

2

THE SKULL

The mammalian skull is a complex structure. It houses and protects the brain and the receptors for five major senses: smell, taste, vision, hearing, and equilibrium. The braincase has adapted to the changes in the size and proportions of the brain. Specializations in the senses of hearing, smell, and sight have frequently resulted in corresponding changes in the skull, as have various adaptations for gathering food and preparing it for digestion. These, along with the skull's ability to resist decomposition and to fossilize, make it one of the most important anatomical units used in mammalian classification. A knowledge of its anatomy is essential for the identification of mammals. The keys in this volume have been constructed primarily on the basis of skull and tooth characters. Teeth will be discussed in Chapter 3.

The skull is composed of two easily disarticulated elements: an upper **cranium** (with braincase and rostral regions, see below) and the **mandible** or lower jaw. In addition, the tongue is partially supported by the **hyoid apparatus**, a component of the visceral skeleton. Only those bones that are visible externally on a cleaned skull are discussed in detail. For convenience, two major regions of the mammalian cranium may be recognized: the **braincase** and the **rostrum**. The braincase is a "box" of bone protecting the brain. Attached to it or associated with it are the **auditory bullae** (not present in all mammals), which house the middle and inner ears; the **occipital condyles**, which articulate with the first vertebra; and numerous processes and ridges that serve as points of attachment for muscles. Several **foramina** and **canals** penetrate the bones and allow for the passage of nerves and blood vessels. The rostrum is composed of the group of bones projecting anteriorly from a vertical plane

drawn through the skull at the anterior edges of the orbits. It includes the upper jaws and the bones that surround the nasal passages and divide these passages from the oral cavity.

2-A On a wolf, coyote, or dog skull (genus *Canis*) locate each of the bones or structures listed below in boldface type. Label each of these on the various views of the coyote skull in Figure 2.1A–C. All terms are listed in the glossary. A key to the numbers on Figure 2.1 is located at the end of this chapter. *Use it only to verify your identifications.*

The dorsal part of the skull is composed mostly of a series of paired bones that meet along the midline. The long slender **nasal bones** roof the **nasal passages**. Posterior to these are the paired **frontals**. Each of these extends down the side of the skull to form the inner wall of the **orbit** or eye socket. The **postorbital process** of the frontal is a projection that marks the posterior margin of the orbit. Posterior to the frontals are the paired **parietals**. A small, unpaired **interparietal** is located between the posterior edges of the parietals; in *Canis*, this is fused posteriorly with the supraoccipital (see below). Low **temporal ridges** arise on the frontals near the postorbital processes and continue posteriorly until they converge to form the sagittal crest. These ridges (including the "crest") increase the area available for attachment of jaw muscles. The posterior portion of the skull is formed by a fused bone, the **occipital**. The **foramen magnum**, through which the spinal cord passes, is located near the center of the occipital and is flanked by two knobs, the

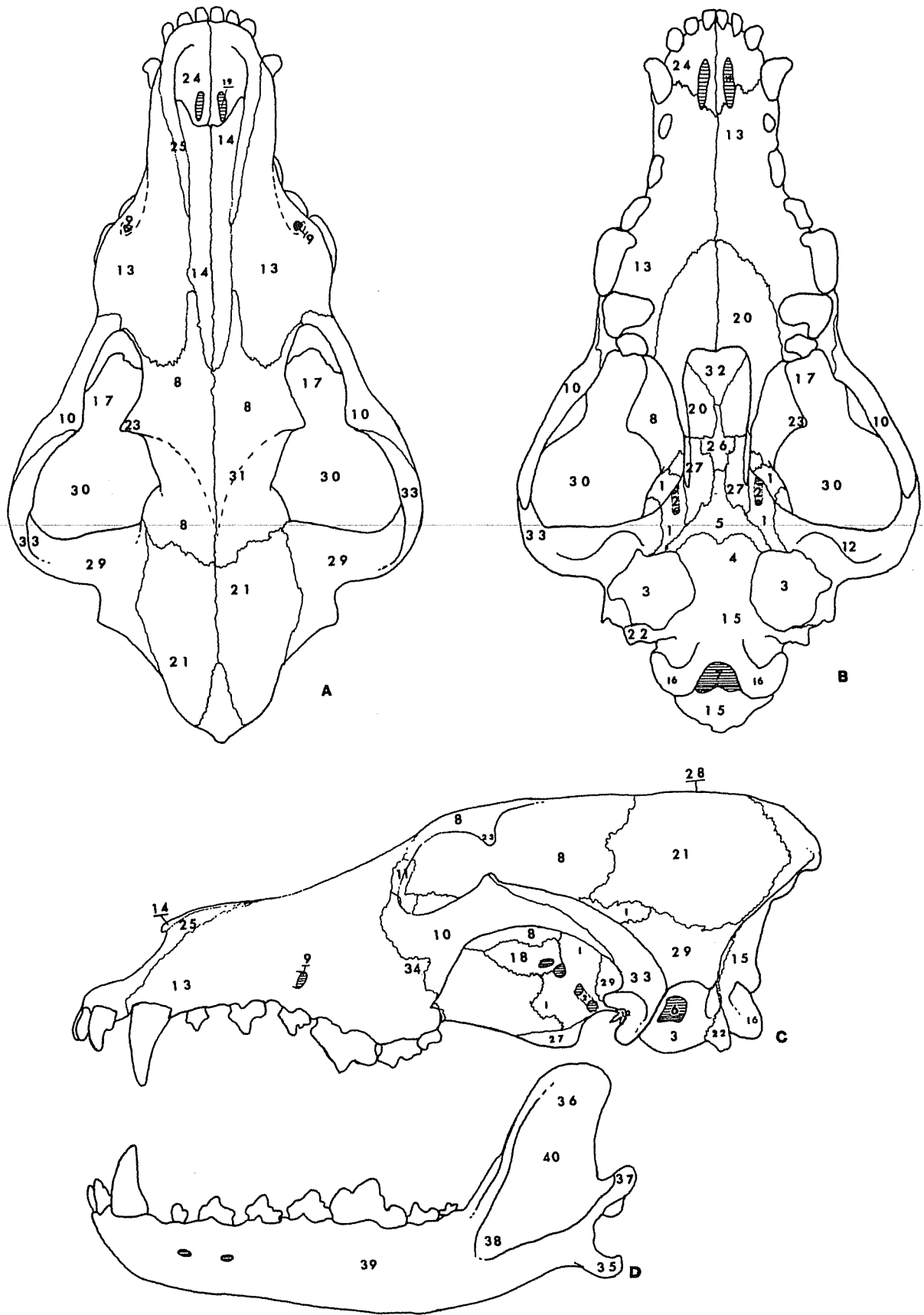


Figure 2.1 Skulls of *Canis*. (A) dorsal view; (B) ventral view; and (C) lateral view of cranium; (D) lateral view of mandible.
 (A. F. DeBlase)

occipital condyles, which articulate with the atlas, the first of the neck vertebrae. In young mammals, four bones fuse to form the single occipital bone of the adult. The names for these are used to designate regions of the occipital. Around the foramen magnum, these are the ventral **basioccipital**, the dorsal **supraoccipital**, and the lateral **exoccipitals**. The **occipital crests** extend laterally from the sagittal crest. Branches of the exoccipitals, the **paroccipital processes**, extend ventrally in close association with the auditory bullae. The entire posterior region of the skull is termed the **occiput**.

The tooth-bearing bones of the upper jaws are the paired premaxillae and maxillae. The **premaxillae**, which meet at the anterior end of the skull, have two major branches. The **palatal branches** of the premaxillae meet along the midline of the skull and form the anterior portion of the **hard palate**; the **nasal branches** of the premaxillae project dorsally and posteriorly to form the sides of the **anterior nares** (also called **external nares**). Posterior to the premaxillae, the **maxillae** form the major portions of the sides of the rostrum. A large foramen in each maxilla is the anterior opening of the **infraorbital canal**. Each canal terminates in the orbit and serves for passage of blood vessels and nerves. In some mammals, this opening is not elongated into a canal and is termed the **infraorbital aperture** or **infraorbital foramen**.

The palatal branches of the premaxillae and maxillae together with the paired **palatine bones** form the **hard palate** that separates the **buccal cavity** (mouth) from the nasal passages at this level. A pair of openings at the suture between the premaxillae and maxillae are the **anterior palatal foramina** (also termed the **incisive foramina**). Posterior and dorsal to the palatine bones are the proximal openings of the nasal passages, the **internal nares**. The **vomer** is an unpaired bone forming a septum between the two nasal passages. The highly convoluted bones within these passages are the **turbinals**. Posterior to the internal nares and the palatine bones are the paired **pterygoids**. Between the paired pterygoids and posterior to the vomer is the unpaired **presphenoid**. This complex bone passes beneath the pterygoid, palatine, and maxillary bones to reappear dorsally in the wall of each orbit where it is termed the **orbitosphenoid** and is perforated by the **optic foramen**. The medial **basisphenoid** lies between the basioccipital and the ventral visible portion of the presphenoid.

The conspicuous bony arches forming the ventral and lateral borders of the orbits and temporal fossae are the **zygomatic arches**. Three bones contribute to each zygomatic arch. Anteriorly, the jugal bone articulates with the **zygomatic process of the maxilla**. Posteriorly, the jugal articulates with the **zygomatic process of the squamosal** bone. A short process on the dorsal edge of the zygomatic arch marks the posterior edge of the orbit. In some mammals (but not in *Canis*), this process is continuous with the postorbital process of the frontal, form-

ing a **postorbital bar**. The postorbital bar separates the orbit or eye socket from the temporal fossa, through which some of the muscles of the lower jaw pass. On the ventral side of the base of each zygomatic process of the squamosal, the **mandibular fossa** provides an articulation surface for the lower jaw.

Between the jugal and frontal bones, at the anterior root of each zygomatic arch, is the small **lacrimal bone**. The foramen in this bone is for passage of the tear, or lacrimal, duct. Anterior to the squamosal, and posterior to the frontal and orbitosphenoid, is the **alisphenoid** bone. Ventrally on this bone, near its suture with the basisphenoid, is a small arch of bone surrounding the **alisphenoid canal**.

The bulbous structures between the mandibular fossae and the occipital condyles are the **auditory bullae**. The opening in the side of each bulla is the **external auditory meatus** across which the tympanic membrane, or eardrum, is stretched. In *Canis*, the **tympanic bone** is the only bone visible on the external surface of the bulla, but in some mammals the **entotympanic bone** is also visible externally. Within each bulla is the **middle ear** chamber containing the three ossicles, the **incus**, **malleus**, and **stapes**. The **otic capsule**, which houses the structure of the inner ear, is covered by the tympanic in *Canis*, but it is visible in primitive mammals that have incomplete auditory bullae. A portion of the **periotic**, one of the bones forming each otic capsule, is frequently exposed between the squamosal and occipital bones. The distal exposed portion of the periotic forms a distinct **mastoid process** in many mammals, but this is not a conspicuous structure in *Canis*. In some mammals (including cats and higher primates), the tympanic and squamosal bones fuse to form a single structure termed the **temporal bone**.

THE MANDIBLE

Compared to the cranium, the mandible is a very simple structure. It is composed of left and right **dentary** bones. The anterior surface of contact between the paired dentaries is the **mandibular symphysis**. This suture is attached fairly firmly in *Canis*, in most other Carnivora, and in many other mammals, and completely fused in primates. But in rodents, most artiodactyls, and many other forms, the two dentaries become easily disarticulated. The horizontal portion of each dentary, the portion that normally bears teeth, is termed the **body**, and the vertically projecting portion is the **ramus**. The **mandibular condyle** is the portion of the mandible that articulates with the mandibular fossa of the cranium. Dorsal to the condyle, the **coronoid process** extends up to fit into the temporal fossa and provides a surface for muscle attachment. Ventral to the condyle, the **angular process** protrudes posteriorly. The shallow depression near the bases

of these processes is the **masseteric fossa**. In some mammals (but not in *Canis*), this depression is very deep and occasionally completely penetrates the mandible, forming a **masseteric canal**.

- 2-B Locate on a *Canis* mandible each of the structures listed above in boldface type. Label these on Figure 2.1D. Check your identifications with the key at the end of this chapter.

VARIATION

The skulls of species of *Canis* may be considered to represent a "typical" mammal skull. From this "typical" structure are many deviations. The postorbital bar, mastoid process, and other structures conspicuous in some mammals, but absent in *Canis*, have already been mentioned.

The relative lengths of braincase and rostrum vary considerably. Mammals such as certain whales and anteaters have relatively short braincases and long rostra, whereas other species, such as humans, *Homo sapiens*, have large braincases and virtually no rostra.

The orbits may be directed anywhere from laterally, as in the pronghorn, to anteriorly, as in humans. They may be low on the head, as in raccoons, or high on the skull, as in woodchucks.

Nasal bones may be absent, short and broad, or long and narrow. Palatal, nasal, or both branches of the premaxillae may be enlarged, reduced, or lost.

Zygomatic arches may be incomplete, weak, or amazingly robust. Auditory bullae may be complete, incomplete, inflated, or compressed.

Many other such variations can and do exist but are far too numerous to list.

- 2-C To get an idea of the range of variation that exists in mammalian skulls, make as many of the following comparisons as possible.
- Compare the degree of separation of the orbit and temporal fossa in a shrew, human or monkey, raccoon, cat, and horse.
 - Compare the bone structure of the temporal region in *Canis*, a cat, and *Homo*.
 - Compare the relative lengths and sizes of the rostrum and braincase in an opossum, shrew, human, coyote, cat, horse, and elephant.
 - Compare the position of the orbits in a human, raccoon, otter, woodchuck, and deer.
 - Compare the size and proportion of the nasal bones in an opossum, human, porpoise, elephant, horse, tapir, and moose.
 - Compare the zygomatic arches of an opossum, shrew, human, *Canis*, rat, North American porcupine, porpoise, and horse.

- Compare the structure of the auditory bullae in a hedgehog, human, *Canis*, kangaroo rat, bear, porpoise, and deer.
- Compare the placement of the foramen magnum in an opossum, monkey, and deer.

DETERMINATION OF MATURITY

There are several methods of determining the absolute or relative age of an individual. These are discussed in detail in Chapter 33. Because most identification keys, including the ones in this manual, are only for adult mammals, it is necessary for you to be able to distinguish between immature and adult animals. Two cranial characteristics are especially helpful in identifying immature specimens, but neither of these always works. An individual in which it is evident that certain teeth are not yet fully erupted is usually an immature specimen. The degree of fusion of cranial sutures is generally also an indication of age. An immature specimen will have poorly fused sutures, and a very old adult can have sutures that are almost indiscernible. If a skull has a fully erupted dentition and fully fused cranial sutures, it should be possible to identify it using the keys in this manual. The keys may or may not correctly identify a specimen that does not meet these criteria.

MEASUREMENTS

Several more or less standardized measurements are used in gaining information about mammalian skulls. Because skulls are complex structures that can vary in many ways, different sets of measurements are used for different groups of mammals. The 10 most frequently taken measurements for a *Canis* skull would not be the same as the 10 for a porpoise or a rodent.

Skull measurements are taken in a straight line between two points (or lines or combinations thereof) and are recorded in millimeters. **Calipers** are customarily used for taking these measurements. Dial calipers are the easiest and most efficient type to use. Although various brands and models differ in design, in most models the centimeters are read directly from the bar, and millimeters and tenths of millimeters are read directly from the dial mounted on the movable slide. Vernier calipers are equally accurate but are slightly more difficult to read. Again, models vary in precise design, but in most models centimeters and millimeters are read directly from the bar, and tenths of millimeters are determined by the best match between gradations on the bar and one of the lines on the sliding scale.

When using calipers, take care not to damage specimens. Calipers should be closed to fit snugly against the bone but be careful not to crush, scratch, or puncture the bone.

The following measurements are some of those most frequently taken. An asterisk (*) indicates those that are taken on most species.

Measurements of the Entire Skull

All measurements of length are taken along the midline of the skull.

Basal length. From the anterior edge of the premaxillae to the anteriormost point on the lower border of the foramen magnum (Fig. 2.2, A–B).

Basilar length. From the posterior margin of the alveolus of either of the median upper incisors to the anteriormost point on the lower border of the foramen magnum (Fig. 2.2, C–B).

***Condylbasal length.** From the anterior edge of the premaxillae to the posteriormost projections of the occipital condyles (Fig. 2.2, A–D).

Condyl canine length. From the anterior edges of the alveoli of the upper canines to the posterior edges of the occipital condyles. (Usually taken instead of condylbasal length in forms in which the premaxillae are frequently lost.) (Fig. 2.2, E–D)

***Greatest length of skull.** From the most anterior part of the rostrum to the most posterior point of the skull (Fig. 2.3, L–M).

***Breadth of braincase.** Greatest width across the braincase posterior to the zygomatic arches (Fig. 2.3, A).

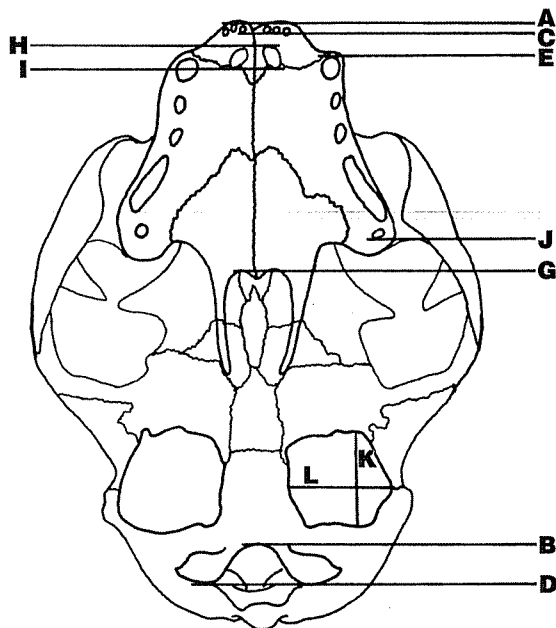


Figure 2.2 *Felis* skull showing points and lines for taking measurements of the ventral side.

(A. F. DeBlase)

***Least interorbital breadth.** Least distance between the orbits (Fig. 2.3, B).

Mastoid breadth. Greatest distance across mastoid bones, on a line perpendicular to the long axis of the skull (Fig. 2.3, D).

***Postorbital constriction.** Least distance across the top of the skull posterior to the postorbital process (Fig. 2.3, C).

Rostral breadth. Least breadth of rostrum between designated points on opposite sides of the skull.

***Zygomatic breadth.** Greatest distance between the outer margins of the zygomatic arches (Fig. 2.3, E–F).

Measurements of Palate and Upper Dentition

Alveolar length and width. Greatest length or width of the alveolus of any specified tooth.

Diastema length. When diastema present, from posterior margin of alveolus of last incisor present to anterior margin of alveolus of first cheek tooth present.

Incisive foramen length. Greatest length of anterior palatal foramen (Fig. 2.2, H–I).

***Maxillary tooth row.** Length from anterior edge of alveolus of first tooth present in a maxilla to

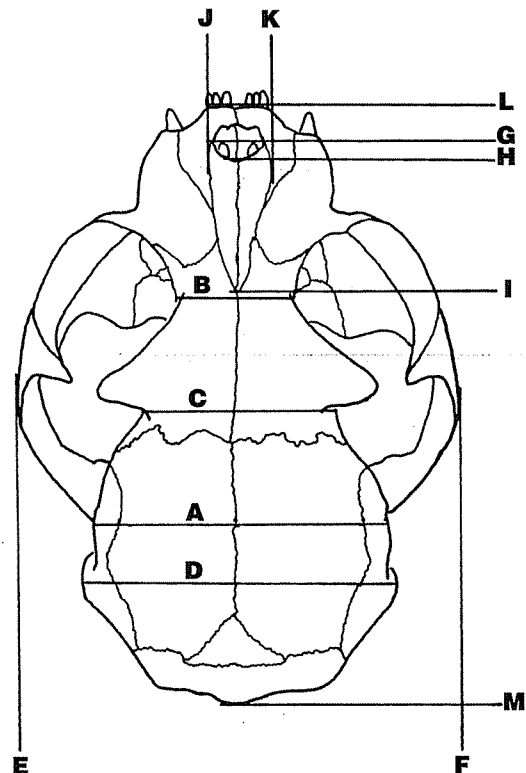


Figure 2.3 *Felis* skull showing points and lines for taking measurements of the dorsal side.

(A. F. DeBlase)

posterior edge of alveolus of last tooth in maxilla (Fig. 2.2, E–J).

***Palatal length.** From anterior edge of premaxillae to anteriormost point on posterior edge of palate (Fig. 2.2, A–G).

Palatilar length. From posterior edges of alveoli of first incisors to anteriormost point on posterior edge of palate (Fig. 2.2, C–G).

Palatal width. Usually width of palate between alveoli of some specified pair of teeth. Occasionally includes alveoli or bony outer edge of palate or teeth.

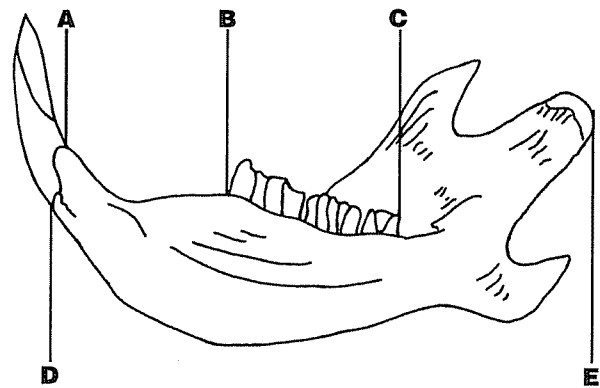


Figure 2.4 Rodent dentary showing points for taking the most commonly used measurements.

(A. F. DeBlase)

Measurements of Other Portions of the Skull

Nasal length. Length of nasals. From anteriormost point of nasal bones to posteriormost point taken along midline (usually) of nasal bones (Fig. 2.3, G–I).

Nasal width. Greatest width across both nasals (Fig. 2.3, J–K).

Nasal suture length. Greatest length of suture between paired nasal bones (Fig. 2.3, H–I).

Postpalatal length. From anteriormost point on posterior edge of palate to anteriormost point on lower edge of the foramen magnum (Fig. 2.2, G–B).

Tympanic bullae length and width. Greatest length and width of bulla (Fig. 2.2, K and L).

Measurements of Mandible and Lower Dentition

Mandibular diastema. Same as for maxillary diastema (Fig. 2.4, A–B).

***Mandible length.** Greatest length of the mandible, usually excluding teeth (Fig. 2.4, D–E).

***Mandibular tooth row.** Length from anterior edge of alveolus of canine (if present) or first cheek tooth to posterior edge of alveolus of last tooth. The incisors are not usually included in this measurement (Fig. 2.4, B–C).

- 2-D Take each of the measurements listed above on the following mammals (not all can be made on all skulls [e.g., length of diastema cannot be taken on an animal without a diastema]). Record measurements to nearest tenth of a millimeter.

Canis or other carnivore
Rat or other rodent
Human or other primate

Compare your figures with those of others in the class.

How closely do yours agree with those of the others who measured the same specimen? (An indication of accuracy.)

- 2-E Remeasure one specimen. How does your second set of measurements compare with your first? (An indication of precision.)

KEY TO LABELING OF FIGURE 2.1

1. alisphenoid bone
2. alisphenoid canal
3. auditory bulla (tympanic bone)
4. basioccipital
5. basisphenoid
6. external auditory meatus
7. foramen magnum
8. frontal
9. infraorbital foramen
10. jugal
11. lacrimal
12. mandibular fossa
13. maxilla
14. nasal bone
15. occipital bone
16. occipital condyle
17. orbit
18. orbitosphenoid
19. palatal (=incisive) foramen
20. palatine
21. parietal
22. paroccipital process
23. postorbital process (of the frontal)
24. premaxilla, palatal branch
25. premaxilla, nasal branch
26. presphenoid

- 27. pterygoid
- 28. sagittal crest
- 29. squamosal
- 30. temporal fossa
- 31. temporal ridge
- 32. vomer
- 33. zygomatic process of squamosal

- 34. zygomatic process of maxilla
- 35. angular process
- 36. coronoid process
- 37. mandibular condyle
- 38. masseteric fossa
- 39. body
- 40. ramus