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4th Edition

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Preface

Congratulations! You have just purchased the most popular and comprehensive set of anatomy flash cards available. *Netter's Anatomy Flash Cards* offer a unique learning resource to supplement the anatomy textbook, atlas, or dissection materials used in medical, dental, nursing, allied health, and undergraduate courses in human anatomy. This set of cards draws on the timeless medical illustrations of Frank H. Netter, MD, and includes not only the musculoskeletal system but also a review of important nerves, vessels, and visceral structures not commonly found in traditional flash card sets.

Each 4 × 6 full-color card details human anatomy as only Netter can. The set is organized regionally in accordance with Netter's widely popular *Atlas of Human Anatomy* (i.e., Head and Neck; Back and Spinal Cord; Thorax; Abdomen; Pelvis and Perineum; Upper Extremity; Lower Extremity). Within each region, cards are arranged sequentially as follows: Bones and Joints; Muscles; Nerves; Vessels; and Viscera. Moreover, the image on each card is referenced to the original plate in the *Atlas of Human Anatomy*, 6th Edition. Because each section opening card is slightly taller, you can easily pull out an entire section of cards for study. In addition, a corner of each card is prepunched so that you can insert it on the enclosed metal ring to keep an entire section of cards in the correct order.

Each card includes a **Comment** section, which provides relevant information about the structure(s) depicted on the front of the card, including detailed information for muscle origins, insertions, actions, and innervation. Most cards also contain a **Clinical** section that highlights the clinical relevance of the anatomy depicted on the front of the card. Bonus online content is available at www.studentconsult.com using the scratch-off PIN code on the first card. Online content includes over 300 **multiple-choice questions** to test your retention of the material. These cards offer an accurate and ready source of anatomic information in an easy-to-use and portable format.

Consensus regarding the specific anatomic details of such topics as muscle attachments or the range of motion of joints can vary considerably among anatomy textbooks. In fact, human anatomic variation is common and normal. Consequently, the anatomic detail provided on these cards represents commonly accepted information whenever possible. I am indebted to and wish to credit the following superb sources and their authors or editors:

Gray's Anatomy for Students, 3rd ed. Drake R, Vogl W, Mitchell A. Philadelphia, Elsevier, 2014.

Gray's Anatomy, 40th ed. Standring S. Philadelphia, Elsevier, 2008.

Netter's Clinical Anatomy, 3rd ed. Hansen JT. Philadelphia, Elsevier, 2014.

Clinically Oriented Anatomy, 7th ed. Moore KL, Dalley DR, Agur AMR. Philadelphia, Lippincott Williams & Wilkins, 2014.

Grant's Atlas of Anatomy, 13th ed. Agur AMR, Dalley AF. Philadelphia, Lippincott Williams & Wilkins, 2013.

My hope is that the Netter Flash Cards will make learning more enjoyable and productive, and that the study of anatomy will inspire you with a sense of awe and respect for the human form.

John T. Hansen, PhD

Professor and Associate Dean

Department of Neurobiology and Anatomy

University of Rochester Medical Center

Rochester, New York

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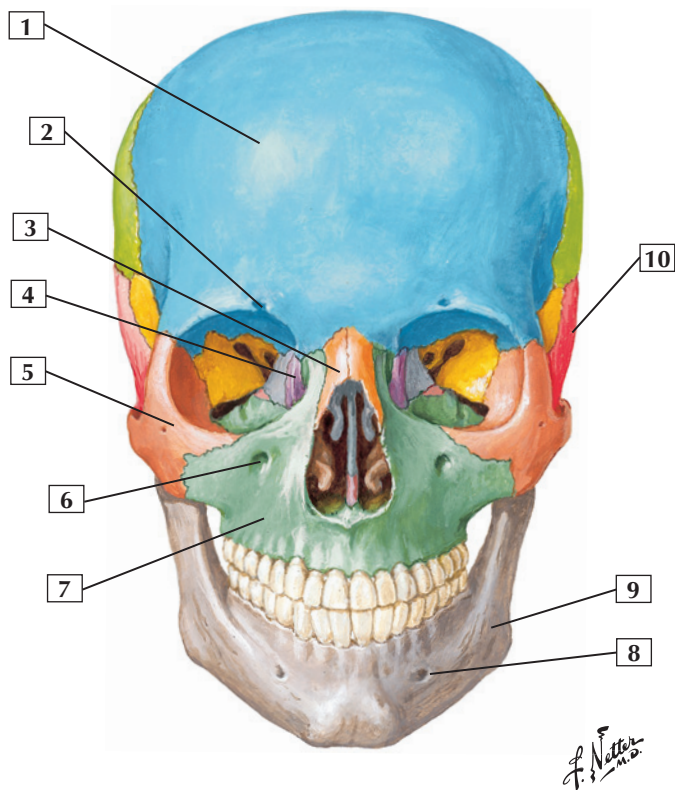
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Skull: Anterior View



1. Frontal bone
2. Supra-orbital notch (foramen)
3. Nasal bone
4. Lacrimal bone
5. Zygomatic bone
6. Infra-orbital foramen
7. Maxilla
8. Mental foramen
9. Mandible
10. Temporal bone

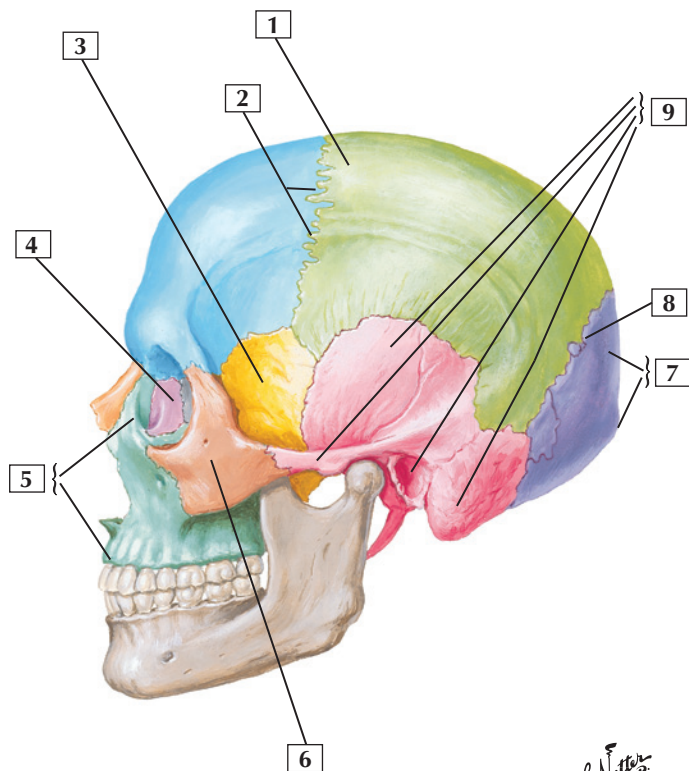
Comment: The skull bones are fused together at immovable, fibrous joints, such as the sutures.

The 2 general classes of skull bones are cranial bones (8 bones), which enclose the brain, and facial bones (14 bones). The 8 cranial bones are the frontal, occipital, ethmoidal, and sphenoidal bones, a pair of temporal bones, and a pair of parietal bones.

Associated bones of the skull include the auditory ossicles (3 in each middle ear cavity) and the unpaired hyoid bone. The skull and associated bones constitute 29 different bones (the 32 adult teeth are part of the mandible and maxilla and are not counted separately).

Clinical: Midface fractures are classified clinically as Le Fort fractures:

- Le Fort I: horizontal fracture detaching the maxilla along the nasal floor
- Le Fort II: pyramidal fracture that includes both maxillae, nasal bones, infra-orbital rims, and orbital floors
- Le Fort III: includes the Le Fort II fracture and both zygomatic bones; may cause airway obstruction, nasolacrimal obstruction, and cerebrospinal fluid (CSF) leakage



Skull: Lateral View



1. Parietal bone
2. Coronal suture
3. Sphenoidal bone
4. Lacrimal bone
5. Maxilla (Frontal process; Alveolar process)
6. Zygomatic bone
7. Occipital bone (External occipital protuberance)
8. Lambdoid suture
9. Temporal bone (Squamous part; Zygomatic process; External acoustic meatus; Mastoid process)

Comment: This lateral view shows many bones of the cranium and some of the sutures of the skull, the immovable fibrous joints between adjacent skull bones. The coronal suture lies between the frontal bone and the paired parietal bones. The lambdoid suture lies between the paired parietal bones and the occipital bone.

The pterion is the site of union of the frontal, parietal, sphenoidal, and temporal bones. A blow to the head or a skull fracture in this region is dangerous because the bone at this site is thin, and the middle meningeal artery, supplying the dural covering of the brain, lies just deep to this area. The asterion is the site of union of the temporal, parietal, and occipital bones.

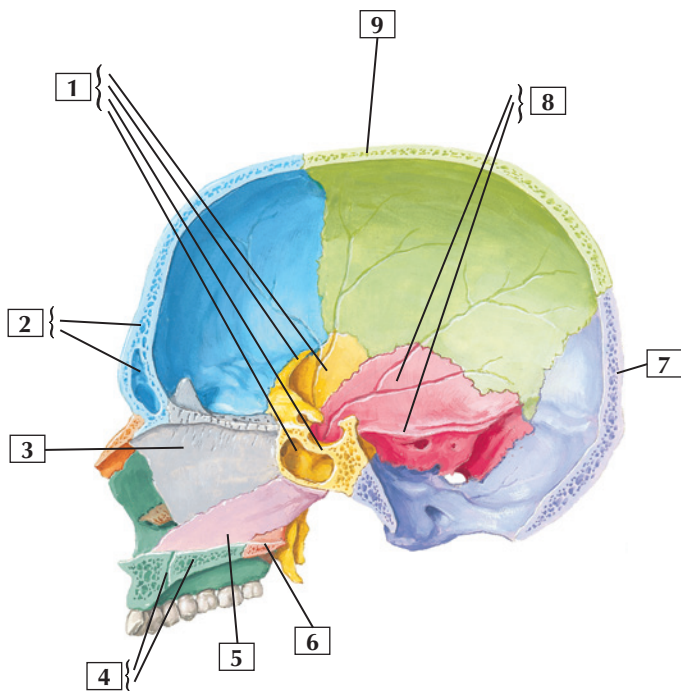
Clinical: Skull fractures may be classified as:

- Linear: have a distinct fracture line
- Comminuted: have multiple bone fragments (depressed if driven inwardly, which can tear the dura mater)
- Diastatic: a fracture along a suture line
- Basilar: a fracture of the base of the skull

A blow to the pterion may damage the middle meningeal artery (or one of its branches), which lies just deep to this thin area of bone, causing an epidural (extradural) hematoma (bleeding between the periosteal layer of dura and the overlying bone).



Skull: Midsagittal Section



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Skull: Midsagittal Section



1. Sphenoidal bone (Greater wing; Lesser wing; Sella turcica; Sphenoidal sinus)
2. Frontal bone (Frontal sinus)
3. Ethmoidal bone (Perpendicular plate)
4. Maxilla (Incisive canal; Palatine process)
5. Vomer
6. Palatine bone
7. Occipital bone
8. Temporal bone (Squamous part; Petrous part)
9. Parietal bone

Comment: Note the interior of the cranium and the nasal septum. The 8 cranial bones enclosing the brain include the unpaired frontal, occipital, ethmoidal, and sphenoidal bones and the paired temporal and parietal bones. The 14 facial bones include the paired lacrimal, nasal, palatine, inferior turbinate (not shown), maxillary, and zygomatic (not shown) bones and the unpaired vomer and mandible (not shown).

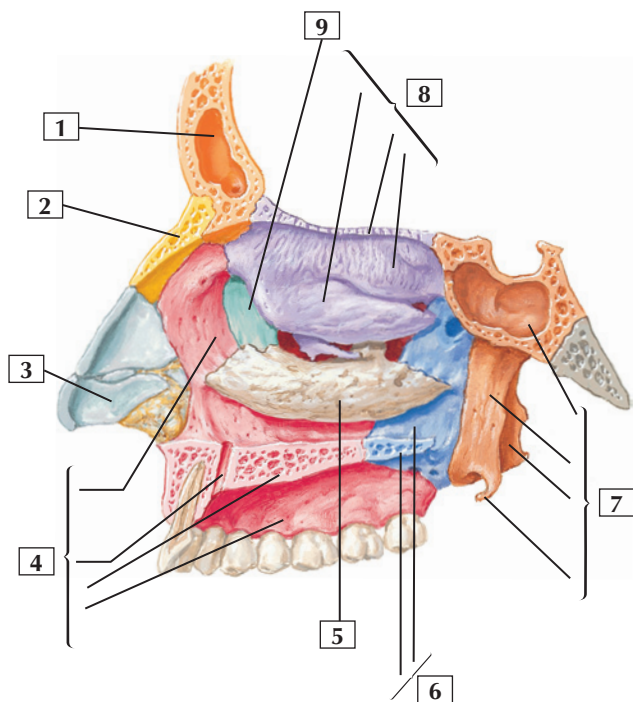
The nasal septum is formed by the perpendicular plate of the ethmoidal bone, the vomer, and the palatine bones and septal cartilages.

The petrous portion of the temporal bone contains the middle and inner ear cavities and the vestibular system.

Clinical: A blow to the skull that results in a fracture can tear the underlying periosteal layer of dura mater, which can result in an epidural (extradural) hematoma and/or leakage of the cerebrospinal fluid (CSF).

A slight deviation of the nasal septum is common. However, if the deviation is severe or a result of trauma, it may be corrected surgically so as not to interfere with breathing.

Lateral Wall of Nasal Cavity



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Lateral Wall of Nasal Cavity



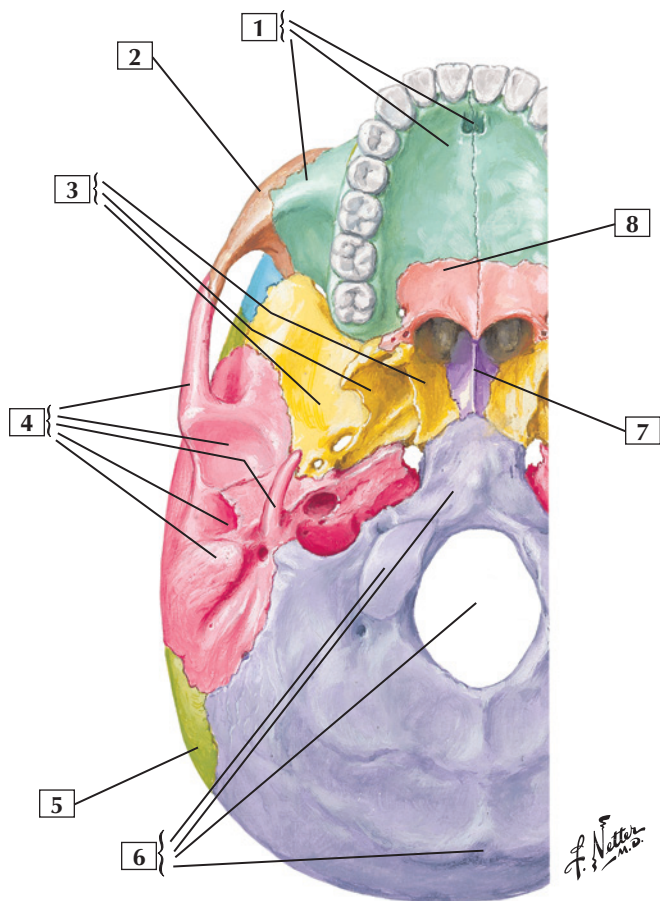
1. Frontal bone (sinus)
2. Nasal bone
3. Major alar cartilage
4. Maxilla (Frontal process; Incisive canal; Palatine process; Alveolar process)
5. Inferior nasal concha
6. Palatine bone (Perpendicular plate; Horizontal plate)
7. Sphenoidal bone (Sphenoidal sinus; Medial and Lateral plates of pterygoid process; Pterygoid hamulus of the medial plate)
8. Ethmoidal bone (Middle nasal concha; Cribriform plate; Superior nasal concha)
9. Lacrimal bone

Comment: The lateral wall of the nasal cavity prominently displays the superior and middle conchae (called *turbinates* when covered with mucosa) of the ethmoidal bone and the inferior concha. Portions of other bones, including the nasal bone, maxilla, lacrimal bone, palatine bone, and sphenoidal bone, contribute to the lateral wall.

The palatine processes of the maxillae and the horizontal plates of the palatine bones make up the hard palate.

Clinical: The pituitary gland lies in the hypophyseal fossa, a depression seen just superior to the sphenoidal sinus in the sphenoidal bone. The pituitary gland can be approached surgically through the nasal cavity by entering the sphenoidal sinus and then directly entering the hypophyseal fossa.

Cranial Base: Inferior View



Cranial Base: Inferior View



1. Maxilla (Incisive fossa; Palatine process; Zygomatic process)
2. Zygomatic bone
3. Sphenoidal bone (Medial plate; Lateral plate; Greater wing)
4. Temporal bone (Zygomatic process; Mandibular fossa; Styloid process; External acoustic meatus; Mastoid process)
5. Parietal bone
6. Occipital bone (Occipital condyle; Basilar part; Foramen magnum; External occipital protuberance)
7. Vomer
8. Palatine bone (Horizontal plate)

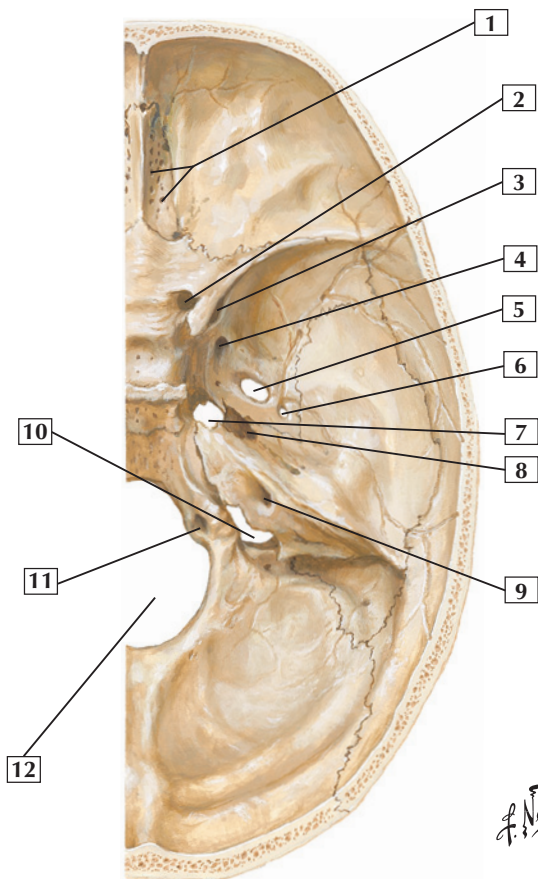
Comment: Cranial bones and facial bones contribute to the base of the skull. Key processes and foramina associated with these bones can be seen in this inferior view.

The largest foramen of the skull is the foramen magnum, the site where the spinal cord and brainstem (medulla oblongata) are continuous.

Clinical: Basilar fractures (fractures of the cranial base) may damage important neurovascular structures passing into or out of the cranium via foramina (openings). The internal carotid artery may be torn, cranial nerves may be damaged, and the dura mater may be torn, resulting in leakage of the cerebrospinal fluid (CSF).



Foramina of Cranial Base: Superior View



Foramina of Cranial Base: Superior View



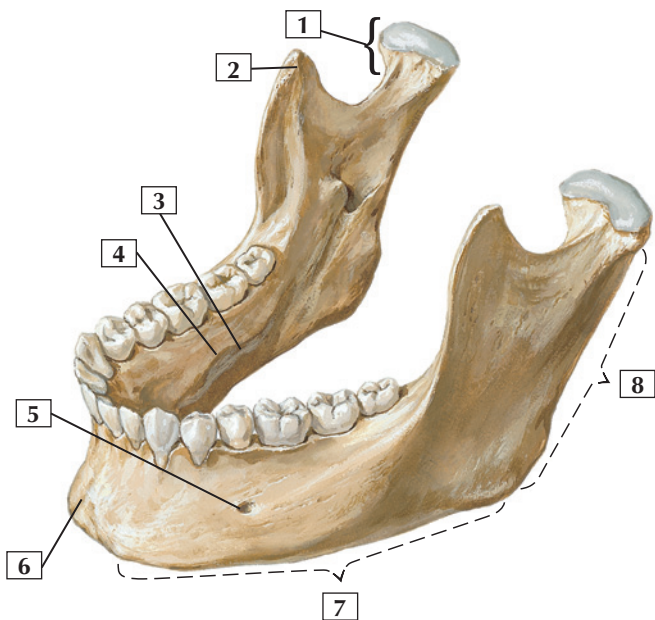
1. Foramina of cribriform plate (Olfactory nerve bundles)
2. Optic canal (Optic nerve [CN II]; Ophthalmic artery)
3. Superior orbital fissure (Oculomotor nerve [CN III]; Trochlear nerve [CN IV]; Lacrimal, frontal, and nasociliary branches of ophthalmic nerve [CN V₁]; Abducent nerve [CN VI]; Superior ophthalmic vein)
4. Foramen rotundum (Maxillary nerve [CN V₂])
5. Foramen ovale (Mandibular nerve [CN V₃]; Accessory meningeal artery; Lesser petrosal nerve [occasionally])
6. Foramen spinosum (Middle meningeal artery and vein; Meningeal branch of mandibular nerve)
7. Foramen lacerum
8. Carotid canal (Internal carotid artery; Internal carotid nerve plexus)
9. Internal acoustic meatus (Facial nerve [CN VII]; Vestibulocochlear nerve [CN VIII]; Labyrinthine artery)
10. Jugular foramen (Inferior petrosal sinus; Glossopharyngeal nerve [CN IX]; Vagus nerve [CN X]; Accessory nerve [CN XI]; Sigmoid sinus; Posterior meningeal artery)
11. Hypoglossal canal (Hypoglossal nerve [CN XII])
12. Foramen magnum (Medulla oblongata; Meninges; Vertebral arteries; Meningeal branches of vertebral arteries; Spinal roots of accessory nerves)

Comment: Key structures passing through each foramen are noted in parentheses.

Clinical: Fractures or trauma involving any of these foramina may result in clinical signs and symptoms associated with the neurovascular elements passing through the foramina. Thus, it is important to know these structures and their relationships to the cranial base.



Mandible: Anterolateral Superior View



*F. Netter
M.D.*

Mandible: Anterolateral Superior View



1. Condylar process (head and neck)
2. Coronoid process
3. Submandibular fossa
4. Mylohyoid line
5. Mental foramen
6. Mental protuberance
7. Body
8. Ramus

Comment: The mandible, or lower jaw, contains the mandibular teeth and the mandibular foramen. The inferior alveolar neurovascular bundle passes through the mandibular foramen; it innervates the mandibular teeth and supplies them with blood. The nerve ends as a cutaneous branch that exits the mental foramen (mental nerve).

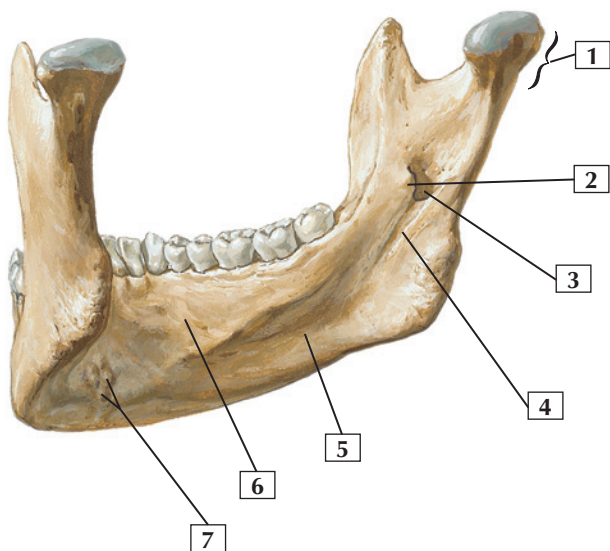
The condylar process of the mandible articulates with the temporal bone, forming the temporomandibular joint.

Because of its vulnerable location, the mandible is the 2nd most commonly fractured facial bone (the nasal bone is 1st). The most common sites of fracture are the cuspid (canine tooth) area and the 3rd molar area.

Clinical: Fractures of the mandible are fairly common. The mandible's U shape renders it liable to multiple fractures, which occur in over 50% of cases. The most common sites of fracture are the cuspid (canine tooth) area and the area just anterior to the 3rd molar (wisdom tooth) area. When fractured, blood oozing from the mandible may collect in the loose tissues of the floor of the mouth, above the mylohyoid muscle.



Mandible: Left Posterior View



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Mandible: Left Posterior View



1. Condylar process
2. Lingula
3. Mandibular foramen
4. Mylohyoid groove
5. Submandibular fossa
6. Sublingual fossa
7. Mental spines

Comment: The inferior alveolar neurovascular bundle enters the mandibular foramen and courses through the bony mandible to supply the mandibular teeth and gums.

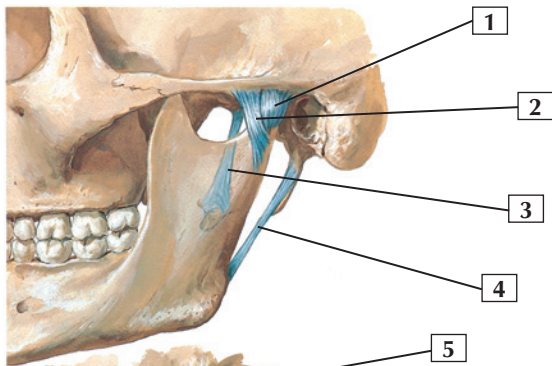
Depressions, or fossae, on the medial side of the mandible mark the locations of the submandibular and sublingual salivary glands.

Clinical: The mandible is the strongest and largest of the facial bones, and its landmarks are used for dental anesthesia via intraoral injections. Properly performed, the infiltrating anesthetic anesthetizes the inferior alveolar nerve and lingual nerve ipsilaterally (on the same side as the injection) where they lie in the pterygomandibular space proximal to the mandibular foramen. This will anesthetize the mandibular teeth (inferior alveolar nerve), the epithelium of the anterior two-thirds of the tongue (lingual nerve), all the lingual mucosa and lingual gingiva (gums) (lingual nerve), all the buccal mucosa and buccal gingiva from the premolars to the midline (mental nerve—terminal branch of the inferior alveolar nerve), and the skin of the lower lip (also via the mental nerve) ipsilaterally.

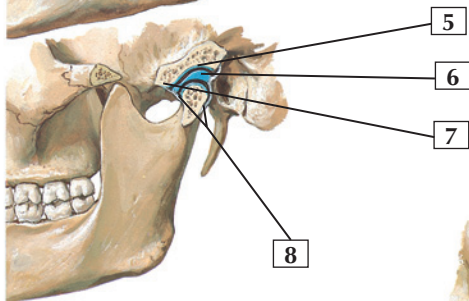


Temporomandibular Joint

Lateral view



Jaws closed



Jaws widely opened
(hinge and gliding
actions combined)

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Temporomandibular Joint



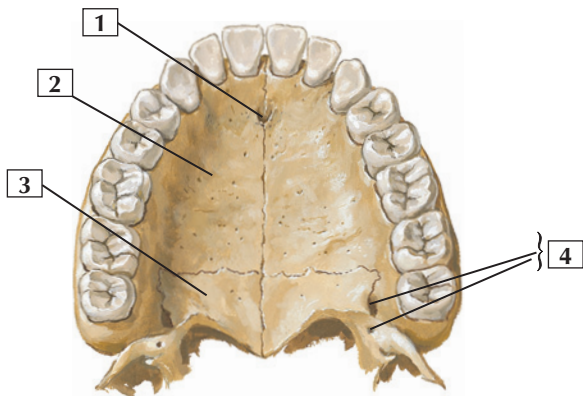
1. Joint capsule
2. Lateral (temporomandibular) ligament
3. Sphenomandibular ligament (*phantom*)
4. Stylomandibular ligament
5. Mandibular fossa
6. Articular disc
7. Articular tubercle
8. Joint capsule

Comment: The temporomandibular joint is the synovial joint between the mandibular fossa and the articular tubercle of the temporal bone and head of the mandible. The joint's 2 synovial cavities are separated by an articular disc of fibrocartilage.

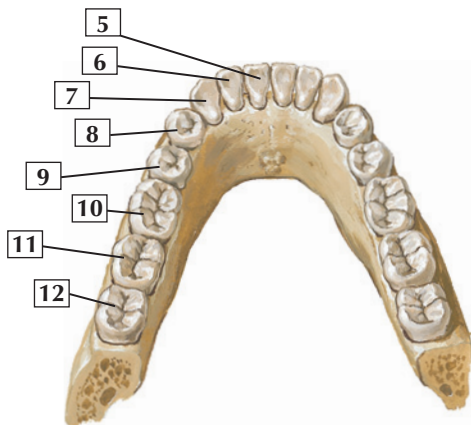
This unique joint combines an upper uniaxial gliding joint, for forward gliding (protrusion) and backward gliding (retraction) movements and some side-to-side motion, with a lower uniaxial hinge joint, below the articular disc, for closing (elevation of) and opening (depression of) the jaw.

This joint contains an articular capsule and is reinforced by the lateral and sphenomandibular ligaments.

Clinical: The temporomandibular joint (TMJ) has both a hinge action and a gliding or sliding action. TMJ problems affect about 25% of the population and can result from trauma, arthritis, infection, clenching or grinding of the teeth (bruxism), or displacement of the articular disc. TMJ problems are more common in women than men.



Upper permanent teeth



Lower permanent teeth

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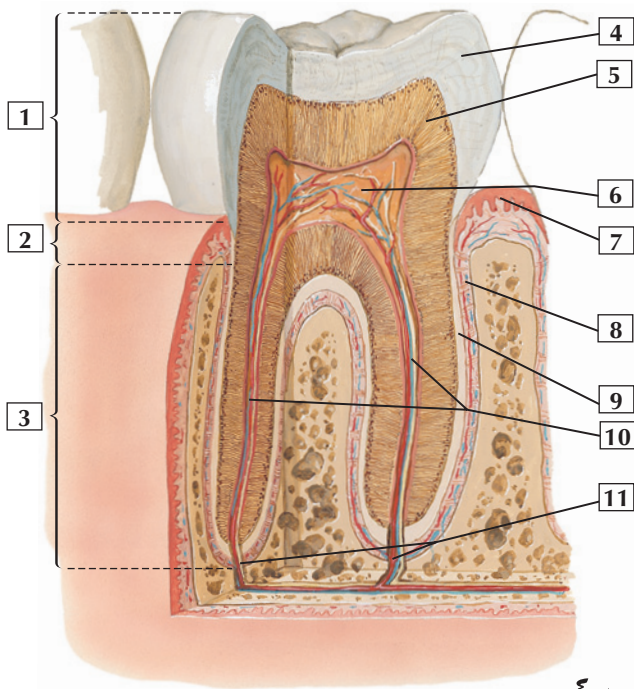
1. Incisive fossa
2. Palatine process of maxilla
3. Horizontal plate of palatine bone
4. Greater and lesser palatine foramina
5. Central incisor
6. Lateral incisor
7. Canine
8. 1st premolar
9. 2nd premolar
10. 1st molar
11. 2nd molar
12. 3rd molar

Comment: Humans have 2 sets of teeth: the deciduous teeth, which total 20, and the permanent teeth (shown in this illustration), which total 32 (16 maxillary and 16 mandibular teeth).

Permanent teeth in each quadrant of the jaw (mandible and maxilla) include 2 incisors, 1 canine, 2 premolars, and 3 molars. The 3rd molars are often referred to as the wisdom teeth.

The maxillary teeth are innervated by the posterior, middle, and anterior alveolar branches of the maxillary nerve. The mandibular teeth are innervated by the inferior alveolar branch of the mandibular nerve.

Clinical: Because of its vulnerable location, the mandible is the 2nd most commonly fractured facial bone (the nasal bone is 1st). The most common sites of fracture are the cuspid (canine tooth) area and just anterior to the 3rd molar area.



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Tooth



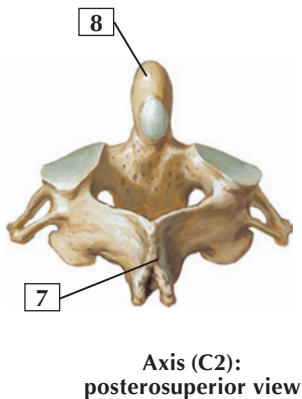
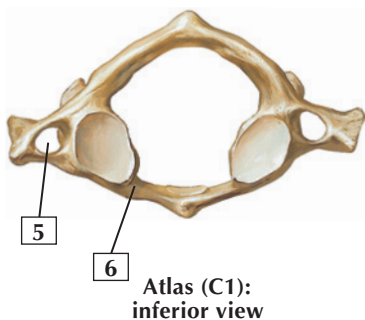
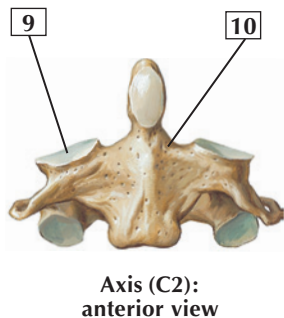
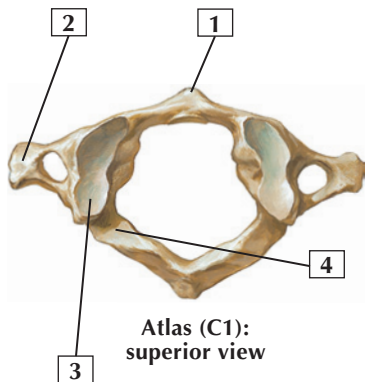
1. Crown
2. Neck
3. Root
4. Enamel (Substantia adamantina)
5. Dentine and dentinal tubules (Substantia eburnea)
6. Dental pulp containing vessels and nerves
7. Gingival (gum) epithelium (stratified)
8. Periodontium (Alveolar periosteum)
9. Cement (Cementum)
10. Root (central) canals containing vessels and nerves
11. Apical foramina

Comment: Each tooth is composed of an enamel-covered crown, dentine, and pulp. The pulp fills a central cavity and is continuous with the root canal. Blood vessels, nerves, and lymphatics enter the pulp through an apical foramen.

The crown projects above the gum, or gingival surface. The narrow portion between the crown and root is called the neck. The root is embedded in the alveolar bone of the maxilla or mandible and is covered by cement, which is connected to the alveolar bone by the periodontal ligament.

Clinical: Dental caries (tooth decay) is caused by oral bacteria that convert food into acids that then form dental plaque (a combination of bacteria, food particles, and saliva). Foods rich in sugars and starch may increase one's risk for forming plaque. If not removed by brushing, the plaque can mineralize and form tartar. Acid in the dental plaque can erode the tooth enamel and create a cavity. This may occur even though enamel (an acellular mineralized tissue) is the hardest material in the human body, consisting of 96% to 98% calcium hydroxyapatite.

Cervical Vertebrae: Atlas and Axis



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Cervical Vertebrae: Atlas and Axis



1. Anterior tubercle
2. Transverse process
3. Superior articular surface of lateral mass for occipital condyle
4. Groove for vertebral artery
5. Transverse foramen
6. Anterior arch
7. Spinous process
8. Dens
9. Superior articular facet for atlas
10. Pedicle

Comment: The 1st cervical vertebra is the atlas. It is named after the Greek god Atlas, who is often depicted with the world on his shoulders. The atlas has no body or spine but is made of anterior and posterior arches. The transverse processes contain a foramen that transmits the vertebral vessels.

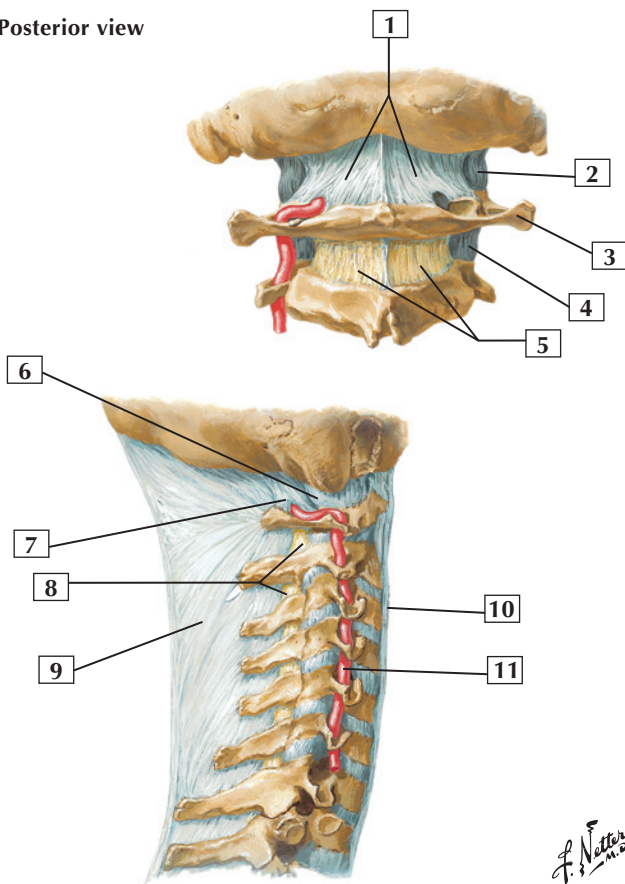
The 2nd cervical vertebra is the axis. Its most characteristic feature is the dens (odontoid process). The dens articulates with the anterior arch of the atlas, providing a pivot about which the atlas and head can rotate (side-to-side action of the head, as in indicating “no”).

Clinical: A blow to the top of the head may fracture the atlas, usually across the anterior and posterior arches. Such a fracture is called a Jefferson fracture. Fractures of the axis often involve the dens or involve a fracture across the neural arch between the superior and inferior articular facets. This is referred to as a “hangman” fracture.



External Craniocervical Ligaments

Posterior view



F. Netter M.D.

External Craniocervical Ligaments



1. Posterior atlanto-occipital membrane
2. Capsule of atlanto-occipital joint
3. Transverse process of atlas (C1)
4. Capsule of lateral atlanto-axial joint
5. Ligamenta flava
6. Capsule of atlanto-occipital joint
7. Posterior atlanto-occipital membrane
8. Ligamenta flava
9. Ligamentum nuchae
10. Anterior longitudinal ligament
11. Vertebral artery

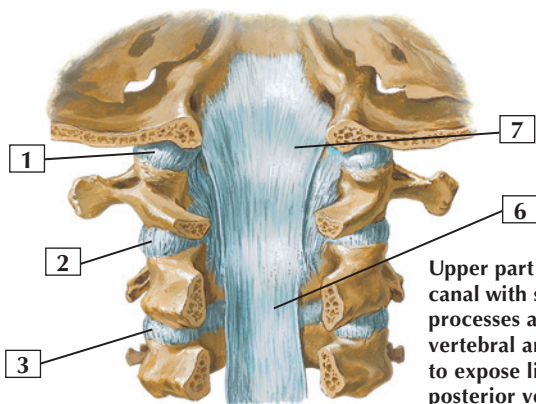
Comment: The atlanto-occipital joint, on each side, is covered with an articular capsule and posteriorly reinforced by the posterior atlanto-occipital membrane.

The ligamentum nuchae is a strong median fibrous septum. It is an extension of the thickened supraspinous ligaments that arise from the spinous process of C7 and extend to the external occipital protuberance.

Clinical: While there are usually 7 cervical vertebrae, fusion of adjacent vertebrae can occur. Most commonly, this fusion in the cervical region is seen between C1 and C2 (the atlas and axis) or between C5 and C6.

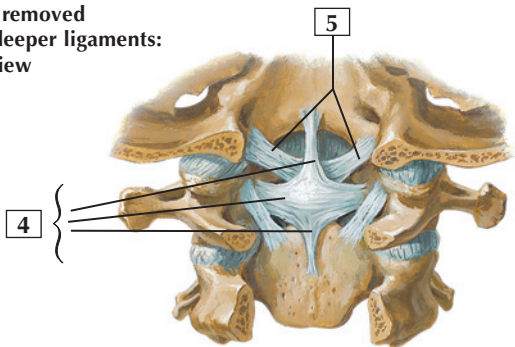


Internal Craniocervical Ligaments



Upper part of vertebral canal with spinous processes and parts of vertebral arches removed to expose ligaments on posterior vertebral bodies: posterior view

Principal part of tectorial membrane removed to expose deeper ligaments: posterior view



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Internal Craniocervical Ligaments



1. Capsule of atlanto-occipital joint
2. Capsule of lateral atlanto-axial joint
3. Capsule of zygapophysial joint (C2-3)
4. Cruciate ligament (Superior longitudinal band; Transverse ligament of atlas; Inferior longitudinal band)
5. Alar ligaments
6. Posterior longitudinal ligament
7. Tectorial membrane

Comment: The atlanto-occipital joint is a biaxial condyloid synovial joint between the atlas and the occipital condyles. It permits flexion and extension, as when the head is nodded up and down, and some lateral bending.

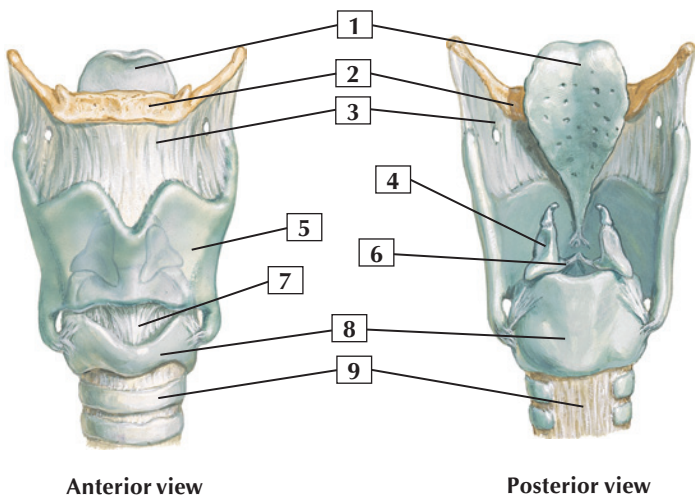
The atlanto-axial joints are uniaxial synovial joints. They consist of plane joints associated with the articular facets and a median pivot joint between the dens of the axis and the anterior arch of the atlas. The atlanto-axial joint permits the atlas and head to be rotated as a single unit, as when the head is turned from side to side.

These joints are reinforced by ligaments, especially the cruciate and alar ligaments. The alar ligaments limit rotation.

Clinical: Osteoarthritis is the most common form of arthritis and often involves erosion of the articular cartilage of weight-bearing joints, including the cervical spine. Extensive thinning of the intervertebral discs and of the cartilage covering the facet joints can lead to hyperextension of the cervical spine, narrowing of the intervertebral foramen, and the potential for impingement of the spinal nerves exiting the intervertebral foramen.



Cartilages of Larynx



J. Netter M.D.