Dissection of the CAT

and comparisons with man

Harrison/Seventh edition

Dissection of the cat

AND COMPARISONS WITH MAN

A laboratory manual on *Felis domestica*

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Preface

This dissection atlas has been widely used over the years in at least two kinds of courses: those in human anatomy when the human body is not available for dissection by the student and those in comparative anatomy in which the thorough study of the cat is a primary goal. We hope this revision will meet the needs of students in these courses more than ever before.

Based on much feedback from users, this edition includes revisions of two important aspects, the illustrations and the terminology. Every pedagogically important view of the cat's body has been drawn from newly dissected material. The result is a complete new set of accurate and esthetically pleasing artwork. Throughout the book, terminology has been changed and updated to conform to the current standards of *Nomina Anatomica* for man and *Nomina Anatomica Veterinaria* for the cat. These changes were made in order to keep all the terminology consistent and uniform and to promote carryover from the anatomy of the cat to the anatomy of man.

Dr. L. E. St. Clair, College of Veterinary Medicine, University of Illinois, did the new dissections, completely supervised the preparation of the new artwork, and revised the terminology. He also revised portions of the manuscript itself to increase the clarity of dissection instructions.

The Publisher

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Introduction

The terms used in this book follow, in general, those listed in *Nomina Anatomica* for man and *Nomina Anatomica Veterinaria* for the cat. Some directional terms do not apply equally to man and the cat, since one stands upright and the other walks on four limbs. **Anterior** in man is **ventral** in the cat; **posterior** is **dorsal.** In the cat, the term **cranial** refers to surfaces toward the head, and **caudal** to those toward the tail. However, for surfaces on the head of the cat, the term cranial is replaced by **rostral;** thus **rostral** and **caudal** indicate opposing directions on the head. Unlike that of the cat, man's head curves and is not considered to be a prolongation of the body; thus rostral is **anterior** and caudal is **posterior.** The terms **superior** and **inferior** are used for directions toward and away from the head of man.

ONE

Skeleton of the cat

A box containing about twenty of the larger representative cat bones should have been issued to you. Select the following bones from your set and find their proper position on the drawing of the skeleton (Fig. 1-1). The first two vertebrae are the **altas** and **axis,** respectively. The **thoracic vertebrae,** to which the **true** and **false ribs** are attached, are situated in the chest. The first nine ribs are called **true ribs,** since each has its own **cartilage** attaching it to the sternum. The last four ribs are called **false ribs,** since each does not have its own attachment to the sternum. The last of the false ribs is also called a **floating rib,** since it has no cartilage attaching it to the sternum. The lower ends of the ribs join the sternum; the cranial bone of the sternum is the **manubrium,** followed by several segments constituting the **body,** or **sternebrae bones,** and the caudal portion, the **xiphoid process.** Next in the spinal column are the **lumbar vertebrae** in the small of the back, then the **sacrum,** consisting of three vertebrae, to which the **ilium** is attached. The tail bones are the **caudal (coccygeal) vertebrae.** There are usually a few remnants of hemal arches, known as **chevron bones,** on the lower surface of the fourth, fifth, and sixth caudal vertebrae.

The **clavicle** is a small bone cranial to the lower end of the **scapula,** and the **hyoid** is caudal to the lower jaw. These bones may be seen on a well-mounted skeleton. The bones of the thoracic limb consist of the following: **humerus, radius, ulna, carpals** (wrist bones), **metacarpals** (palm-of-the-hand bones), and **phalanges** (finger or toe bones).

The bones of the pelvic limb are as follows: **femur, patella** (kneecap), **tibia, fibula, tarsals** (ankle and heel bones), **metatarsals** (instep bones), and **phalanges** (toe bones).

Arrange the skull and the representative bones of the spinal column in a straight line with the head farthest away. Determine whether each of the remaining bones belongs to the right or left side, and place it in its proper position on the right or the left of the vertebrae representing the spinal column. Refer to the mounted skeleton for aid in determining whether or not a given bone is on the right or the left.

Compare Figs. 1-1 and 1-2, and observe that the skeletons of the cat and man are constructed on the same general plan. If you place the mounted cat's skeleton up on its hind legs or place the mounted human skeleton on its hands and knees and compare them, the close similarity of structure will be much more evident and striking.

Whenever you come to a scientific or technical term and you are not sure of its meaning, look in the back of the book for its definition.

SKULL, DORSAL (Fig. 1-3)

Look in the back of the manual for definitions of many of the technical terms used.

Observe the **incisive (premaxillary) bones** at the sides of the **external nasal apertures.** These bones bear the **incisor teeth.** How many are there? At each side of the middorsal line, immediately caudal to the nasal apertures, are the **nasal bones.** Lateral to these and also to the incisive bones are the **maxillary bones.** Each maxillary normally bears one **canine,** three **premolars,** and one small **molar.** Farther caudal on the dorsal surface are the **frontal bones,** which meet one another along the **middorsal suture** and project laterally as the **postorbital,** or **zygomatic, process** of the frontal bone.

A shorter discussion of the anatomy of the cat is given in Harrison, B. H.: *Manual of comparative anatomy,* ed. 3, St. Louis, 1970, The C. V. Mosby Co.

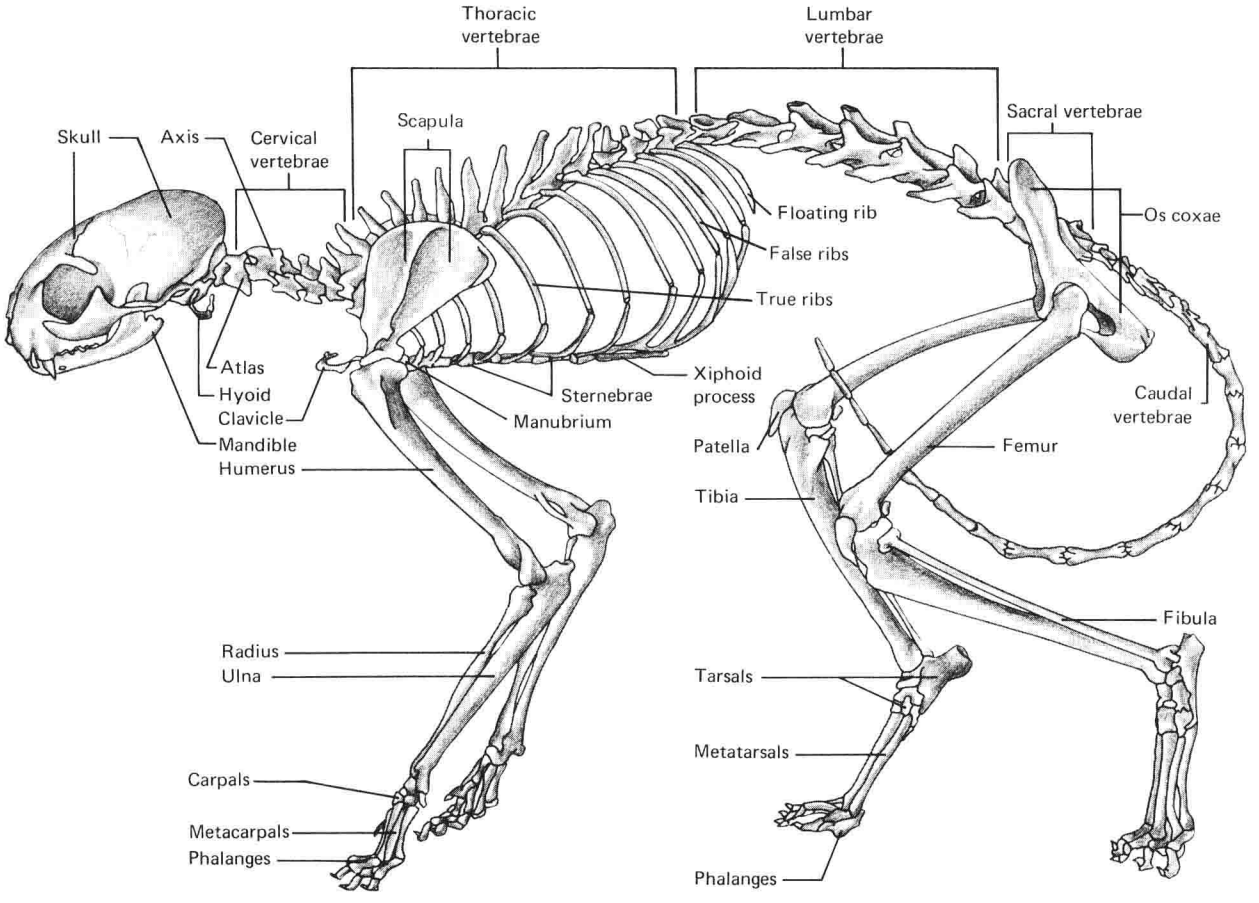

Fig. 1-1. Skeleton.

The orbit of the eye is bounded laterally by the **zygomatic arch,** which bears at its caudal extremity the **postorbital,** or **frontal, process** of the malar, directed toward the postorbital process of the **frontal bone,** mentioned in the previous paragraph. The **zygomatic arch,** joins caudally with the **zygomatic process** of the **temporal bone** to form the **zygomatic arch.** The **orbit of the eye** and the **temporal fossa** are bounded laterally by the **zygomatic arch.**

Caudal to each frontal bone, meeting one another along the middorsal line, is a **parietal bone,** and lateral to each of these is the **squamosal portion of the temporal bone.** Caudal to and slightly between the parietals sometimes may be seen a small **interparietal bone,** and caudal to it is the **supraorbital bone.** This latter bone bears a transverse ridge, known as the **nuchal crest,** for the attachment of the muscles of the dorsal part of the neck, and it also bears a **dorsal median sagittal crest,** which extends forward between the parietals.

Within the limits of the orbit of the eye may be seen, when viewed from above, a portion of the **palatine bone** with two small openings, the palatine foramina. The more lateral opening is for the **passage of the palatine branch of the facial nerve,** and the median opening is for the **sphenopalatine branch** of the same nerve. These foramina can be seen better in ventral view. Rostral to the **palatine bone** is the **lacrimal bone,** which also bears an opening at its medial border, the **lacrimal canal,** through which pass the tears or secretion of the lacrimal gland into the nasal chamber. The part of the maxillary bone rostral to and below the front of the eye contains the large **infraorbital foramen** for the passage of the infraorbital nerves and blood vessels. These nerves are branches of the maxillary branch of the **fifth (trigeminal)**

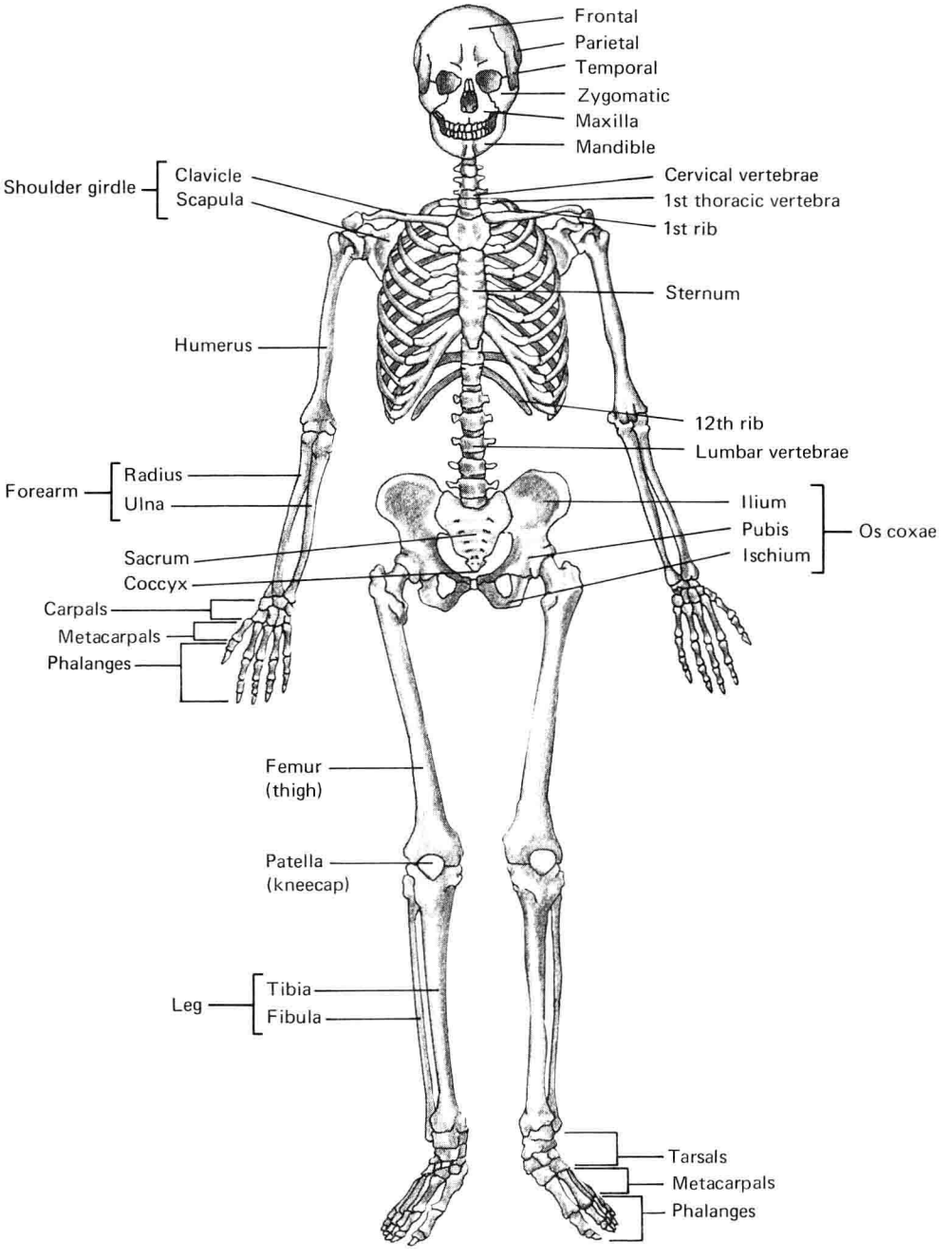

Fig. 1-2. Human skeleton, anterior view.

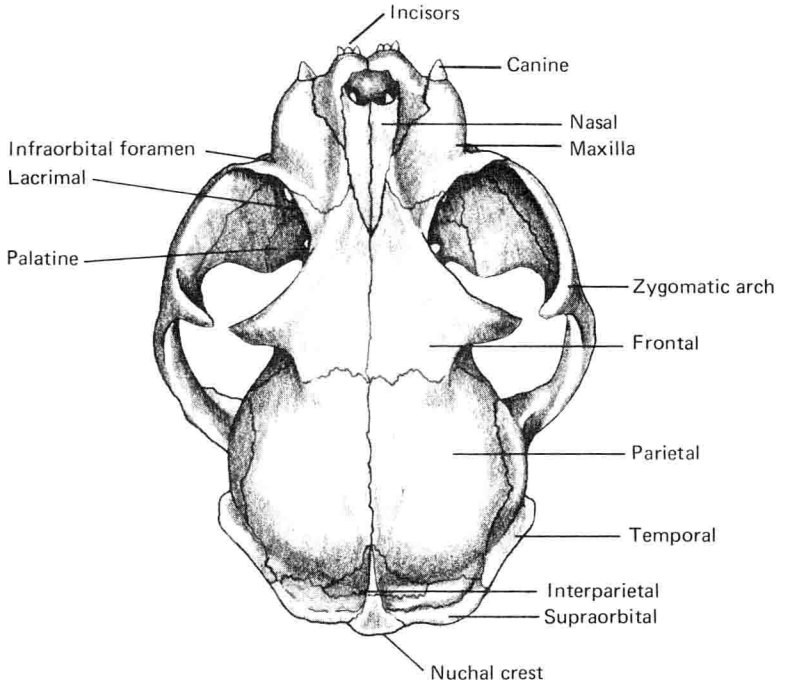

Fig. 1-3. Bones of skull, dorsal view.

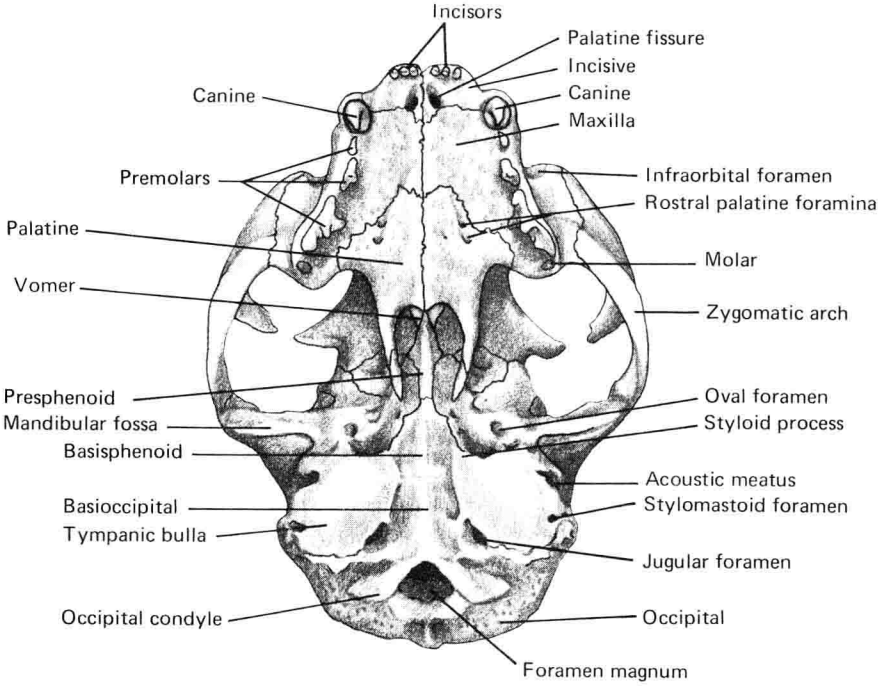

Fig. 1-4. Bones of skull, ventral view.

nerve. Other bones of the orbit will be considered later.

SUTURES OF SKULL

The bones of the skull are joined by means of immovable articulations, known as **sutures.** These sutures are designated by combining names of the bones between which they are situated, such as **nasomaxillary suture** between the nasal and maxillary bones. Often, when a suture separates the two corresponding bones of opposite sides, the prefix "inter" is used, such as the **intermaxillary suture** between the maxillaries, which shows on the ventral surface. The sutures bounding the parietal bone, however, have not been named by this system. The suture caudal to or behind the parietals, separating them from the occipital, is known as the **lambdoid suture.** Separating the parietals and squamous portions of the temporal bones is the **squamous suture,** and the transverse suture separating the two parietals from the two frontals is the **coronal suture.** Separating the two nasals, the two frontals, and the two parietals is the **median sagittal suture.**

SKULL, VENTRAL (Fig. 1-4)

As you make this study, it would be most helpful to have the disarticulated, or individual, bones of the skull to examine also.

Examine the ventral surface of a skull. The **incisive bone** almost surrounds the palatine fissure. The limiting sutures may be difficult to determine in an adult skull. The **incisive bones** bear the **incisor teeth.** The **maxillary bones** are immediately caudal, meeting one another along the midventral line, and in the fully developed specimen each bears one **canine,** three **premolars,** and one small **molar.** The **palatine bones** are caudal to the **maxillary bones,** and parts of them form the roof of the mouth, known as the hard palate. Sometimes, in the embryonic stage of man, the palatine process from one side does not come across and meet its mate from the other side, resulting in a **cleft palate.** So far as is known, this does not occur in the cat. The **vomer** lies dorsal to the median line of the maxillary and palatine bones and helps separate the two **nasal chambers;** in man the vomer pushes up into the cranial chamber, separating parts of the **cerebral hemisphere** of the **cerebrum.** The flattened part of the vomer may be seen by looking into the caudal nasal openings. The soft palate, which is membranous, lies caudal to the bony part and separates the cranial part of the pharynx into the **nasopharynx** and the **stomodeal part.** The **presphenoid bone** may be seen as a small, elongated bone along the median line caudal to the vomer, forming part of the roof of the pharynx and nasal passage. Lateral to the presphenoid bone is the **pterygoid process** (see Fig. 1-5) of the sphenoid (see Fig. 1-6) bone, also forming part of the roof and sides of the pharynx and extending background and downward as long, slender projections about one-half inch apart. Each sharp point is a **hamular process** (see Fig. 1-6) of the pterygoid. Within the caudomedial wall of each orbit lie two distinct portions of the sphenoid region, which may be seen if a fairly young skull is examined. There are found four or five foramina, which include the **optic foramen,** for the passage of the optic nerve.

Ventral to the optic foramen is the **orbital fissure,** or **foramen,** through which pass the **third** (motor occulus), the **fourth** (pathetic or trochlear), and the **sixth** (abducent) cranial nerves, and the ophthalmic branch of the **fifth** (trigeminal) cranial nerve. The **optic** and **orbital foramina** may not show in a strict ventral view (see lateral view, Fig. 1-5). The greater wing of the basisphenoid bone projects dorsally and laterally as a long process between the lateral edges of the frontal and temporal bones and joins a ventrally directed process from the parietal.

In the cat, the **presphenoid** and its orbital extentions are fused into one bone, while the **basisphenoid** and its wings are fused with one another. In man, all six bones are fused into one and are called the **sphenoid.** The fusion of bones is a sign of advancement and indicates, in this small way, that man is higher than the cat. Examine these parts (if available) on disarticulated skulls of cat and man.

The **basisphenoid** lies caudal to the presphenoid along the midventral line. About halfway from this midventral line on the basisphenoid to the articulating **mandibular fossa** for the lower jaw is the **oval foramen;** rostral and medial to it is the **round foramen.** The oval foramen is for the passage of the mandibular branch of the fifth (trigeminal) nerve, and the round foramen is for the maxillary branch of the trigeminal. The last two foramina complete the series of four mentioned previously. Lateral to the oval fora-

men is a transverse depression, the **mandibular fossa,** for the articulation of the lower jaw. Fit the jaw into this depression.

The large, oval prominences caudal to the mandibular fossae are the **tympanic (auditory) bullae,** which are probably for the amplification of sound. Between them is the **basioccipital bone.** The large **foramen magnum** is at the caudal end of the skull and through it passes the spinal cord. The **occipital condyles** are prominences on each side of the foramen magnum and close to it. These articulate on the first vertebra of the spinal column, the **atlas.**

Close to the inner surface of the posterior extremity of the tympanic bulla is the large **jugular foramen** for the passage of the ninth, tenth, and eleventh nerves. On the rostrolateral surface of the bulla is the external **acoustic (auditory) meatus,** which leads to the tympanic membrane. Caudal to this are one or two small **stylomastoid foramina.** The small **mastoid process** of the **temporal bone** projects forward, almost covering one small foramen. At the rostromedial angle of the tympanic bulla, projecting ventrally forward and medially, is the **styloid process.** Just rostral to this process is a **foramen for the exit of the eustachian tube** from the middle ear. Only a portion of the **ethmoid bone** can be seen in the complete skull. This part constitutes the **conchae,** or **turbinate bones,** which project into the nasal chamber (see Fig. 1-6).

SKULL, LATERAL (Fig. 1-5)

Keep in mind the parts that you will see in the lateral view that you identified in the ventral view study. The **occipital condyles** project ventrally near the posterior part of the skull. Above these condyles is the **nuchal crest,** or **ridge,** that passes toward the **acoustic meatus,** which is the large opening on the lateral surface of the **tympanic bulla.** The nuchal crest becomes continuous with the **linea temporalis,** which joins the **zygomatic process** of the **temporal** and **zygomatic arch.** On the caudal surface of the bulla is the small **jugular process** of the occipital bone, a short distance lateral to the occipital condyles. Rostral to this process, about halfway to the acoustic meatus, is the much larger **mastoid process.** One or two **stylomastoid foramina,** for the passage of branches of the seventh cranial nerve, lie rostral to the mastoid process. If the skull is not thoroughly cleaned, these small openings may not be seen. Within the opening of the auditory meatus and medial to the tympanic membrane are the small ear bones, **malleus, incus,** and **stapes** (see Fig. 6-3). These cannot be seen unless the bone is cut away, which may be done later.

The foramen for the passage of the **lacrimal duct** is at the rostrolateral edge of the **lacrimal bone,** and the **infraorbital foramen** may also be seen in the lateral view. Caudal to the lacrimal and below the frontal a part of the **palatine bone** may be observed containing two openings,

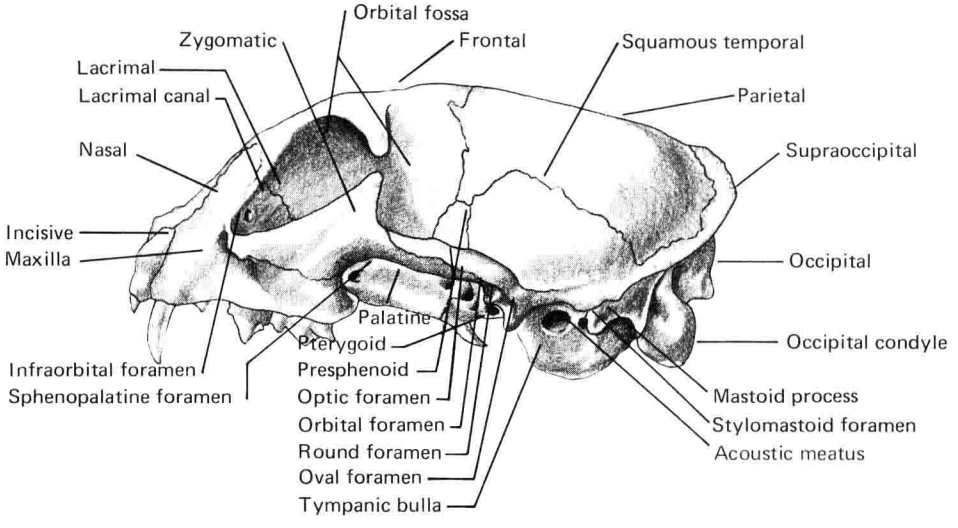

Fig. 1-5. Bones of skull, lateral view.

the outer and smaller **palatine foramen** for the passage of the **palatine branch of the maxillary nerve** and the larger and medial **sphenopalatine foramen** for the **sphenopalatine branch** of the same nerve. The former foramen is the caudal end of the palatine canal. The other end is in the roof of the mouth, in or near the suture separating the maxillary and palatine bones. A small part of the **ethmoid bone** forms a part of the rostromedial wall of the orbit between the **frontal, lacrimal,** and **palatine bones.**

SKULL, MEDIAN SAGITTAL (Fig. 1-6)

Examine the half skull. Do you have the right or the left half? The skulls that have been soaked in formalin hold the bones together much better than the fresh specimens; hence these are sawed in half for this study. We now wish to see the relationships between the bones of the skull and the larger parts of the brain. Observe that the cranial cavity is partially divided by a bony partition, or septum, which extends ventrally from the parietal and occipital bones. This is the **internal occipital protuberance (tentorium),** which is unossified in man. The larger and quite irregular cavity rostral to the **tentorium** is filled almost entirely by the **cerebrum,** with a **fossa for the olfactory bulbs,** filling the comparatively small area against the nasal chamber. The **cribriform plate,** which is a part of the ethmoid bone, separates the nasal and cranial chambers, and through it pass many olfactory nerves from the olfactory bulbs onto the **turbinate bones (conchae)** of the **nasal cavity.** There are three of these **conchae** in man, projecting into each nasal chamber from the lateral wall. The upper two are **ethmoturbinates,** and the lower is the **maxilloturbinate.** Being much more complicated in the cat than in man, these turbinate bones have relatively more surface for nerve endings, which probably accounts in part for the keener sense of smell in the cat.

The lowest depression on the median plane of the skull, rostral to the lower end of the **tentorium,** is the **sella turcica,** or **pituitary fossa,** in which is lodged the **pituitary endocrinal gland.** Immediately dorsal to this gland is the **diencephalon** of the brain. Above the olfactory bulbs the **frontal sinus** may be seen, providing the skull has been cut slightly to one side of the median plane. This cavity is in the frontal bone. Rostral to it on each side is the **ethmoid sinus,** which is within the spaces in the ethmoid bone.

The **ethmoid sinus** is relatively larger in the cat than in man, as is also the **maxillary sinus.** It is believed that these sinuses drain better in animals that carry the body and head in a horizontal position. Man is more prone to sinus trouble. The **conchae** are projections that curve from the lateral walls into each nasal chamber. Each concha has many folds, onto which go the olfactory nerve endings for the sense of smell and many blood vessels for warming and moistening the air. The nose is an air conditioner for the lungs.

The cavity behind the **tentorium** is largely occupied by the **cerebellum** and the **medulla**

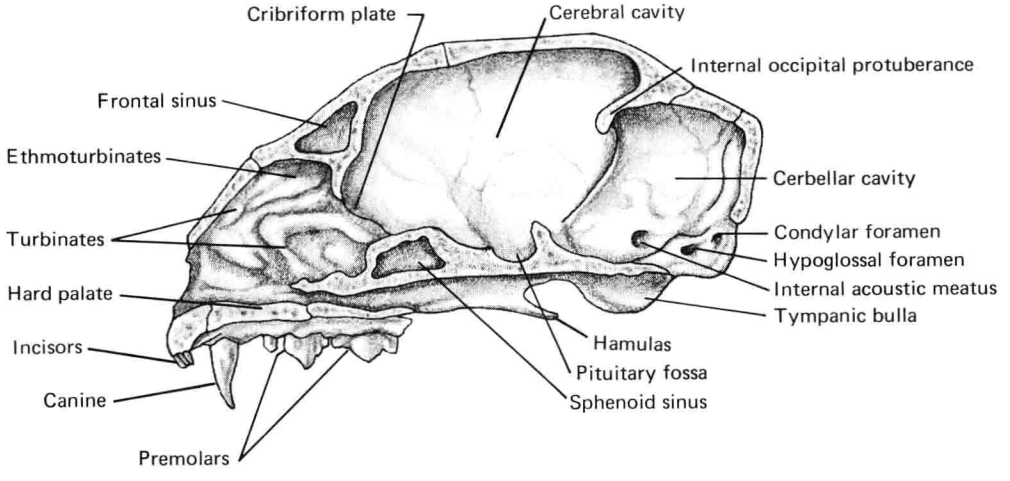

Fig. 1-6. Bones of skull, median sagittal view.

oblongata. In the lower lateral wall of the skull, which surrounds the cerebellum, is the **petrosal portion of the temporal bone,** which has an irregular inner surface and often a slightly different color. It contains the **semicircular canals** and the **cochlea.** The latter contains the **organ of Corti** of the inner ear. The inner surface of the petrous portion of the temporal bone has two depressions. Within the lower depression are two foramina. The more dorsal of the two is the **canalis facialis** for the passage of a branch of the seventh nerve, and the ventral foramen is the **internal acoustic meatus** for the passage of the eighth (auditory) nerve. The upper depression on the inner surface of the petrosal part has no foramina and is of no special significance. In the lateral wall of the **foramen magnum** are two foramina: the lower is the **hypoglossal foramen,** and the more dorsal is the **condylar foramen.** Above and rostral to the **hamular process** and the **palatine bone** is the internal naris and above it, the sphenoid sinus. There is some evidence from a comparative study of the nerves and vertebrae of various animals that the skull has been derived by a fusion of vertebrae.

DEVELOPMENT OF SKULL

There are **two principle kinds or types of bones** in the skull that differ in their embryological development.

1. The **membranous** (dermal or superficial) bones develop directly from loose connective tissue. These are the incisive, maxillary, zygomatic, palatine, lacrimal, nasal, frontal, parietal, and interparietal bones of the skull.

2. The **endochondral** (cartilaginous or deep) bones of the skull are the vomer, presphenoid, basisphenoid, basioccipital, ethmoid, and ethmoturbinate. These are preformed in cartilage. The **occipital** and the **temporal bones** are each a combination of the two types of bone. The supraoccipital part of the occipital is membranous, and the occipital condyles are endochondral. In the temporal bone the process of the temporal, which forms the caudal half of the **zygomatic arch,** and the large, curved squamous portion are membranous, while the **petrosal** portion and the **bulla** are endochondral. Both the membranous and endochondral types have **haversian systems** when fully formed; they cannot be distinguished histologically when fully formed.

FORAMINA OF SKULL

1. The **foramen magnum** is the large opening in the occipital bone for the passage of the spinal cord to join the medulla oblongata of the brain. The spinal accessory nerves and the vertebral arteries also pass through this opening.

2. The **hypoglossal foramen** passes through the occipital bone at the inside lower portion of the foramen magnum, opens on the ventral surface with the jugular foramen, and transmits the **hypoglossal nerve.**

3. The **condylar foramen** opens on the inside upper part of the occipital condyle and transmits a vein from the **transverse sinus.**

4. The **jugular foramen** is at the junction of the tympanic bulla and the occipital bone in the caudomedial surface of the bulla. It transmits the **inferior cerebral vein** and the **ninth, tenth,** and **eleventh nerves.**

5. The **stylomastoid foramen** is between the stylomastoid process and the lateral caudal border of the bulla. It serves as a passage for a **branch of the seventh nerve.**

6. The **facial canal** passes through the medial part of the petrous portion of the temporal bone. It is the principal exit for branches of the **facial nerve.**

7. The **internal acoustic meatus** is below the facial canal on the medial surface of the petrous portion and serves as a passage for the **eighth (auditory) nerve** from the brain into the inner ear.

8. The **external acoustic meatus** is on the lateral surface of the tympanic bulla for the entrance of sound waves to the tympanum.

9. The **foramen for the eustachian tube** is lateral to the styloid process at the rostral edge of the tympanic bulla.

10. The **oval foramen** is at the basal caudolateral edge of the basisphenoid bone, medial to the mandibular fossa. It transmits the mandibular branch of the **trigeminal nerve** and **middle meningeal artery.**

11. The **round foramen** is in the base of the basisphenoid, rostral and slightly medial to the oval foramen, and serves as a passage for the **maxillary branch of the trigeminal nerve.**

12. The **orbital fissure,** or **foramen,** is between the presphenoid and basisphenoid bones laterally. Through this fissure pass the **third, fourth,** and **sixth cranial nerves** and the **ophthalmic branch of the fifth.**

13. The **optic foramen** is lateral in the pre-

sphenoid bone and transmits the **optic nerve.** Laterally and rostrally there may be a small **ethmoid foramen.**

14. The **olfactory foramina** pass through the cribriform plate of the ethmoid bone and permit the **olfactory nerves** to spread out on the turbinate bones of the nasal cavity.

15. The **sphenopalatine foramen** is the larger and more medial of the two in the palatine bone of the ventromedial wall of the orbit of the eye. It transmits the **sphenopalatine artery** and the **caudal superior nasal nerve,** which is a branch of the **fifth (trigeminal) nerve.**

16. The **palatine canal** is lateral to the sphenopalatine foramen and passes through to the rostrolateral edge of the palatine bone on the ventral surface of the hard palate. It transmits the **greater palatine nerve** and **artery.**

17. The **palatine fissure** is on each side of the median line, between the bases of the canine teeth, and is bounded by the incisive and and maxillary bones. The **nasopalatine nerve,** which is a branch of the maxillary, passes through it.

18. The **infraorbital foramen** is in the maxillary bone, below and rostral to the eye. It is large and transmits the **infraorbital nerve.** Sometimes two foramina are present instead of one, depending on where the nerve branches.

19. The **lacrimal canal** is between the lacrimal and maxillary bones in the rostromedial wall of orbit. The **lacrimal duct** passes through it on the way to the nasal chamber.

SOME DIFFERENCES IN SKULLS OF THE CAT AND MAN

1. Man has twenty-two separate skull bones, whereas the cat has thirty-five to forty.

2. Frontal and parietal bones are enlarged and pushed higher in man, whereas the jaws are relatively smaller and less protruding than those in the cat.

3. The incisive and maxilla on each side fuse into one bone in man but are separate in the cat.

4. The two frontal bones that are separate in embryo man become fused in the adult, but they remain separate in the adult cat.

5. The several parts of the sphenoid are fused into one bone in man but are in two principal parts in the adult cat.

6. The ossified dura mater forms a part of the parietal bone known as the tentorium in the cat but remains unossified in man.

7. A part of the hyoid branchial arch ossifies and forms the part of the temporal bone known as the styloid process in man but is not so formed in the cat.

8. The nuchal crest and the tympanic bullae are well formed in the cat but are absent in man.

9. An interparietal is often present as a separate bone in the cat but is only occasionally found in man.

10. The caudolateral wall of the orbit of the eye is well ossified in man but is only partially ossified in the cat.

11. Each half of the upper jaw of the cat has three incisors, one canine, three premolars, and one molar, whereas man has two, one, two, and three, respectively.

12. The inferior nasal conchae of man are separate bones, whereas in the cat these are parts of the maxillary bones, the maxilloturbinates or ventral nasal conchae.

13. The mandibles of the cat are easily separated from one another at the symphysis, whereas in man they are strongly fused.

14. The cat normally has thirteen pairs of ribs, but occasionally there are fourteen or even fifteen pairs. These extra ribs appear adjacent to the seventh cervical vertebra, adjacent to the first lumbar vertebra, or at both of these locations. In man there are usually twelve pairs of ribs, but extra pairs may appear at the same locations as those mentioned for the cat. Such an abnormal or unusual structure, which appears suddenly in an animal and is not present in its ancestors for several generations, is called an "anomaly." This anomaly, when it occurs by the first lumbar vertebra in man, is called a "gorilla" rib, since it is more often found in the gorilla.