THE SKELETAL SYSTEM

OVERVIEW

Although you will not be required to dissect the rat's skeletal system, a study of several articulated and disarticulated skeletons will reveal many interesting features. In addition, a mounted human skeleton should also be available for comparison. You will note that the bones are named identically. Generally, it is only the number and size of bones that differ. Their arrangement in the various mammals is determined by differences in the methods of feeding, support, and locomotion.

The skeleton of all vertebrates is internal, known as the *endoskeleton*. It may be divided into two main areas:

AXIAL SKELETON — This portion includes the *skull, vertebral column, ribs,* and *sternum.*

APPENDICULAR SKELETON — This includes the bones of the *pectoral* and *pelvic* supporting *girdles* and the *limbs*.

Note: Throughout the study of the rat skeleton, refer to the labeled photographs at the end of this chapter, pages 25 to 30.

THE AXIAL SKELETON

THE SKULL — The *skull* includes the bones of the *cranium*, the bony vault that protects the brain, the *facial bones*, the *hyoid bone*, and the tiny *auditory ossicles* in the middle ear. The *mandible*, or lower jaw, will be treated as a part of the skull's facial bones.

The Cranium — A comparison of the names and numbers of *cranial* bones of the human and of the rat is given in the table on the next page.

Examine the skull in different views. Check the names of the bones as labeled on the photographs, pages 26 to 28.

Various canals, fossa, foramina, condyles and processes are to be located in these bones. Identify them.

Frontals — Although there is only a single *frontal* bone in humans, in the area of the forehead, the frontals are paired in the rat. Here they form the anterior portion of the cranium, one on either side of the mid-dorsal line. These bones also serve as parts of the wall of the *orbit*, the bony socket for the eyeball.

Parietals — These paired bones lie just posterior to the frontal bones and can best be seen in dorsal (top) view of the skull.

Interparietal — This single bone, posterior to the parietals, extends across both right and left sides of the skull. There is no interparietal bone in humans.

Occipital — This single bone is the most posterior bone of the skull. A large opening, the *foramen magnum*, permits the exit of the *spinal cord* from the skull.

Number of Cranial Bones

Name of Bone	Rat	Human
Frontal	2	1
Parietal	2	2
Interparietal	1	—
Occipital	1	1
Temporal		2
Squamosal	2	
Tympanic Bulla	2	
Otic Capsule (petrosal portion)	2	
Sphenoid		1
Presphenoid	1	
Basisphenoid	1	
Ethmoid	1	1
TOTAL	15	8

On either side of the foramen magnum locate a rounded swelling of bone, the *occipital condyles*. These articulate with the uppermost bone of the *vertebral column*, the *atlas*, permitting the head to move in a dorso-ventral direction.

Temporal — In humans this paired bone forms part of the lateral wall of the skull. In the rat it is composed of the following three pairs of bones:

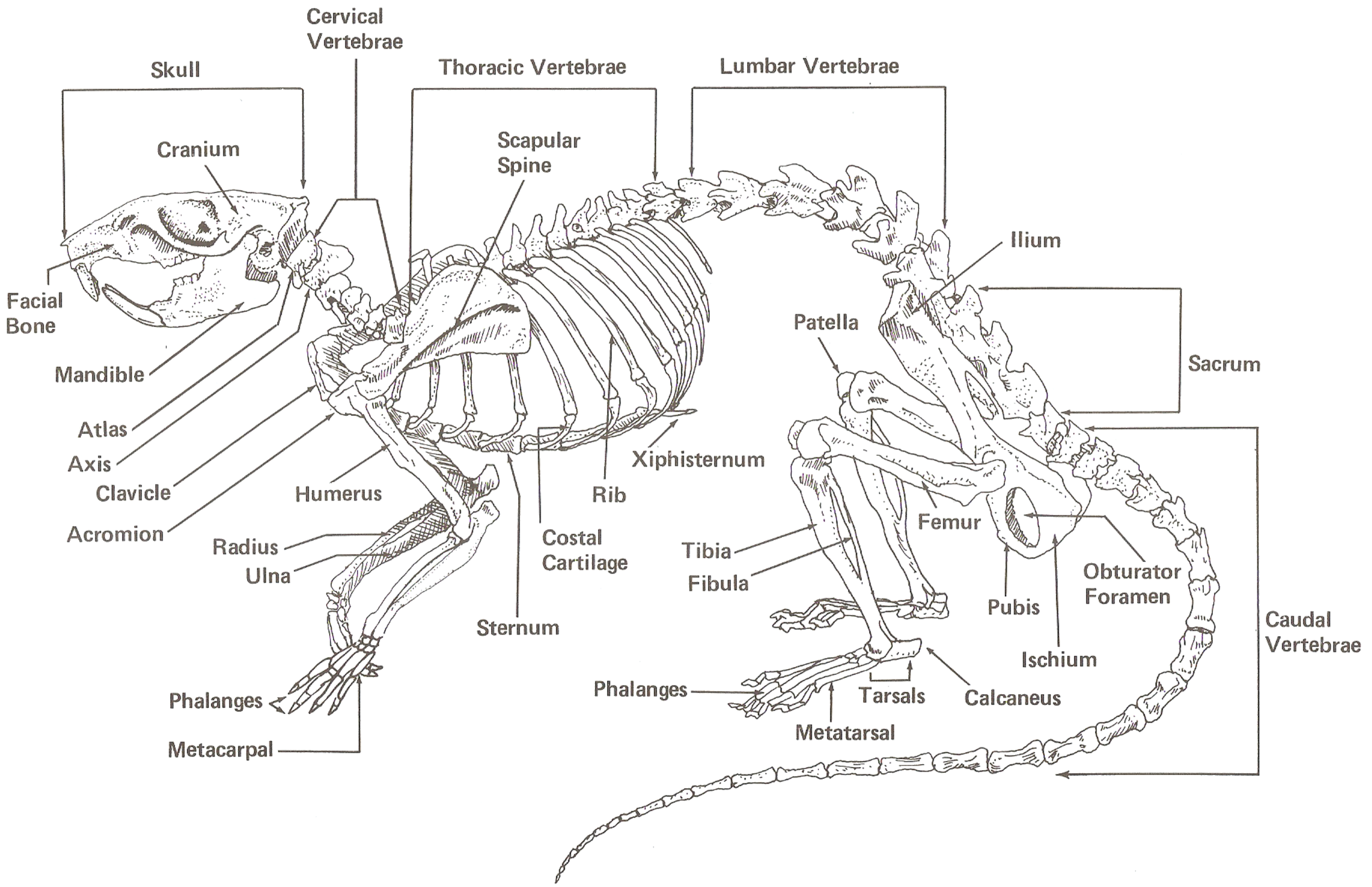
Squamosals — These paired bones lie on the lateral surface of the skull. A process which projects forward and laterally, the *zygomatic* process, forms a major part of the *zygomatic arch* of the *cheek*.

Tympanic Bulla — This circular paired bone houses the *tympanic cavity*, or *middle ear*, in which the tiny bones known as the *auditory ossicles* are located. The outer opening, the *external auditory meatus*, is in life covered by the *tympanic membrane* or ear drum.

Otic Capsule — This paired bone, the thick petrosal portion of the temporal bone, lies posterior to the tympanic bulla. It contains the *inner ear* mechanism, the receptor for sound and equilibrium. It can be seen by looking through the *foramen magnum* into the *cranial cavity*.

Sphenoid — In humans this is a single bone; in the rat it is two bones.

Presphenoid — This unpaired bone is best seen in lateral view near the lower portion of the *orbit*. Find the large passageway within the orbit, the *optic foramen*, which permits the passage of the *optic nerve* from the eye to the brain. The optic foramen passes through the anterior end of the presphenoid bone.



RAT SKELETON (LATERAL VIEW)

Basisphenoid — Directly posterior to the presphenoid lies a second unpaired bone, the *basisphenoid*. It forms a part of the floor of the cranium. A depression towards the center of the basisphenoid, the *sella turcica*, holds the pituitary gland. From its central region, "wings" extend laterally outward to form a part of the posterior *orbit*. One of the larger foramina which penetrates this bone is the *middle lacerate foramen*, which serves as a passageway for a branch of the internal carotid artery.

Ethmoid — This unpaired bone is not readily visible in skull preparations unless they have been cut to expose the mid-sagittal section of the skull. It is characterized by a *perpendicular plate* in the center which extends into the nasal cavity and divides it in two. A perforated *cribriform* plate permits the exit of the *olfactory nerve* from the brain into the nasal cavity. Laterally, the ethmoid is composed of paper-thin, convoluted bones, known as the *turbinates*.

The Facial Bones — A comparison of the names and numbers of *facial bones* of the rat and man is given below:

Number of Facial Bones

Name of Bone	Rat	Human
Nasal	2	2
Premaxilla (incisive)	2	—
Maxilla	2	2
Palatine	2	2
Zygomatic	2	2
Vomer	1	1
Lacrimal	2	2
Turbinates	4	2
Mandible	2	1
TOTAL	19	14

Nasal — This paired bone is the most anterior of the dorsal bones of the rat's skull. It articulates with the frontal bones posteriorly.

Premaxilla (Incisive) — This paired bone lies lateral to the nasal bones. The enlarged upper *incisor teeth* originate from the premaxilla bones; thus the second name (*incisive*). Most of the *nasal cavity* wall is made of these bones. Posteriorly the *premaxillary bones* articulate with the *maxilla*.

Maxilla — This large paired bone is directly posterior to the *premaxilla*. The three upper *molar teeth* originate from the maxilla.

A slender *zygomatic process* extends postero-laterally to join the *zygomatic bone* and the zygomatic process of the *squamosal* to become the *zygomatic arch*, commonly known as the *cheek bone*. This process serves as part of the origin for the primary chewing muscle, the *masseter*.

A large hole through the maxilla, the *infraorbital foramen*, near the lower anterior border of the orbit, allows the passage of nerves and blood vessels.

Palatine — This paired bone can be seen in a ventral view of the skull. The *palatine bones* form the posterior portion of the *hard palate*. The anterior portion is formed by the maxilla and premaxilla bones.

Zygomatic — As already indicated, this bone forms the central portion of the *zygomatic arch of the cheek*. Anteriorly it articulates with the *zygomatic process* of the *maxilla*, posteriorly with the *zygomatic process* of the *squamosal*.

Vomer — This unpaired bone is located dorsal to the *palatine bones* and ventral to the *perpendicular plate* of the *ethmoid*. Together, the vomer and the perpendicular plate constitute part of the septum of the nasal cavity, separating the right from the left side.

Lacrimal — This is a small paired bone located at the anterior end of the orbit, dorsal to the *infraorbital foramen*. The *lacrimal foramen* passes through the bone, allowing for the passage of the *lacrimal* (tear) *duct* from the eye to the *nasal cavity*.

Turbinates — These four bones, two *naso-turbinals* and two *maxillo-turbinals*, are fine, paper-thin, convoluted bones associated with the nasal cavity.

Mandible — This paired bone forms the *lower jaw*. It serves as the attachment of the lower *incisors* as well as the *molars*.

Posteriorly one finds three prominences. The most anterior is the *coronoid process* for the attachment of the temporalis muscle. Further posteriorly, note the rounded *condyloid process*, which articulates with the *mandibular fossa* of the *squamosal* in the upper jaw, permitting the rat to open and close its mouth. It also permits the jaws to move back and forth as in grinding movements. The furthest posterior and ventral prominence is the *angular process*, which serves as the insertion for a portion of the *masseter* muscle. A large hole, the *mandibular foramen*, is located on the medial surface of the condyloid process near its base.

Hyoid Bone — A single U-shaped bone, the *hyoid*, is located at the base of the skull. It serves to anchor the muscles of the *tongue* anteriorly, and to support the cartilage of the *larynx* posteriorly. It is one of the few bones of the body that does not articulate with another bone.

Auditory Ossicles — These six tiny bones, three on each side of the *middle ear*, transmit sound waves from the *tympanic membrane* to the *inner ear*.

They are named the *hammer (malleus)*, the *anvil (incus)*, and the *stirrup (stapes)*.

The Vertebral Column

The outstanding characteristic of the vertebrates is the possession of a backbone, or *vertebral column*. It serves as an attachment for the muscles of the back, and gives support to the head and trunk and shape to the body. It can be made rigid, yet is flexible in allowing for bending, bowing, and contortions. The rat is known for its ability to twist its body to squeeze into and out of tight places; an impossible task without the resiliency and flexibility of the *vertebral (spinal) column*.

A typical vertebral bone consists of the *body* or *centrum*, *neural arch* with *spine*, a pair of lateral *transverse processes*, and the posterior *articular facets* at the points where the vertebrae meet. A pad of cartilage, the *intervertebral disc*, forms a protective cushion between adjacent vertebrae.

Five sections of the vertebral column are readily identified:

1. **Cervical** — These *seven* bones are in the neck region. Virtually all mammals, even the long-necked giraffes, have seven *cervical* vertebrae. The topmost two are the *atlas* and *axis*. They permit free movement and rotation of the head. You will note that the *occipital condyles* of the skull articulate with the *atlas*.

The cervical vertebrae can be readily identified by the presence of two holes, the *transverse foramen*, for the passage of the vertebral artery. They are located laterally, one on each side.

2. Thoracic — These are the *thirteen* vertebrae at the dorsal surface of the thorax. Humans have only twelve thoracic vertebrae.

Besides protecting the thoracic viscera and serving as attachments for the muscles in this area, they serve as points of origin for the ribs.

They can be identified by their long dorsal *spinous processes*. The most unusual of these is to be found in the second thoracic vertebra. Not only is its spinous process extremely long, but it is also further extended by a small triangular cap which articulates with it.

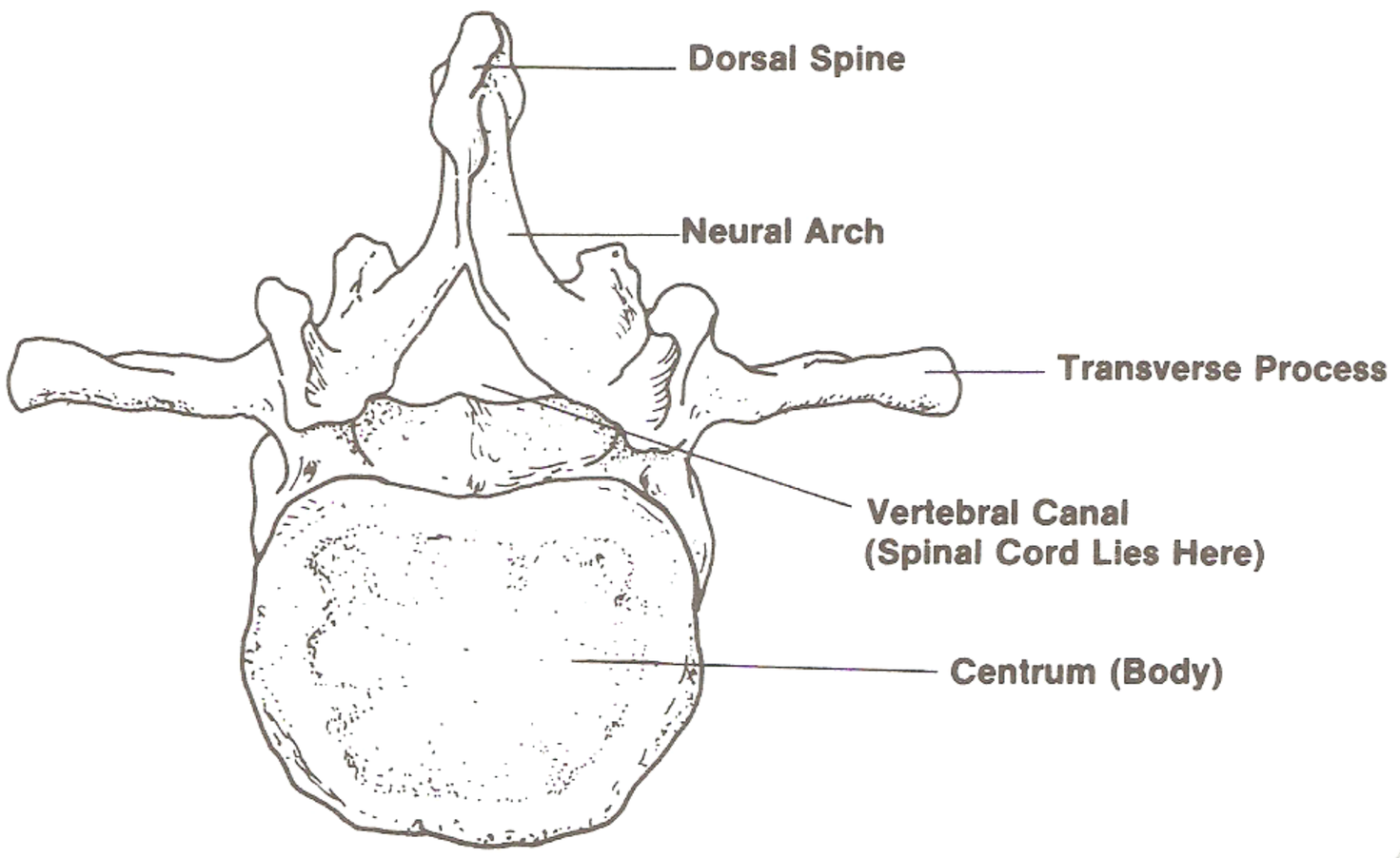
3. Lumbar — These *six* vertebrae are the heaviest and strongest. They support the abdominal and lower trunk muscles. Humans have only five vertebrae in this region.

Besides their size, the *lumbar vertebra* may be distinguished by their enlarged transverse processes, which project anteriorly and ventrally.

4. Sacral — This region of the vertebral column is dorsal to the *pelvic (hip) bones*. In adult rats it consists of four fused bones, providing this area with greater rigidity. In humans it consists of five fused bones.

5. Caudal — These are the bones of the rat's tail. They vary from 27 to 30 in number. In humans, 3 to 5 fused bones make up the coccyx, at the base of the spine.

As the above discussion implies, there are variations between species in the number of vertebrae. Some examples are given on the next page.



VERTEBRA (Human, Lumbar)

Comparative Number of Vertebrae

Region	Rat	Cat	Pig	Human
Cervical	7	7	7	7
Thoracic	13	13	14–15	12
Lumbar	6	7	6–7	5
Sacral (Fused)	4	3	4	5
Caudal	27–30	21–25	20–23	3–5 (coccyx) (fused)
TOTAL	57–60	51–55	51–56	32–34

The Ribs and Sternum

The *rib cage*, or thoracic basket, of the rat is conical in shape; narrower anteriorly, wider posteriorly. It consists of:

— 13 *thoracic vertebrae* dorsally
— 26 *ribs*, 13 on each side, extending laterally and ventrally from these vertebrae
— 1 *sternum* or *breast bone* mid-ventrally, composed of 6 segments.

RIBS — Each rib consists of the following:

Capitulum (head) — This is the most dorsal portion of the rib. It articulates with the *centrum* of the *thoracic vertebra*.

Neck — This short region is directly behind the *capitulum*.

Tubercle — This prominence at the end of the *neck* region articulates with the *transverse process* of the *thoracic vertebrae*.

Shaft — This is the elongated curved portion of the rib, which extends laterally and ventrally toward the *sternum*. The ventral (distal) portion of the rib is not ossified; it is made of flexible cartilage material, *costal cartilage*.

Of the thirteen pairs of ribs, only the anterior seven pairs are attached to the *sternum* directly. These are known as the *true ribs*. The eighth, ninth, and tenth pairs are joined to the seventh rib, not directly to the sternum. These are known as *false ribs*. The last three pairs articulate with the *thoracic vertebrae*, are not joined to the sternum at all, and are known as *floating ribs*.

STERNUM — The *sternum* is commonly known as the *breast bone*. It consists of six bony elements, the *sternebrae*, and one of cartilage.

Manubrium — This is the most anterior of the *sternebrae*. It is triangular in shape and serves as the attachment for the first two pairs of ribs.

Sternebrae — The next four sternebrae are small elongated bones, each serving as the insertion for at least one pair of ribs.

Xiphisternum — This is the most posterior of the *sternebrae*. It is narrower and more elongated than the others. No ribs are attached to this segment of the *sternum*.

Xiphoid Cartilage (Process) — The xiphoid cartilage is a flattened round extension of the *xiphisternum*.

THE APPENDICULAR SKELETON

The appendicular skeleton consists of the *pectoral girdle* and the attached *forelimbs*, and the *pelvic girdle* and the attached *hind limbs*.

Pectoral Girdle

The term *pectoral girdle* refers to the bones supporting the forelimbs.

SCAPULA — This is commonly known as the *shoulder blade*. It is triangular in shape. An elongated slender spinous process runs along the lateral surface of the bone, separating the more anterior *supraspinous fossa* from the more posterior *infraspinous fossa*. The spine extends beyond the main body of the scapula as the *acromion process*. A second hook-shaped process on the medial surface is known as the *coracoid process*. Between these two processes is a shallow depression, the *glenoid cavity*, which is the socket for the *humerus*, the upper arm.

CLAVICLE — This paired bone, commonly known as the *collar bone* in humans, joins the *acromion process* of the scapula to the *sternum*. Actually, two tiny pieces of cartilage, together with a small bone, the *omosternum*, connect the clavicle to the *manubrium* of the *sternum*.

Look at a mounted rat skeleton to see the relationship between the scapula, clavicle, and sternum, for here the axial and appendicular skeletons are joined. Note how the pectoral girdle provides support for the thorax as well as for the upper limbs.

Forelimbs

HUMERUS — This is the paired bone of the upper arm. It articulates proximally with the *glenoid cavity* of the *scapula*.

An outstanding feature of the rat humerus is the very prominent crest on its anterior surface, the *deltoid tuberosity*, for the attachment of the *deltoid muscle* of the shoulder. In humans, the deltoid tuberosity is much reduced.

RADIUS and **ULNA** — Distally, the humerus articulates with the two bones of the lower foreleg, the *radius* and *ulna*. The radius, the shorter of the two, lies on the medial side. By means of antagonistic muscles, *pronators* and *supinators*, the radius is able to rotate about the ulna. This permits the rat to turn the palm of the foreleg downward, in the *prone* position, as when standing with legs extended, or to turn the palm upward, in the *supine* position, as when the forelegs are used during eating.

The *ulna*, on the lateral side, articulates with the humerus at the *elbow joint*. The *olecranon process* projects beyond the humerus posteriorly. It serves as the attachment for the large *triceps brachii muscles*.

CARPALS — These are *nine* small irregular bones that form the *wrist*. In humans these bones number only eight.

METACARPALS — These are the *five* bones of the palm of the foreleg.

PHALANGES — These are the bones of the *digits*. The first *digit*, the thumb or *pollex*, is reduced and has only two *phalanx* bones, while the remaining four digits have three phalanx bones each; proximal, middle, and distal. Thus, the total number of phalanges of each forelimb is *fourteen*. It is the same in humans.

Pelvic Girdle

The pelvic girdle consists of the paired *os coxae*, or hip bones, and the *sacrum*.

OS COXAE — Each of these hip bones consists of several bones that fuse early in life into a single bone on each side. The *os coxae* is composed of the following elements:

Ilium — This is the longest component of the *os coxae*. It is a thin, narrow bone which extends anteriorly and dorsally. The anterior medial surface articulates with the *sacrum* to form the *sacro-iliac* joint.

Ischium — This bone is located in the dorsal posterior portion of the *ox coxae*.

Pubis — This bone is located in the ventral posterior portion of the *os coxae*. At the ventral mid-line the *pubic symphysis*, a pad of cartilage, unites the two os coxae.

Acetabulum — This is the rounded cup-shaped depression that serves as the socket for the *femur*.

Acetabular Bone — This is a small bone within the *acetabulum*.

Obturator Foramen — This hole within the *os coxae* separates the *ilium, ischium*, and *pubis* from one another. It is the largest *foramen* of the body.

Hind Limbs

FEMUR — This is the *thigh* bone. It articulates proximally with the os coxae by means of a ball-shaped *head* which fits into the *acetabulum* socket. It is a large, heavy bone with several prominences, known as *trochanters*, for the attachment of powerful leg muscles.

PATELLA — This *sesamoid* bone is the *knee cap*, located between the femur and the bones of the lower hind leg.

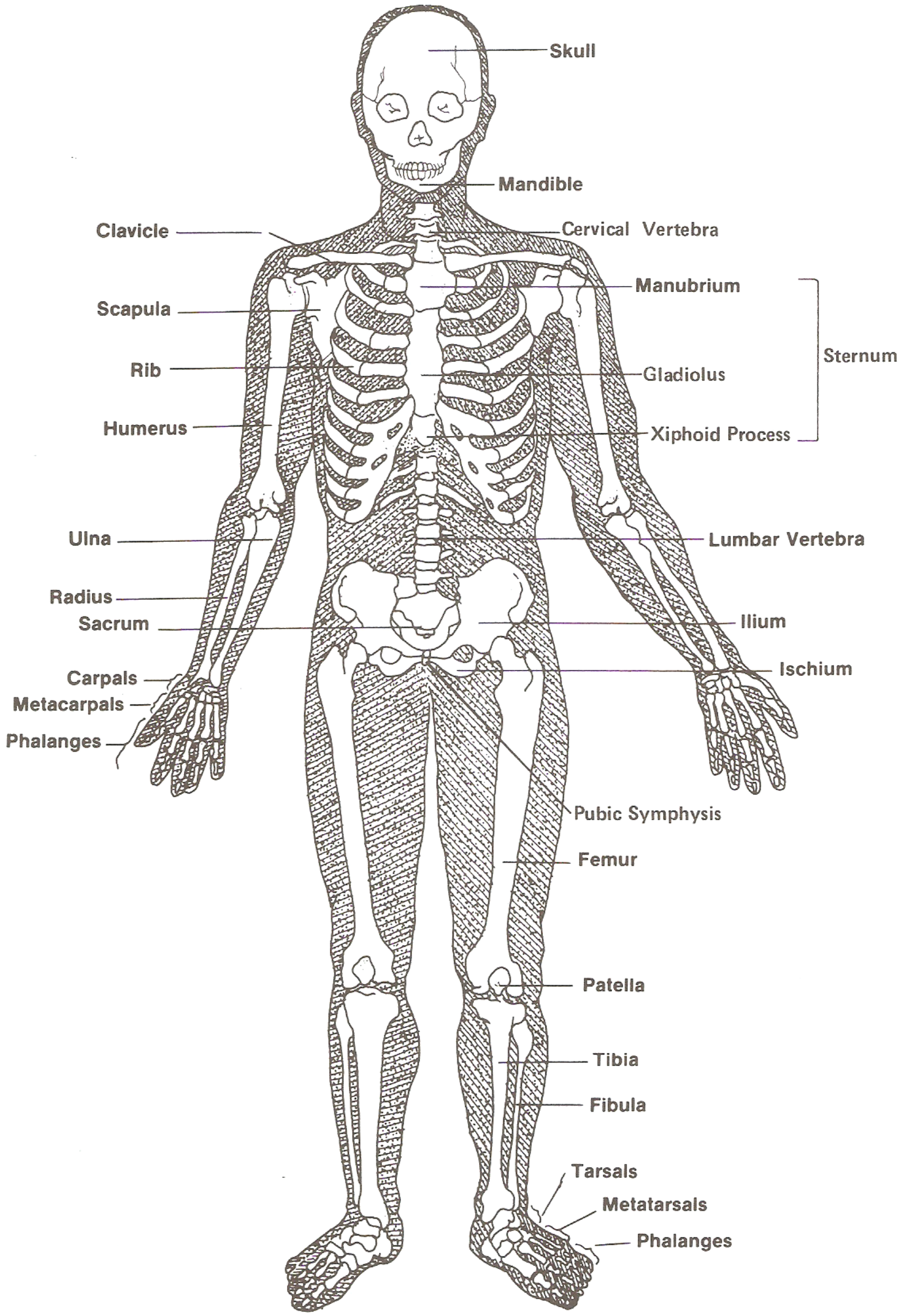
TIBIA — This is the large medial bone of the lower hind leg.

FIBULA — This slender lateral bone is fused to the tibia distally.

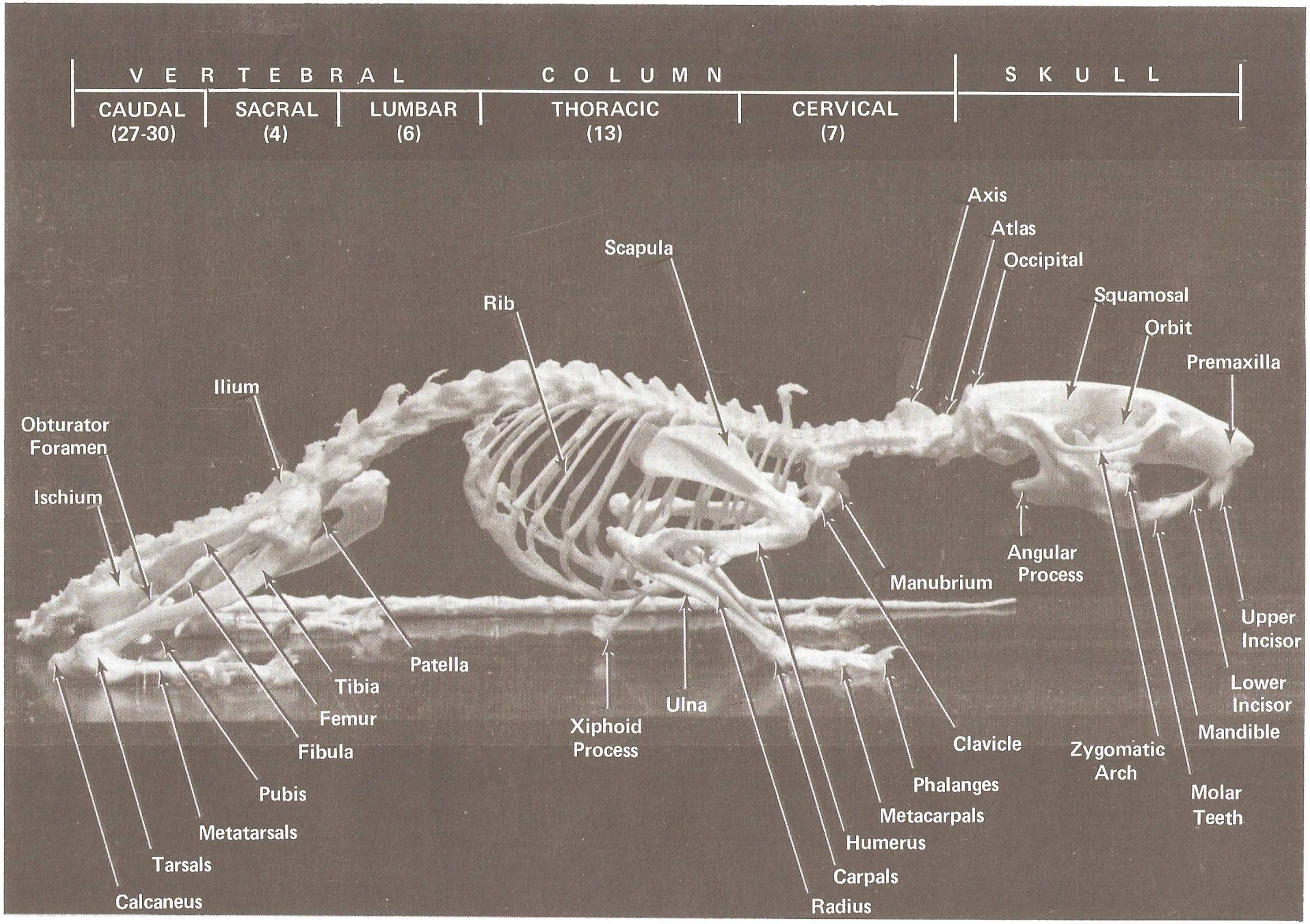
TARSALS — These eight bones comprise the *ankle* and the *heel*. In humans there are only seven *tarsals*. A number of small *sesamoid* bones are also to be found here.

METATARSALS — These five bones form the sole of the foot.

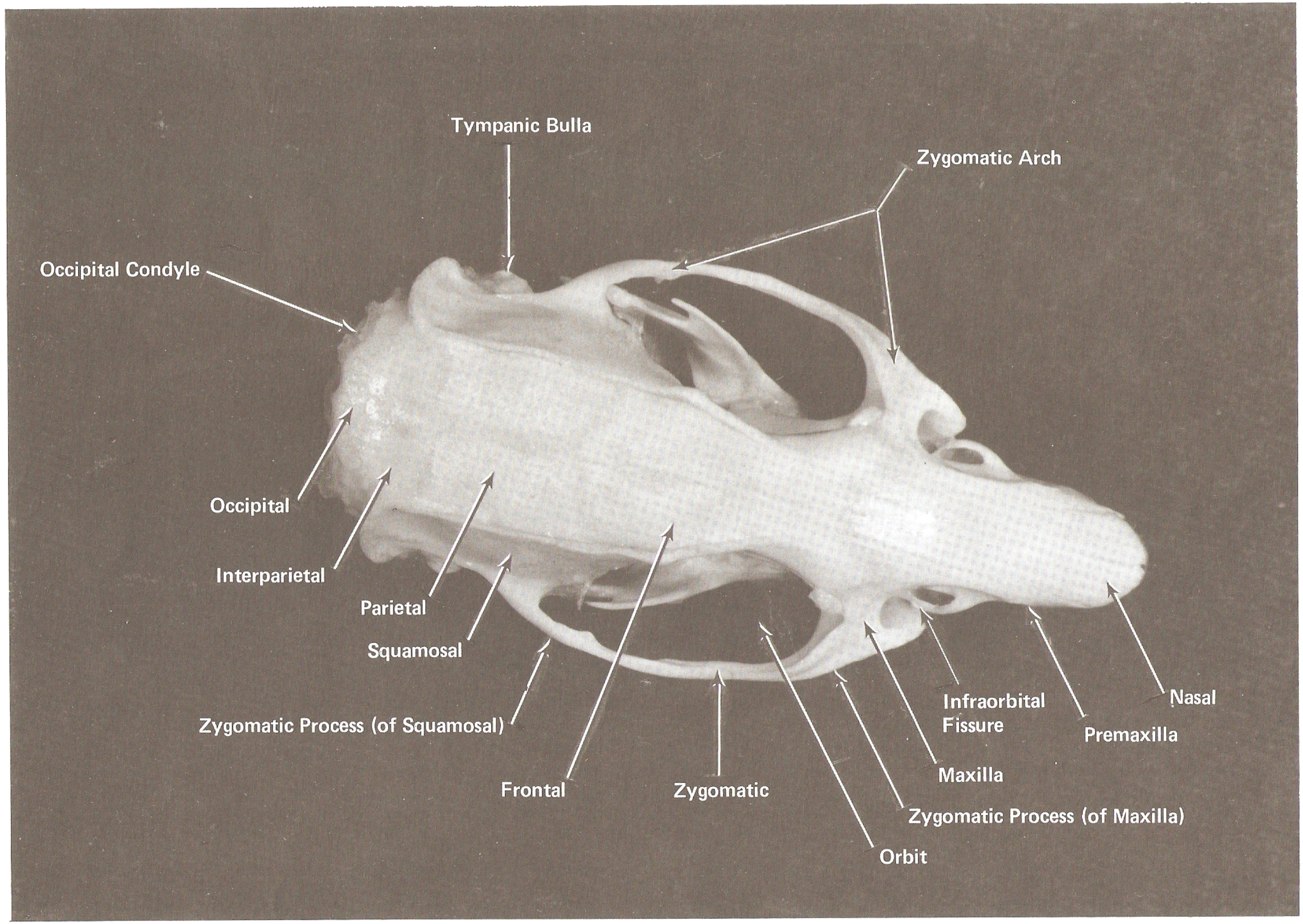
PHALANGES — These are the bones of the *toes*. The first digit consists of only two *phalanx* bones. The remaining four have three *phalanxes* each: proximal, middle, and distal. Thus, the total number of *phalanges* of each hind limb is *fourteen*. This is the same as in humans.



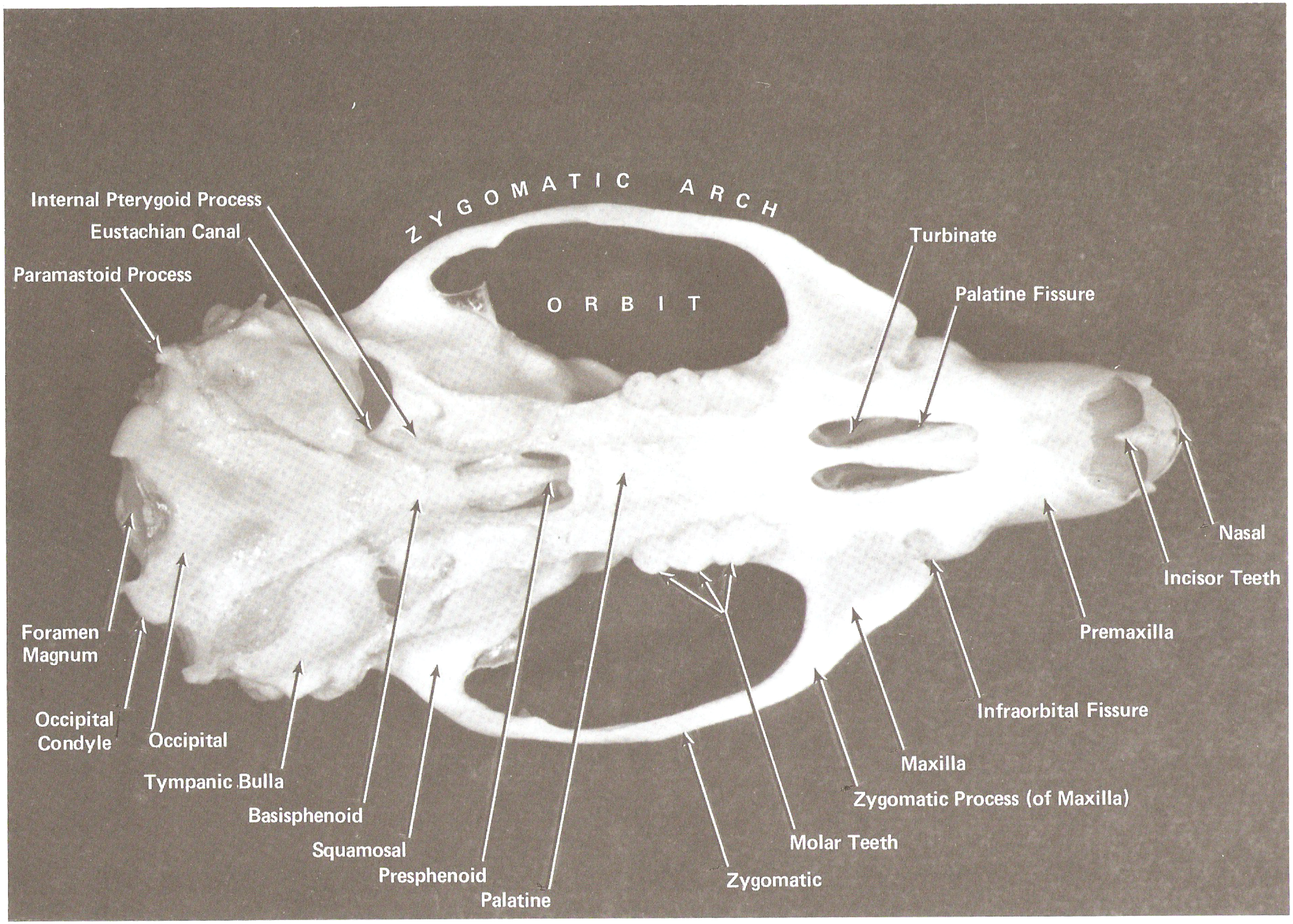
THE HUMAN SKELETON



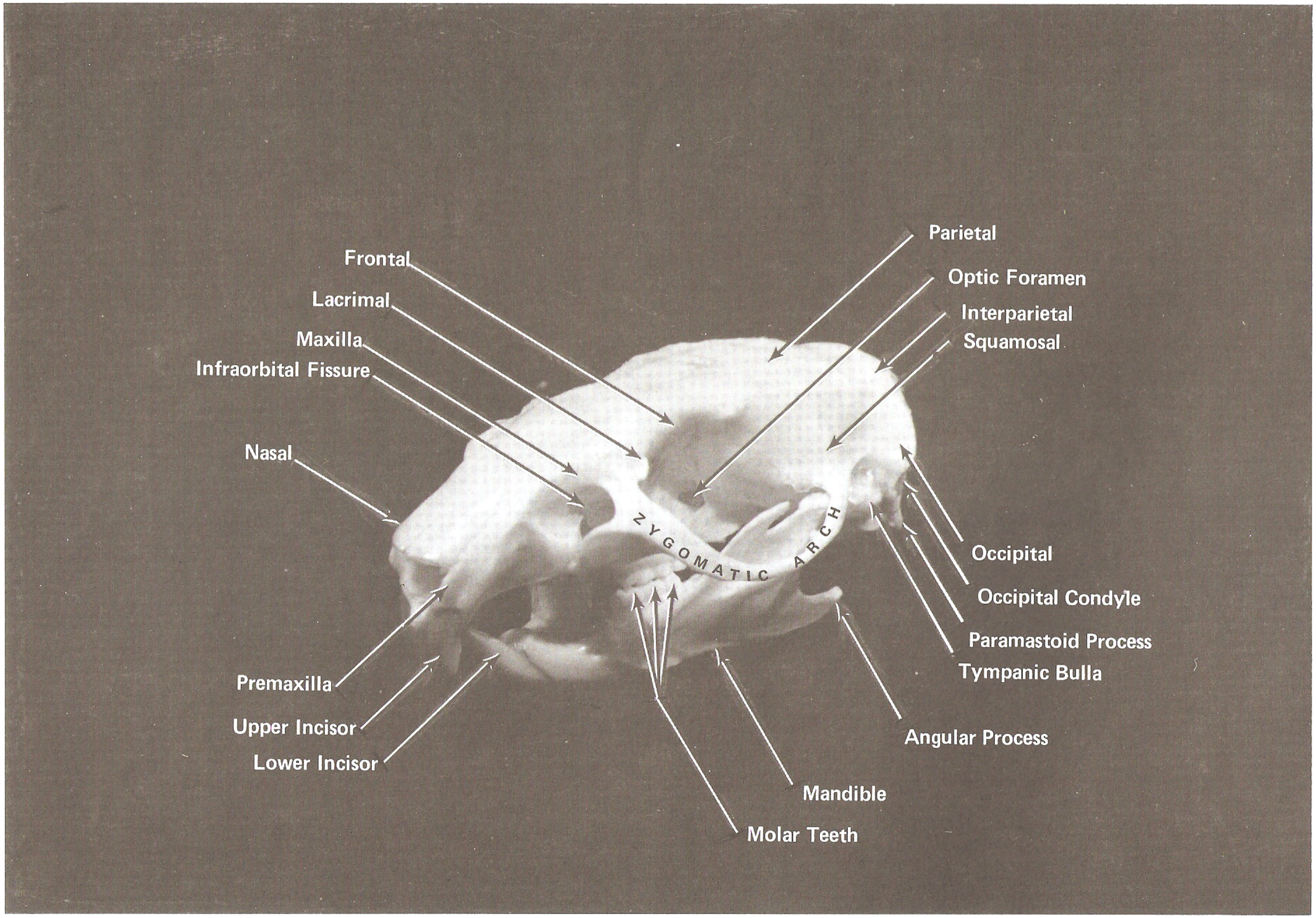
THE SKELETON (LATERAL VIEW)



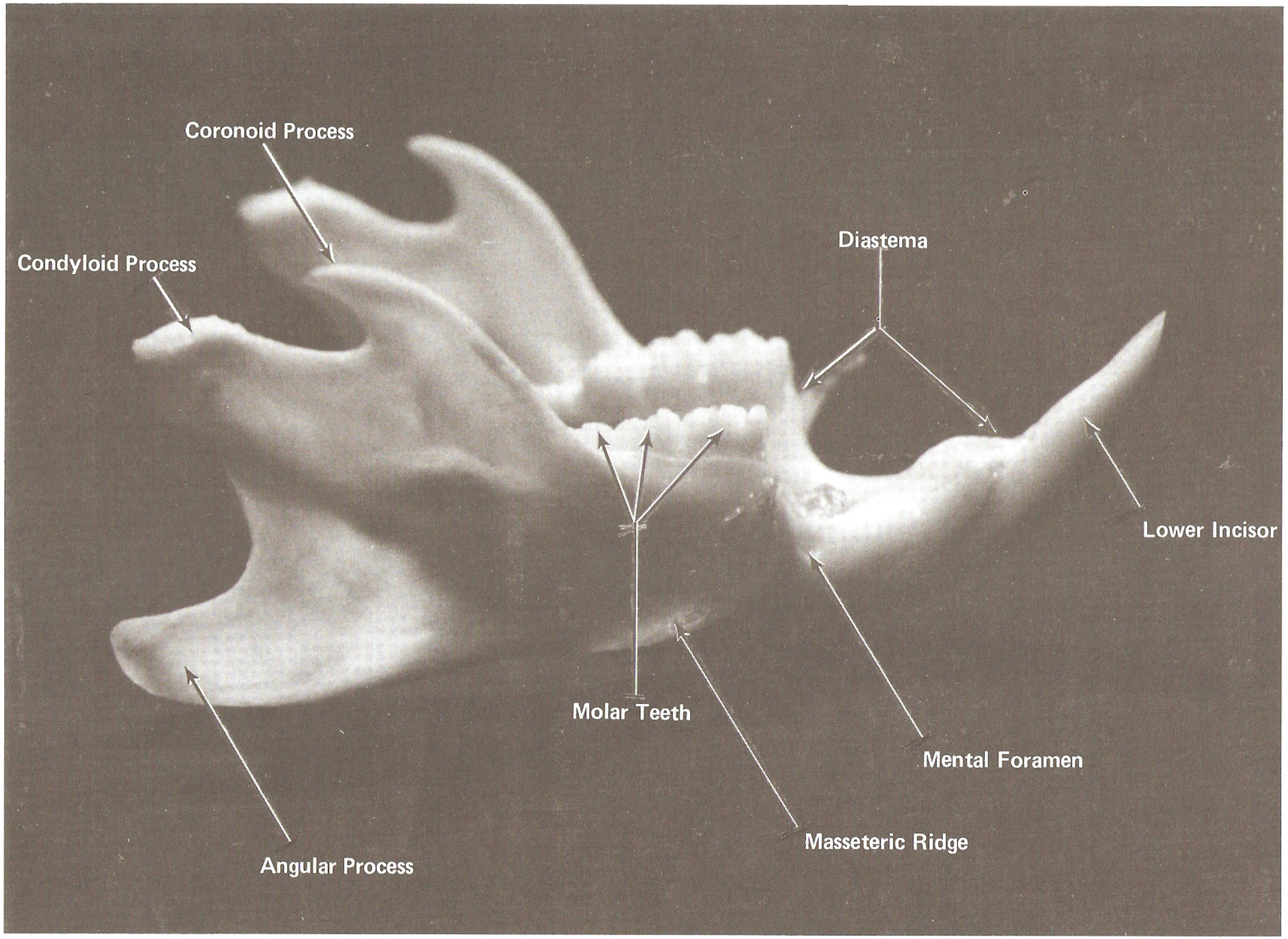
SKULL (DORSAL VIEW)



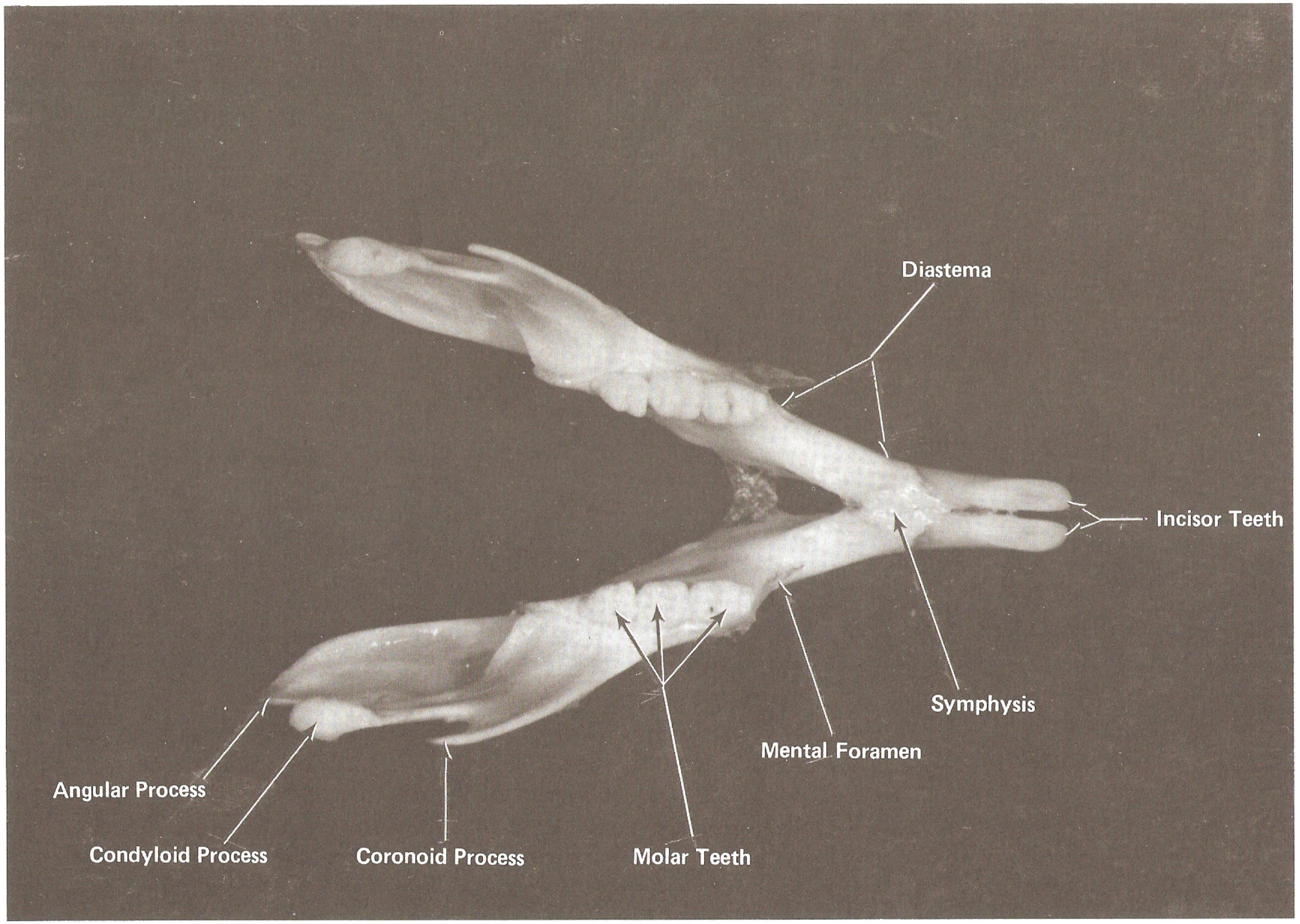
SKULL (VENTRAL VIEW)



SKULL (DORSO-LATERAL VIEW)



MANDIBLE (LATERAL VIEW)



MANDIBLE (DORSAL VIEW)

THE UROGENITAL SYSTEM

The *urinary* and *genital* systems have distinct and unique functions. The first serves to remove nitrogenous and other wastes and to maintain the body's water balance, while the other functions in the reproduction of the species. However, due to the similarity of their developmental origins and the sharing of common structures, they are usually considered as a single system, the *urogenital system*.

We will first study the urinary system, which is similar in males and females. We will then proceed to study the reproductive systems of the two sexes, including some anatomical features of the pregnant rat.

You are responsible for learning the reproductive systems of both male and female rats. After studying your specimen, examine the reproductive system of a specimen of the opposite sex.

THE URINARY SYSTEM

The Dissection

Use your forceps and scissors to remove the liver, stomach, spleen, pancreas, and the intestines. Leave about two inches of the colon intact. Carefully remove the fat in the lower pelvic area. Do not injure or destroy delicate urinary or genital ducts or organs.

Locate the following:

KIDNEYS — The kidneys are large, brown, bean-shaped structures on either side of the vertebral column at the level of the third to fifth lumbar vertebrae. Although they bulge into the abdominal cavity, they lie beneath the peritoneum, or *retroperitoneally*, often surrounded by fat.

Note: Find the *adrenal glands*, the small, round nodules of globular tissue, usually embedded in fat, which lie anterior to the medial border of the kidney. Although not a part of the urinary system, their physical location and blood supply are closely associated with the kidneys.

Clear the kidneys to expose the *renal arteries, renal veins*, and the delicate *ureters*.

Some of the parts of the kidney are the:

Hilus — This is a central depression in the medial surface of the kidney. The ureters exit the kidney at the hilus.

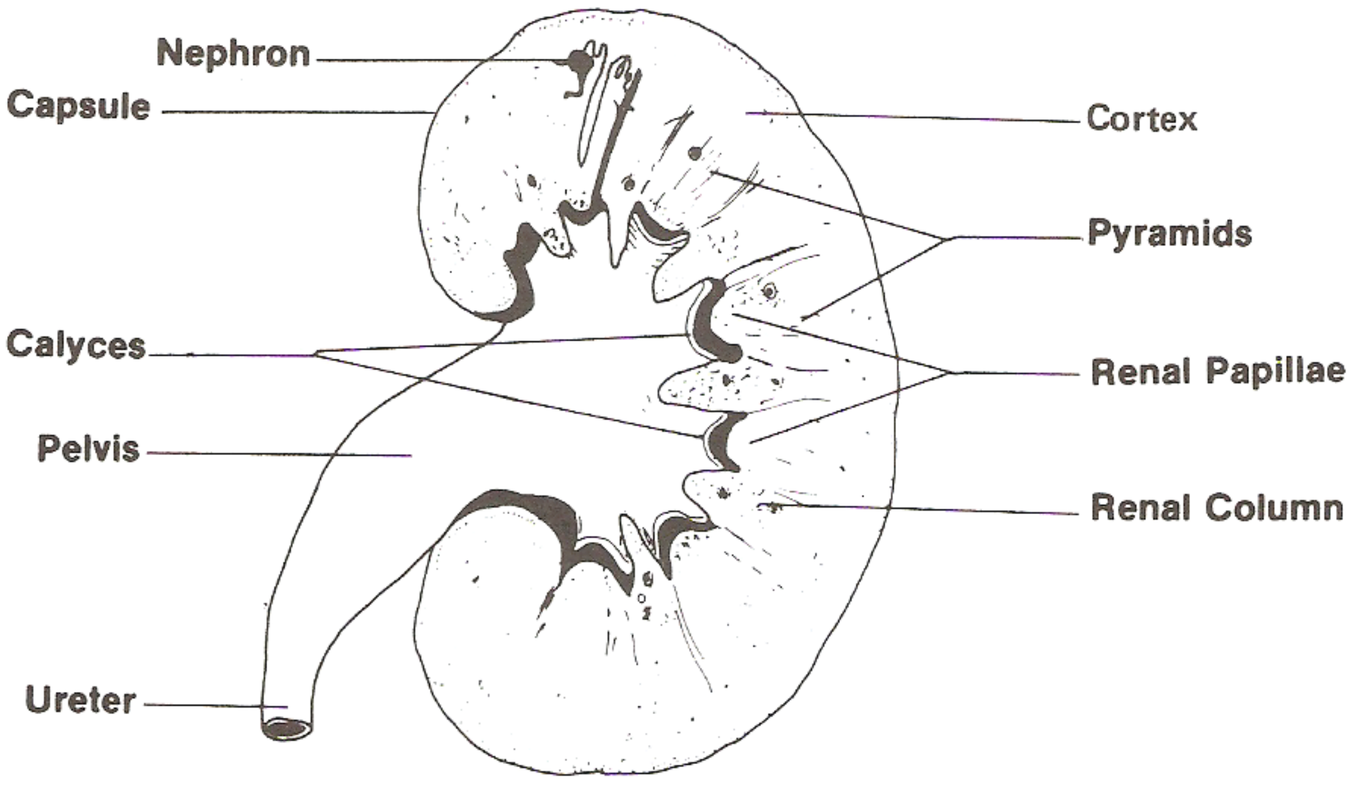
In order to observe the following structures it is necessary to cut one of the kidneys in frontal section as in the diagram on the next page.

Renal Sinus — This is a central cavity that contains fat, branches of the renal vessels, and the *renal pelvis*. The pelvis is the funnel-shaped expanded portion of the ureter within the renal sinus.

Renal Cortex — This is the outer layer of kidney tissue.

Renal Medulla — This is the more central portion of the kidney, beneath the cortex.

Renal Papilla — This is a cone-shaped projection of the medulla enclosed by the pelvis.



HUMAN KIDNEY (Frontal Section)

Identify and study the following urinary structures posterior to the kidneys:

URETERS — These narrow extensions of the *renal pelvis* are very fine tubules that transport urine from the kidneys to the *urinary bladder*. Trace them from the pelvis of the kidney posteriorly through fat and connective tissue to the urinary bladder. **Caution:** The ureters are very narrow and easily torn. In addition, take care not to injure the associated reproductive structures.

URINARY BLADDER — This structure is usually contracted into a small pear-shaped organ in preserved specimens. It is located mid-dorsally. In males, genital glands and ducts are found in close association with the *urinary bladder*. Its function in both sexes is to temporarily store urine that has come down from the kidneys by way of the ureters.

URETHRA — This unpaired tube transports urine from the urinary bladder to the exterior. In males it also transports *seminal fluid* and passes through the *penis*. In females it is independent of the genital system. This is true in humans as well as in rats. Lift the urinary bladder and find the *urethra* extending postero-dorsally. The urethra will be studied further in the following sections.

To this point only the urinary structures have been examined. They are alike in males and females.

GENITAL SYSTEM — FEMALE

If your specimen is a female, continue the dissection as directed here. If your specimen is a male, continue as directed in the next section (page 120). However, whether your specimen is female or male, you are responsible for knowing the reproductive structures of both. Therefore, work closely with a student whose rat is of the opposite sex of your specimen.

The Dissection

The dissection of the genital system in female rats is easier than in males, as most of the organs are within the abdominal cavity, readily accessible. However, the most posterior organs lie dorsal to the *pubic* bones.

Palpate the musculature at the base of the abdominal cavity. Locate the pelvic bones mid-ventrally. Scrape the muscles off this area. Find the *pubic symphysis*, the cartilaginous mid-point between the two pubic bones. With your scalpel or with a sharp razor blade, press down upon the pubic symphysis to separate the pubic bones. Complete the separation of the *pelvic girdle* by holding the two hind legs firmly and bending them sharply dorsally. It may be necessary to remove some of the medial elements of the pubic bones in order to fully expose the posterior genital structures.

Also, cut anteriorly into the urinary and vaginal apertures.

OVARIES — These are the female gonads. They produce the female gametes, ova, and female sex hormones. They are located posterior and lateral to the kidneys, usually embedded in fat. Clear some of the fat. The ovaries are small round structures. By the use of a hand lens you will see blister-like bulges upon the ovaries. These bulges may be developing *follicles* that contain *egg cells (ova)*, or they may be the remains of follicles, known as *corpora lutea*. Each ovary may be enclosed within a *periovarial sac (ovarian bursa)*. This should be cut open and removed in order to better see the ovary. The ovaries are suspended from the dorsal body wall by a peritoneal membrane called the *mesovarium*.

OVIDUCTS (FALLOPIAN TUBES) — Again, use the hand lens to examine these fine coiled tubes. They will be found near the ovaries, extending posteriorly beyond the periovarial sacs.

UTERINE HORNS (CORNUA) — Trace the oviducts posteriorly to where they join the much wider *uterine horns*. Each horn extends posteriorly and medially to form the letter "V." The rat embryos develop in these two horns of the uterus, rather than in a single medially located uterus as in humans. Each uterine horn is attached to the dorsal body wall by a membrane known as the *broad ligament*.

Depending upon the sexual maturity of your specimen and the stage of its reproductive cycle, it may be pregnant with near full term or immature embryos. Such pregnant rats will be studied in the following section.

BODY OF UTERUS — This refers to mid-dorsal structure formed by the union of the two *horns of the uterus*. Further dissection of this structure will reveal, however, that it does not have a single cavity, but the lumens of the horns continue throughout the body as two distinct tubes, opening by separate orifices into the *vagina*. The portion of the uterus that projects into the vagina is known as the *cervix*.

VAGINA — This leads from the openings of the uteri and the cervix to the exterior of the body. Externally, it appears as a continuation of the body of the uterus. Its exterior opening is known as the *vaginal aperture*. It is closed in young females by the *hymen* until puberty, about the tenth week of life.

URETHRA — This part of the urinary system has already been described (see page 118). It lies ventrally atop the *vagina*.

CLITORIS — This is a small papilla that projects from the ventral side of the external *urethral (urinary) aperture* (anterior to the vulva). It is homologous to the *penis* in males and also has associated paired *preputial* glands similar to those in males.

Examine the photograph on page 123 to find these structures.

The Pregnant Rat

Each class should have several pregnant specimens available for study. They may be ordered from supply houses.

The reproductive structures of the female rat undergo drastic changes during pregnancy. The enlargement of the uterine horns is but one example. In addition, new structures which do not exist at all in the rat prior to pregnancy, such as the placenta, develop. Finally, the delicate fetus, in different stages of development, and its anatomical relationship to its mother, are revealed in the study of the pregnant rat.

The Dissection

Proceed as in the dissection of the non-pregnant female rat. Then, cut open one of the rounded swellings on the surface of a uterine horn. Examine the developing embryo. Find the following structures:

PLACENTA — This is a disc-shaped, vascular, spongy mass attached to the uterine wall. The exchange of food, oxygen, and wastes between the embryo and the mother takes place across the walls of the *placenta*.

UMBILICAL CORD — This twisted cord connects the embryo to the placenta. It contains one *umbilical vein* and two *umbilical arteries*. The mark left by the cord, after it falls off the surface of the abdomen of the newborn animal, is known as the *navel*.

EMBRYO — Note the different stages of development of the embryos of the different specimens. Note the development of the head, eyes, limbs, digits, etc.

CHORION — This extra-embryonic membrane remains on the uterine wall when the embryo is removed. Soon after implantation of the embryo, the *chorion* sends finger-like projections into the uterine tissue to anchor the embryo and to obtain nutrition. Later, the chorion develops into the embryonic portion of the *placenta*.

AMNION — This inner membrane bag surrounds the embryo and is filled with *amniotic fluid* which protects the developing embryo.

GENITAL SYSTEM — MALE

The Dissection

The reproductive structures of the male do not all lie in the *abdominal cavity*. Some lie dorsal to the *pubic* bones, while the testes and associated structures lie in the *scrotal sacs*.

Thus, the dissection must involve all three areas. It must also trace the ducts and tubes that project from one area to another and tie the entire system into one.

Palpate the musculature at the base of the abdominal cavity. Locate the medial pelvic bones. Scrape the muscles off this area. Find the *pubic symphysis*, the cartilaginous ventral mid-point between the two pubic bones. With your scalpel or with a sharp razor blade, press down upon the pubic symphysis to separate the pubic bones. Complete the separation of the *pelvic girdle* by holding the two hind legs firmly and bending them sharply dorsally. It may be necessary to remove some of the medial elements of the pubic bones in order to fully expose the posterior genital structures.

Locate the *scrotum* and the two *scrotal sacs* of which it is composed. Cut them open from the ventral surface to expose the testes and associated structures.

Also, cut anteriorly into the *urogenital aperture*. This will expose the *penis* and its associated structures. Be careful not to injure or damage any of the internal structures.

Find the following structures:

TESTES — These are the male gonads. They produce sperm as well as male sex hormones. Locate them in the scrotum. They are enclosed in a tough membrane, the *cremasteric pouch*. Cut open the pouch. The testes are oval-shaped, light brown in color. Accessory structures to the testes are also found within the pouch. The posterior portion of the testes is attached to the pouch by a ligament, the *gubernaculum*, which is a portion of the dorsal mesentary known as the *mesorchium*. **Note:** Other reproductive glands contributing to seminal fluid production are considered accessory to the testes.

EPIDIDYMIS — The semilunar-shaped epididymis, composed of convoluted tubules, partly surrounds the testis. The epididymis is divided into three parts: the *head,* anterior to the testis; the *body*, lateral to the testis; and the *tail*, posterior to the testis. The sperm produced in the testis pass by way of tiny *efferent ductules* at the anterior end of the testis to the head of the epididymis. The epididymis serves as a maturation and storage area for sperm.

DUCTUS DEFERENS (VAS DEFERENS) — This is the tube that transports sperm and seminal fluid from the testis into the abdominal cavity. The *ductus deferens* originates at the tail end of the *epididymis*, and passes anteriorly to join the urethra from the *urinary bladder*. Its anterior aspects will be described in greater detail below.

SPERMATIC CORD — The ductus deferens is only one of the vessels leaving the testis. It is joined by the *spermatic artery* and *vein*, together with nerves, lymph vessels, and connective tissue. They are all united by a tough outer fascia to form the *spermatic cord*.

INGUINAL CANAL — Follow the *spermatic cord* anteriorly through a short channel in the abdominal wall. This is the *inguinal canal*, which leads into the abdominal cavity.

Note: During embryological development the testes are at first located within the abdominal cavity, as are the ovaries of mature female specimens. The testes later descend through the *inguinal canal* into the scrotum. In humans and most mammals they remain there throughout life. In rodents, however, they may be withdrawn and returned into the abdominal cavity. During periods of sexual activity the testes will be lowered; at other times, especially at times of stress or danger, they will be withdrawn.

SPERMATIC ARTERY AND VEIN — These originate in the solid mound of *fat* atop the testis. They continue anteriorly as part of the spermatic cord. Once the spermatic cord has penetrated the abdominal cavity these vessels separate from the *ductus deferens* and pass antero-medially to join the *aorta* and *vena cava*, respectively.

SEMINAL VESICLES — Within the abdominal cavity, near the juncture of the ductus deferens and the urethra, find two leaf-shaped glands, the *seminal vesicles*. Their lateral edges are scalloped. They add their secretions to the seminal fluid.

COAGULATING GLANDS — These are found on the medial borders of the *seminal vesicles*, and may be separated from them. They serve to coagulate the seminal fluid and are necessary for impregnation.

PROSTATE GLANDS — In the rat there are two prostate glands, each bilobed. They are located dorsally, near the base of the *seminal vesicles*. Their secretions also add to the seminal fluid and are responsible for the activation of the sperm.

DUCTUS DEFERENS — The anterior portion of this duct will now be described. After passing from the testis into the abdominal cavity, the *ductus deferens* loops dorsally over the base of the *ureter*, near the urinary bladder, and continues postero-ventrally. The *urethra*, emerging from the urinary bladder, joins the ductus deferens, and the single unified tube penetrates the *prostate gland* at the proximal end of the *penis*.

From that point on, the urethra continues as a merged tube, the *urogenital canal*, which carries sperm and seminal emissions in addition to urine. The end of each ductus deferens is slightly swollen and forms the *ampullary gland*.

PENIS — Follow the urethra, or urogenital canal, caudally to the beginning of the *penis*. The penis is the cylindrical copulatory organ of males. Laterally projecting muscles, the *ischiocavernosum*, hold the base of the penis in place. Trace these to their attachment in the pelvic girdle near the pubic symphysis. Within the ischiocavernosum muscle, find the origins of a cylindrical mass of vascular erectile tissue, the *corpus cavernosum*, which runs through the length of the penis. A second corpus cavernosum lies alongside the first. A third cylindrical mass of vascular erectile tissue, the *corpus spongiosum*, lies ventrally within the penis in a groove between the two corpora cavernosa. The urethra passes through the corpus spongiosum, which originates from the *bulbocavernous* muscle.

During copulation the three cylinders of vascular tissue engorge with blood, thereby resulting in an erection.

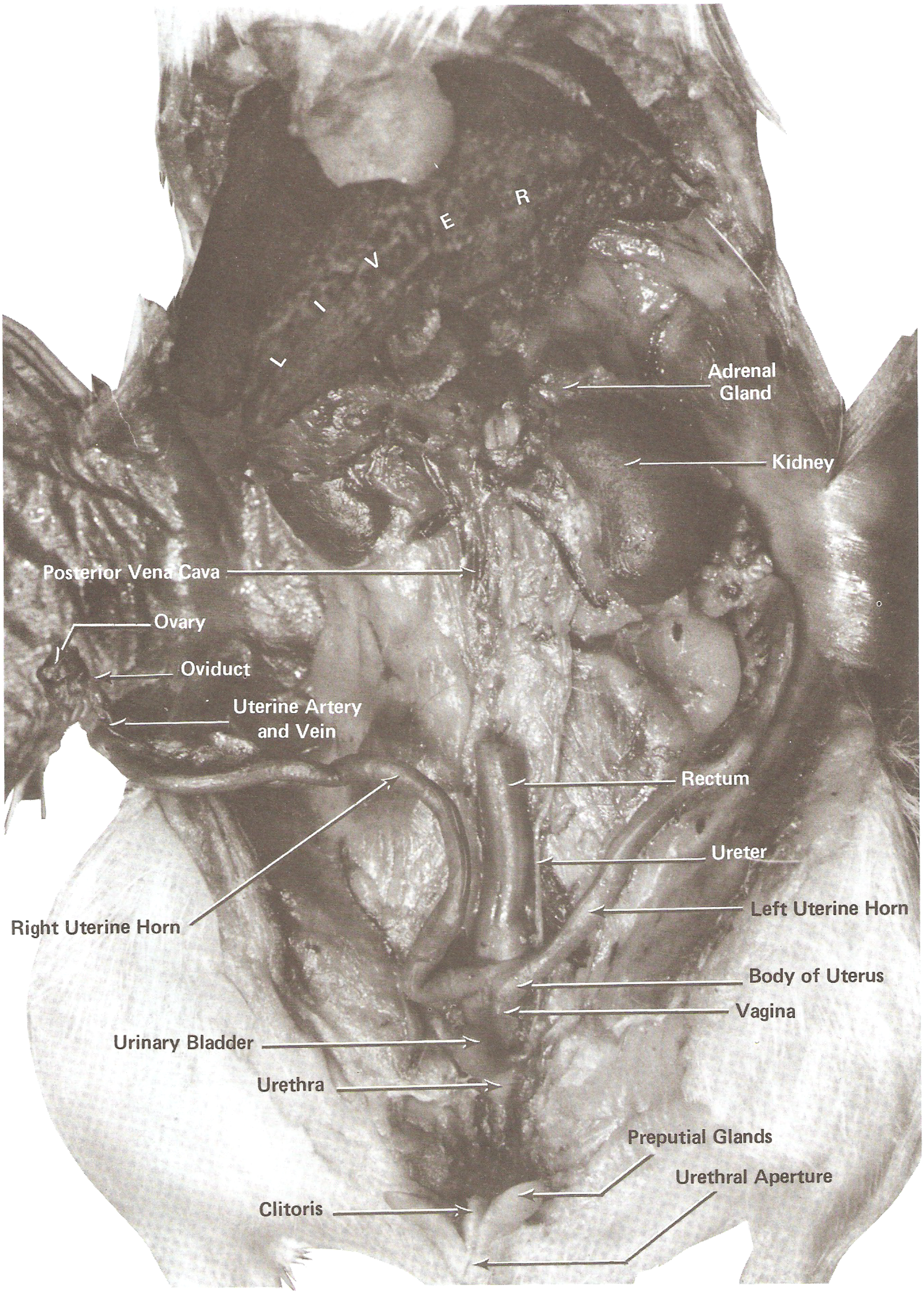
PENIS BONE (BACULUM) — In the rat and in a few other mammals, a small bone, a *baculum*, is found at the distal end of the penis. It helps support the organ during copulation. It is embedded on the ventral surface below the skin.

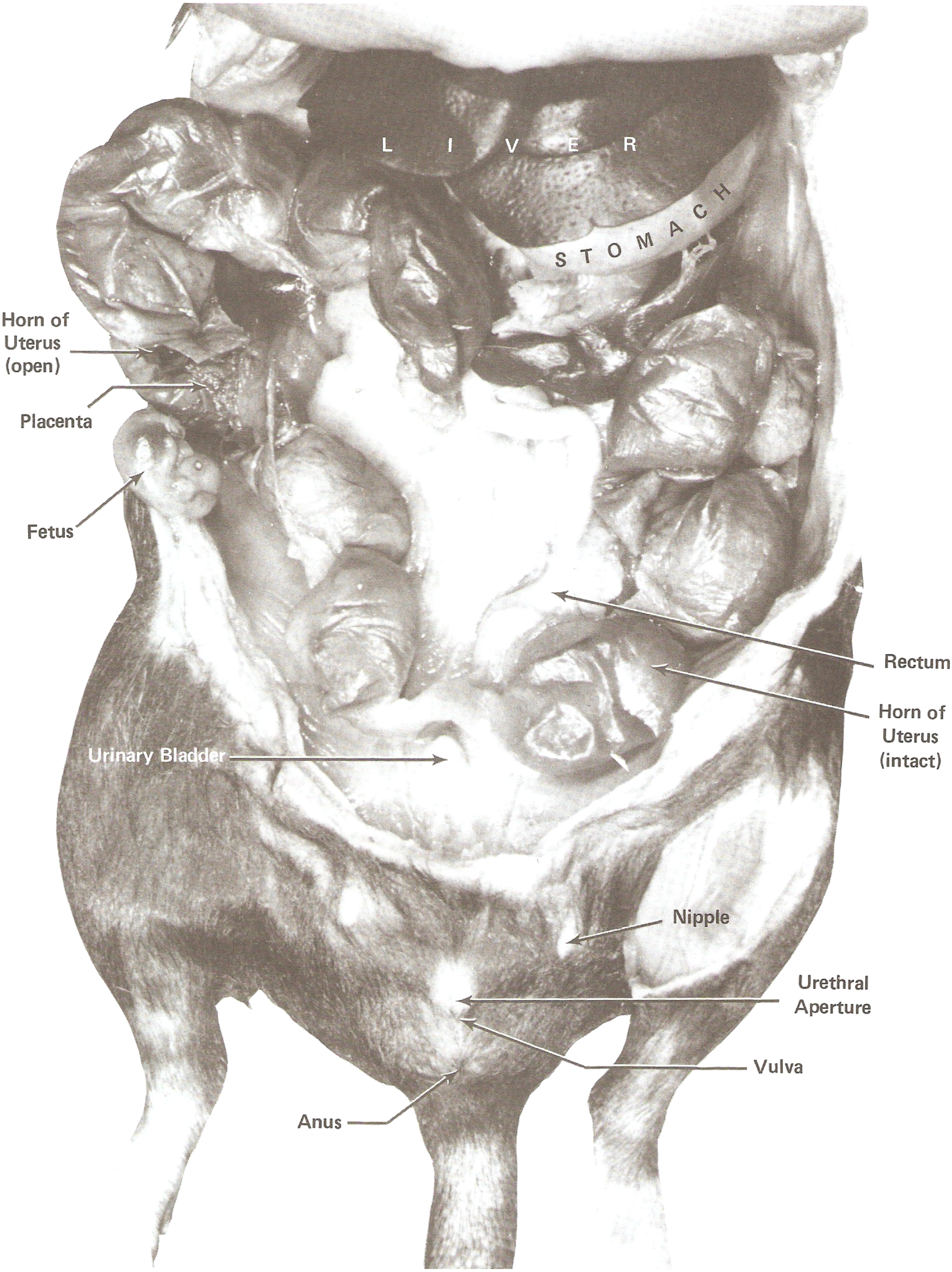
BULBOURETHRAL (COWPER'S) GLANDS — These are a pair of accessory sex glands contributing to the seminal fluid. They are found on either side at the base of the penis.

GLANS PENIS — Locate the distal end of the penis. Its terminal portion is a conical structure known as the *glans penis*. Here the urethra opens to the outside; the opening is known as the *urogenital aperture*.

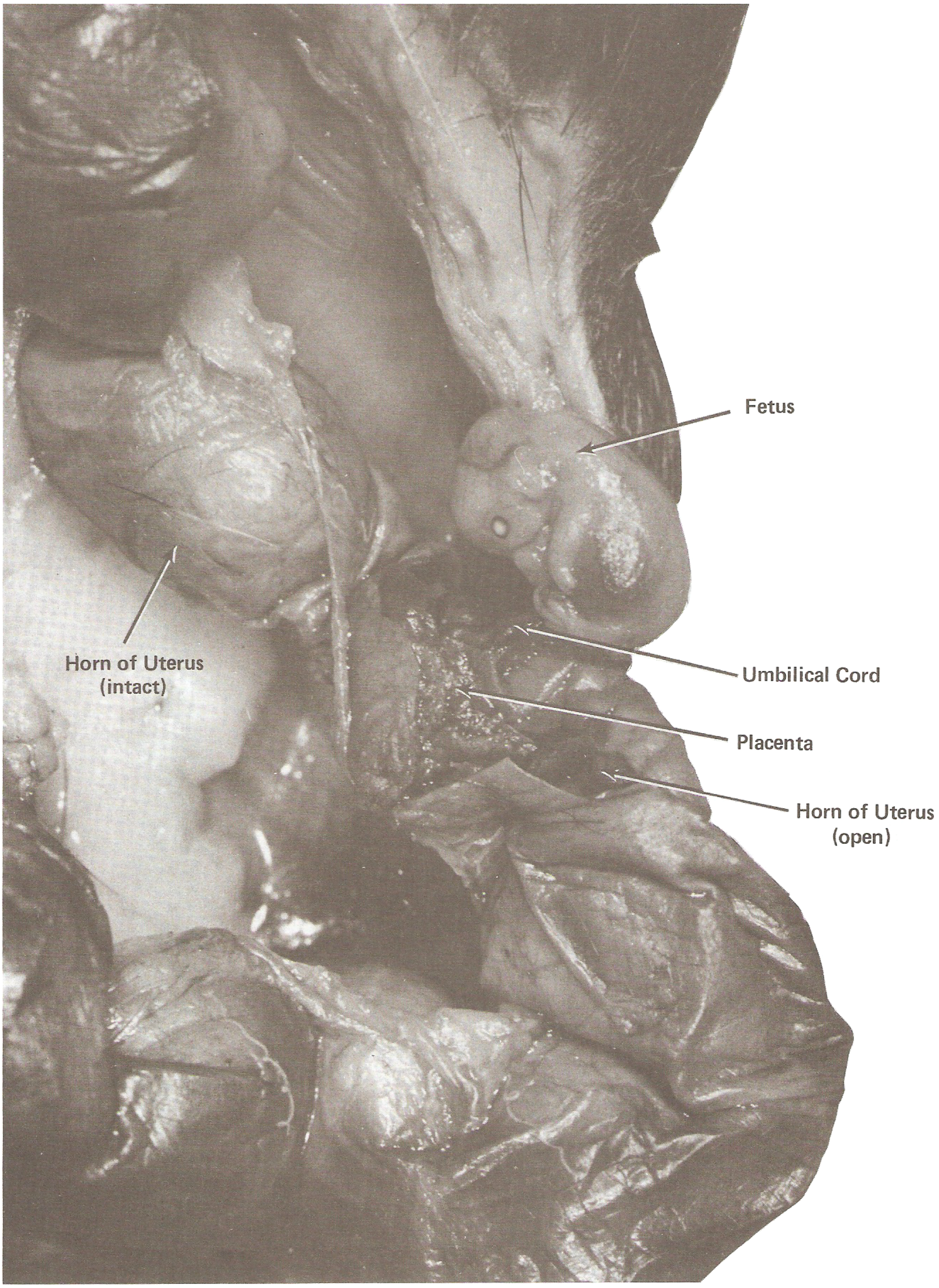
PREPUCE — A sheath of skin, also known as the *foreskin*, covers the glans penis. During circumcision in humans the foreskin is removed. *Preputial glands* can be found on either side of the prepuce, extending laterally and posteriorly.

Examine the photograph on page 126 to find these structures.

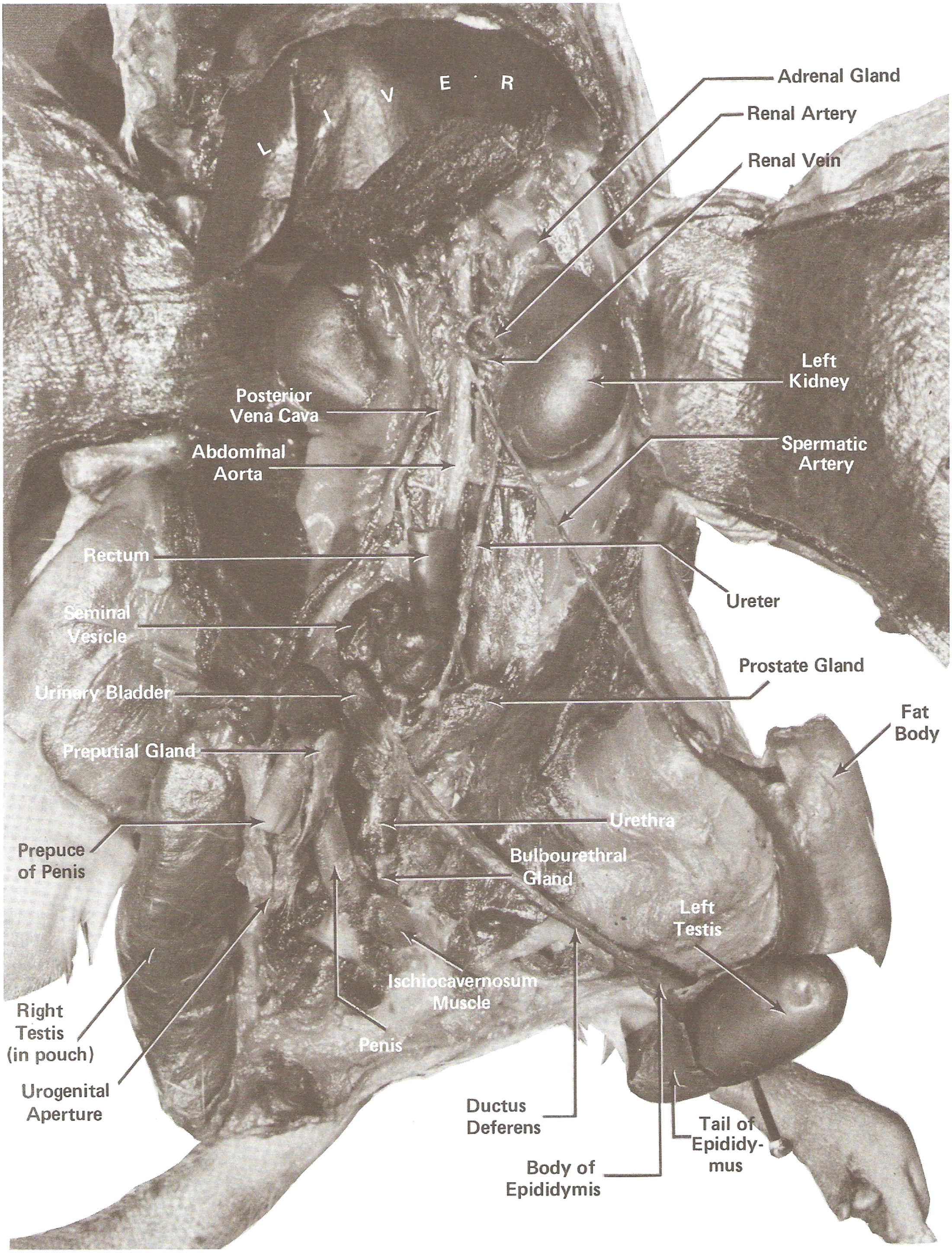

LIVER
Adrenal Gland
Kidney
Posterior Vena Cava
Ovary
Oviduct
Uterine Artery and Vein
Rectum
Ureter
Right Uterine Horn
Left Uterine Horn
Body of Uterus
Vagina
Urinary Bladder
Urethra
Preputial Glands
Urethral Aperture
Clitoris



PREGNANT FEMALE



RAT FETUS, CLOSE-UP (Photo Inverted for Clarity)


L I V E R
Adrenal Gland
Renal Artery
Renal Vein
Left Kidney
Posterior Vena Cava
Abdominal Aorta
Spermatic Artery
Rectum
Ureter
Seminal Vesicle
Prostate Gland
Urinary Bladder
Fat Body
Preputial Gland
Urethra
Prepuce of Penis
Bulbourethral Gland
Left Testis
Ischiocavernosum Muscle
Right Testis (in pouch)
Penis
Urogenital Aperture
Ductus Deferens
Tail of Epididy-mus
Body of Epididymis

THE NERVOUS SYSTEM

INTRODUCTION

We will begin our study of the nervous system with an overview. This discussion will be followed by the most delicate dissection you will be called upon to make, to find and expose narrow cranial and spinal nerves. The brain and spinal cord of the rat will be exposed. A study of two specialized sense organs, the eye and the ear, will complete this unit.

Overview

The nervous system functions as a communications network between the various parts of the body. It also permits us to perceive the outer environment and properly respond to its stimuli. It consists of the *central* and *peripheral* nervous systems.

The central nervous system is the *brain* and the *spinal cord*, while the peripheral nervous system consists of the nerve pathways and sense organs located outside the central nervous system.

The basic units of the nervous system are the nerve cells, or *neurons*. Their function is to receive stimuli, transmit messages to the central nervous system, interpret sensations, and transmit messages from the central nervous system to other parts of the body.

TYPES OF NEURONS — There are three types of neurons.

1. **Sensory (Afferent) Neurons** — These receive stimuli and are found within *sense organs* or *receptors*. They transmit these sensations to the brain or spinal cord.

2. **Interneurons (Association Neurons)** — These neurons lie within the central nervous system and transmit messages up and down the spinal cord and between the different areas of the brain and spinal cord.

3. **Motor (Efferent) Neurons** — These carry messages from the central nervous system to the *effectors* (muscles or glands) that will respond to the stimulus.

PARTS OF A NEURON — The diagram on the next page indicates the structure of a typical motor neuron. It consists of the:

Cell Body — This is the enlarged portion of the neuron containing the nucleus. It is located within the gray matter of the spinal cord or brain.

Dendrites — These are thin protoplasmic extensions protruding from the cell body. They are highly branched and serve as reception areas for signals coming to the neuron from other cells.

Axon — This is the long narrow extension that carries impulses away from the cell body.

Myelin Sheath — This lipid covering protects the narrow axon. It is composed of cell membranes of *Schwann cells* repeatedly wrapped around the axon.

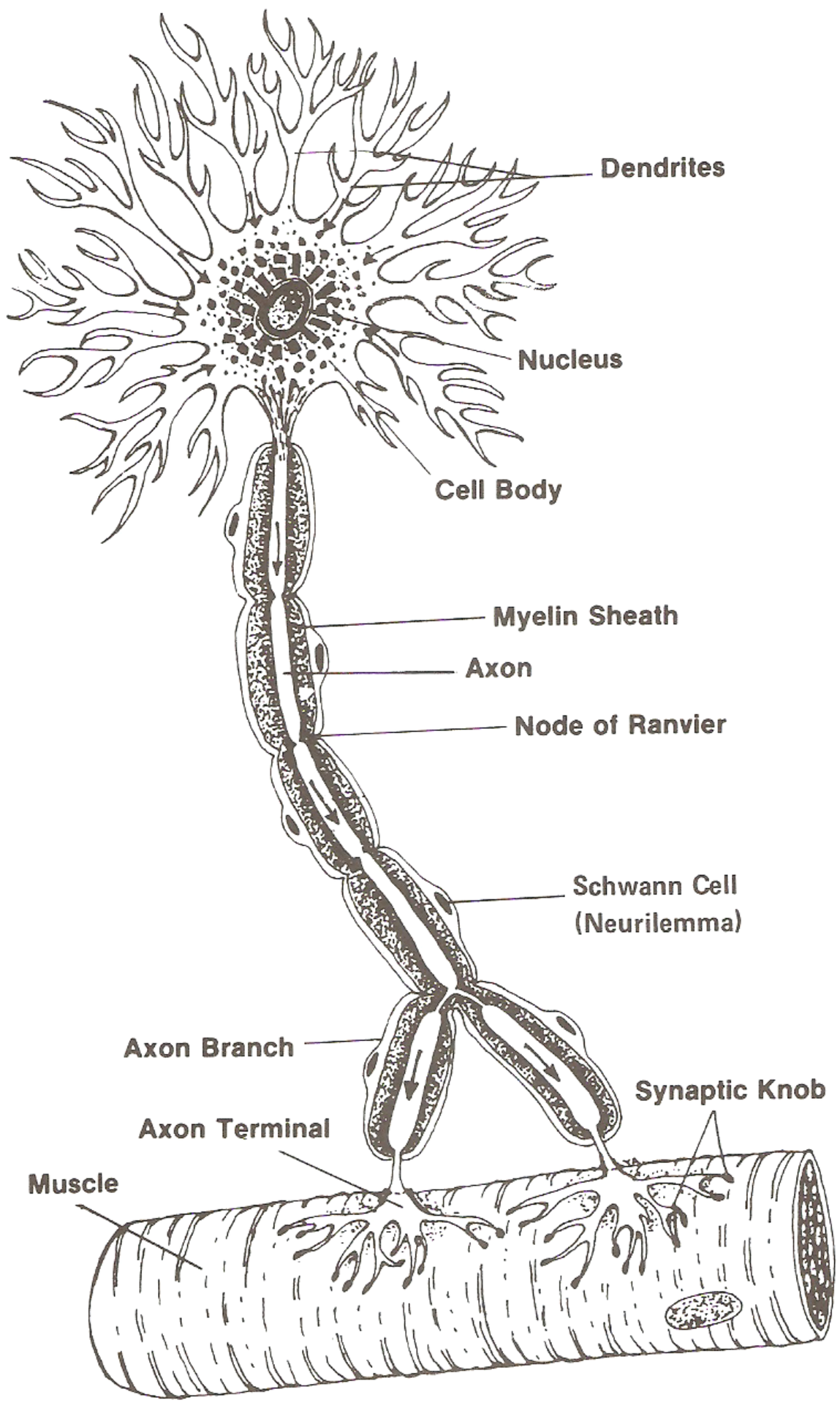
Schwann Cells — The principal parts of these cells, namely, the cytoplasm, nucleus, and outer cell membrane, form the external boundary of the myelin sheath, the *neurilemma*.

Nodes of Ranvier — These are gaps in the myelin sheath that occur at the junctions of adjacent Schwann cells.

Axon Terminals — These are the non-myelinated, branched endings of the axons.

Synaptic Knobs — These button-like terminals of the axon are usually embedded within muscular or glandular tissue.

The area where nerve tissue interacts with muscle tissue is known as the *neuro-muscular junction*. It is here that the nerve impulse from the central nervous system is translated into action. When the impulse reaches the synaptic knobs, *transmitter substances* are released. These are chemicals such as *acetylcholine* and *epinephrine*, which initiate changes resulting in contraction or secretion.



MOTOR NEURON

THE BRAIN

The Dissection

Place the rat on the dissection tray with the dorsal side upward. It is necessary to exercise extreme caution throughout this dissection, because it is very easy for a novice to injure the delicate brain tissue.

At the top of the skull use your scalpel to make a mid-dorsal cut from the back of the snout to the middle of the neck. Loosen the skin from the underlying musculature and reflect back. Remove any muscles along with the fibrous *epicranial aponeurosis* covering the top of the rat's skull. Expose the bony *cranium*. Use a heavy scalpel and nick the skull along the mid-ventral line. Don't cut too deeply. Insert a strong pair of forceps right below the bone. Grasp the bone firmly and bend back to break. Again insert the forceps, grasp the next piece of bone, and break. You will thus expose the entire dorsal surface of the brain. A tough white membrane will generally adhere to the broken bone or the top surface of the brain. This is the *dura mater*, the outer layer of the *meninges*, a three-layered membrane covering the brain and spinal cord. The delicate middle layer is the *arachnoid*. The innermost layer is a thin, highly vascular membrane that adheres to the surface of the brain, following its contours and convolutions. It is known as the *pia mater*. Peel away any dura mater covering the brain. This procedure usually removes the arachnoid too. Also, note the large venous blood vessels, the *sinuses*, which run through the dura mater. They will generally be removed with the dura. A tough layer of dura, known as the *tentorium*, will also be found between the cerebrum and cerebellum. In some mammals, for example, in the cat, it is a bony plate.

The arterial blood supply reaches the brain by way of the ventral side through blood vessels such as the *carotid* and *vertebral arteries*, forming the *Circle of Willis*, an anastomosis (coming together) of several arterial branches at the base of the brain. This can best be seen in ventral view.

Note: It is possible to decalcify the bones of the skull and spinal column by first removing the skin and some of the overlying musculature and immersing the specimen, head down, in a beaker of *10% hydrochloric acid* for a period of about five days. Handle and store the acid carefully. Upon removing it from the solution, wash the specimen thoroughly. You will find that the bones of the skull and the vertebrae will be soft and pliable, and may easily be cut with scissors and an ordinary scalpel. This will make the dissection much easier. There is also a greater likelihood that delicate brain, spinal cord, and nerve tissue will remain undamaged.

Although most parts of the brain studied will be described as seen in dorsal view, some require observation of the ventral surface, and others require a sagittal view. The text will indicate when a ventral or sagittal view is necessary.

Carefully remove the brain from the cranium and observe the *ventral* surface and the *cranial nerves*. Then, cut open the brain in the *mid-sagittal plane*. Your instructor may make model demonstration dissections of the rat brain available to you. You may also be provided with sheep brains, which are much larger, to help your study.

Parts of the Brain

The vertebrate brain is divided into three main anatomical regions:

— **Prosencephalon (Forebrain)**
— *Telencephalon*
— *Diencephalon*
— **Mesencephalon (Midbrain)**
— **Rhombencephalon (Hindbrain)**
— *Metencephalon*
— *Myelencephalon*

Locate and identify the following parts of the brain.

Prosencephalon (Forebrain)

TELENCEPHALON — This is the most anterior portion of the brain.

OLFACTORY BULBS — These are paired extensions of the anterior portion of the brain. The olfactory nerves travel from the nasal passages to the brain by way of the foramina in the *ethmoid* bones of the skull to terminate in this area.

Olfactory Tracts — These are elongated narrow pathways extending posteriorly from the *olfactory bulbs* to the ventral surface of the *cerebral hemispheres*.

CEREBRUM — This is the largest part of the rat's brain. It consists of a right and left *hemisphere*, with a deep *longitudinal cerebral (median) fissure* separating the two halves. The higher mammals have many folds, or *convolutions*, on the surface of the cerebrum. This offers greater surface area for the outer gray matter, or *cortex*. The rat's cerebrum is virtually smooth, with a minimal of cerebral cortex for its cranial volume. The cavities within the hemispheres are the *lateral ventricles*.

Corpus Callosum — These nerve fibers, at the base of the *cerebral hemispheres*, connect the two halves ventrally. The *corpus callosum* is best seen in sagittal view.

DIENCEPHALON — This is the second portion of the forebrain, directly posterior to the telencephalon. It is the part of the brain immediately surrounding the *third ventricle*.

Third Ventricle — This is an unpaired cavity in the diencephalon. Like the other ventricles in the brain, it contains cerebro-spinal fluid. It communicates anteriorly with the two *lateral ventricles* through an opening, the *foramen of Monro*. Posteriorly it communicates with the fourth ventricle through a passageway, the *cerebral aqueduct (aqueduct of Sylvius)*. The ventricles and cerebral aqueduct may be seen in sagittal section.

The *diencephalon* consists of three parts:

1. **Epithalamus** — This is the area dorsal to the third ventricle.

Tela Choroidea — This is a thin, roof-like vascular membrane that covers the diencephalon.

Pineal Body (Epiphysis) — This is a slender stalk that projects from the rear of the diencephalon. Its hormonal function is unknown. It may be involved in sexual development.

2. **Thalamus** — This area of gray matter forms the lateral walls of the third ventricle. It is best seen in a sagittal section of the brain.

3. **Hypothalamus** — This area lies ventral to the third ventricle, and is best seen in a ventral view of the brain. It forms the floor of the diencephalon.

Infundibulum — This is a short stalk from the *hypothalamus* projecting ventrally and anteriorly along the mid-line.

Pituitary Gland (Hypophysis) — This small bilobed gland is suspended at the end of the *infundibulum*. It secretes numerous hormones, some of which regulate other endocrine glands. It lies within the *sella turcica*, a depression within the *sphenoid* bone. Often, when the brain is removed from the cranium, the pituitary gland stays behind.

The *optic nerves* from the eyes cross just anterior to the pituitary gland. This crossing-over of nerves is known as the *optic chiasma*.

Mesencephalon (Midbrain)

The mesencephalon (midbrain) is posterior to the diencephalon. Two prominent areas, best seen in sagittal view, are the:

Anterior Colliculus — an optic center

Posterior Colliculus — an auditory center.

Rhombencephalon (Hindbrain)

METENCEPHALON

CEREBELLUM — This is a large area directly posterior to the cerebrum. The cerebrum and cerebellum are separated by the *tentorium*, a tough membrane of *dura mater*, which extends ventrally between the two major parts of the brain. The cerebellar surface reveals deep and extensive folds, or *convolutions*, extending from right to left sides. It consists of two lateral lobes, a median lobe known as the *vermis*, and two very small lateral extensions known as *paraflocculi*. Each parafloeculus lies within a socket of the petrosal portion (otic capsule) of the temporal bone. The function of the cerebellum is to coordinate muscular activity and balance.

PONS — This portion of the metencephalon lies posterior to the *cerebellum* and is best seen in dorsal view. The pons has connecting links to the lobes of the cerebellum. It controls some of the respiratory reflexes.

MYELENCEPHALON

MEDULLA (MEDULLA OBLONGATA) — This is the elongated posterior region of the brain. It is continuous posteriorly with the spinal cord. It controls the vital functions of heartbeat and breathing.

Fourth Ventricle — The cavity of the medulla is the *fourth ventricle*, which communicates posteriorly with the central canal of the spinal cord. It is covered dorsally by a roof-like membrane called the *tela choroidea*.

THE CRANIAL NERVES

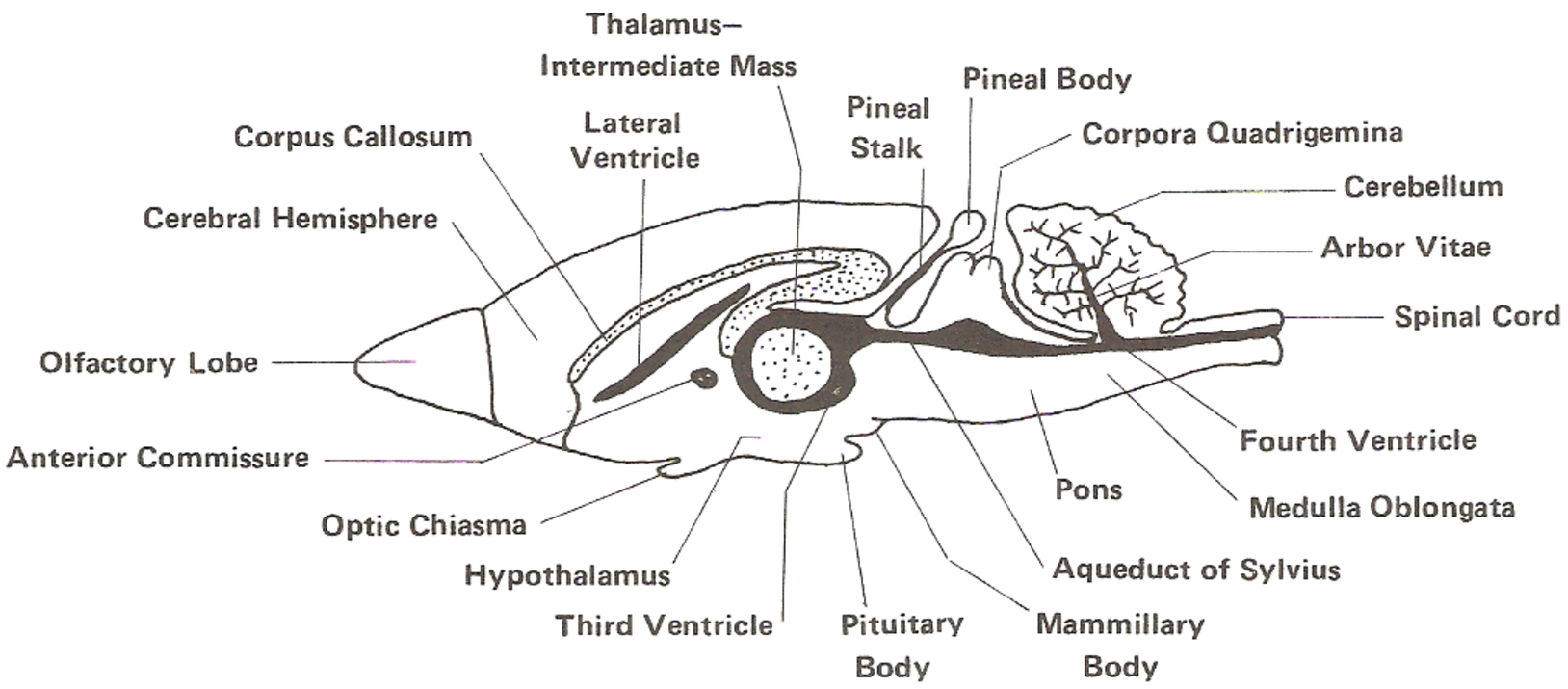
Twelve pairs of cranial nerves originate from the ventral surface of the brain. The cranial nerves exit through foramina in the skull and innervate the organs of the head and other regions.

These nerves may be *sensory*, carrying impulses to the brain, or *motor*, carrying impulses from the brain to muscles and glands, or *mixed*, carrying both sensory and motor fibers. The cranial nerves of all vertebrates have similar names and similar functions.

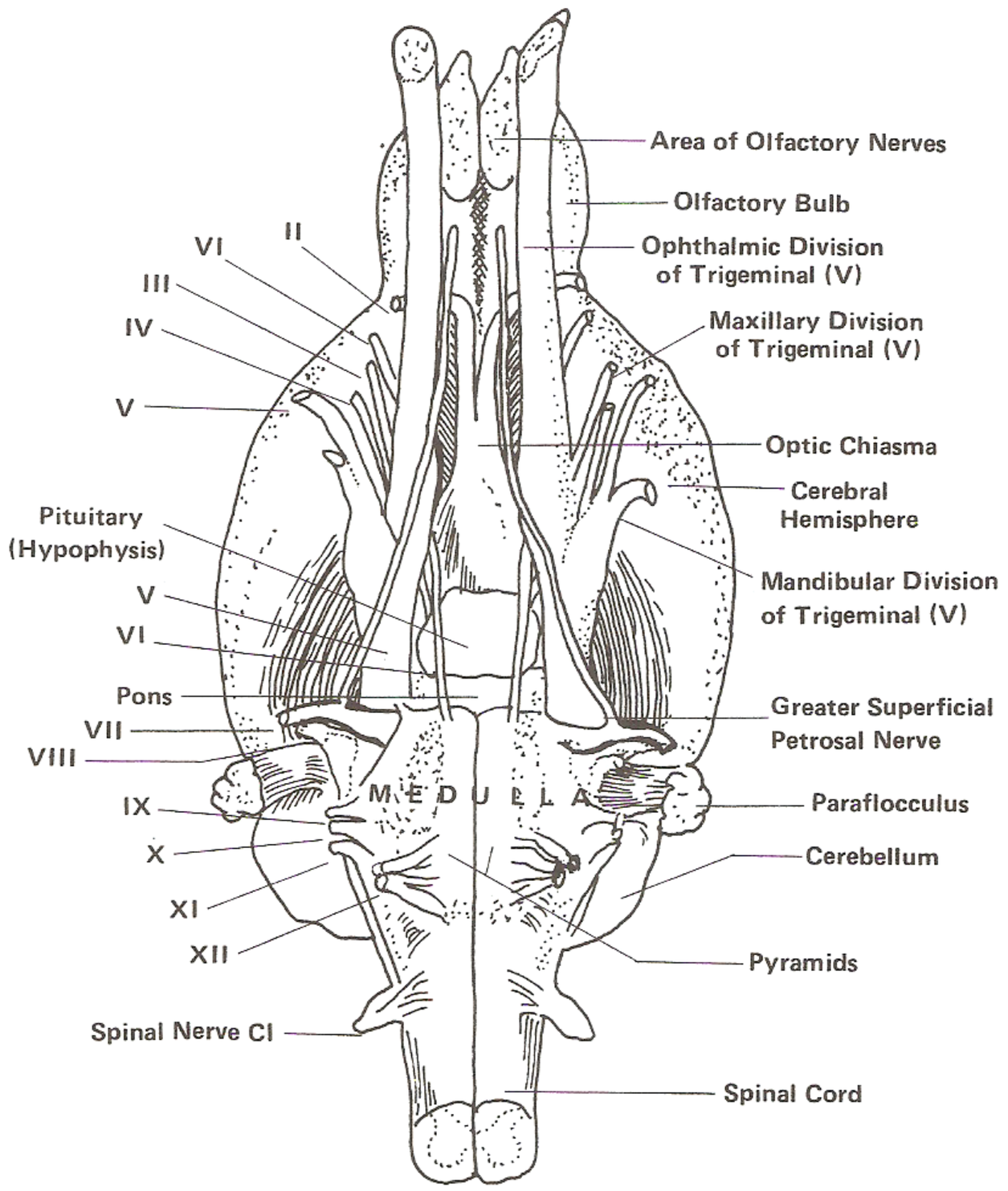
The following table summarizes the locations and actions of the cranial nerves.

TABLE OF CRANIAL NERVES

Name of Nerve	Origin on Surface of Brain	Type of Nerve	Distribution
I. Olfactory	olfactory bulb	sensory	nasal epithelium
II. Optic	thalamus	sensory	retina of eye
III. Oculomotor	cerebral peduncle	motor	most eye muscles
IV. Trochlear	mesencephalon	motor	to one eye muscle
V. Trigeminal	pons	mixed	*sensory:* skin, face *motor:* jaw
VI. Abducens	anterior medulla	motor	to one eye muscle
VII. Facial	medulla, near V	mixed	*sensory:* taste buds *motor:* tear glands, salivary glands, jaw
VIII. Stato-Acoustic	medulla, posterior to VII	sensory	hair cells of inner ear
IX. Glossopharyngeal	posterior medulla	mixed	*sensory:* tongue, pharynx *motor:* pharynx, salivary glands
X. Vagus	medulla, posterior to VIII	mixed	*sensory:* larynx, lungs, heart, stomach *motor:* pharynx, larynx, heart, stomach, intestines
XI. Spinal Accessory	medulla, anterior spinal cord	motor	neck and shoulder muscles
XII. Hypoglossal	postero-ventral medulla	motor	tongue muscles



RAT BRAIN (SAGITTAL VIEW)



RAT BRAIN (VENTRAL VIEW)

SPINAL CORD AND SPINAL NERVES

The spinal cord is a continuation of the medulla of the brain. It lies within the *vertebral canal* of the vertebrae. One pair of *spinal nerves* exits between each two vertebrae *(intervertebral canal)*.

The cord thickens in the cervical and sacral areas. Here, numerous and complexly branching nerves *(brachial plexus* and *lumbosacral plexus)* exit.

Thirty-four pairs of *spinal nerves* arise from the spinal cord of the rat. Each spinal nerve arises from two roots, the *dorsal root*, which is *sensory*, and the *ventral root*, which is *motor*. These unite a short distance from the cord to carry sensory and motor impulses to and from the spinal cord. For this reason, all spinal nerves are known as *mixed* nerves. Find the prominent rounded swellings on the dorsal root proximal to its union with the ventral root. These enlargements contain the cell bodies of the sensory neurons and are known as *dorsal root ganglia*.

The following table indicates the number of pairs arising from each section of the cord, plus a comparison between the rat and other mammals.

Number of Spinal Nerves

Region	Rat	Cat	Pig	Man
Cervical	8	8	8	8
Thoracic	13	13	14	12
Lumbar	6	7	7	5
Sacral	4	3	4	5
Caudal (Coccygeal)	3	7–8	—	1
TOTAL	34	38–39	33	31

The Dissection

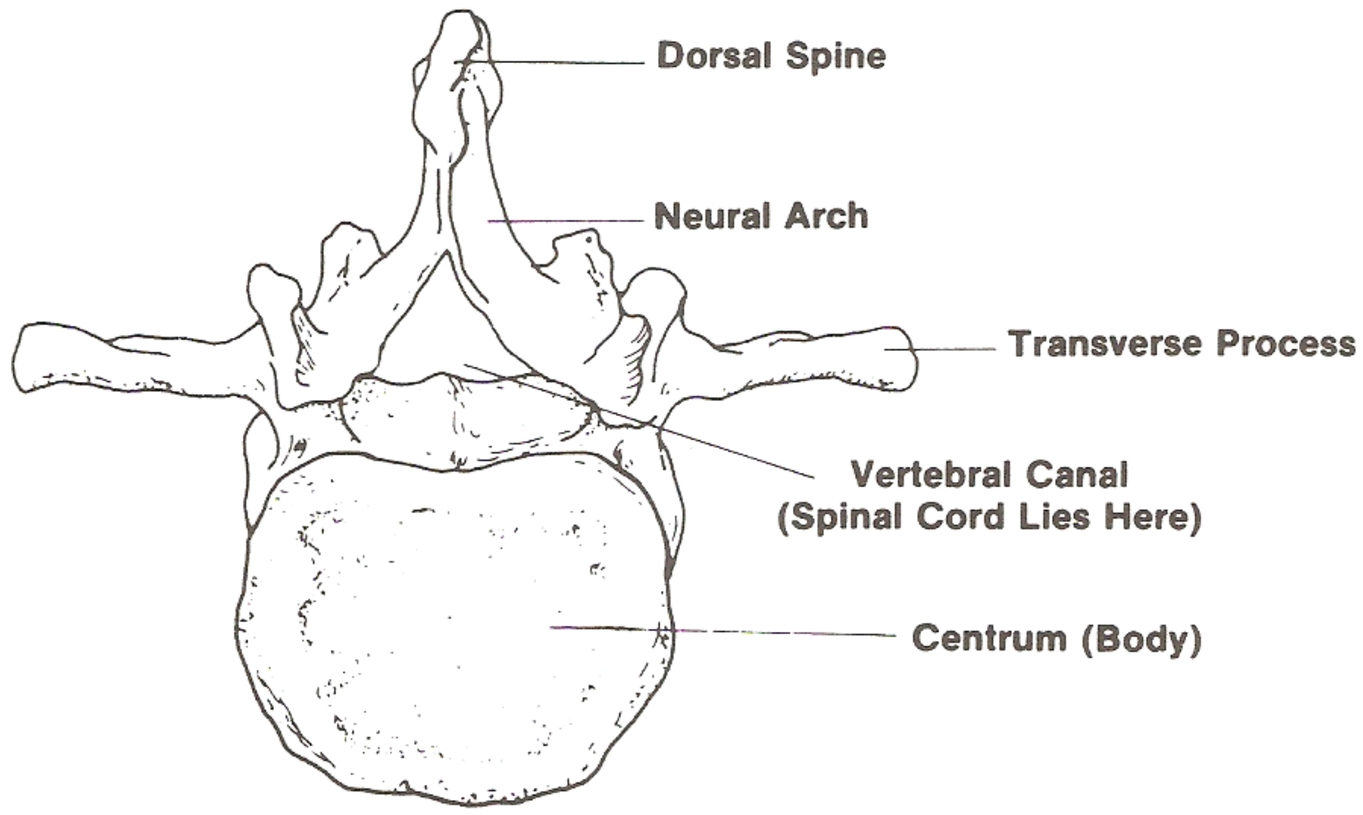
Remove the skin and musculature posterior to the brain. Continue till you reach the base (origin) of the tail.

You will feel the bony vertebral column. Use a strong scalpel to cut away the vertebral *spines*. Then, using strong scissors or bone clippers, cut away the *neural arches* of the vertebrae to expose the spinal cord. Point your instruments horizontally, not down. Cut only a millimeter or two at a time. Otherwise, you may injure the delicate spinal cord and spinal nerves. Work on one vertebra at a time. As you remove the neural arches, look for the origins of the spinal nerves. Note that the spinal cord at first dips ventrally rather sharply at the neck area. It then returns to its more dorsal, characteristic position.

Continue the cutting process in a posterior direction until the entire spinal cord has been exposed.

The spinal cord terminates posteriorly as a narrow *filum terminale*. The end fibers plus the caudal spinal nerves form the *cauda equina* (literally, *horse's tail*).

Like the brain, the spinal cord is surrounded by the three protective membranes, the *meninges*.



VERTEBRA (Human, Lumbar)

Spinal Nerves

Brachial Plexus

The *brachial plexus* is a coming together of five different *cervical nerves* as they exit the spinal cord. From this entangled mass arise four major nerves which enter the *forelimb*. This plexus also gives rise to several other nerves that do not enter the forelimb, most notably, the *phrenic nerve*.

The Dissection

Turn the rat ventral side up in the dissection pan. Find the *vagus nerve* running alongside the common carotid artery, lateral to the trachea. Continue to explore the lateral neck muscles with your rigid probe. Locate the complexly branching *cervical* nerves leading to the forelimb. Explore anteriorly in the musculature near the vertebral column and locate other cervical nerves exiting laterally.

Find the *phrenic nerve* leading to the diaphragm. Trace it anteriorly, without tearing, to its origin in the cervical vertebrae.

PHRENIC NERVE — The first four cervical nerves serve the neck muscles. The ventral branch of the fourth cervical nerve joins the fifth cervical nerve to form the *phrenic nerve*, which leads to the *diaphragm*. Trace this nerve along the side of the neck as it heads medially and posteriorly past the large blood vessels, past the heart, to its tripod-shaped terminal upon the anterior surface of the diaphragm. See the photograph on page 146.

The fourth, fifth, sixth, seventh, and eighth cervical nerves and the first thoracic nerve contribute to the *brachial plexus*. The nerves emerge between the scalene muscles, the plexus formation occurring in the *axilla*. Out of this plexus, or running together of nerves, several major nerves arise which proceed to the arm. Identify the following:

ULNAR NERVE — to the posterior portion of the forearm

MEDIAN NERVE — to the medial surface of the forearm

RADIAL (MUSCULOSPIRAL) NERVE — leaves the axilla with the *ulnar* and *median nerves* and passes to the forearm

AXILLARY NERVE — enters the arm anterior to the *radial nerve*.

Lumbosacral Plexus

As its name indicates, this plexus is located in the posterior region of the rat. It is formed by the union of the sixth lumbar and first sacral nerves. From these, several major nerves of the hip and thigh arise.

The Dissection

Turn the rat dorsal side up in the dissection pan. Return to your dissection of the lower part of the spinal cord. Note the large nerves which exit the cord in this area. Trace them. Note how the plexus is formed. Follow the large *sciatic nerve* over the thigh into the leg. See the photograph on page 145. Locate and identify the following nerves:

FEMORAL NERVE — This originates from the third and fourth lumbar nerves. It has superficial and deep branches into the thigh. It may be seen on the anterior medial surface of the thigh.

Saphenous Nerve — This is one of the main superficial branches of the femoral nerve. It runs superficially down the medial surface of the thigh and lower leg, accompanied by the artery and vein of the same name.

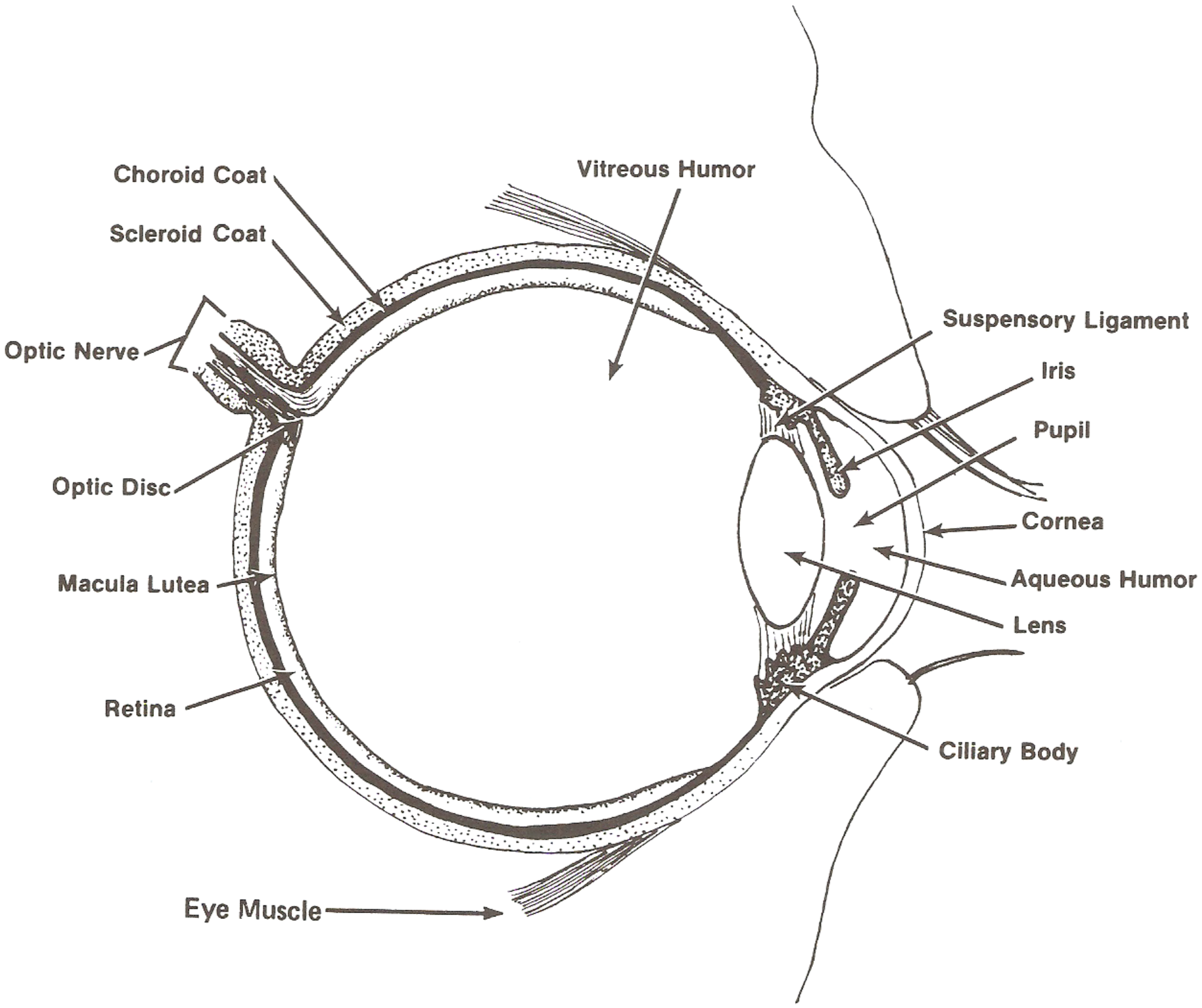
SCIATIC NERVE — This is formed primarily from the sixth lumbar nerve. The sciatic nerve is a thick nerve trunk which gives off many superficial and deep branches. It follows the dorsal surface of the thigh. Two of its branches are the:

Tibial Nerve — to the tibia

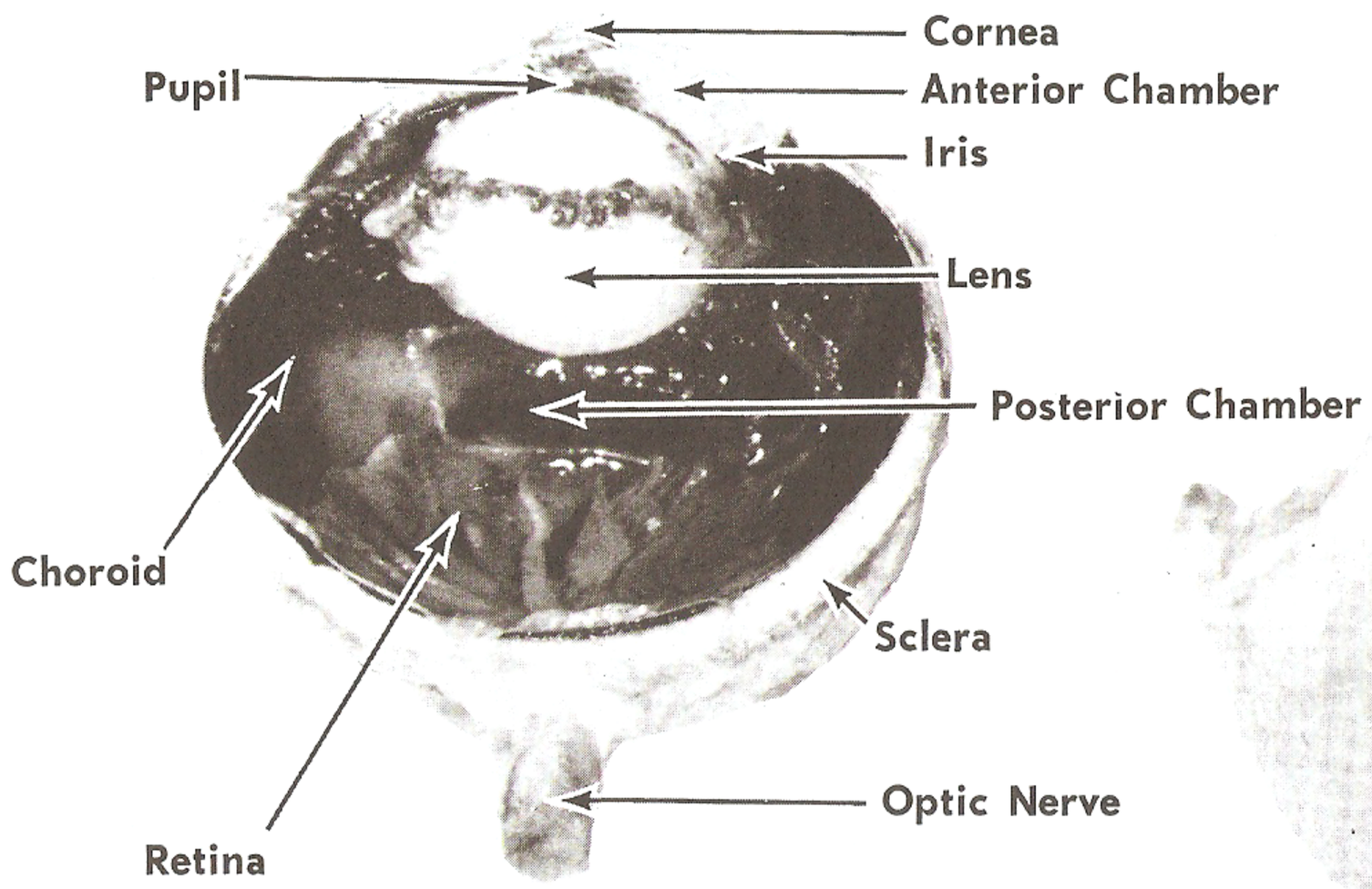
Common Peroneal Nerve — to the fibula.

THE EYE

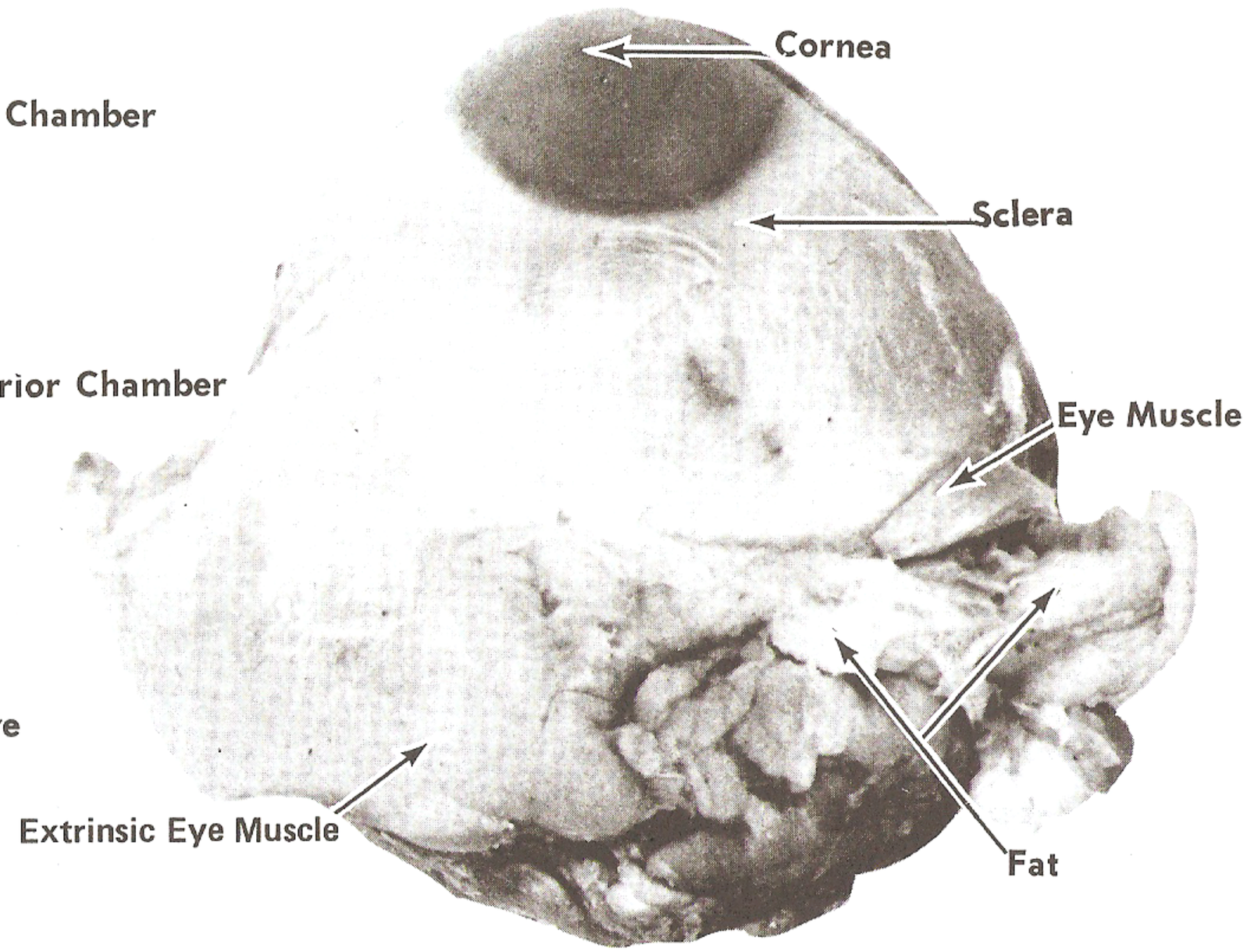
Due to the extremely small size of the rat's eye, dissection for students is difficult. The sheep's eye has been used for the photograph on the next page.



HUMAN EYE



Transverse Section



External View

SHEEP EYE (TRANSVERSE SECTION AND EXTERNAL VIEW)

The external view reveals some of the extrinsic *eye muscles* that move the eye. Also visible is the thick layer of *fat* covering the rear of the *eyeball*.

The transverse section reveals the interior of the eyeball. The fat and muscle layers have been removed. The stump of the *optic nerve* may be seen exiting from the rear of the eye.

The *sclera, choroid*, and *retina* are seen.

Locate and identify on your specimen all of the structures pictured.

THE EAR

The ear is extremely difficult to dissect. The structures of the inner ear are very small and are, furthermore, embedded in bone. The dissection can be more readily carried out if that portion of the skull in which the ear lies is first separated from the rest of the head. In addition, the instructor should prepare demonstrations of sagittal sections of the skull.

The following description of the ear is essentially the same for the rat and man.

The ear is primarily an organ of hearing and equilibrium. It is divided into three regions: the *external*, the *middle*, and the *internal* (inner) ear.

External Ear

The external ear consists of the large, externally visible *pinna (auricle)*. This funnel-shaped structure is made of supporting elastic cartilage covered by skin. The *anterior* and *posterior auricular muscles* act to move the ear. This enables the rat to detect sounds more readily. By small variations in the movement of the ear the rat is able to avoid enemies and detect its prey.

The *external auditory meatus*, at the proximal end of the pinna, is the opening through which sound waves enter. The *external auditory canal* carries the sound waves toward the *tympanic membrane*, or eardrum. The tympanic membrane separates the outer from the middle ear.

Middle Ear

The middle ear is the name commonly given to the *tympanic cavity*, which lies within a bone, the *tympanic bulla* of the *temporal bone*.

Three small bones, known collectively as the auditory ossicles, are found in the middle ear: the *malleus* (hammer), the *incus* (anvil), and the *stapes* (stirrup). The malleus is attached to the tympanic membrane and articulates with the incus, which, in turn, moves the stapes. The plate of the stapes is attached to a membrane, the *oval window* of the *cochlea*.

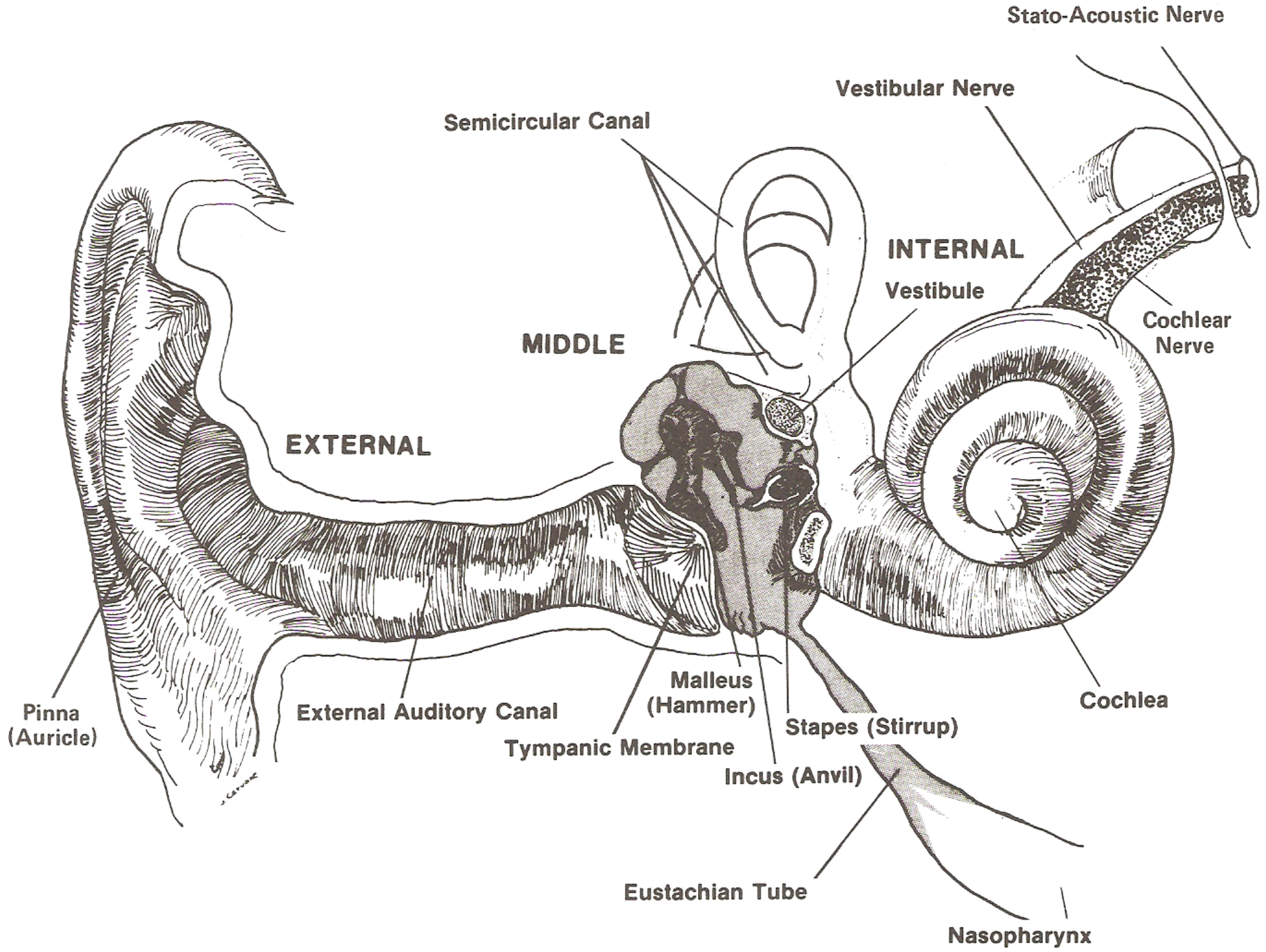
The *Eustachian tube* leads from the middle ear to the nasopharynx. It serves to equalize pressure against the tympanic membrane. It may also be instrumental in leading an upper respiratory infection towards the middle ear, thereby causing severe earaches.

Internal Ear

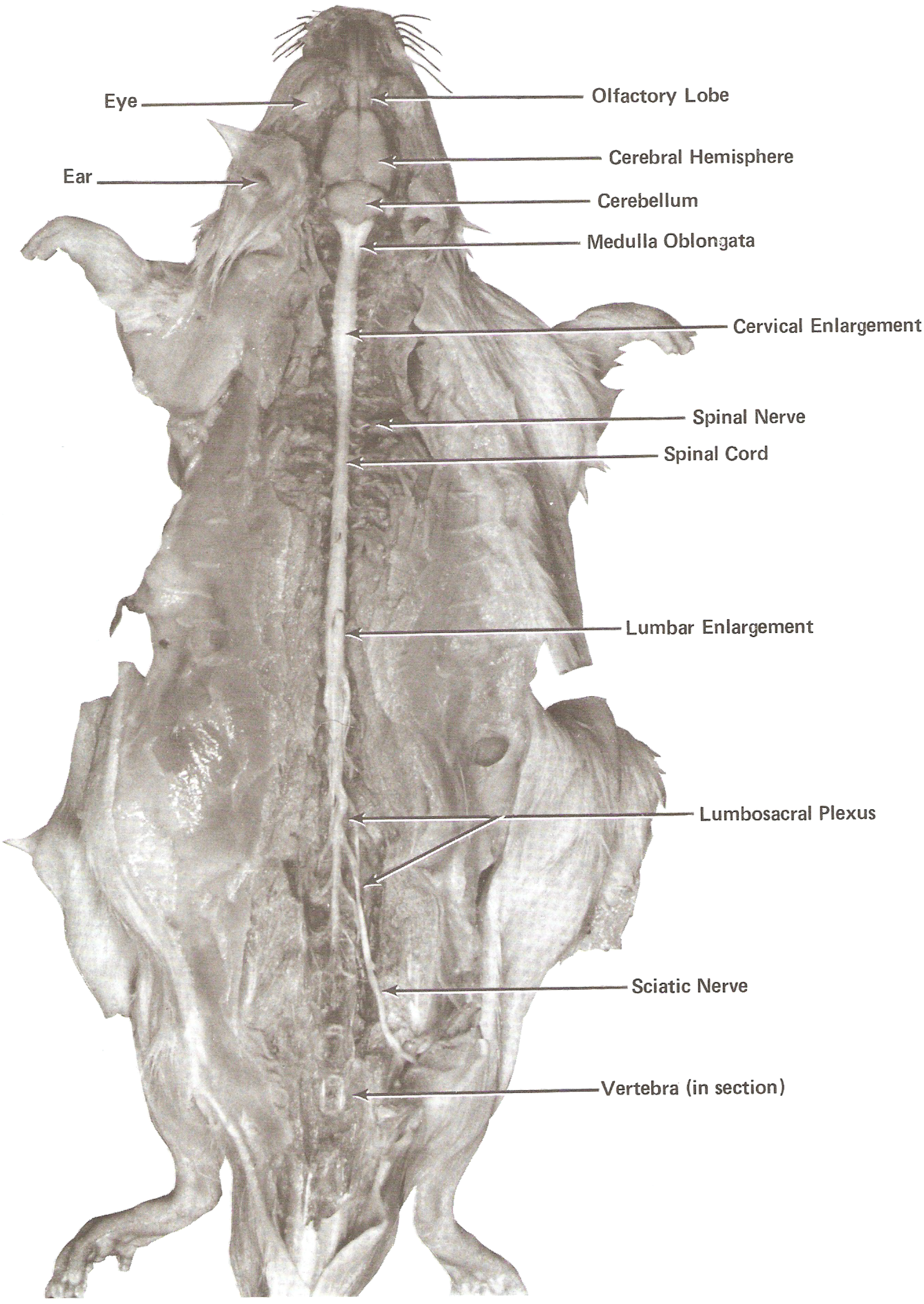
This is the main area of hearing. Here neurons receive sound waves and pass them to the brain for interpretation. The structures of the inner ear lie within a *bony labyrinth* within the petrosal portion (otic capsule) of the *temporal bone*.

The primary receptor of sound, the *organ of Corti*, is located within the snail-shaped *cochlea*. Fluids within the cochlea are disturbed by sound waves, and these move the delicate sensory hairs. These impulses are passed to the brain by the *stato-acoustic nerve*, the eighth cranial nerve.

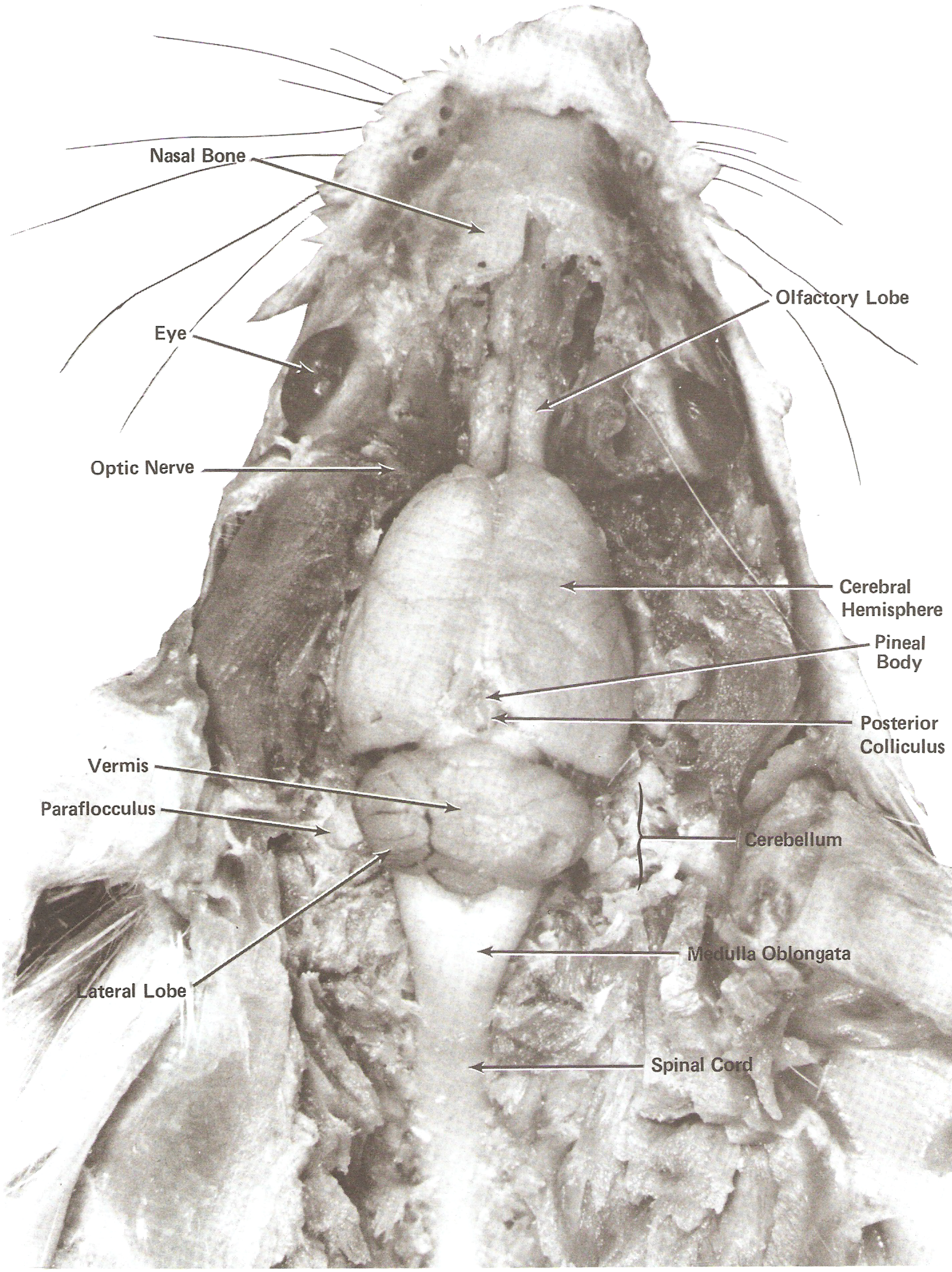
Sensations of equilibrium and balance are also transmitted by the *stato-acoustic* nerve. These sensations originate in three pairs of fluid-filled *semicircular canals*. These are oriented in the three planes of space: frontal, sagittal, and transverse. In addition, two membranous sacs, the *utricle* and the *saccule*, are sensitive to changes in equilibrium and balance.



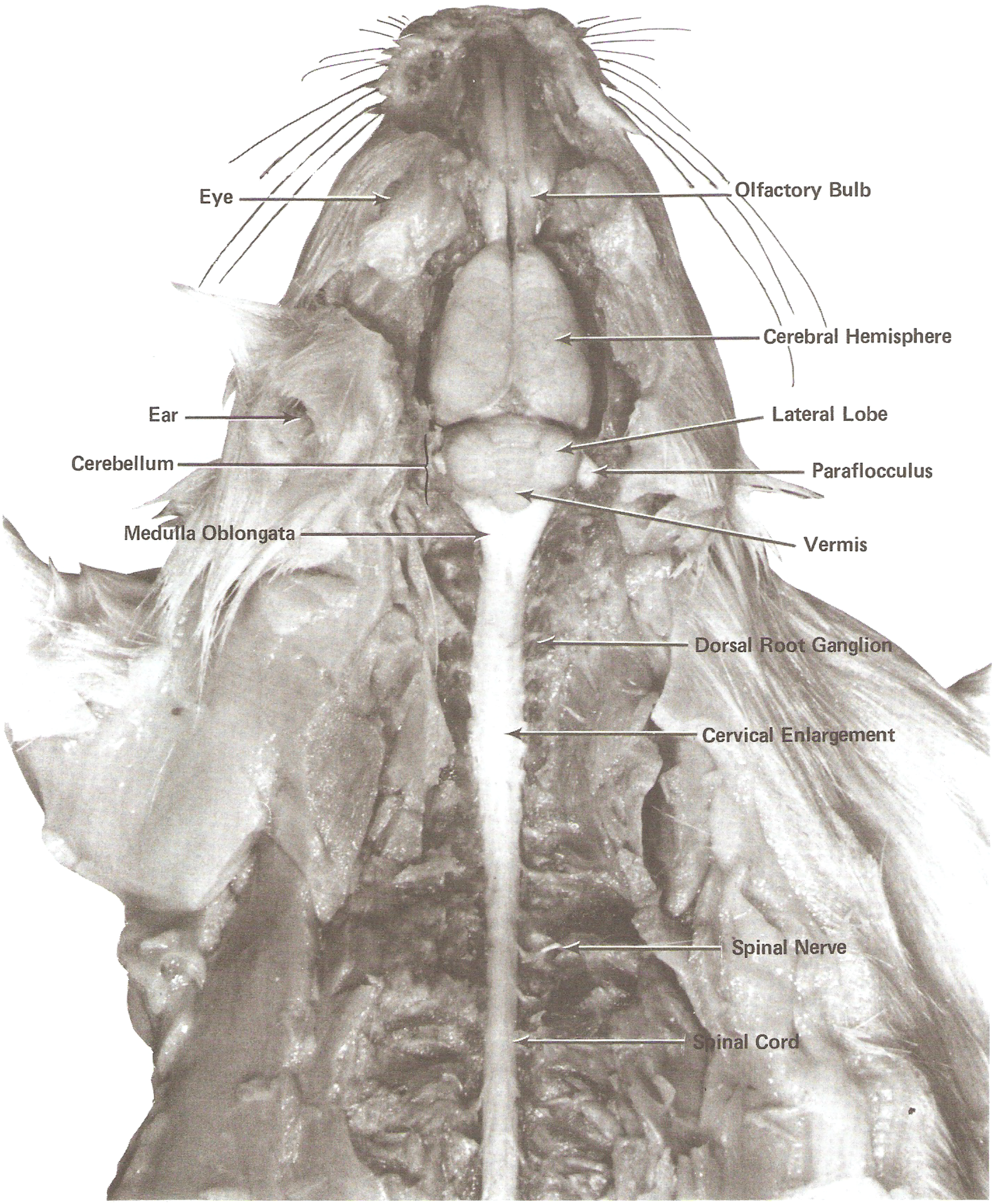
HUMAN EAR



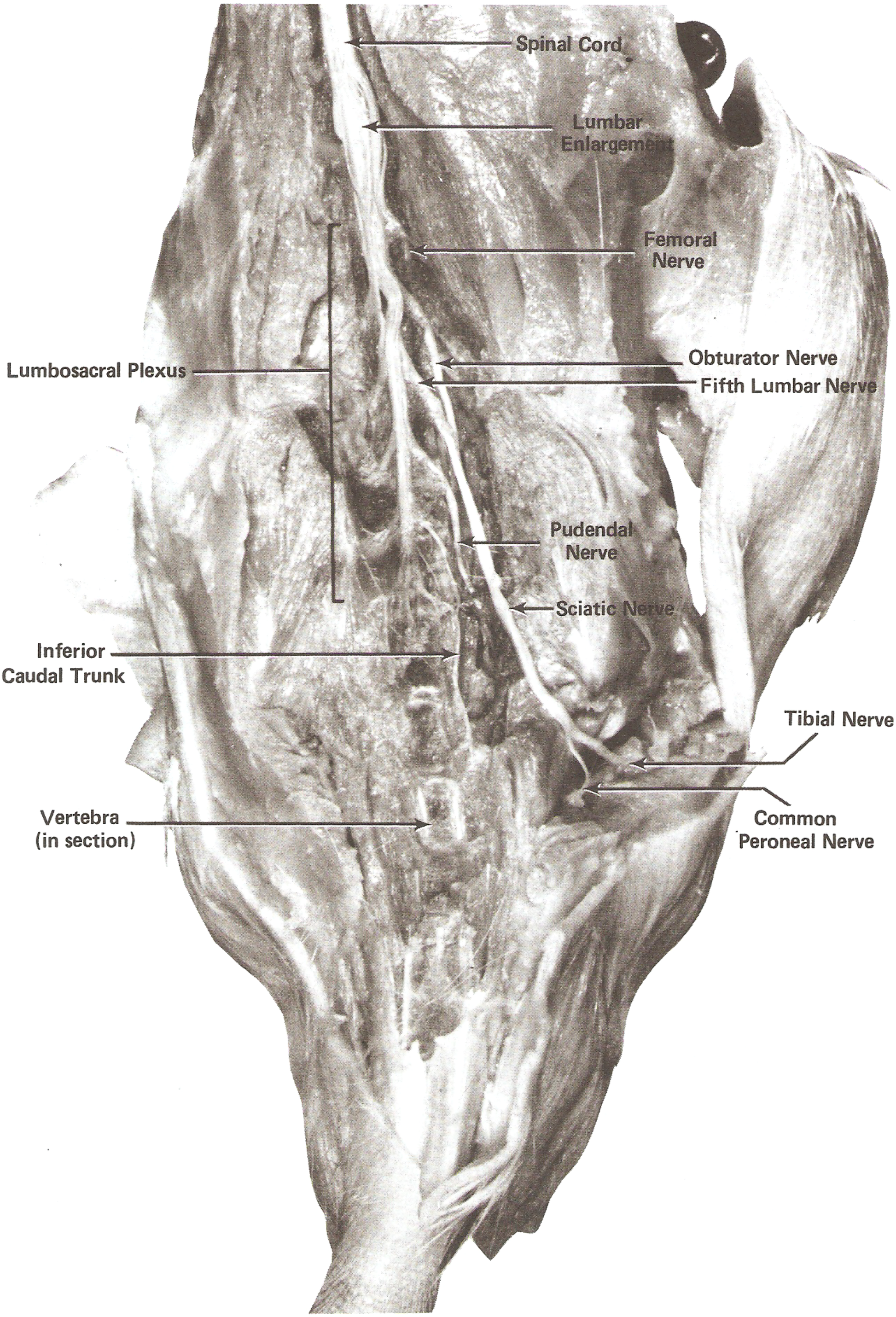
BRAIN AND SPINAL CORD (DORSAL VIEW)



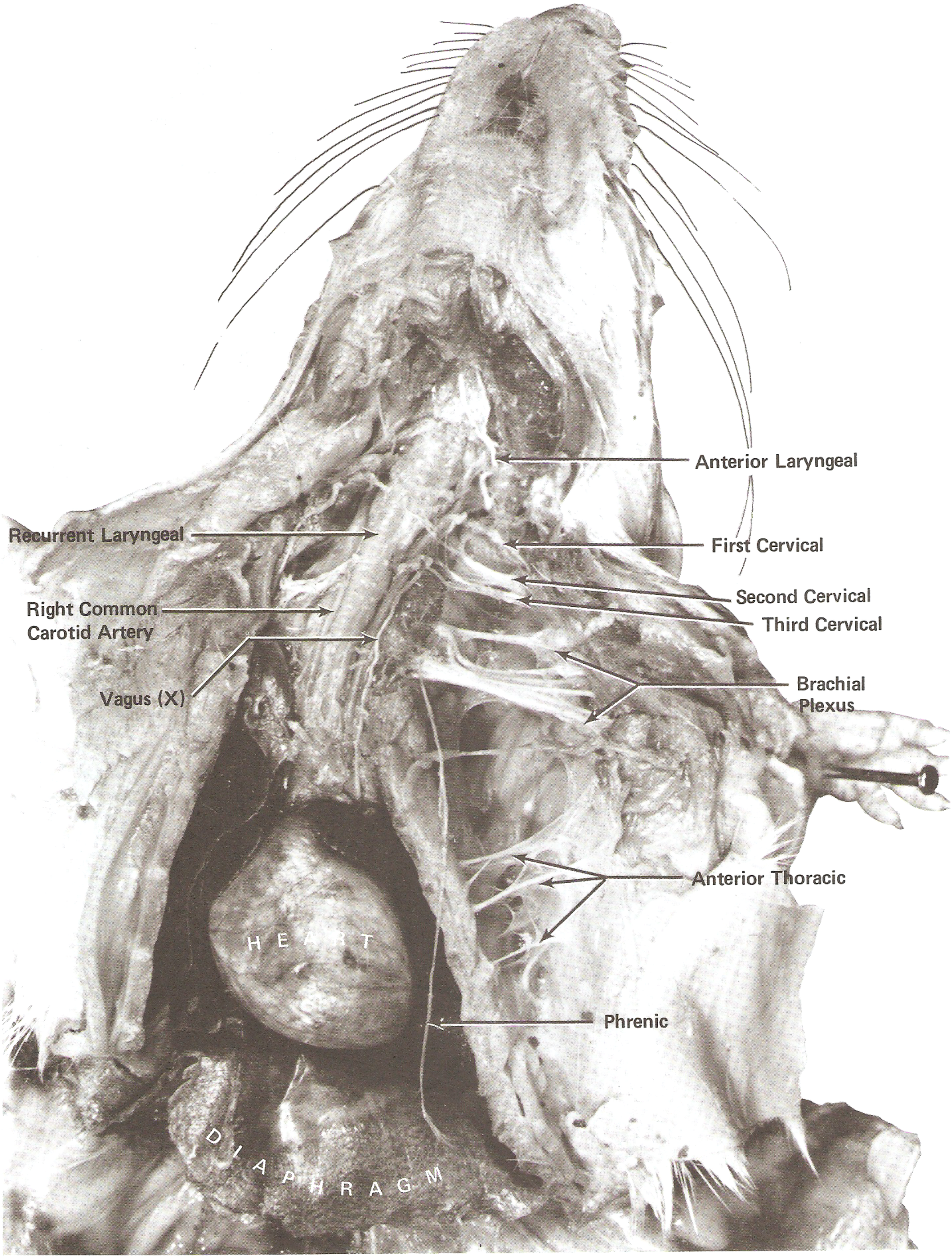
THE BRAIN (DORSAL VIEW)



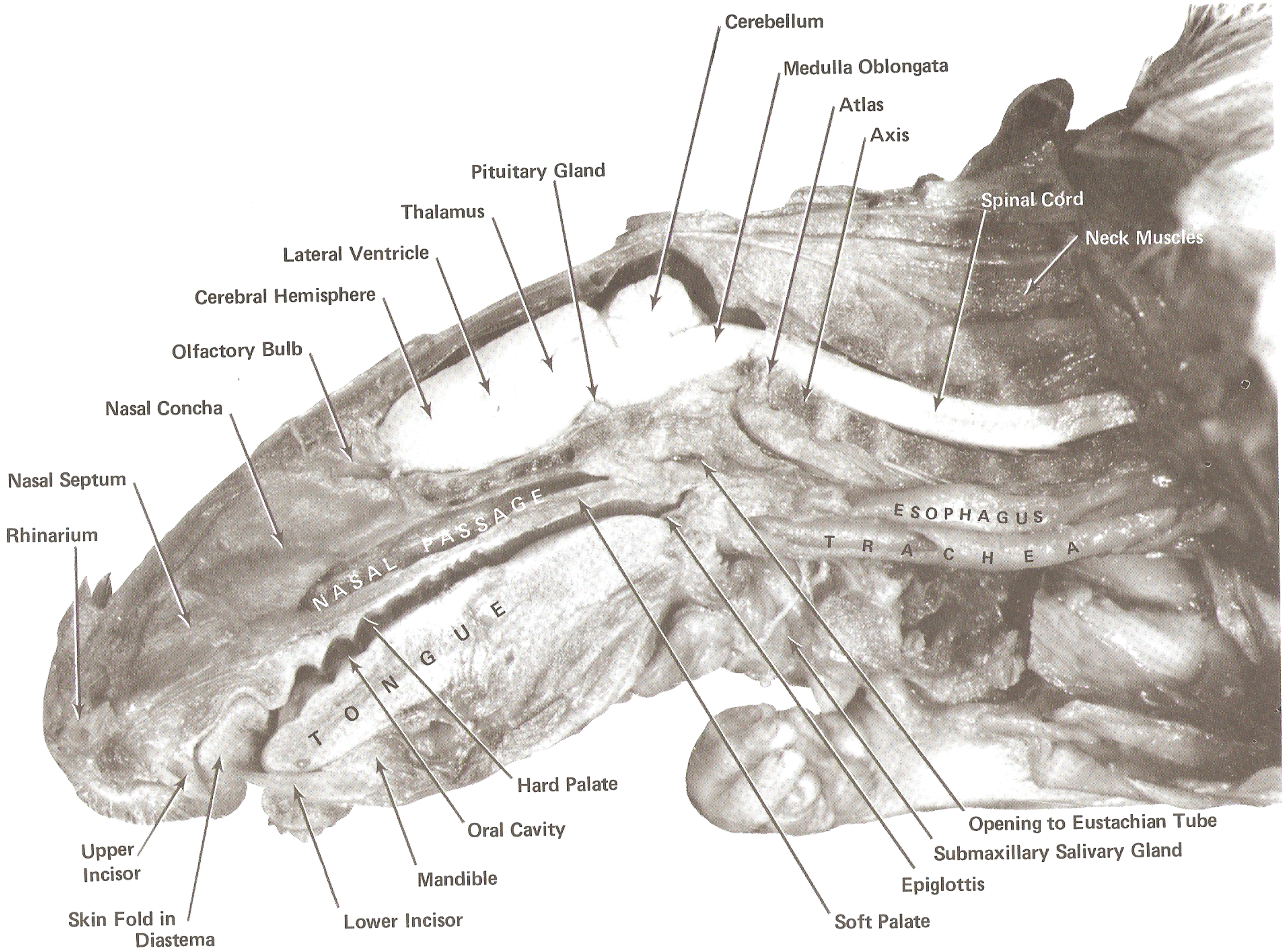
BRAIN AND UPPER SPINAL CORD (DORSAL VIEW)



LOWER SPINAL CORD (DORSAL VIEW)



CERVICAL AND THORACIC NERVES (VENTRAL VIEW)



HEAD AND NECK (SAGITTAL VIEW)