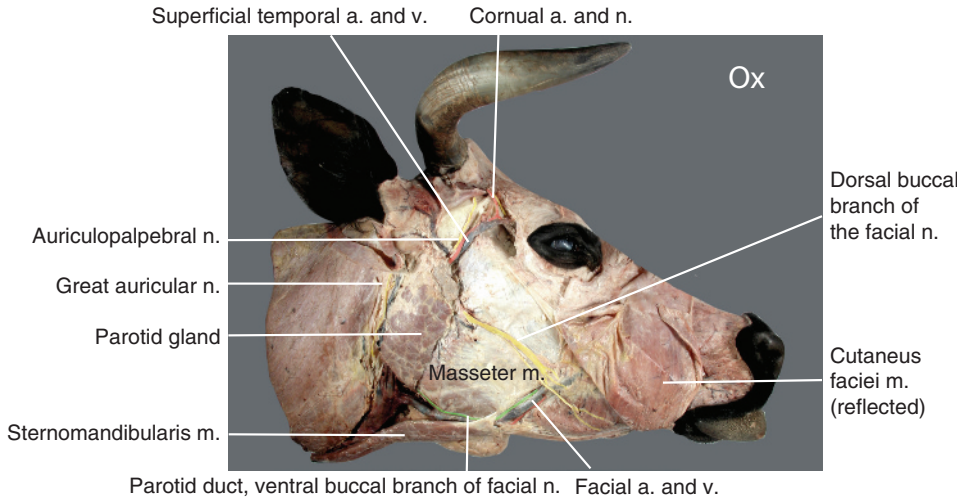


Figure 1.17 Dissection of superficial structures of the bovine head: lateral view. Note that the **cutaneus faciei** muscle is reflected dorsally to uncover facial vessels (artery and vein), nerves, and the parotid duct.

Box 1.13

The sternomandibularis muscle in cattle (sternozygomaticus in goats) forms the ventral boundaries of the jugular groove for the external jugular vein. The external jugular vein is used as prime site for venipuncture in ruminants. This muscle is absent in sheep, making the ovine jugular groove less distinct.

To study the muscles of the head, understand that these muscles are broadly similar in goats and cattle and any variation does not merit attention. With the help of Figures 1.17 and 1.18, identify the muscles listed on your lab ID list.

After removal of the skin and the **cutaneus faciei muscle**, the majority of superficial muscles of the head will be identified on the

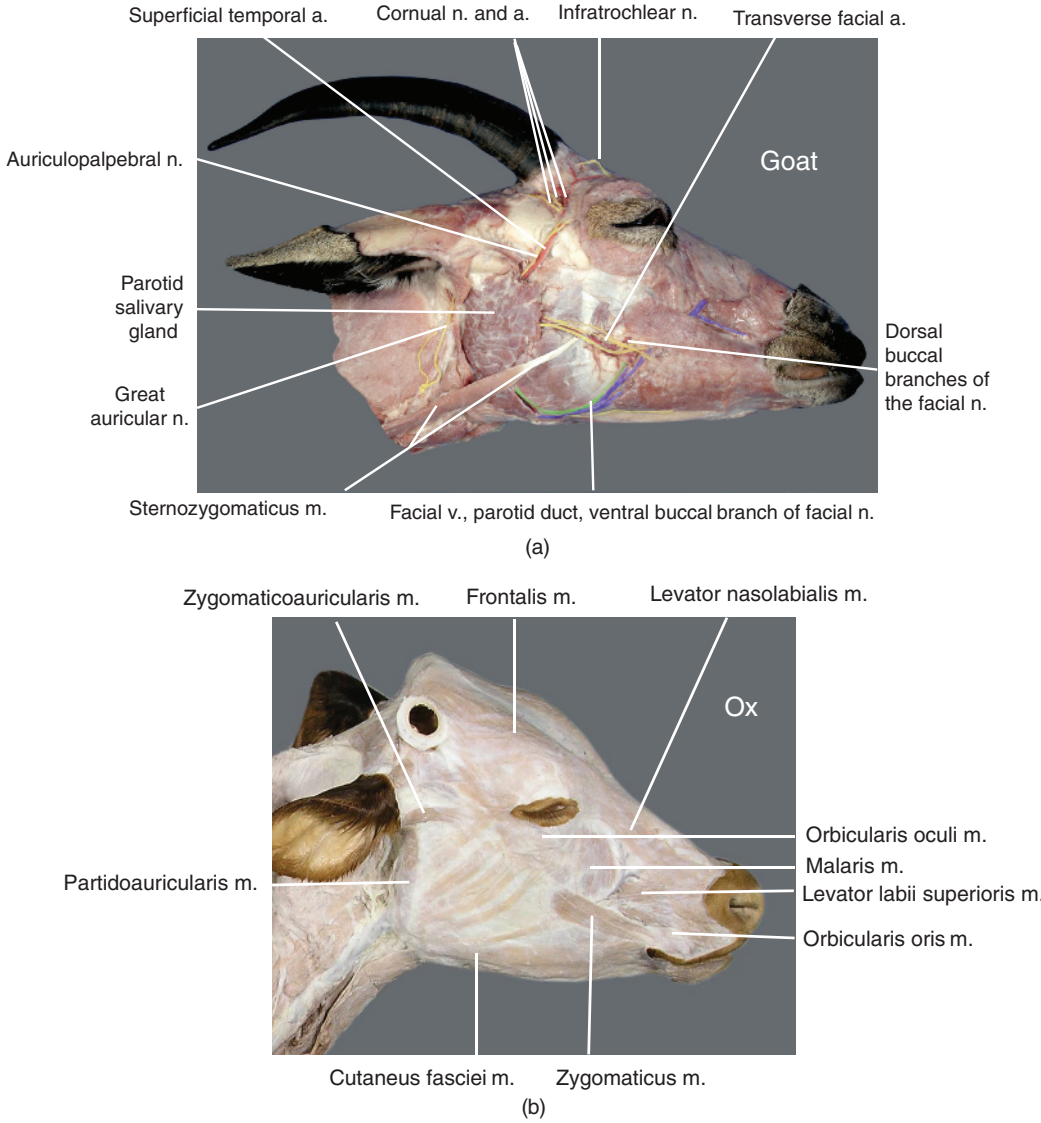


Figure 1.18 (a) Superficial structures of goat head: lateral view. Note the distinct tendon of the sternozygomaticus muscle inserting on the zygomatic arch. (b,c) Selected superficial muscles of the bovine (b) and caprine (c) heads.

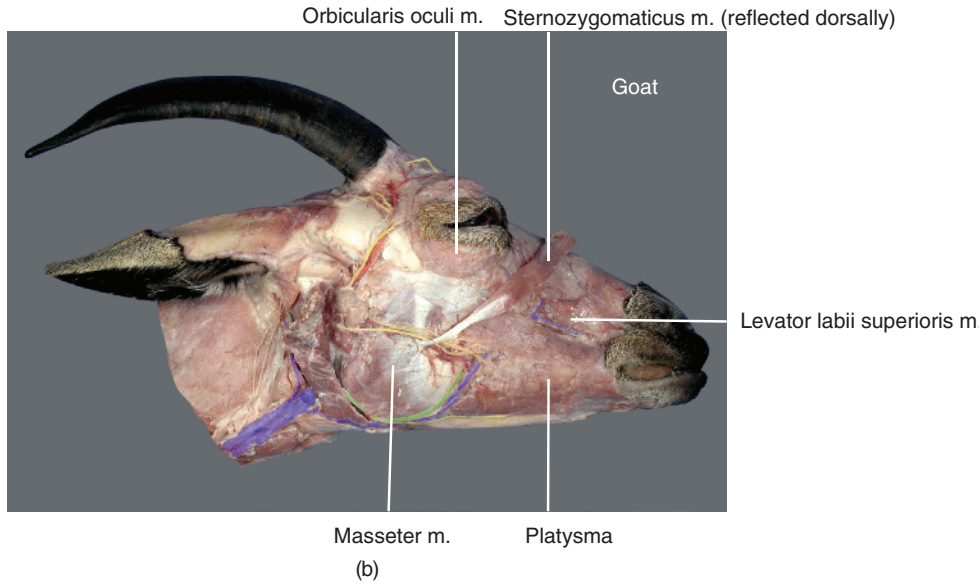


Figure 1.18 (*Continued*)

lateral view. Few muscles will be identified on the medial (sagittal) view.

Like those of the horse, the muscles of the head in ruminants can be broadly divided into eight groups:

1) **Cutaneous muscles**
2) **Muscles of facial expression**
3) **Muscles of mastication**
4) **Pharyngeal muscles**
5) **Laryngeal muscles**
6) **Hyoid muscles**
7) **Lingual muscles, and**
8) **Extraocular muscles.**

To save time and focus on clinically important muscle groups, we suggest identifying the muscles listed on your lab ID list. If you studied the horse or dog head muscles, you should be familiar with the nomenclature and muscle groups in ruminants. There follows a brief discussion of the head muscle groups. Most of these muscles will not be dissected but you should understand the innervation and action of muscles of facial expression, muscles of mastication, laryngeal and pharyngeal muscles.

1.7.1 Cutaneous Muscles

Goal: Identify the cutaneus faciei in cattle and platysma in goats.

The major cutaneous muscles of the head are the **cutaneus faciei** in cattle (Figures 1.17 and 1.18b), and the **platysma** muscle in goats and sheep (Figure 1.18c).

The cutaneus faciei muscle in cattle twitches the skin around the face. It is present in the horse and is equivalent to the facial part of the platysma in dog and small ruminants.

The cutaneus faciei originates from the fascia around the lateral mandible and blends with the orbicularis oris muscle (the orbicularis oris is a muscle of facial expression around the mouth).

Remove the cutaneous muscles of the head and superficial fascia to trace the more important superficial structures of the head (e.g., salivary glands, lymph nodes, nerves, and blood vessels).

1.7.2 Muscles of Facial Expression

Goal: Know innervation for the muscles of facial expression. Identify the orbicularis oculi only.

The muscles of facial expression are also known as mimetic muscles. They are responsible for closing of the eyelids and mouth and for movements of the lips, nose, and ears. Motor branches from the **facial nerve (CN VII)** innervate them.

There are several muscles in this category (Figure 1.18b,c). However, the most important superficial mimetic muscles include **orbicularis oculi** (closes the eyelids), **frontalis** (elevates the upper eye lid), **malaris** (depresses the lower eyelid and helps in widening the palpebral fissure), **buccinator** (forms the foundation of the cheek), **orbicularis oris** (surrounds the mouth), **levator nasolabialis** and **levator labii superioris muscles** (elevate the nose and upper lip), and **depressor labii inferioris** (depresses the lower lip). There is no need to identify these muscles.

1.7.3 Muscles of Mastication

Goal: Know innervation for the muscles of mastication. Identify the masseter muscle only. If need be, the rest of the mastication muscles could be studied in prosected specimens.

The muscles of mastication (or masticatory muscles) assist with chewing food (opening and closing the jaws). They include **masseter, temporal, digastricus, medial** and **lateral pterygoid** muscles.

The muscles of mastication in the horse are like those of the bovine with minor differences in shape and size (e.g., digastricus has three parts in the horse but two parts in cattle).

Muscular motor branches of the **mandibular nerve** (subdivision of the trigeminal nerve, CN V) innervate muscles of mastication.

The digastricus muscle opens the jaw, and the rest of the mastication muscles (temporalis, masseter, medial and lateral pterygoids) close the jaw.

Use a cow skull and mandible to identify the general location of the muscles of mastication. Identify the masseter muscle on your specimen.

The **masseter muscle** covers the ramus and caudal body of the mandible. It originates from the zygomatic arch and facial tuberosity and inserts on the ramus of the mandible (Figure 1.17).

The **temporal muscle** (or temporalis) is indistinct in ruminants when compared with that of the horse and dog. It is deeply located in the laterally located temporal fossa of the skull (Figure 1.4). Thin rostral auricular muscles cover the temporal muscle. The rostral auricular muscles are thin and belong to the muscles of facial expression.

The **digastricus muscle** has caudal and rostral bellies in the dog. In the horse, it has an occipitomandibular part in addition to the rostral and caudal bellies. In ruminants, the digastricus is considered to have one part because the tendinous separation between the rostral and caudal bellies is indistinct. Additionally, the left and right muscles are connected across the intermandibular fossa. The **digastricus muscle** originates from the paracondylar process of the occipital bone (Figure 1.6) and inserts on the caudomedial surface of the mandible. There is no need to dissect it.

The **medial** and **lateral pterygoid muscles** occupy the pterygopalatine fossa deep to the zygomatic arch. There is no need for dissection of the pterygoid muscles.

1.7.4 Pharyngeal Muscles

Goal: Know nomenclature and function of pharyngeal muscles. Pharyngeal muscles are studied in details in small animals (dogs and cats). They will not be covered in detail or dissected here. There follows a brief synopsis of their nomenclature and innervation. There is no need to identify them.

1.7.4.1 Nomenclature of Pharyngeal Muscles

The prefix in the name of a pharyngeal muscle indicates its origin, which could either be a laryngeal cartilage or bone of the hyoid apparatus **(crico-, thyro-, hyo-, or stylo-).** The suffix is always the word -**pharyngeus** for all of the pharyngeal muscles.

The pharyngeal muscles of interest include **cricopharyngeus, thyropharyngeus, hyopharyngeus,** and **stylopharyngeus**. These muscles can be identified as one group on the dorsolateral surface of the esophagus.

The pharyngeal muscles originate from the laryngeal cartilages and from the hyoid apparatus. They assist with food swallowing (deglutition). The left and right muscles insert on the median dorsal wall of the esophagus. Collectively, they act as an upper esophageal sphincter to propel the food down the esophagus. The pharyngeal muscles contract en masse.

Branches from cranial nerves IX (**glossopharyngeal**) and X (**vagus**) supply the pharyngeal muscles.

1.7.5 Laryngeal Muscles

> **Goal:** Know the function and innervation of the cricoarytenoideus dorsalis muscle only. There is no need to dissect the laryngeal muscles.

The muscles of the larynx are divided into (i) **intrinsic laryngeal muscles** which connect various cartilages of the larynx, and (ii) **extrinsic laryngeal muscles** which connect the sternum with the thyroid cartilage or the thyroid cartilage with the hyoid apparatus. These muscles are studied more extensively in the horse and dog. They will not be dissected.

The first (intrinsic) group includes the **cricoarytenoideus dorsalis**, **cricothyroideus**, and **thyroarytenoideus** muscles. The **thyroarytenoideus muscle** is located deep to the lamina of the thyroid cartilage. Therefore the lamina of the thyroid cartilage should be reflected or fenestrated to uncover the thyroarytenoideus muscle. The thyroarytenoideus has two parts: the vocalis muscle rostrally, and the ventricularis muscle caudally.

The **cricoarytenoideus dorsalis** is the only intrinsic laryngeal muscle that dilates the glottis; the rest of the intrinsic laryngeal muscles close the glottis.

The second (extrinsic) group includes a long thin **sternothyroideus** muscle that spans the distance between the sternum (manubrium) and thyroid cartilage, and the short **thyrohyoideus** muscles between the lateral surface of the thyroid cartilage and thyrohyoid bone of the hyoid apparatus.

The caudal (recurrent) laryngeal nerve innervates all of the laryngeal muscles except the cricothyroideus muscle. The cranial laryngeal nerve, a branch of the vagus nerve (CN X), innervates the latter.

1.7.6 Hyoid Muscles

> **Goal:** There is no need to dissect the hyoid muscles. Your instructor may prepare a prosected specimen for identification of the superficial hyoid muscles.

The hyoid muscles are attached to bones of the hyoid apparatus. There are several muscles in this group. All of the hyoid muscles are of minor significance and will not be dissected.

Identify the most superficial hyoid muscles including the **mylohyoideus, geniohyoideus,** and **thyrohyoideus muscles**.

The long hyoid muscles, the **omohyoideus** and **sternohyoideus**, have their origin from the shoulder and sternum, respectively. They are located below the trachea.

1.7.7 Lingual Muscles

> **Goal:** Know the function and innervation of the lingual muscles. There is no need to dissect them.

The lingual muscles are divided into **intrinsic lingual muscles** (form the substance of the tongue) and **extrinsic lingual muscles** (move the tongue).

The lingual muscles receive more attention in the study of the dog anatomy. They are innervated by the **hypoglossal nerve (CN XII).**

1.7.8 Extraocular Muscles

Goal: Identify the action and innervation of the extraocular muscles but there is no need for their dissection. If needed, your instructor will prepare a prosected specimen.

The extraocular muscles move the eyeball. They are similar among domestic animals. There are seven extraocular muscles. Four **rectus muscles (dorsal, ventral, lateral,** and **medial), two oblique muscles (ventral** and **dorsal oblique**), and one retractor muscle **(retractor bulbi).** The action of the extraocular muscles is synonymous with their names. They are innervated by several cranial nerves.

A thin **levator palpebrae superioris** is located on the dorsal surface of the dorsal rectus muscle. It is not part of the extraocular muscles because it inserts on the superior eyelid. The action of the levator palpebrae superioris muscle is synonymous with its name, in that it elevates the upper eyelid.

The **oculomotor nerve (CN III)** innervates five muscles. They include all rectus muscles except the lateral rectus muscle. In addition, it innervates the ventral oblique muscle and levator palpebrae superioris.

The **abducent nerve (CN VI)** innervates two muscles: the lateral rectus and retractor bulbi muscles.

The **trochlear nerve (CN IV**) innervates one muscle: the dorsal oblique muscle.

A thin connective tissue sheet known as the **periorbita** envelops the extraocular muscles.

The action and innervation of the extraocular muscles are more clinically important in dogs and horses, especially when conducting cranial nerve examination. The anatomy of the eye muscles is similar to that of the horse. (For a more detailed description of eye muscles see M. Mansour, J. Steiss, and R. Wilhite *Equine Anatomy Guide: The Head and Neck*: 2016.)

Dissection of the extraocular muscles is time-consuming because of their deep location within the orbit and deep to the zygomatic arch. In general, the extraocular muscles are not clinically important in ruminants; we recommend that students become familiar with their innervation and general area of location. If needed, a prosected specimen can be used to demonstrate their location.

1.8 Blood Vessels, Lymph Nodes, and Nerves of the Head

1.8.1 Blood Vessels (Arteries and Veins)

Goal: Identify some of the major branches of the common carotid artery including the facial artery in cattle, the transverse facial artery in goat, and the superficial temporal and cornual arteries in both cattle and goats. Unlike in other domestic animals, the internal carotid artery is much modified in ruminants. Of the veins of the head, identify the external jugular, maxillary, linguofacial, facial, and frontal veins. Note that the facial artery is absent in small ruminants where the lingual artery is the direct branch off the external carotid artery. At the end of this unit watch **videos 6 and 7**.

1.8.1.1 Arteries of the Head

Only clinically important arteries of the head and neck are discussed here.

Study arteries of the head on a bovine head cut off the neck. The head can be split into equal halves along the midline. Use one side for blood vessels and nerves. With help of Figure 1.19(a), skin the head and carefully reflect the cutaneous muscles of the head.

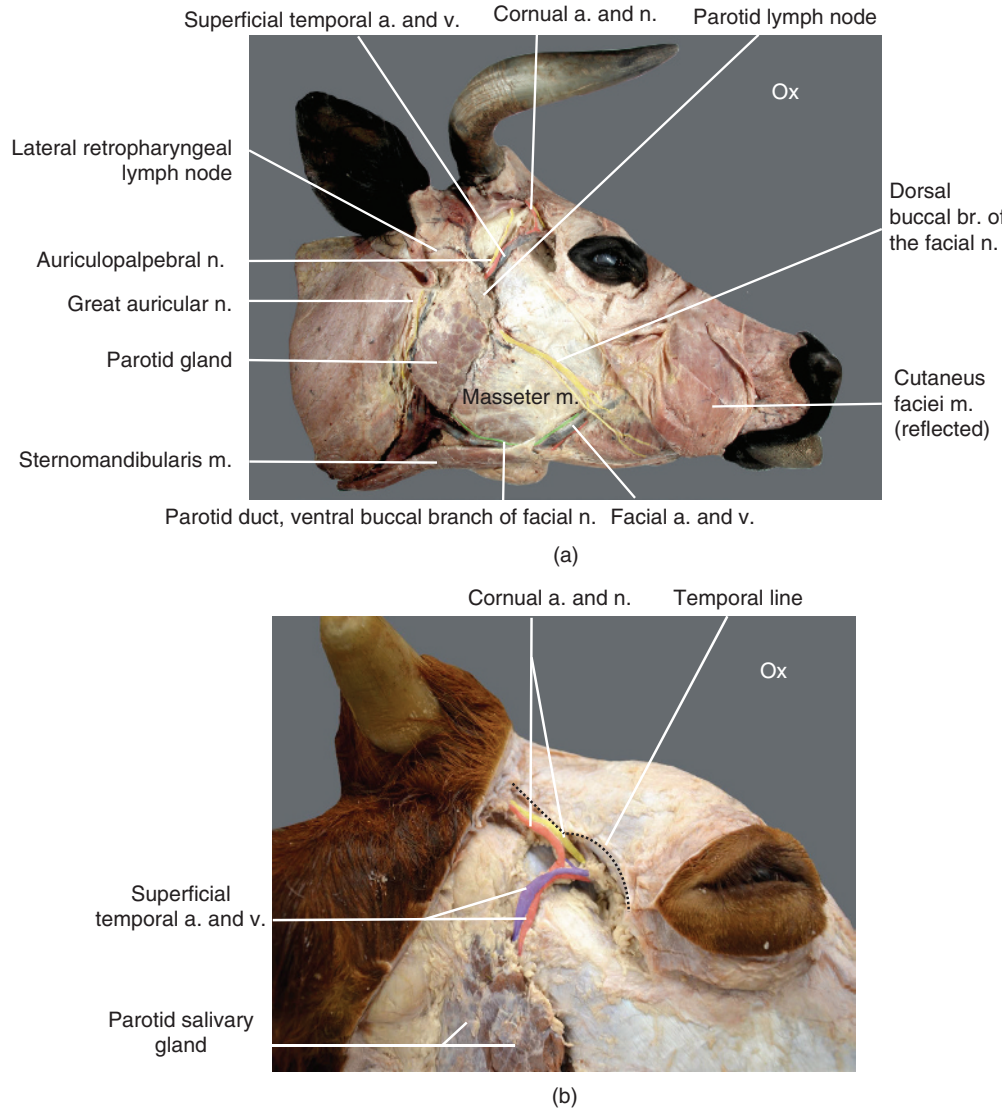


Figure 1.19 (a) Bovine head: lateral view. The cutaneus faciei muscle is reflected cranially to uncover the superficial vessels and nerves of the bovine head. The parotidoauricularis muscle that covers the parotid salivary gland is removed. (b) Bovine head: lateral view. Close-up view of the superficial temporal artery and vein, and cornual artery and nerve. In dehorning operations, the cornual nerve is blocked along the bony temporal line. The cornual artery is a branch of the superficial temporal artery.

Branches of the **common carotid artery** supply the head. Identify bilaterally located common carotid arteries located within the **carotid sheath**. The **carotid sheath** is found close to the esophagus in the visceral space of the neck.

Branches of the common carotid artery in ruminants are similar to other domestic animals. The regression of the internal carotid artery in ruminants after birth is one exception. The internal carotid artery supplies the brain in other species. In ruminants, the brain is supplied by branches from the maxillary and occipital arteries forming a complex network of fine arteries known as the ***rete mirabile***. The rete mirabile will not be dissected.

In the bovine head, follow the **external carotid artery** which serves as the major cranial continuation branch of the common carotid artery beyond the occipital artery. It gives off several branches that include the **linguofacial trunk** (gives the **lingual** and **facial arteries**), **caudal auricular,** and **superficial temporal arteries**. It continues as **maxillary artery** to supply the deep structures of the head. The maxillary artery gives several deep branches that are of no clinical value and should not be dissected.

The most clinically important arteries in ruminants that you should identify are the **cornual artery** (Figure 1.19b) that supplies the horns in the ox, buck, and ram; the **facial artery** (Figure 1.19b) in cattle (absent in small ruminants); and the **transverse facial artery** in goats (Figure 1.20). Identify the facial artery running along the ventral border of the masseter muscle accompanied by the ventral buccal branch of the facial nerve, facial vein, and parotid duct (Figure 1.19a).

The cornual artery is a branch of the **superficial temporal artery** (Figures 1.17, 1.18, and 1.19a,b). Note the clinical significance of the cornual artery (Box 1.14).

Box 1.14

The **cornual artery**, a branch of the **superficial temporal artery**, should be ligated or clamped at its origin to prevent bleeding in dehorning operations in adult ruminants.

Identify the **superficial temporal**, **cornual, facial,** and **transverse facial arteries** on lateral views of a goat and cow heads (Figures 1.18a and 1.19a,b).

In goats, the **transverse facial artery** courses with the dorsal buccal branch of the facial nerve. Identify the **dorsal buccal nerve** and transverse facial artery as they cross the lateral surface of the masseter muscle in goats (Figure 1.18c).

The transverse facial artery is present in both small ruminants and in cattle. It a branch of the superficial temporal artery.

Note that the facial artery and transverse facial arteries are used for pulse evaluation in cattle and goats, respectively (Box 1.15). The rostral branches of the facial artery supply blood to lips and muzzle region. They will not be discussed.

Box 1.15

The facial artery is used for pulse evaluation in cattle. The artery crosses the ventral border of the mandible in front of the masseter muscle accompanied by the facial vein, ventral buccal branch of the facial nerve, and parotid duct (Figure 1.19a). The facial artery is absent in goats and instead the transverse facial artery serves the role of the facial artery for pulse evaluation in goats.

In horses, the facial, masseteric, and transverse facial arteries are sites for pulse evaluation.

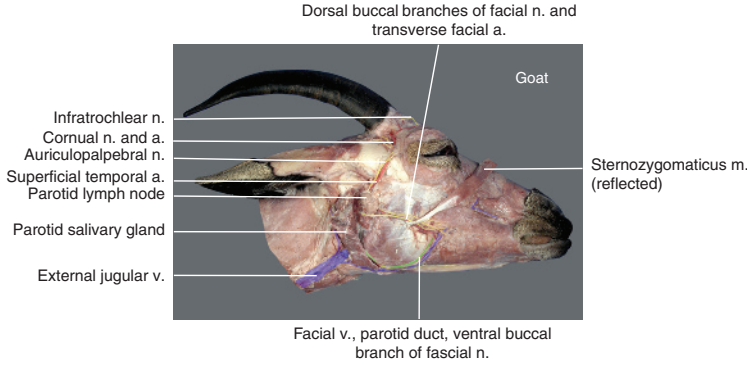


Figure 1.20 Caprine head: lateral view. Parotid gland, parotid lymph node, vessels and nerves of the goat head.

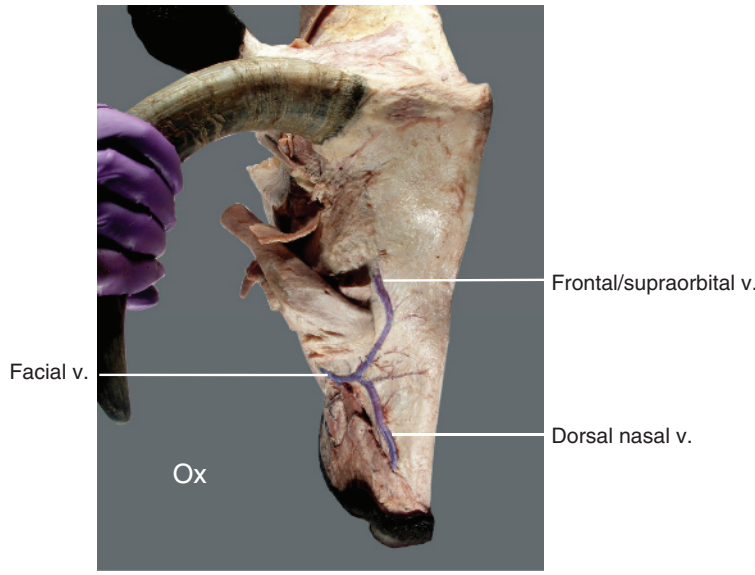


Figure 1.21 Bovine head: dorsal view. The facial vein travels dorsally across the face and gives rise to the lateral and dorsal nasal veins. The **facial vein** is continued dorsally by the angularis oculi vein (courses to medial canthus of the eye) and the **frontal vein** (courses more dorsally in the supraorbital groove towards the supraorbital foramen). At the supraorbital foramen, the frontal vein becomes the supraorbital vein. The supraorbital vein drains into the ophthalmic plexus within the bony orbit.

Named branches from the facial artery (inferior and superior labial arteries) are variously distributed in the rostral head below and above the lips to supply the muzzle region (they will not be dissected). A similar pattern exits for branches of the **facial vein**, which is satellite to the facial artery (Figure 1.21).

1.8.1.2 Veins of the Head

Goal: Identify the external jugular, maxillary, linguofacial, facial, dorsal nasal, angularis oculi, and frontal veins. Know the clinical significance of the external jugular and frontal veins.

The superficial veins of the head drain into the **external jugular vein**, which carries venous blood from the head and neck back toward the right side of the heart. The external jugular vein joins other veins at the thoracic inlet to form the cranial vena cava. It is a major site for venipuncture.

As in other species, the external jugular vein is formed by confluence of the **maxillary** and **linguofacial** veins (Figure 1.22).

The **frontal vein**, a large vein, runs in the supraorbital groove medial to the eye (Figures 1.1 and 1.2). It is clinically important in cattle and must be avoided when surgically entering the rostral frontal sinus. The frontal vein is continued rostrally by the angularis vein (passes to the medial canthus of the eye) and caudally by the supraorbital vein (passes through the supraorbital foramen to join the ophthalmic plexuses within the orbit of the eye).

Identify the facial vein and its continuation by the frontal vein over the orbit (Figure 1.21).

1.8.2 Lymph Nodes of the Head and Neck

Goal: Identify the major lymph nodes of the head and know which is important in meat inspection (Figures 1.19, 1.20, 1.22, and 1.23). Abnormal appearance of lymph

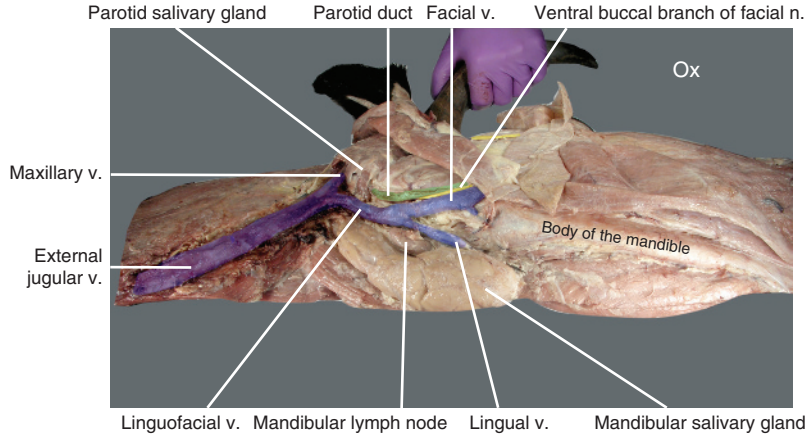


Figure 1.22 Right bovine sagittal head and neck section: ventrolateral view. Note that the external jugular vein is formed by the confluence of the maxillary and linguofacial veins.

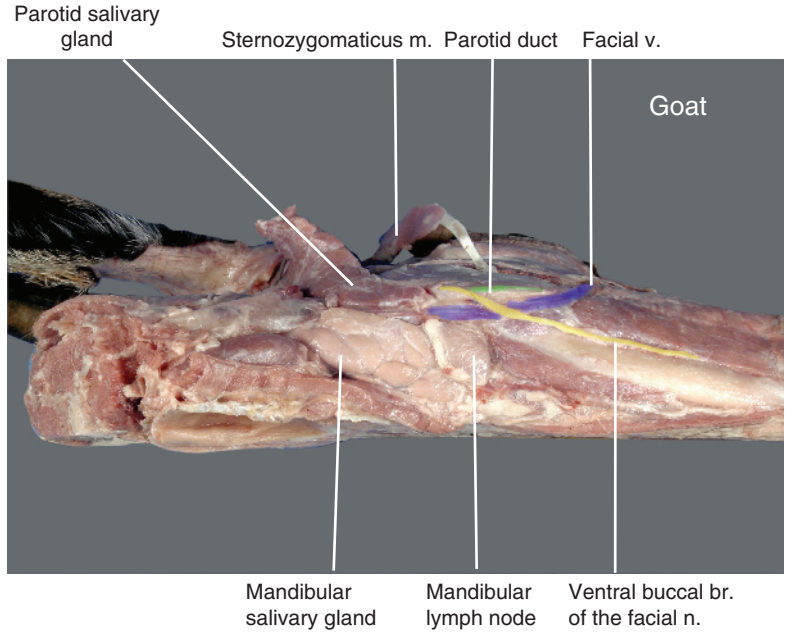


Figure 1.23 Caprine right half head and neck: ventrolateral view. Note that the mandibular salivary gland is located caudal and medial to the mandibular lymph node.

nodes suggests pathology in the area drained by those nodes.

The major lymph nodes of the head and neck are like other domestic animals. They include **(i) parotid, (ii) mandibular, (iii) retropharyngeal (medial** and **lateral retropharyngeal),** and **(iv) deep cervical** (cranial, middle, and caudal groups) (Figure 1.24).

Other lymphoid structures include five tonsils: pharyngeal, palatine, tubal, lingual, and tonsils of the soft palate.

Identify the **medial retropharyngeal lymph nodes** on midsagittal section of the bovine

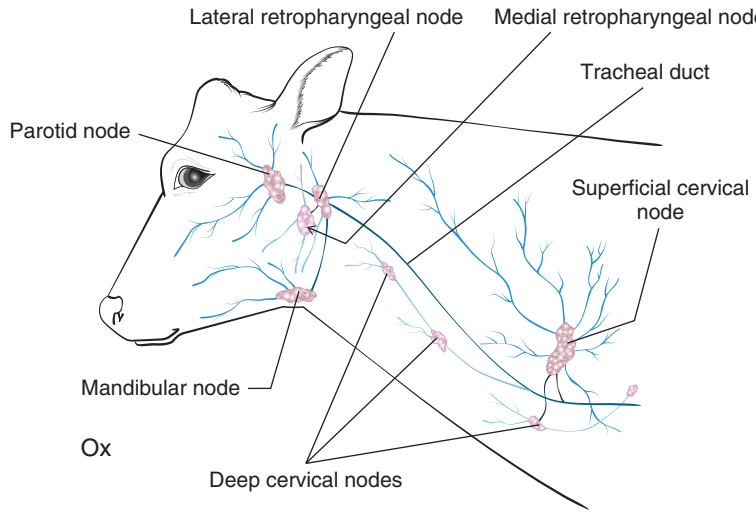


Figure 1.24 Lymphocenters of the bovine head and neck.

head. The **parotid, lateral retropharyngeal,** and **mandibular lymph nodes** should be identified on lateral and ventral views of the head with the help of Figures 1.19a, 1.20, 1.22, and the following description:

- **Parotid lymph node:** located in the rostral border of the of parotid salivary gland.
- **Lateral retropharyngeal lymph node:** ventral to the wing of the atlas and medial to the caudal aspect of the mandibular salivary gland.
- **Mandibular lymph nodes:** 1–3 lymph nodes that are located rostral and lateral to the mandibular salivary glands close to the caudal angle of the mandible. They are oval in shape.

Lymph is channeled from distinct areas of the body to a target lymph node (inflow) by the way of afferent lymphatic vessels. Lymph vessels leaving lymph nodes (out flow) to join the next lymph node or vein are known as efferent lymphatic vessels.

A single or group of lymph nodes form a single unit known as a **lymphocenter.** For example, the **lateral retropharyngeal lymphocenter** contains one large lymph node. It is the main collection center for lymph fluid from the entire head in ruminants. Identify the lateral retropharyngeal lymph node located on the lateral head below the wing of the atlas (Figure 1.24).

From the lateral retropharyngeal lymphocenter, the lymph outflow is to the tracheal lymphatic duct of the neck. The pathway of the lymph from the tracheal duct is variable and lymph could be channeled either to the large veins at the thoracic inlet or directly to the thoracic duct (the duct will be identified later with the thorax).

Box 1.16

The parotid lymph node is located along the rostral edge of the parotid salivary gland. It drains the region of the eye. In cattle, this node is usually inspected in slaughterhouses to determine cancer of the eye. The main lymph collection in the center of the head, the lateral retropharyngeal, is also inspected to rule out general head infections.

The medial retropharyngeal lymph node may become inflamed and could interfere with swallowing and breathing by causing compression in the region of the larynx and/or oropharynx. Identify the medial retropharyngeal lymph node on a medial (sagittal) section of the head.

1.8.3 Nerves of the Head

Goal: Know the nomenclature of cranial nerves and their broad functions, especially if you are learning these nerves for the first time. Identify the **cornual nerve** (branch of the maxillary subdivision of the trigeminal nerve that supplies the horn in the ox (Figure 1.19b); the **dorsal and ventral buccal** and **the auriculopalpebral nerve branches of the facial nerve** (CN VII). Know the function and clinical significance of the cornual nerve (blocked in dehorning operations), dorsal buccal nerve of CN VII (subject to injury on lateral recumbency), and auriculopalpebral nerve (blocked to prevent blinking of eye during eye examination).

Twelve (12) pairs of **cranial nerves** (CNN) supply the structures of the head. Names and roman numerals designate these nerves. The numerals reflect the rostral to caudal sequence of origin from the brainstem. **Parasympathetic fibers** are present in **cranial nerves III, VII, IX, and X**.

1.8.3.1 Summary of Cranial Nerves and Their Functions

Below is a brief overview of CNN names and functions. The formina by which they pass from the brainstem to outside of the skull are discussed. Some of the branches that you need to know are disused with the head or eye.

Olfactory nerve (CN I). The olfactory nerve conveys the sense of smell. Its fibers pass from the olfactory mucosa on the ethmoid concha to the olfactory bulb of the brain through the **cribriform plate**. There is no need to identify this nerve.

Optic nerve (CN II). The optic nerve conveys the special sense of vision. Its fibers pass through the **optic canal**. Identify the optic nerve on the eye ball or section (see section 1.13). On axial section of the eye the optic nerve is identified as optic disc (see section 1.13).

Oculomotor nerve (CN III). The oculomotor controls eye movement by innervating four extraocular muscles. The parasympathetic fibers in CN III cause constriction of the pupil and control the shape of the lens (accommodation). The oculomotor nerve passes through the **foramen orbitorotundum**. There is no need to identify this nerve.

Trochlear nerve (CN IV). This controls eye movement by suppling one extraocular muscle (dorsal oblique muscle). It passes through the **foramen orbitorotundum**. There is no need to identify this nerve.

Trigeminal nerve (CN V). The trigeminal nerve has three branches that include two sensory divisions (**maxillary** [V1] and **ophthalmic** [V2] **nerves**), and one division that has both sensory and motor fibers (**mandibular** nerve [V3]). Overall, the trigeminal subdivisions convey the sense of touch, pain, and temperature (hot and cold). The mandibular subdivision of the trigeminal nerve innervates muscles of mastication.

All the trigeminal nerve divisions, except the mandibular division, pass through the **foramen orbitorotundum**. Several branches of the trigeminal nerve pass out of the skull to receive sensation from the surface of the head. Identify the location of the **supraorbital, infraorbital,** and **mental nerves** and know their functions.

Abducent nerve (CN VI). The abducent nerve controls eye movement by innervating two extraocular muscles (lateral rectus and retractor bulbi muscles). It passes through the **foramen orbitorotundum**. No need to identify this nerve.

Facial nerve (CN VII). The facial nerve supplies motor innervation to the muscles of facial expression. It has parasympathetic components that regulate tear and saliva production. It supplies salivary glands, lacrimal glands, and secretion in the nasal cavity. It also conveys taste sensations from the rostral two-thirds of the tongue.

Individual branches of the facial nerve that are of clinical interest include the **dorsal** and **ventral buccal branches** which supply most muscles of facial expression, the **auriculopalpebral nerve** that controls movement of the ear (auricular muscles) and closing and opening of the palpebral fissure (orbicularis oculi muscle). The facial nerve passes out of

the skull through the **stylomastoid foramen**. Identify the **buccal branches** and **auriculopalpebral nerve** (Figures 1.19a and 1.20).

Vestibulocochlear nerve (CN VIII). The vestibulocochlear nerve conveys the special sense of hearing and balance. There is no need to identify this nerve.

Glossopharyngeal nerve (CN IX). The glossopharyngeal nerve, as its name suggests, is related to the tongue and the pharynx. It innervates the pharyngeal muscles and pharyngeal mucosa. The parasympathetic component in the CN IX carries the special sense of taste from the caudal third of the tongue. It also regulates saliva production along with the facial nerve.

The glossopharyngeal nerve exists the brainstem through the **jugular foramen**. There is no need to identify this nerve.

Vagus nerve (CN X). The vagus nerve is the longest of the cranial nerves and is known as the "wonderer" nerve because it supplies vast areas of the body from the head to caudal abdomen. It regulates movement (peristalsis) and general sensation of the viscera in the thorax and abdomen. In the cranial region of the body, it innervates some of the pharyngeal muscles and pharyngeal mucosa along with the glossopharyngeal nerve. The vagus nerve slows the heart rhythm. In the neck, the vagus nerve is intimately associated with the sympathetic trunk. It is known as **vagosympathetic trunk**. Identity the vagosympathetic trunk in the neck region (see section 1.15.2. The branches of the vagus will be discussed with the thoracic cavity.

Motor branches of the vagus, the **recurrent laryngeal (caudal laryngeal)** and **cranial laryngeal nerves**, supply the laryngeal muscles.

The vagus nerve passes through the **jugular foramen**.

Accessory nerve (CN XI). The accessory nerve innervates some muscles of the neck, including the **trapezius muscle** located over the dorsal border of the scapula (see section 1.15.1). The accessory nerve controls movement of the head and shoulder. It has **dorsal** and **ventral branches**.

Identify the **dorsal branch** of the accessory nerve passing to the deep (medial) surface of the trapezius muscle (see section 1.15.2).

The accessory nerve passes through the **jugular foramen**.

Hypoglossal nerve (CN XII). The hypoglossal nerve controls movement of the tongue. Its somatic motor fibers innervate the intrinsic and extrinsic muscles of the tongue. The hypoglossal nerve exits the skull through the **hypoglossal canal**.

Examination of specific cranial nerves is more important in small animals (dogs and cats) and in horses. It does not often have practical application in ruminants. However, regional nerve blocks on the head have important clinical utility in cattle (anesthesia in dehorning operations, eye removal, eye examination, and suturing of lacerations on the muzzle region).

The most important superficial nerves of the head include branches of the facial nerve (CN VII), and the trigeminal nerve (CN V). Identify the **auriculopalpebral, dorsal,** and **ventral buccal branches of the facial nerve**, **cornual nerve** (branch of maxillary subdivision (V1) of the trigeminal), the **infraorbital nerve** (continuation of the maxillary division of the trigeminal nerve), and **mental nerve** (continuation of inferior alveolar nerve). The inferior alveolar nerve itself is a branch of the mandibular division of the trigeminal nerve (V2).

Note the course of the ventral buccal nerve along the ventral edge of the masseter muscle and body of the mandible (Figures 1.19a and 1.20). Compare this location with the location of the dorsal buccal branch. The ventral buccal branch is reasonably more protected by the medial edge of the body of the mandible, and the ventral and rostral edges of the masseter muscle.

The course of the ventral buccal branch of the facial nerve in ruminants is different from that in the horse and dog. In the latter species, the dorsal and ventral buccal branches of the facial nerve cross the lateral surface of the masseter muscle, making the dorsal and ventral buccal branches

of the facial nerve equally vulnerable to compression forces (e.g., in lateral recumbency during general anesthesia). In ruminants, only the dorsal buccal branch is vulnerable to damage from prolonged lateral recumbency.

Box 1.17

Cranial nerve damage can be manifested in different clinical presentations depending on the functions of the cranial nerve involved.

The dorsal buccal branch of the facial nerve (CN VII) for example is vulnerable to damage in lateral recumbency during general anesthesia when the head is not properly padded.

Box 1.18

Regional anesthesia in ruminant head

In cattle, physical restraint and local anesthesia are used as a safe alternative to general anesthesia when performing surgical procedures on the head. Examples of these procedures include dehorning and eye removal.

In dehorning operations, the following nerves are blocked in cattle and goats

In cattle

- The **cornual nerve** (arises from the zygomaticotemporal nerve, a branch of the maxillary division of the trigeminal nerve [CN V]) is blocked midway along the temporal line between the lateral canthus of the eye and the lateral base of the horn (Figure 1.19b).
- The **great auricular nerve** (branch of the 2nd cervical nerve [C2]) is blocked between the horn and the base of the ear or by ring block around the base of the horn.

In goats

- In addition to the **cornual** and **great auricular nerves**, the **infratrochlear nerve** (branch of the ophthalmic division of the trigeminal nerve) is blocked mid-way between the medial canthus of the eye and medial base of the ear (medial to the cornual nerve block).
- Because it is difficult to block all of the branches of the above three nerves in small ruminants, general anesthesia is the preferred option when performing dehorning in adult goats.
- Dehorning in both cattle and goats is best performed on young animals (1–2 weeks of age) by removal of the epiceras (germinal epithelium located at the border of the tiny cornual process). Cauterization can be used to remove both the **epiceras** and **scent glands** in male goats. These glands are located between the horns. They are activated by testosterone, the male steroid hormone. During the breeding season they produce strong odor (considered offensive by owners) that attracts female goats.

Other nerve blocks include:

- Infraorbital nerve block for nasal laceration or placing of a nose ring in bulls.
- Auriculopalpebral nerve block for eye examination. The auriculopalpebral nerve is the branch of the facial nerve (CN VII) that crosses the zygomatic arch to supply the orbicularis oculi muscle (from the palpebral branch of the auriculopalpebral nerve). The auriculopalpebral nerve block is performed by injection of an anesthetic agent under the skin midway between the lateral canthus of the eye and the base of the ear at the level of the zygomatic arch.
- Enucleation (removal) of the eye is performed by either retrobulbar or Peterson's

Box 1.18 (Continued)

nerve block. Peterson's nerve block is more difficult to perform than the retrobulbar nerve block. It requires familiarity with the bony prominences at the site of injection. The landmarks for needle placement are the angle made by the temporal of the zygomatic bone and the zygomatic process of the squamous temporal bone (Figure 1.25). The coronoid process and pterygoid crest could hinder needle placement (review these bony landmarks in Figure 1.25). More details on how to perform retrobulbar nerve blocks are discussed in Box 1.19.

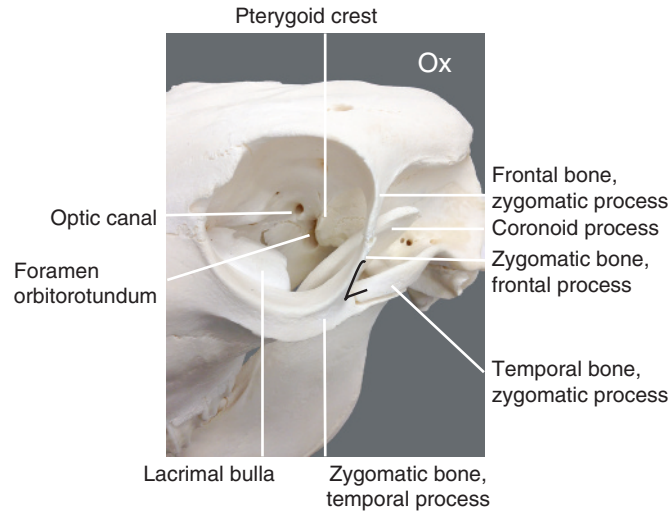


Figure 1.25 Bovine skull and articulated mandible: caudolateral view. Figure shows the landmarks for Peterson's nerve block for enucleation of the eye. The angle formed by the frontal process of the zygomatic bone and the zygomatic process of the temporal bone is used for anesthetic injection. The ramus of the mandible (coronoid process) and the pterygoid crest are in the needle pathway and should be avoided.

Box 1.19

Four-point retrobulbar nerve block

The retrobulbar nerve block is used as an easier alternative to the more challenging Peterson's nerve block for (i) enucleation of the eye, or (ii) surgery of the cornea. The aim is to anesthetize the nerves (cranial nerves III, IV, V [V1–2], and VI) coursing to the eye through the foramen orbitorotundum.

The needle placement for retrobulbar technique is performed by injecting a local anesthetic at four sites behind the globe of eye. The sites include injections at the medial and lateral canthi of the eye, and above the superior and inferior eyelids. Care should be taken to avoid puncturing the eyeball or damaging the lacrimal bulla. Fingers could be used to deflect the globe of the eye away from the tip of the syringe when advancing the needle.

In Peterson's eye block in the ox, the local anesthetic is deposited to anesthetize nerves exiting the **foramen orbitorotundum**. Identify this foramen on the skull. Nerves passing through foramen orbitorotundum in cow, sheep, and pig include:

- CN III (oculomotor nerve)
- CN IV (trochlear nerve)
- CN V (ophthalmic [V-1] and maxillary [V-2] divisions of trigeminal nerve)
- CN VI (abducent nerve).

1.9 Salivary Glands

Goal: Identify the major salivary glands (parotid, mandibular, and sublingual) and the course of their ducts. Secretion of saliva from salivary glands is an important source of electrolytes (bicarbonates), mucus, and digestive enzymes. Copious production of saliva in ruminants is essential for food fermentation in the forestomach (rumen and reticulum).

The major salivary glands of ruminants are generally like other domestic animals and include (i) **parotid**, (ii) **mandibular**, and (iii) **sublingual** (**monostomatic** and **polystomatic divisions**).

Other salivary glands of minor importance include *dorsal, middle, and ventral buccal salivary glands. There is no need to identify the buccal salivary glands*.

With the help of Figures 1.17, 1.18, 1.22, and 1.23 and the following description, identify the **parotid, mandibular,** and **monostomatic sublingual glands.** *Reflect the parotidoauricularis muscle to expose the parotid salivary gland. Be careful to preserve the maxillary vein (located in the gland substance) and facial nerve deep to the gland.*

The **parotid salivary gland** is located medial to the thin parotidoauricularis muscle between the ventral border of the mandible and the wing of the atlas. It is rectangular in shape. The **parotid duct** arises from the rostral border of the gland in small ruminants and ventrolateral aspect in cattle. It opens in the upper vestibule of the mouth close to upper molar 2 (M2) cheek tooth. The duct courses along the ventral border of the masseter muscle and the body of the mandible before it turns dorsally on the lateral side of the head.

Identify the **parotid duct** in the ox coursing along the ventral and rostral edges of the masseter muscle accompanied by the **facial vein, facial artery,** and **ventral buccal branch** of the facial nerve. The parotid gland is relatively smaller than that of the horse (Figures 1.17 and 1.18). In goats, the parotid duct has a similar course but the facial artery is missing.

The **mandibular salivary gland** lies in the caudal border of the mandible and curves rostrally into the intermandibular area. The gland has a crescent shape and is relatively larger than the parotid salivary gland. Identify the ventral part of the mandibular salivary gland in the intermandibular region (Figure 1.23). Be sure to differentiate between the mandibular salivary gland and mandibular lymph node. The dorsal part of the mandibular salivary gland lies deep to the parotid salivary gland and wing of the atlas.

The **mandibular** and monostomatic sublingual ducts open at the **sublingual caruncle**. Identify the sublingual caruncle on floor of the lower jaw of your specimen or on a plastinated specimen (Figure 1.15).

1.10 The Pharynx

Goal: Identify the major parts of the pharynx on a median sagittal section of the head (Figure 1.26).

The pharynx is defined by some anatomists as the crossing place for food and air. It has three parts: (i) **oropharynx,** (ii) **nasopharynx,** and (iii) **laryngopharynx.** Identify the three parts on mid-sagittal section of the head (Figure 1.26).

1.10.1 Oropharynx

The oropharynx extends from the root of the tongue to the rostral surface of the epiglottic cartilage (Figure 1.26). It contains the **palatine tonsil.** It is relatively narrow.

1.10.2 Nasopharynx

The nasopharynx is located dorsal to the soft palate (Figure 1.26). It extends from the choanae to the end of the soft palate. It contains the

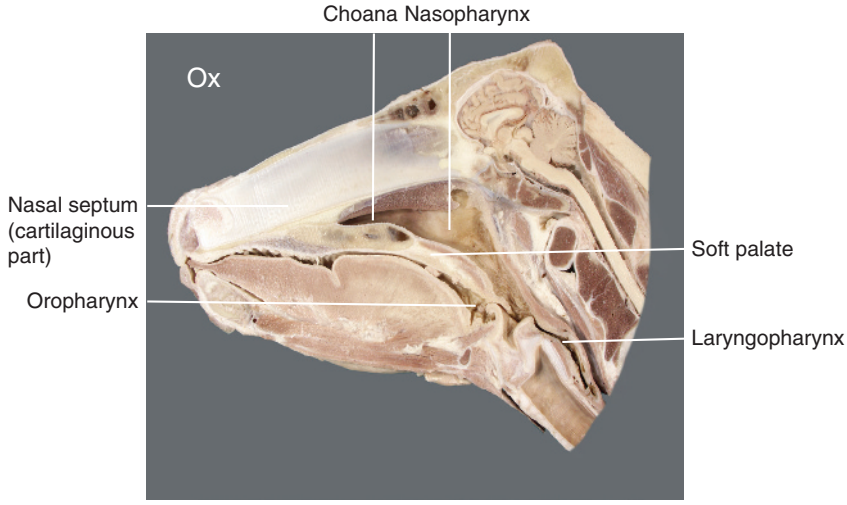


Figure 1.26 Bovine median sagittal section of the head passing through the nasal septum. Study the major regions of the pharynx that include the oropharynx, nasopharynx, and laryngopharynx. The nasal septum has small caudal bony part, and large cartilaginous rostral part that does not project distal to the choana.

opening of the auditory tube. In ruminants, the nasopharynx is incompletely divided by a pharyngeal septum. It contains the pharyngeal tonsils and the tubal tonsils in its caudal region.

1.10.3 Laryngopharynx

The laryngopharynx is located dorsal to the larynx and joins the esophagus caudally (Figure 1.26). The lumen of the laryngopharynx is closed by what is clinically known as the upper esophageal sphincter.

The **soft palate** continues from the hard palate caudally. It separates the nasopharynx dorsally from the oropharynx ventrally. The free margins of the soft palate form two mucosal arches:

1) **Palatoglossal arch:** extends from the lateral margins of the soft palate to the root of the tongue. Using sagittal section, pull the tongue towards you to demonstrate the palatoglossal arch coursing from the soft palate to the root of the tongue.
2) **Palatopharyngeal arch:** extends from the caudal part of the soft palate to fan over the entrance of the esophagus.

1.11 Tongue

Goal: Identify the **torus linguae** and **lingual fossa** on the bovine tongue and know their clinical significance. Know that the hypoglossal nerve (CN XII) innervates the intrinsic and extrinsic muscles of the tongue. Other cranial nerves of the tongue convey general sense (trigeminal, CN V and CN IX) and special sense of taste (facial and glossopharyngeal nerves, CN VII and CN IX).

The tongue is the principal organ of prehension in cattle. Small ruminants use their lips for prehension.

The tongue is subject to trauma and laceration associated with sharp objects or infectious processes. The extrinsic and intrinsic muscles of the tongue are innervated by the hypoglossal nerve (CN XII).

The tongue of ruminants has two special features of clinical interest. Using Figures 1.27 and 1.28 identify the raised caudal part of the tongue known as the **lingual torus** (or **torus linguae**). Additionally, a distinct transverse depression can be seen in the middle of the tongue in front of the lingual torus. This depression is known as lingual **fossa** (or **fossa linguae**).

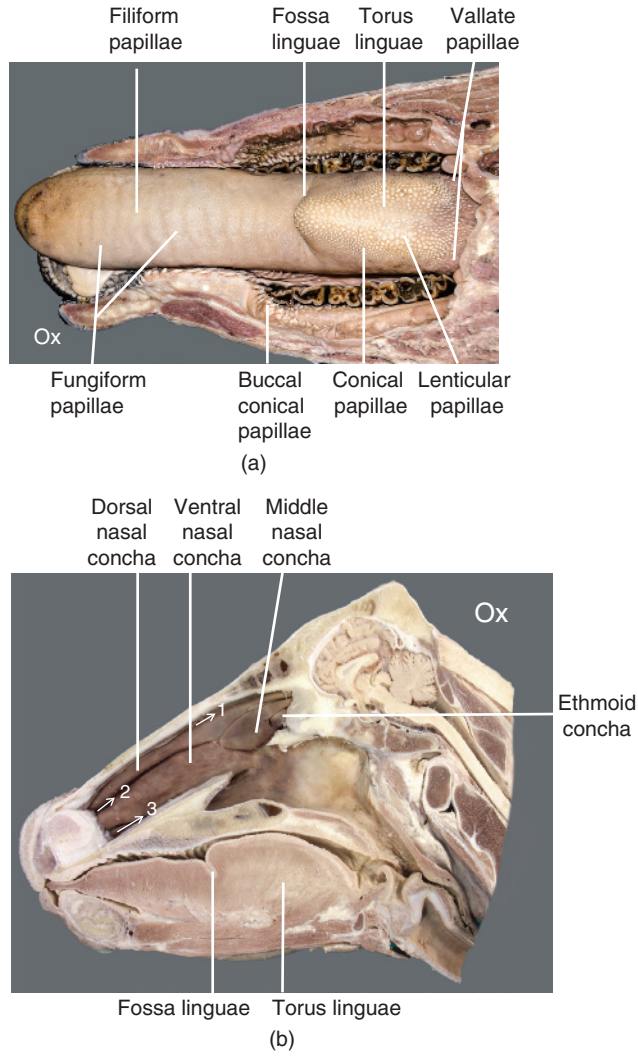


Figure 1.27 (a) Bovine tongue. The torus and fossa linguae (lingual torus and lingual fossa) are peculiar features on the bovine tongue. Note their clinical significance in Box 1.20. (b) Bovine median sagittal section of the head. The nasal septum has been removed to demonstrate the nasal and ethmoid conchae. The paper-thin spaces between the nasal conchae (arrows) are the dorsal nasal meatus (1), middle nasal meatus (2), and ventral nasal meatus (3). A common nasal meatus is the space that communicates with 1–3 meatuses and is located immediately lateral to the nasal septum and medial to the nasal and ethmoid conchae.

Box 1.20

Food tends to collect in the **lingual fossa.** The fossa is considered a potential site for harboring microbes. It has a delicate mucosa that can easily be pierced by sharp contaminated objects.

The **torus linguae,** the concave elevation at the root of the tongue, can present an obstacle to passage of a balling gun or cattle mouth Frick speculum. The gun must be carefully passed over the torus linguae before dispensing the bolus, otherwise the ball will be chewed and spilled out.

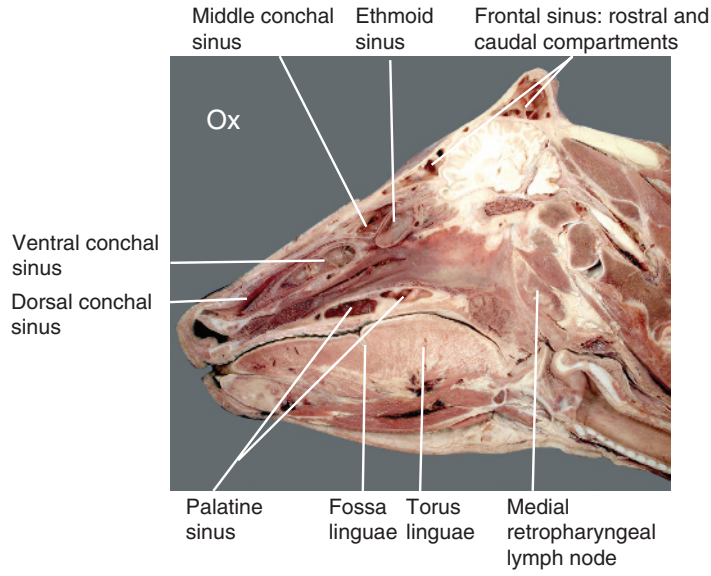


Figure 1.28 Median sagittal section of the bovine head. Conchae are opened to show the sinusal space within each.

1.12 The Larynx and Hyoid Apparatus

Goal: Identify bones and cartilages of the larynx and hyoid apparatus and some of the associated muscles (cricoarytenoideus dorsalis) on a sagittal section of the head or prosected specimen. Compare clinical significance with the horse and dog.

1.12.1 Larynx

The laryngeal cartilages include the **cricoid, thyroid, arytenoid,** and **epiglottis** from caudal to cranial, respectively (Figure 1.29). They are generally similar to other species with slight variations that merit some attention.

A feature of the ruminant thyroid cartilage relevant in palpation of the larynx is the prominence at its caudoventral aspect. This feature is located more cranially in the equine larynx.

Use a hemi-dissected ox larynx and compare it with that of the horse.

In ruminants, the cuneiform processes of the arytenoid cartilages are absent but the corniculate processes are very prominent when inspected by laryngoscope. Additionally, the aryepiglottic fold curves sharply as it connects the base of the epiglottis to the arytenoid cartilage.

On a sagittal section of the larynx, identify the **vocal fold** and laryngeal cartilages (Figure 1.29).

Box 1.21

Anatomy of the larynx is clinically more important in horses because of a condition known as laryngeal hemiplegia. Laryngeal hemiplegia (also called roaring) is mostly caused by damage to the left recurrent laryngeal nerve, a branch of the left vagus nerves. The condition is produced by a partial paralysis of the intrinsic laryngeal muscles, especially the cricoarytenoideus dorsalis muscle.

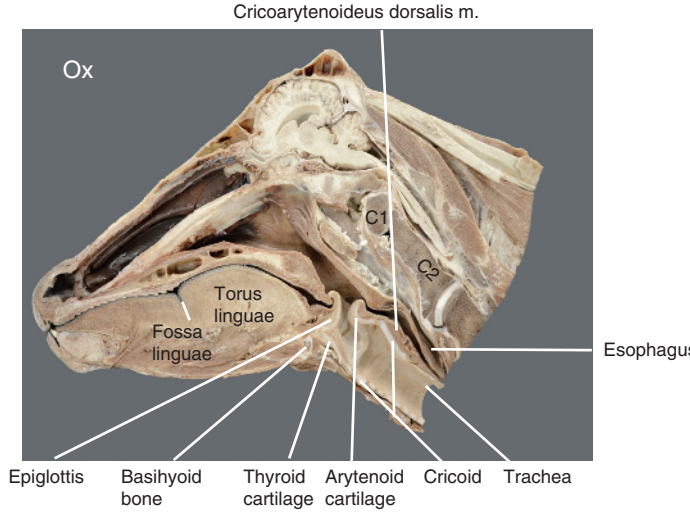


Figure 1.29 Bovine median sagittal section of the head. Identify laryngeal cartilages from caudal to rostral.

Neither the vestibular folds nor the lateral ventricles are present in ruminants.

Be familiar with the term glottis. The **glottis** is defined as the valvar region that controls the entrance to the trachea. The vocal processes of the arytenoid cartilages, the vocal folds, and the opening cleft (**rima glottidis**) form the glottis. In laryngoscopy, the size of the rima glottidis varies with the stage of respiration and abduction of the vocal folds.

1.12.2 Hyoid Apparatus

The bones of the hyoid apparatus are broadly like those of the horse except for a short lingual process and relatively distinct epihyoid bone (Figure 1.30).

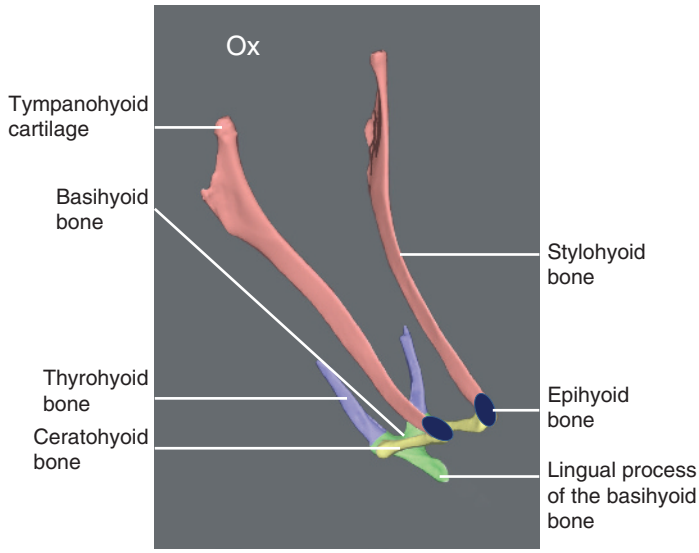


Figure 1.30 Bones of the bovine hyoid apparatus.

With the help of Figure 1.30, identify the **stylohyoid, epihyoid, ceratohyoid, basihyoid, lingual process of the basihyoid,** and **thyrohyoid bones.** All the hyoid bones are paired except for the basihyoid and lingual process.

The thyrohyoid bone articulates with the rostral cornu of the thyroid cartilage of the larynx.

1.13 The Eye

Goal: Identify the major structures and layers of the eyeball. Keep in mind the importance of the parotid lymph node in diagnosing cancers of the eye in cattle. If you have studied the anatomy of the eye before, your instructor may opt for omitting the eye from your syllabus. The anatomy of the eye is best studied on prosected specimens using a fresh and/or fixed cow eyeball.

Understand that the anatomy of the eye is clinically more important in small animals and in equine practice.

The eye in ruminants is located within a complete bony orbit. This is similar to the horse but different from the dog where the orbit rim is incomplete. A dense collagenous orbital ligament bridges the gap.

Ocular disorders are common in cattle and can be a result of nutritional, congenital, infectious, traumatic, or neoplastic factors.

Because the dissection of the eye is typically covered in equine anatomy and anatomy of small animals, the structures of the eye are not included in your lab ID of the head. Nevertheless, we have included the most salient information here. Identify the structures of the eye in bold typeface in this section with the help of Figures 1.31, 1.32, 1.33, 1.34, 1.35, and 1.36.

The eyeballs of horses and cattle are recessed in the bony orbit with a large **fat pad** behind the eye. The fat pad serves as a protection cushion against physical trauma.

1.13.1 Superficial Features of the Eye

Identify superficial features of the eye including superior and inferior **palpebrae** (upper and lower eyelids).

The thin translucent mucosal layer covering the interior of the eyelids is the **palpebral conjunctiva**. The palpebral conjunctiva reflects back on the white of the eye (sclera) as **bulbar conjunctiva**.

The angle between the palpebral and bulbar conjunctiva is the **fornix**. The space formed by the angle of reflection or fornix is the **conjunctival sac**. Dorsal and ventral conjunctival sacs are thus recognized.

Superior and inferior **puncta** (singular form is punctum) can be located near the **medial canthus** (or commissure) of the eye

Box 1.22

- In cattle, the eye is surgically removed when cancer of the eye is diagnosed. You need to review the landmarks for needle placement for enucleation of the eye. These are discussed in Figure 1.25.
- The parotid lymph node is inspected for diagnosis of eye cancer in slaughterhouses. The most common cancer of the eye in cattle is squamous cell carcinoma.
- Infectious bovine keratoconjunctivitis (IBK), or pink eye, is the most common ocular bacterial disease of cattle. It is spread between herds by the face fly *Musca autumnalis* and causes ulceration of the cornea.
- Diseases of eye in small animals include glaucoma (increased intraocular pressure) and cataract (increased opacity of the lens with aging). Glaucoma can be caused by inadequate drainage of the aqueous humor which is continuously produced by the ciliary body.

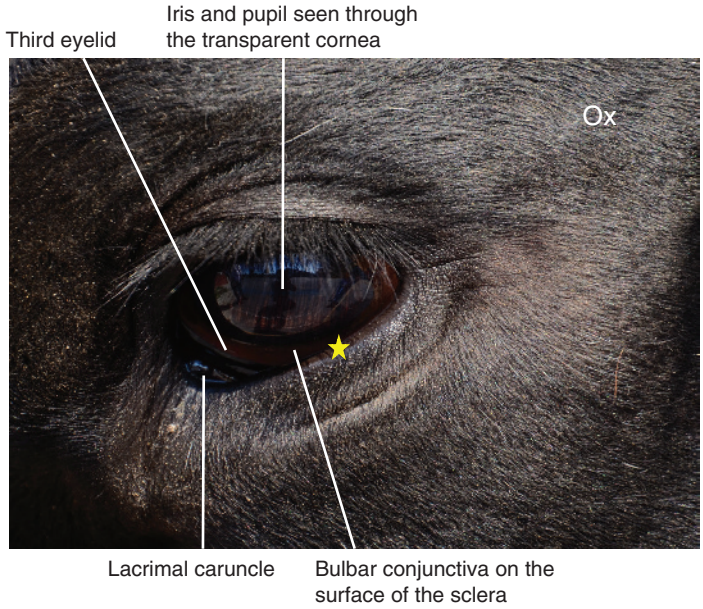


Figure 1.31 External features of the bovine eye. Note that the bovine iris is wide horizontally. Yellow star denotes the location of the palpebral conjunctiva on the lower eyelid. The bulbar conjunctiva covers the surface of the sclera (white of the eye).

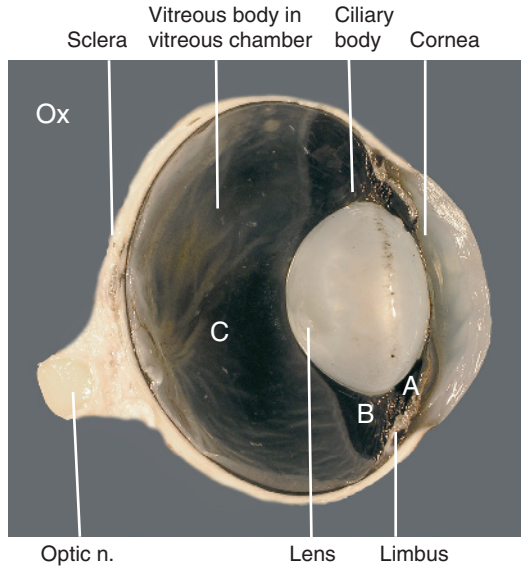


Figure 1.32 Bovine eye: section through the optic axis. A, anterior chamber; B, posterior chamber; C, vitreous chamber.

on the superior and inferior lids, respectively. This is where tears collect to pass from the puncta through lacrimal canaliculi to the **lacrimal sac**.

From the lacrimal sac, the tears pass through a single duct, the **nasolacrimal duct**, to empty in rostral part of the nasal cavity and out through the nose.

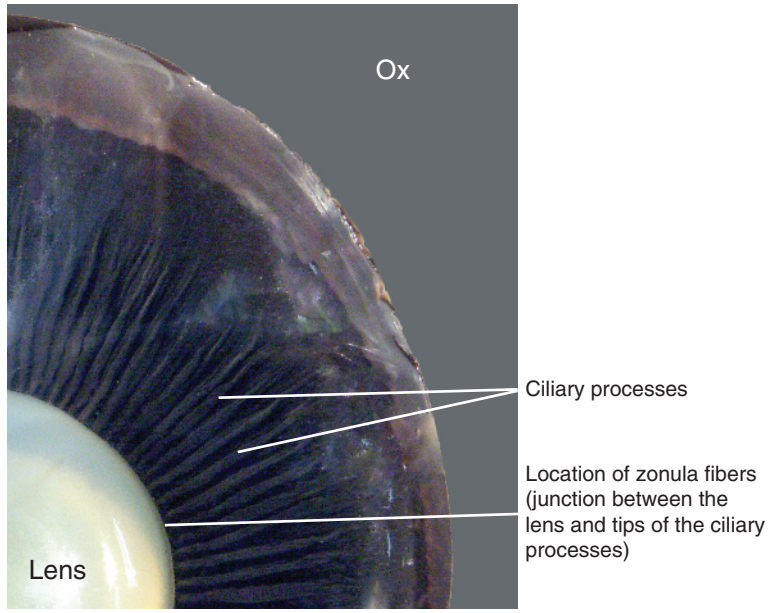


Figure 1.33 Posterior view of the eye, equatorial section of the bovine eye. Note the topographic relationship of the ciliary processes of the ciliary body, zonules (less visible), and lens.

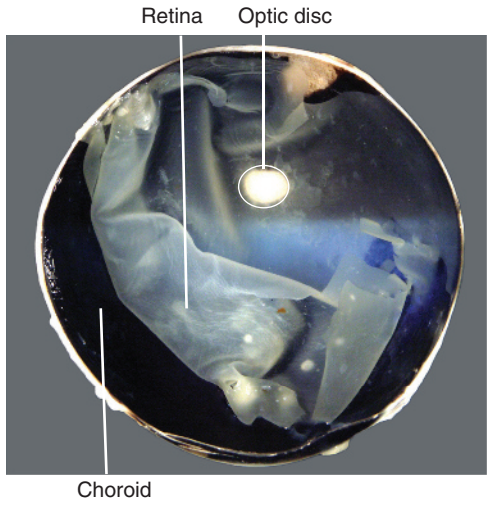


Figure 1.34 Vitreous chamber of a bovine eye (the vitreous body was removed): posterior view. Note that the retina appears as thin transparent membrane peeled off from the dark outer choroid layer. The retina is more firmly attached at the optic disc.

The **lacrimal gland, conjunctiva,** and the **gland of the third eyelid** are the main producers of tears.

Box 1.23

Staining from increased tearing (epiphora) and congestion of the conjunctival blood vessels is visible grossly especially with conjunctivitis (inflammation of the conjunctiva of the eye).

1.13.2 Layers of the Eye

The eye ball has three concentric layers known as eye tunics. From exterior to interior, the eye tunics are (i) outer **fibrous tunic**, (ii) middle **uvea** (or vascular tunic), and (iii) inner **nervous** tunic. Use Figures 1.32–1.36 to study the eye parts and tunics.

The outer fibrous tunic is composed of the **sclera** (white of the eye) and **cornea** (transparent and avascular). The relatively dark junction between the sclera and cornea is known as the **limbus**.

The middle vascular tunic is pigmented and is composed of the **iris** and **ciliary body** anteriorly, and **choroid** posteriorly.

The choroid has outer pigmented and inner vascularized parts. Blood vessels that supply the eye are located in the uvea.

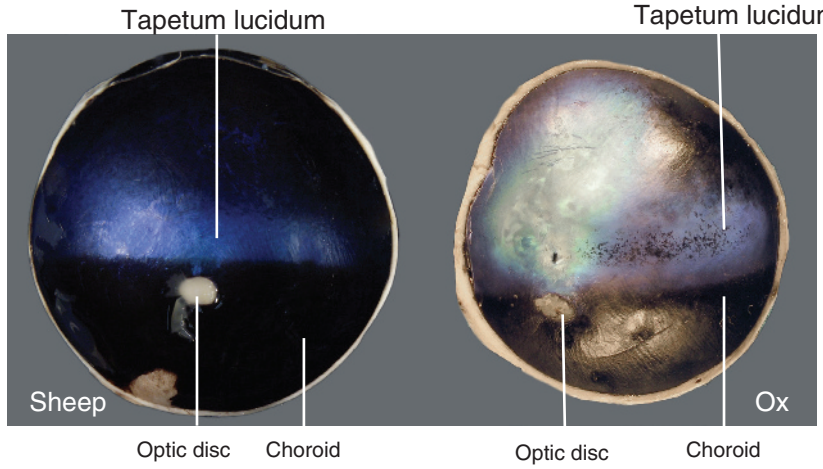


Figure 1.35 Fundus of the eye (view of the interior posterior surface of eye that include the area of the optic disc). Sheep (left) and bovine (right) eye axial sections showing tapetum lucidum and optic disc. The vitreous bodies and retinae have been removed.

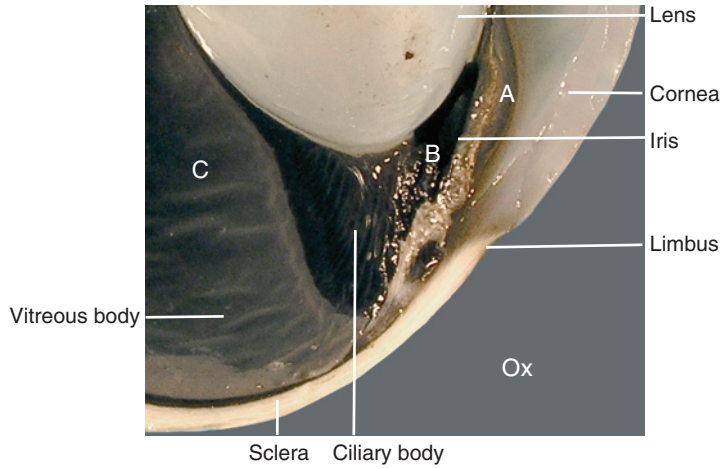


Figure 1.36 Bovine eye: axial section. Magnified anterior portion of the eye. Note the anterior chamber between the cornea and iris (A), the posterior chamber between the iris and ciliary body (B), and the vitreous chamber with vitreous body between the ciliary body and choroid (C). A, anterior chamber; B, posterior chamber; C, vitreous chamber.

The **iris** can be viewed through the transparent cornea. The bovine iris is wide horizontally and has **iridic granules** (**corpora nigra**) that are more prominent on the upper edge of the iris.

The size of the pupil is regulated by two smooth muscles: **constrictor** and **dilator pupillae**.

The constrictor pupillae muscle constricts the pupil in response to increased light intensity. It is innervated by parasympathetic fibers from the oculomotor nerve (CN III). The parasympathetic fibers of the oculomotor also supply the **ciliary muscle** (smooth muscle at the base of the ciliary body). The ciliary muscle regulates accommodation of the lens

(changes in lens shape from default oval shape to round shape). Rounding of the lens assists with near vision.

The dilator muscle increases the size of the pupil opening in response to fear and darkness. It is innervated by the sympathetic system that originates in cranial thoracic segments of the spinal cord.

Sympathetic fibers to the eye travel from the thoracic region through the vagosympathetic trunk in the neck to synapse in the cranial cervical ganglion at the base of the skull.

Postganglionic axons leave the cranial cervical ganglion to supply the structures of the head, including the dilator pupillae of the eye.

The **ciliary body** is composed of radially oriented **ciliary processes** (Figure 1.33). Projecting from the tips of the ciliary processes to circumference of the lens are the **zonular fibers**.

The ciliary muscle regulates tension on the zonules. When the ciliary muscle contracts, the zonules relax and the shape of the lens then changes from oval to round, allowing the eye to focus on close objects.

The **innermost** nervous layer is the **retina** (Figure 1.34). The retina consists of a posterior (visual or sensitive) area that covers the choroid, and anterior nonvisual (or nonsensitive or non-nervous) area that covers the back of the ciliary body and iris. Histologically, the retina has several layers.

The posterior view of the eye is called the **fundus**. Identify the white circular **optic disc** in the fundus (Figure 1.35). The optic disc is an area where the axons of the optic nerve exit the eye to convey visual impulses to the brain.

Identify the choroid in the posterior chamber of the eye. The area of choroid that has metallic blue and green colors is called the **tapetum lucidum** (Figure 1.35). The tapetum lucidum reflects light at night to increase visualization. The nature of the structure of the tapetum lucidum is different among domestic animals. It is fibrous in herbivores (cattle and horse) and cellular in carnivores (dogs and cats).

1.13.3 Sectioning of the Eyeball

Using a sharp scalpel, section the eye either in a horizontal or vertical plane. Identify the chambers of the eye. Be gentle when you cut through the eyeball. Fluid (aqueous humor and vitreous body) will ooze out.

1.13.3.1 Chambers of the Eye

With the help of Figures 1.32 and 1.36, use the tip of your probe to identify the following eye chambers.

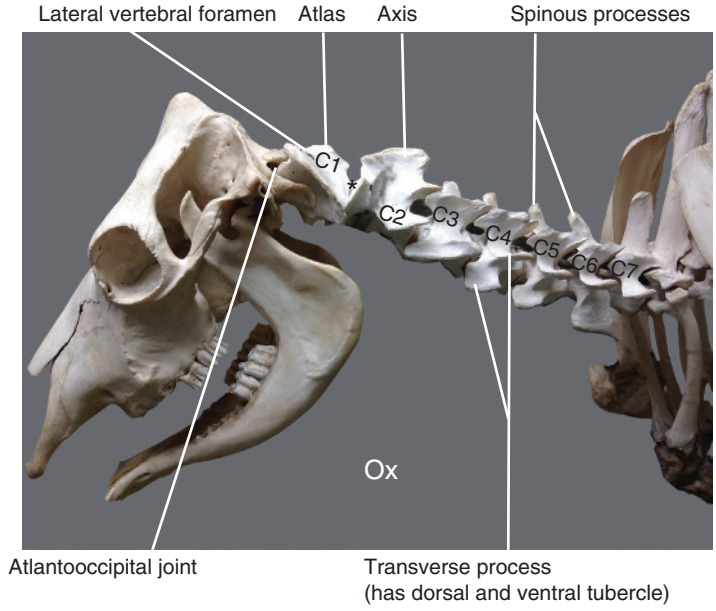
- **Anterior chamber:** the space between the cornea and iris.
- **Posterior chamber:** a narrow space between the iris and lens. The anterior and posterior chambers contain aqueous humor. The aqueous humor is a clear watery fluid produced continuously by the ciliary body.
- **Vitreous chamber:** the large space behind the ciliary body. In the live animal, the vitreous chamber is filled with a jelly-like substance known as the **vitreous body**. The vitreous body gives the round shape of the eye and helps keep the retina tucked to the interior of the choroid.

1.13.4 Drainage Pathway of the Aqueous Humor

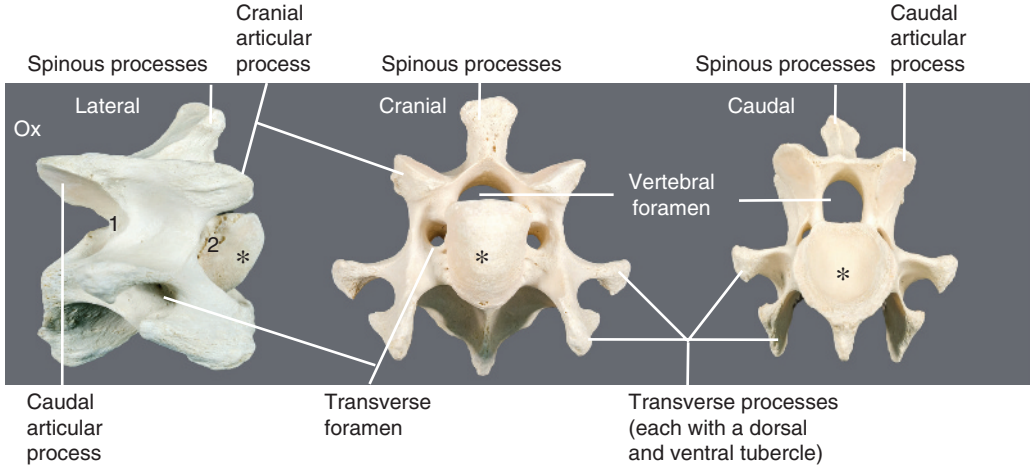
The aqueous humor is continuously produced by the ciliary body and circulates from the posterior chamber, through the pupillary opening, to the anterior chamber. From the anterior chamber, it passes to the angle between the iris and cornea (known as the **iridocorneal angle**) to where it passes through the trabecular meshwork before emptying into the scleral venous plexus to join the venous circulation.

1.14 Neck Skeleton

Goal: Study the features of the cervical vertebrae, and the articulations of the skull with the atlas (atlantooccipital joint) and the atlas with the axis (atlantoaxial joint).



(a)



(b)

Figure 1.37 (a) Bovine cervical vertebrae. Note the large wings of the atlas (palpable in the live animal). The atlas has lateral vertebral foramen (on the dorsal arch) and alar foramen (in the wings, not visible here). Transverse foramina are present on wings of the atlas in horses and dogs but are absent in ruminants. Note the dorsal and ventral tubercles of transverse processes of C2–C7 (two-pronged transverse processes; see Figure 1.37b). *Atlantoaxial joint. C7 has a large spinous process. (b) Three close-up views (lateral, cranial, and caudal) of a bovine cervical vertebra. In the articulated skeleton, the summation of the vertebral foramina forms the vertebral canal. 1, cranial vertebral notch; 2, caudal vertebral notch. The articular surfaces of the cranial articular processes are directed dorsomedially. The articular surfaces of the caudal articular processes are directed ventrolaterally. * Body of the vertebra.

With the help of a bovine articulated skeleton and Figure 1.37 spend a moment to study the osteology of the neck. Like other mammals, ruminants have seven cervical vertebrae (**C1–C7**). The first (C1) and second vertebrae (C2) are the **atlas** and **axis**, respectively.

Note that the atlas and axis have modified shapes and peculiar features compared to the rest of the cervical vertebrae. The atlas differs from a typical cervical vertebra as it lacks a body and instead has dorsal and ventral arches. The ventral arch is large and replaces the "body" found in other vertebrae.

Note the lateral vertebral foramen on the dorsal arch. Additionally, the atlas has large transverse processes commonly called the **wings of the atlas.** The wings of the atlas differ from the two-pronged transverse processes of C2–C7 vertebrae. Being large and superficial, the wings of the atlas are palpable in the live animal.

The atlas has lateral vertebral and alar foramina but lacks the transverse foramina that pierce the transverse processes of C2–C6 vertebrae. The vertebral artery and nerve pass cranially through the transverse foramina of C6–C2 vertebrae and the lateral vertebral foramen of the atlas to supply the brain.

In the atlas, the first cervical spinal nerve exits the vertebral canal through the lateral vertebral foramen. The nerve divides into dorsal and ventral branches after it exits the lateral vertebral foramen. The ventral branches of the first cervical spinal nerve pass through the alar foramen.

Locate the lateral vertebral foramen on the dorsal craniolateral surface of the dorsal arch of the atlas.

In contrast to ruminants, which lack a transverse foramen, the atlas in horses and dogs has a transverse foramen.

Oxen and horses have cranially located **alar foramina**. This foramen is incomplete in the dog and is called the alar notch. This foramen conveys the ventral branch of C1 cervical spinal nerve.

Note the modified articulations between the atlas and skull (**atlantooccipital joint**) and atlas and axis (**atlantoaxial joint**) (Figure 1.37a).

The axis also differs from the rest of the cervical vertebrae. It has an elongated spine and modified cranial articular process known as the **dens**, or **odontoid process**. Note these features on the skeleton.

1.15 Neck Muscles, Nerves, and Vessels

Goal: Identify the esophagus, external jugular vein, nuchal ligament, and the muscles that form the dorsal and ventral boundaries for the jugular groove or jugular furrow. Understand that the location of the esophagus on left side of the neck and its relation to the trachea are important when passing a stomach tube. Compare the muscular boundaries for the external jugular groove (or furrow) in goats, sheep, and cattle. Identify the major structures within the carotid sheath (common carotid artery and vagosympathetic trunk) and major lymph nodes in the neck (superficial cervical lymph nodes). Do not attempt to identify the deep cervical lymph nodes. Identify the dorsal branch of the accessory nerve (CN XI) coursing to the trapezius muscle.

1.15.1 Neck Muscles

Goal: Identify the dorsal and ventral muscular boundaries of jugular groove.

The neck muscles can be divided into superficial and deep groups. There is little merit in studying the deep neck muscles.

With the help of Figures 1.38, 1.39, and 1.40, identify the superficial muscles of the neck including the clinically relevant muscles that form the boundaries for the **jugular groove** (or **jugular furrow**) (Figures 1.38 and 1.39).

The muscles that form the dorsal and ventral boundaries of the jugular furrow include the brachiocephalicus muscle

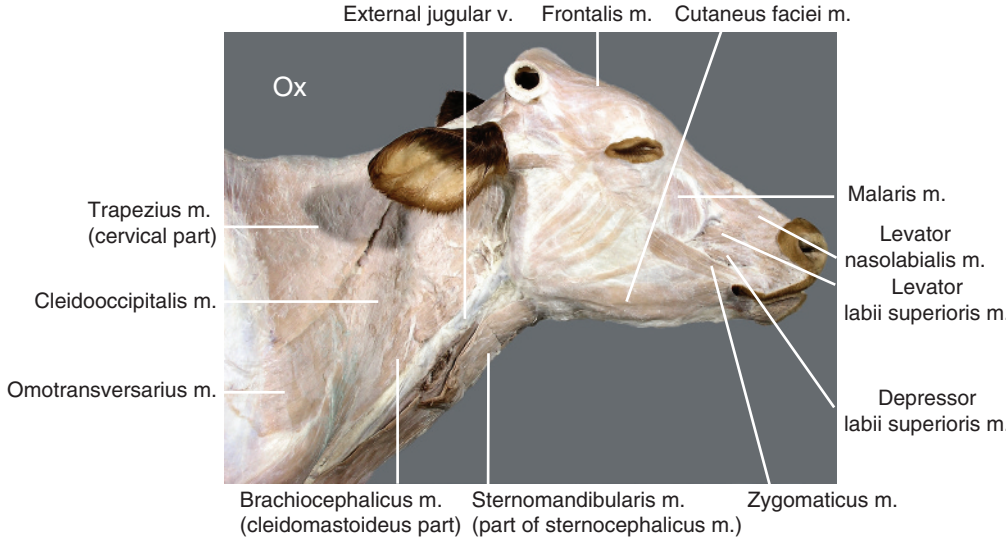


Figure 1.38 Bovine superficial neck and head muscles. Identify the **dorsal** and **ventral** boundaries of the jugular groove formed by the cleidomastoideus muscle (ventral part of the brachiocephalicus muscle) and sternomandibularis muscle (superficial part of the sternocephalicus muscle), respectively. The deep part of the sternocephalicus muscle is formed by the sternomastoideus muscle.

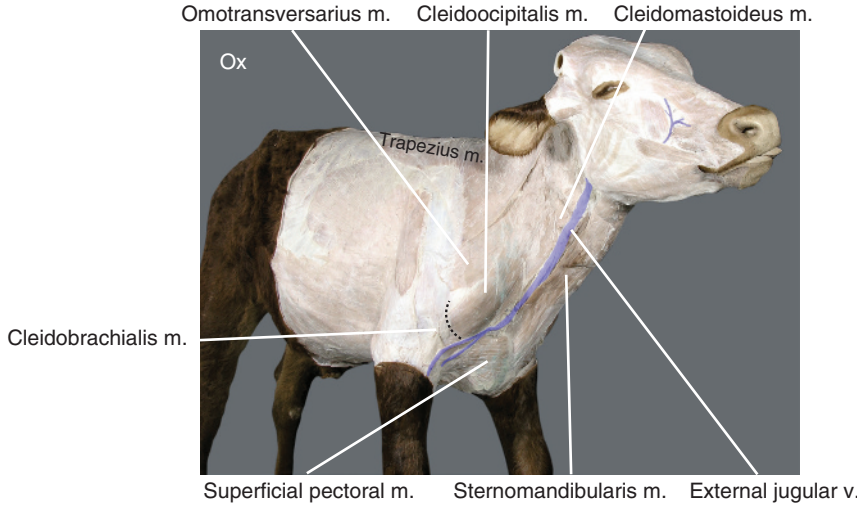


Figure 1.39 Bovine superficial muscles of the neck. Clavicular intersection shown by dotted line. Trapezius muscle has cervical and thoracic parts.

dorsally (cleidomastoideus plus cleidooccipitalis muscles), and the sternomandibularis muscle ventrally. In goats, the sternomandibularis muscle is known as the sternozygomaticus muscle. The sternozygomaticus muscle is absent in sheep (Box 1.24).

Box 1.24

Note that the sternozygomaticus muscle is absent in sheep, making the jugular groove less distinct in this species when compared with the ox and goat.

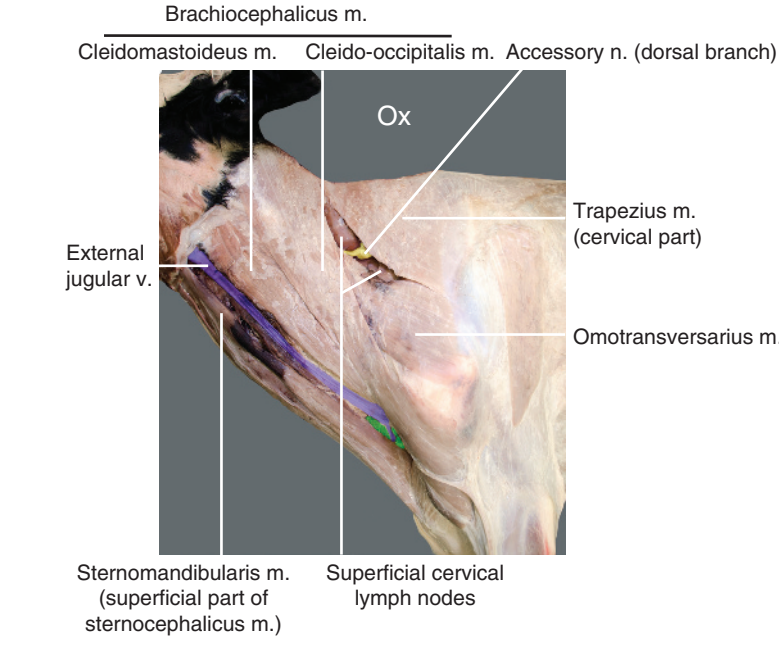


Figure 1.40 (a) Left lateral view of the bovine neck. Dorsolateral superficial muscles of the neck. Note the location of the large superficial cervical lymph nodes between the cervical part of the trapezius, omotransversarius, and cleidooccipitalis muscles. (b) Ventral neck muscles (goat). The thin sternohyoideus and sternothyroideus muscle are separated and the sternohyoideus is reflected cranially. The two muscles are fused at their origin from the manubrium (called sternothyrohyoideus muscle when fused). The sternohyoideus inserts on the basihyoid at the midline. The sternothyroideus muscle inserts laterally on the lamina of the thyroid cartilage. The two muscles help with swallowing by drawing the larynx and hyoid apparatus caudally.

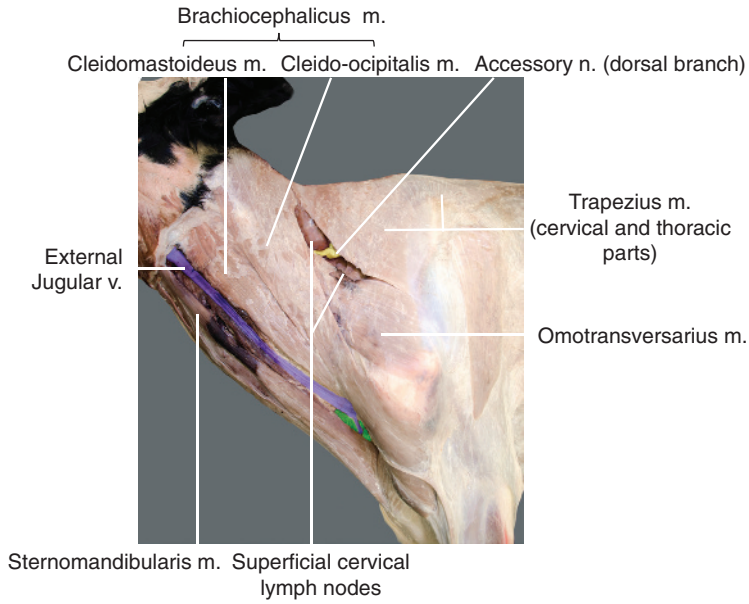


Figure 1.41 Dorsal branch of the accessory nerve (yellow in figure) coursing deep to the cervical part of the trapezius muscle.

1.15.1.1 Superficial Neck Muscles

Study the superficial muscles of the neck in detail on the dorsolateral and ventral aspects of the neck (Figures 1.40 and 1.41). We omitted the middle and deep muscles from our discussion but you need to transect all of them en masse to uncover the nuchal ligament.

1.15.1.1.1 Brachiocephalicus Muscle

The **brachiocephalicus muscle** is a broad compound muscle that forms the dorsal boundary for the jugular furrow. The brachiocephalicus is located on the dorsolateral surface of the neck and runs obliquely along the area between the brachium and dorsolateral surface of the skull. It comprises three fused muscles. The **clavicular intersection** (remnant of the clavicle at the shoulder) is technically considered the origin for the three parts of the brachiocephalicus muscle. The clavicular intersection divides the brachiocephalicus muscle into cranial and caudal parts (Figure 1.39).

The cranial portion of the brachiocephalicus has two parts, **cleidooccipitalis** dorsally, and **cleidomastoideus** ventrally. The cleidomastoideus lies directly dorsal to the external jugular vein (Figure 1.40a). These parts can also be named as separate muscles: the **cleidooccipitalis** and **cleidomastoideus muscles** (Figure 1.40a). The cleidooccipitalis muscle is absent in the horse but present in the dog.

The caudal part of the brachiocephalicus extends from the shoulder (clavicular intersection) to the brachium. It is known as the **cleidobrachialis muscle** (Figure 1.39).

1.15.1.1.2 Omotransversarius Muscle

The omotransversarius muscle extends from the scapula in the shoulder region to the wing of the atlas (transverse process of C1) (Figure 1.40a).

Note that the dorsal branch of the **accessory nerve** (CN XI) courses caudally along the dorsal surface of the omotransversarius muscle. This nerve supplies several neck muscles including the omotransversarius, brachiocephalicus, and trapezius muscle, a shoulder girdle muscle (Figure 1.40a).

Find the **superficial cervical lymph nodes** at the cranial border of the scapula and in the space between the omotransversarius and

cervical part of the trapezius muscle. Use Figure 1.40(a) to locate the **omotransversarius muscle** and the **superficial cervical lymph nodes**.

1.15.1.1.3 Trapezius Muscle

The trapezius muscle has cervical and thoracic parts. Identify the cervical and thoracic trapezius parts of the trapezius muscle (Figure 1.40a). This is a triangular, fan-shaped muscle that originates on the dorsal border of the neck (cervical part) and withers (thoracic part) and inserts distally on the spine of the scapula. The dorsal branch of accessory nerve (CN XI) innervates both parts (Figure 1.40a).

1.15.1.1.4 Sternocephalicus Muscle

The sternocephalicus muscle is a large V-shaped ventral neck muscle that originates from the sternum (manubrium) and first costal cartilage and inserts on the head. It has two parts: the **sternomandibularis** (**sternozygomaticus** in goats) and **sternomastoideus** muscles. The names of these parts are descriptive of their origin and insertion points. These parts are sometimes called the mandibular and mastoid parts of the sternocephalicus muscle.

The sternomandibularis inserts on the mandible in cattle (Figure 1.17), and on the zygomatic arch in goats (Figure 1.18c). The sternozygomaticus is absent in sheep.

The sternocephalicus (specifically the sternomandibularis part) and brachiocephalicus (specifically the cleidomastoideus part) muscles form the ventral and dorsal parts of the muscular boundaries for the jugular furrow, respectively.

1.15.1.1.5 Sternothyroideus and Sternohyoideus Muscles

The left and right **sternothyroideus** and **sternohyoideus** muscles are relatively thin, flat muscles located in between the left and right sternocephalicus muscle on the ventral neck (Figure 1.40b). They cover the ventral surface of the trachea. They extend from the sternum (manubrium) to the thyroid cartilage (sternothyroideus muscle) and basihyoid bone of the basihyoid apparatus (sternohyoideus muscle). These muscles are fused in the caudal neck and at their origin from the manubrium of the sternum but are separated at their insertion points on the lateral lamina of the thyroid cartilage (sternothyroideus muscle) and basihyoid bone (sternohyoideus muscle).

Trace the sternothyrohyoideus muscles from their origin at the sternum to their insertion on the lateral surface of the thyroid lamina and on the ventral surface of the basihyoid bone (Figure 1.40b).

1.15.1.2 Deep Neck Muscles

As mentioned earlier, the deep neck muscles will not be dissected. Those who are interested in dissection of these muscles should read the following summary and consult other textbooks (see Appendix B) for more details and figures. The deep cervical muscles, depending on their location, either extend or flex the neck or move the neck sideways. Here is brief summary their nomenclature and location.

Neck muscles located deep to the superficial layer on the dorsolateral aspect of the neck can be classified into middle and deep layers. These muscles are generally located dorsal to the cervical vertebrae. They are also considered as extensors of the neck. Reflection of the trapezius cervicis and brachiocephalicus muscles will expose a middle layer composed largely of the serratus ventralis cervicis ventrally, rhomboideus cervices muscle dorsally, and the omostransversarius muscle in between them. The omostransversarius is a strap muscle that inserts to the wing of the atlas. The large muscle deep to the rhomboideus cervicis is the splenius muscle.

The rhomboideus in ruminants has cervical and thoracic parts but lack the capitis part found in dogs. The **hump** in zebu cattle such as Brahman cattle (*Bos indicus*) is produced by enlargement of the rhomboideus muscle. European breeds (*Bos taurus*) lack a hump.

Reflect the serratus ventralis cervicis to expose the longissimus group of muscles running longitudinally parallel with the cervical vertebrae. These muscles represent the cranial extension of an intermediate portion of the epaxial musculature (muscles of the

trunk lying dorsal to the transverse processes of the vertebrae in the abdominal, thoracic, and cervical vertebrae). The epaxial muscles in the neck region include longissimus cervicis, longissimus atlantis, and longissimus capitis.

The muscle located deep to the splenius is the semispinalis capitis which has two parts: the complexus and biventer. Reflect semispinalis capitis muscle to expose the nuchal ligament (see section 1.16).

Muscles lying along and ventral to the transverse processes of cervical vertebrae (hypaxial muscles) include the intertransversarius muscle, dorsal and ventral scalenus, longus capitis, and multifidus cervicis. The muscle that covers the ventral surfaces of the vertebral bodies is the longus colli muscle. Collectively, these muscles flex the neck.

Short neck muscles in the occipital region lying just behind the skull are classified into obliquus capitis caudalis and obliquus capitis cranialis lying cranial and caudal to the wing of the atlas, respectively.

Dorsal to obliquus muscles are rectus capitis dorsalis major and rectus capitis dorsalis minor. The rectus capitis dorsalis (major part) originates from the spine of C2 (axis) and inserts on the nuchal region near the external occipital protuberance. The major part of the muscle is further divided into superficial and deep parts. The minor portion of the rectus capitis dorsalis originates from the dorsal surface of the atlas and inserts on the caudal surface of the skull. There is no need to spend time dissecting the deep muscles of the neck.

1.15.2 Nerves of the Neck

Goal: Identify the bilateral nerves of the neck that include the **accessory nerve, recurrent laryngeal nerve,** and the **vagosympathetic trunk** (Figures 1.41 and 1.42).

Branches of eight cervical spinal nerves supply structures of the neck. Identify only **C2** and its **great auricular** branch that conveys sensation from the caudal surface of the horn (Figure 1.18a).

The **accessory nerve** (CN XI) courses from the skull to the neck under the wing of the atlas. Here it divides into dorsal and ventral branches.

Dorsal branch: passes dorsal to the second cervical nerve (C2). It supplies the cleidooccipitalis and trapezius muscles. Follow the dorsal branch of the accessory nerve across

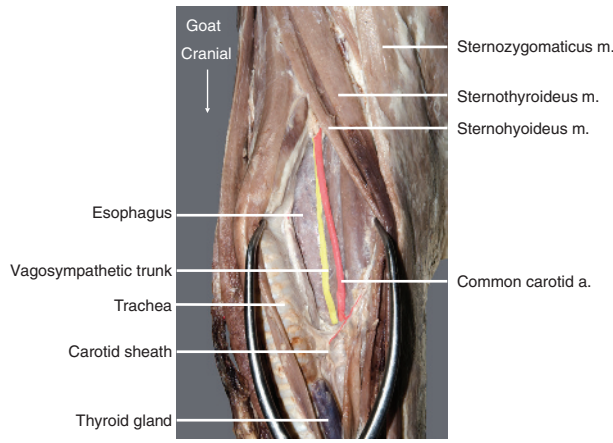


Figure 1.42 Goat neck: ventral view. Dissection of common carotid artery and vagosympathetic trunk by spreading the ventral neck muscles apart using a Gelpi self-retaining retractor. The common carotid artery and the vagosympathetic trunk are partially separated. Spreading of the mid-ventral neck muscles (combined sternothyrohyoideus muscles) is also used for exposure of the trachea.

the dorsal surface of the **omotransversarius** muscle to supply the omotransversarius and trapezius muscles (Figure 1.41).

Ventral branch: passes ventral to C2. It supplies the sternomandibularis (sternozygomaticus in small ruminants), sternomastoideus, and cleidomastoideus muscles.

The **vagosympathetic trunk** is located dorsal to the **common carotid artery** in the carotid sheath (Figure 1.42a).

Find the **recurrent laryngeal nerve** lateral to the trachea. As the nerve approaches the larynx the name of the nerve is changed to the **caudal laryngeal nerve**. Find the caudal laryngeal nerve in the proximity of the **thyroid gland**.

The caudal laryngeal nerve supplies all the laryngeal muscles except the cricothyroideus muscle, which is supplied by the **cranial laryngeal nerve**. The cranial laryngeal nerve originates from the vagus nerve (CN X) soon after it emerges from the skull. The caudal laryngeal nerve originates from the vagus in the thoracic region.

1.15.3 Blood Vessels of the Neck

Goal: Identify the **external jugular vein** in the jugular furrow (Figures 1.41 and 1.43). The branches of the external jugular vein were previously discussed with the vessels of the head (Figure 1.22). Open the carotid sheath and identify the **common carotid artery** along with other contents that include the vagosympathetic trunk, internal jugular vein in the ox (absent in small ruminants) and tracheal trunk. Branches of the common carotid artery were also discussed with the vessels of the head.

The muscular boundaries of the **jugular groove** that houses the **external jugular vein** are discussed earlier with the neck muscles. It is bounded ventrally by the **sternomandibularis** and dorsally by the **brachiocephalicus** muscles (Figures 1.38, 1.39, and 1.41). The brachiocephalicus muscle in ruminants is a multipart muscle with three divisions: cleidobrachialis, cleidomastoideus, and cleidooccipitalis muscles. The sternocephalicus muscle is also compound muscle with mandibular and mastoid parts: sternomandibularis and sternomastoideus muscles, respectively.

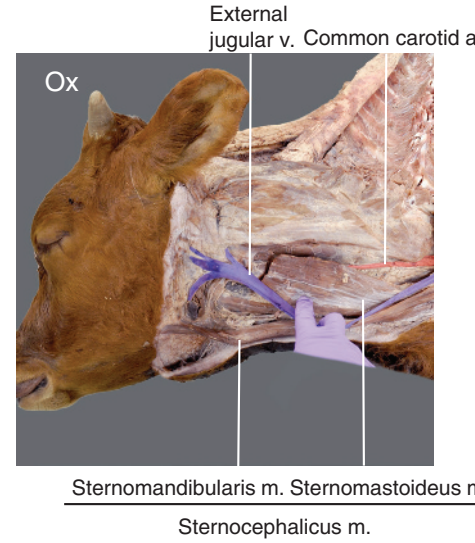


Figure 1.43 Dissection of the external jugular vein and common carotid artery (bovine of the neck: left lateral view). The brachiocephalicus muscle (dorsal boundary of the external jugular vein) is removed to uncover the common carotid artery. The external jugular vein is pulled down to demonstrate the sternomastoideus muscle which forms the medial border of the jugular furrow. It is transected in the cranial neck.

Transect the sternomastoideus muscle (mastoid portion of the sternocephalicus) that covers the common carotid artery in the caudal part of the neck. This muscle forms the medial boundary of the external jugular vein (Figure 1.43).

Dissect the fascia from the carotid sheath to uncover the **common carotid artery**, **internal jugular vein**, and the **vagosympathetic trunk**. The trunk is located on the dorsal surface of the common carotid artery (Figure 1.42). The branches of the common carotid artery were discussed with the vessels of the head.

1.16 Nuchal Ligament

Goal: Identify the funicular and laminar parts of the nuchal ligament and their

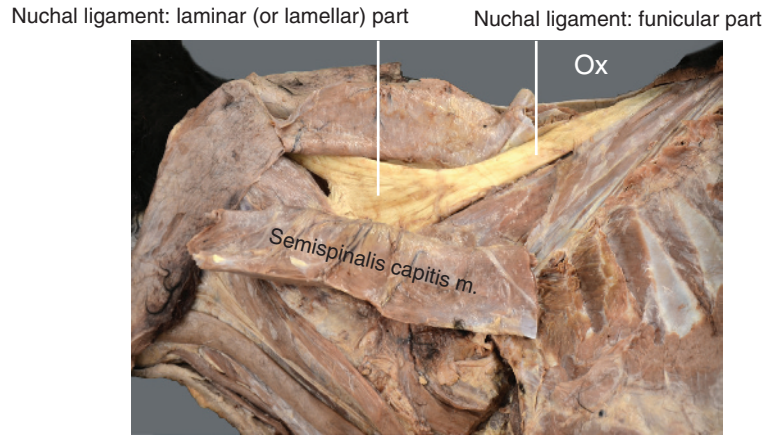


Figure 1.44 Bovine nuchal ligament: left lateral view of deep neck muscles. The semispinalis is freed from the nuchal ligament and reflected ventrally. The funicular part of the nuchal ligament courses between the first few thoracic vertebrae to the external occipital protuberance. The laminar part spans the distance from C2 to C7 and merges with the funicular part. It has cranial (paired) and caudal (unpaired) parts.

attachments. Understand the function and clinical significance of the nuchal ligament.

The **nuchal ligament** in cattle is substantial and is like that in the horse but is different in size and shape from that of the dog. It is elastic in nature and has both **funicular** and **laminar (or lamellar) parts** (Figure 1.44). The nuchal ligament is located deep to the dorsal deep muscles of the neck above the cervical spines.

The nuchal ligament in goats consists of two parts as in cattle.

The nuchal ligament supports the heavy weight of the head as well as head movement.

With the help of Figure 1.44 and the following description, study the two parts of the nuchal ligament and their insertion on a cow skeleton.

Funicular part: consists of paired cord-like structures. It runs from the skull (external occipital protuberance) caudally to the summits of the highest spines of the withers. It is round cranially, and flat caudally. The funicular part continues caudally as the supraspinous ligament. A **supraspinous bursa** is located between the ligament and the summit of T1 thoracic vertebral spine.

Laminar or lamellar part: the laminar part is located ventral to the funicular part. It consists of a pair of flat sheets cranially, and an unpaired sheet caudally. The cranial pair sheets extend between C2 and C4. The caudal unpaired sheet extends from C6/7 to T1.

In bullfights, the picador gouges and damages this ligament, making it difficult for the bull to hold the head high.

Box 1.25

The nuchal ligament acts as barrier to spread of cervical abscesses between the left and right sides of the neck. It also helps direct inflammatory excaudate fluid ventrally in the direction of gravity away from the chest.

1.17 Surface Topography (Head and Neck)

Goal: This section is intended to provide some information on palpable structures on the head and neck of live cattle. It is provided to help students carry out palpation exercises and give applied context to gross anatomy (Figures 1.45, 1.46, 1.47, 1.48, 1.49, and 1.50).

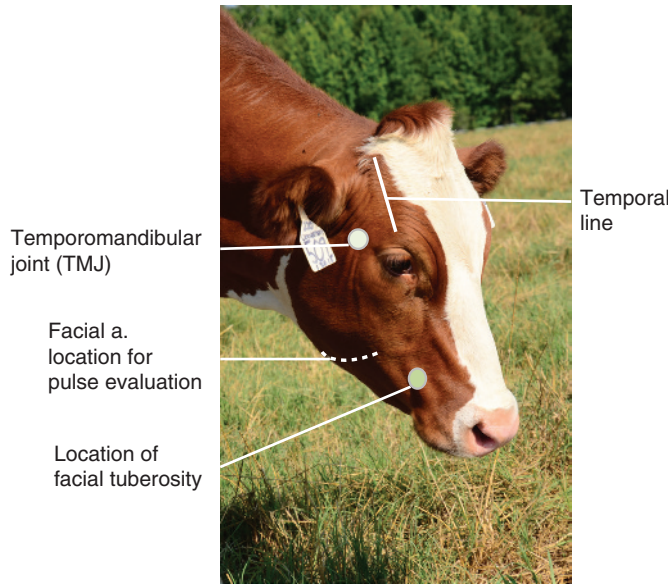


Figure 1.45 Palpable structures on the lateral surface of live cattle. The straight white solid line caudal to the eye depicts the temporal line, a landmark for localization of the cornual nerve and cornual artery. The curved white dotted line depicts the course of the facial artery, facial vein, and parotid duct. The filled circles depict approximate locations of temporomandibular joint (TMJ) and the facial tuberosity.

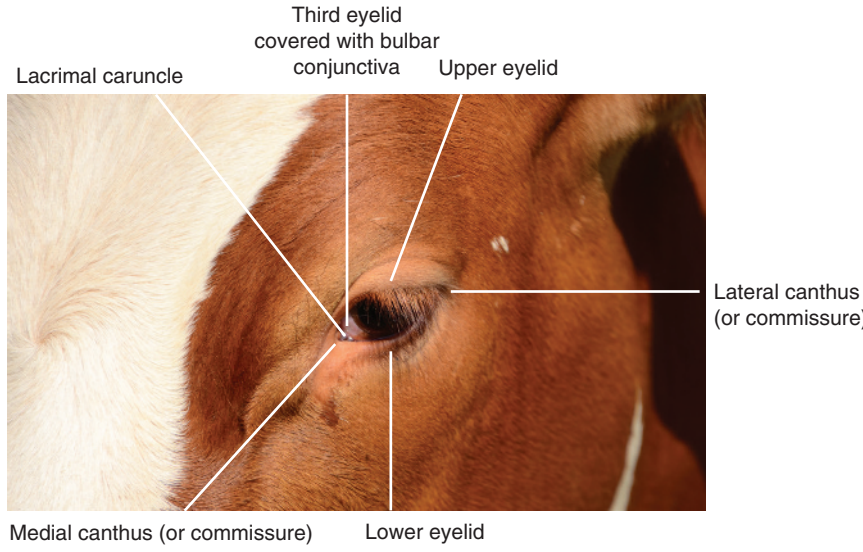


Figure 1.46 External features of the eye. The inner surface of the upper (superior) and lower (inferior) eyelids is lined with palpebral conjunctiva. The third eyelid is covered by bulbar conjunctiva of the third eyelid.

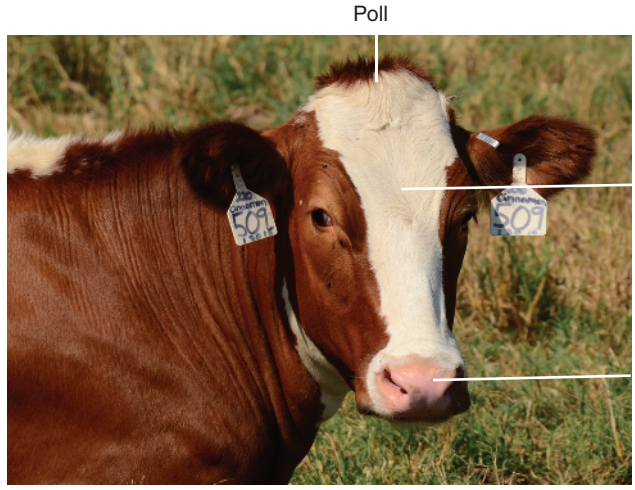


Figure 1.47 Common terms for areas on the bovine head. The poll (intercornual protuberance) is the highest point on the bovine skull.

Figure 1.48 Jugular groove or furrow containing the external jugular vein, a major site for venipuncture in domestic animals including cattle. The muscular boundaries for the jugular groove include the brachiocephalicus muscle dorsally (specifically the cleidomastoideus part), and sternomandibularis muscle ventrally (superficial part of the sternocephalicus). Pulling the head up and to the opposite side is helpful in visualization of the jugular groove.

Figure 1.49 Technique for opening the mouth and holding it open for teeth inspection or medication. Pry the mouth open by placing several fingers at the corner of the mouth inside the space behind the incisor teeth (diastema). Note that the tongue is grabbed and pulled to one side to hold the mouth open.

Figure 1.50 Another technique for mouth opening. A rope or custom cattle halter is helpful in restraining the animal by an assistant. The mouth is opened and tongue pulled to one side through the diastema.

Box 1.26

The **median caudal vein** (Figure 1.51) in cattle is located under the ventral midline of the tail in association with a satellite artery, the **median caudal artery**. The vein can be used for withdrawal of small amount of blood from the tail. Because of the proximity to the artery, venous blood collected from this site may become mixed with arterial blood. The artery can also be used for pulse evaluation. The vein should be accessed between two successive caudal vertebrae as both the vein and artery are protected with hemal arches in their course under vertebral bodies. You should avoid fecal contamination when collecting blood from the median caudal vein.

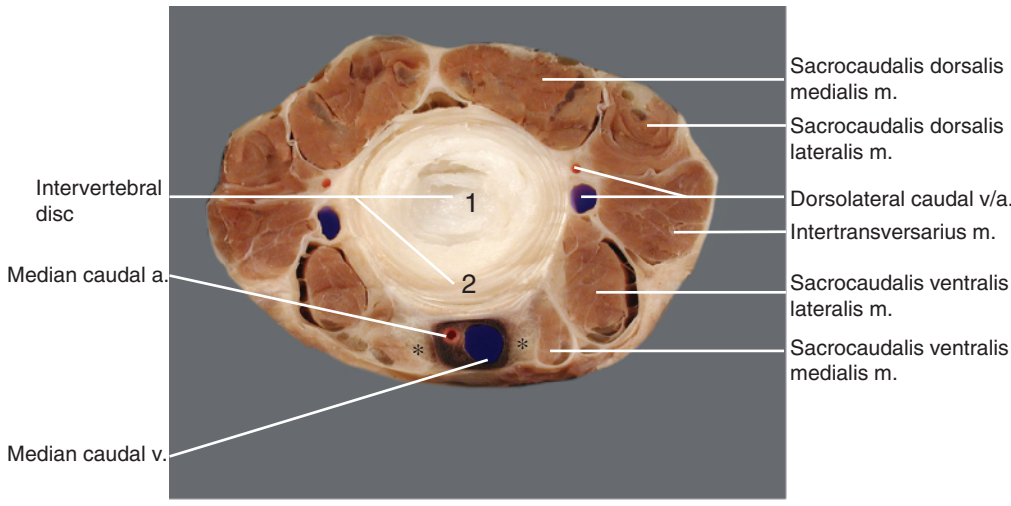


Figure 1.51 Cross-section of a cow tail showing location of the **median caudal vein** (tail vein) and **median caudal artery** on the midline of the ventral surface of the proximal third of the tail. * Hemal arch. 1, nucleus pulposus; 2, anulus fibrosus of the intervertebral disc.

1.18 Lab ID List for the Head and Neck

There is no need to identify items in *italics*.

A. Skeletal features of the bovine skull (bones, foramina, paranasal sinuses, mandibles, and teeth).

Identify the structures that pass through listed foramina.

1. Optic canal
2. Foramen orbitorotundum
3. Supraorbital foramen
4. Infraorbital foramen
5. Mental foramen
6. Facial tuberosity
7. Temporal line
8. Temporal fossa
9. Supraorbital groove
10. Horn (horn sheath, cornual process)
11. Intercornual protuberance
12. External occipital protuberance
13. Zygomatic arch (zygomatic bone and zygomatic process of the temporal bone)
14. Incisor teeth (1–4)–lower jaw (central–first intermediate–second intermediate–corner)
15. *Crown (spatula-shaped incisor tooth)*
16. *Neck (peg-shaped in old cow or goat)*
17. *Root (embedded in gum)*
18. *Incisor tooth surfaces: labial, lingual, and occlusal surfaces*
19. Cheek teeth (P2–P3–P4; M1–M2–M3)
20. Diastema
21. Frontal bone (cornual process)
22. Zygomatic process of the frontal bone
23. Frontal process of the zygomatic bone
24. Temporal process of the zygomatic bone
25. Zygomatic process of the temporal bone
26. Pterygoid crest
27. Frontal sinus
    a. Rostral compartment
    b. Caudal compartment
    i. Cornual diverticulum
    ii. Nuchal diverticulum
    iii. Postorbital diverticulum
    d. Oblique septum
    e. Median septum separating left and right frontal sinuses
28. Maxillary sinus
29. Palatine sinus
30. Lacrimal bone
31. Lacrimal bulla
32. Nasal bone
33. Incisive bone
34. Nasoincisive notch
35. Maxilla
36. Rim of the orbit

B. Mandible

37. Coronoid process
38. Condylar process
39. Ramus
40. Mental foramen
41. Mandibular foramen (identify structures passing through this foramen)
42. Mandibular symphysis

C. Dental formula

43. Permanent teeth: 2 × (I 0/4, P 3/3, M 3/3) = 32 total
44. *Temporary teeth*: 2 × (DI 0/4, DP 3/3) = 20 total

D. Muscles (some will be identified on the neck, see section J).

45. Cleidomastoideus m. (ID on the head or neck)
46. Masseter m.
47. Sternocephalicus m. (ID on head or neck)
    a. Sternomandibularis m. on cow head (absent in sheep)
    b. Sternozygomaticus m. (goat)
    c. Sternomastoideus m.

E. Nerves and vessels supplying structures on the head

Nerves

48. Auriculopalpebral n. (know where the nerve is blocked and clinical significance)
49. Cornual n. (know where the nerve is blocked and clinical significance)
50. *Great auricular n.* (C2) (know function)

51. *Infratrochlear n.* (goat) (know function)
52. Facial n.
    a. Dorsal buccal branch of VII
    b. Ventral buccal branch of VII

Arteries

53. Facial a. in bovine (pulse, absent in goats)
54. Transverse fascial a. (pulse in goat. Present in bovine)
55. Superficial temporal a.
56. Cornual a.

Veins

57. Facial v. (bovine)
58. *Transverse facial v.* (goat)
59. Frontal v. (cow)
60. Linguofacial v.
61. Maxillary v.
62. Angularis oculi v.

F. Salivary glands

63. Parotid salivary gland
64. Mandibular salivary gland
65. Monostomatic sublingual
66. Parotid duct

G. Lymph nodes of the head

67. Parotid lymph node
68. Mandibular lymph node
69. Medial retropharyngeal lymph node (medial view)
70. Lateral retropharyngeal lymph node (bovine)

H. External features

71. *Scent glands in goats* (know general location only)
72. *Epiceras* (know function)
73. Nasolabial plate
74. *Opening of the nasolacrimal duct* (know location)

I. Oral/pharyngeal structures (on paramedian section)

75. Dental pad
76. Incisive papilla
77. *Nasopharynx*
78. *Oropharynx*
79. *Laryngopharynx*
80. Soft palate
81. Dorsal, ventral, and middle concha
82. Dorsal, middle, and ventral nasal meatuses
83. Laryngeal cartilages(cricoid–thyroid–arytenoid–epiglottis)
84. Basihyoid
85. Tongue
    a. Torus linguae (lingual torus)
    b. Fossa linguae (lingual fossa)

J. Neck

86. Nuchal ligament (funicular and laminar parts)
87. Vertebral formula:
    Cattle: C7–T13–L6–**S5**–Cd variable (Cd 18–20)
    Goat: C7–T13–L6 (7)–**S5**–Cd variable (Cd 16–18)
    Sheep: C7–T13–L6 (7)–**S4**–variable (Cd 16–18)

Muscles of the neck

88. Sternocephalicus m. in ox and goat (two parts: sternomandibularis + *sternomastoideus*)
    a. Sternomandibularis m. (ID on cow's head, absent in sheep)
    b. Sternozygomaticus m. (in goat, same as sternomandibularis in cow)
89. Brachiocephalicus m. (three parts: cleidobrachialis + cleidooccipitalis + *cleidomastoideus, may be absent*)
90. Trapezius m. (cervical part)
91. Omotransversarius m. (in sheep, it fuses to cleido-occipitalis m.)
92. Rhomboideus m. (two parts: cervical + thoracic)
93. *Sternohyoideus m.*
94. *Sternothyroideus m.*
95. *Pharyngeal muscles (cricopharyngeus and thyropharyngeus muscles same as other species)*

Lymph nodes of the neck

96. Superficial cervical lymph nodes (also known as pre-scapular lymph nodes)

Nerves of the neck

97. Accessory nerve (dorsal and ventral branch)
98. Recurrent laryngeal n. (ID left nerve in the thorax and its continuation in neck as Cd laryngeal n.)
99. Vagosympathetic trunk
100. *Great auricular n.*

Other structures in the neck region

101. Common carotid a.
102. Trachea
103. Esophagus (cervical part)
104. External jugular v. (ID dorsal and ventral boundaries for the jugular groove)
105. Thyroid gland
106. Cervical thymus (in young animals)