See 20

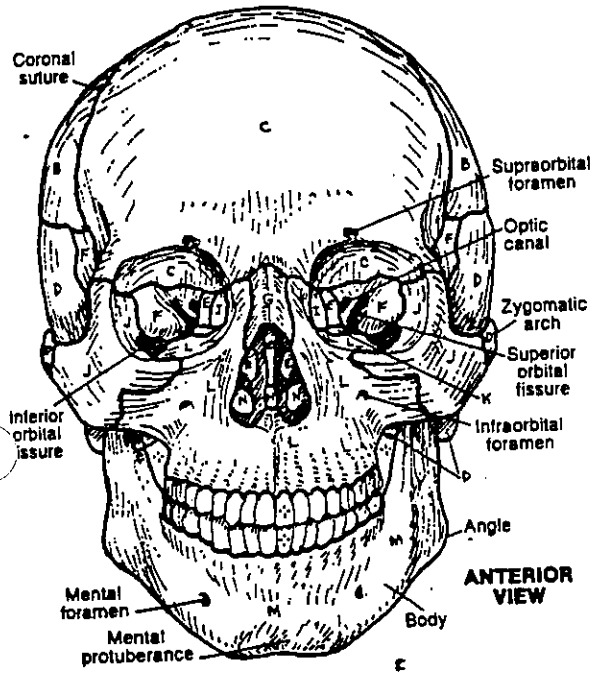
III. SKELETAL SYSTEM

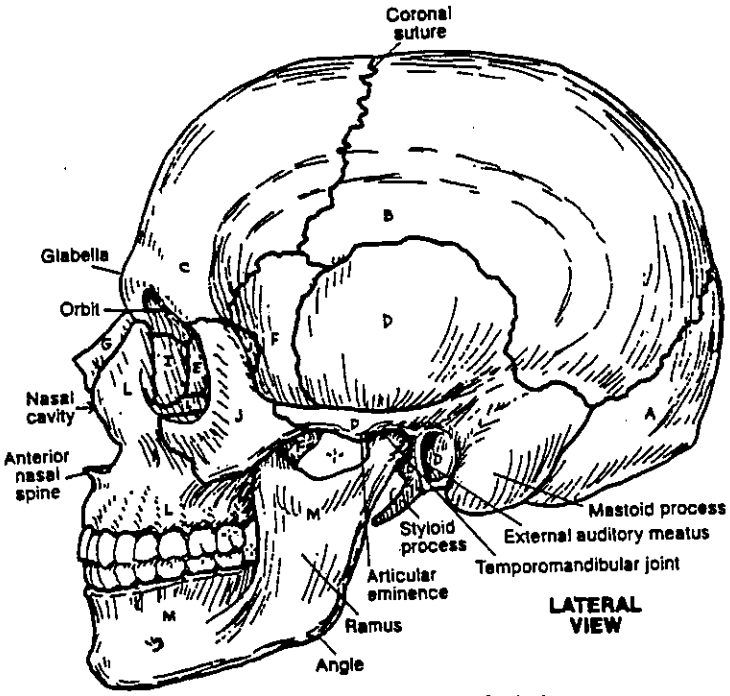
BONES OF THE SKULL (1)

CRANIAL (8):*
OCCIPITAL (1)$_A$ PARIETAL (2)$_B$ FRONTAL (1)$_C$
TEMPORAL (2)$_D$ ETHMOID (1)$_E$ SPHENOID (1)$_F$

FACIAL (14):*
NASAL (2)$_G$ VOMER (1)$_H$ LACRIMAL (2)$_I$
ZYGOMATIC (2)$_J$ PALATINE (2)$_K$ MAXILLA (2)$_L$
MANDIBLE (1)$_M$ INFERIOR NASAL CONCHA (2)$_N$

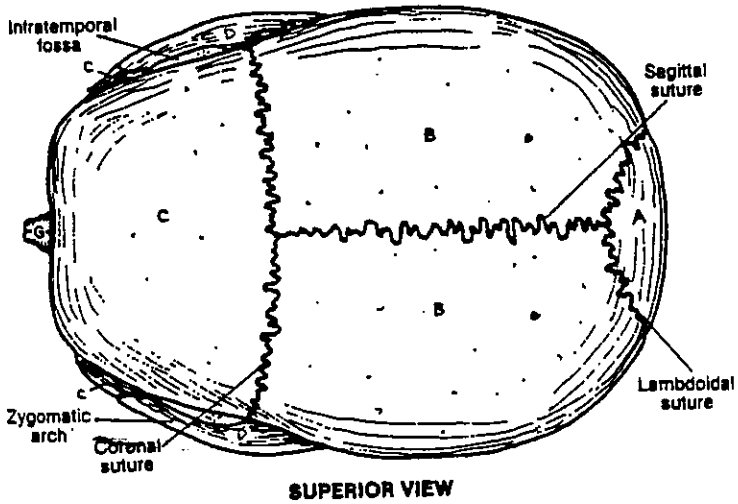
CN: Work with this plate and the next one at the same time. Save the brightest colors for the smallest bones; use light colors on bones with surface detail. Work one bone at a time, coloring it where it appears in any of the 7 views shown on this and the next plate. (1)In the anterior view, do not color the darkened areas in the orbits and nasal cavity.

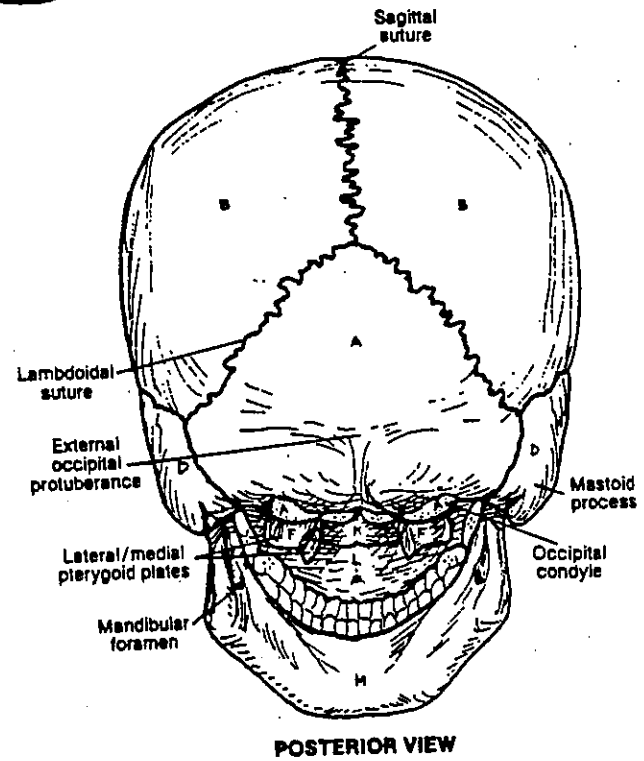




The skull is composed of *cranial bones* (forming a vault for the brain) and *facial bones* (giving origin to the muscles of facial expression and providing buttresses protecting the brain). Except for the temporomandibular joint (a synovial joint), all bones are connected by generally immovable fibrous sutures.

The orbit is composed of 7 bones, has 3 significant fissures/canals, and is home to the eye and related muscles, nerves, and vessels. The most delicate of the skull bones is at the medial orbital wall (I). The external nose is largely cartilaginous and is, therefore, not part of the bony skull.

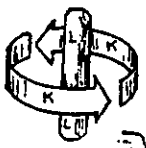




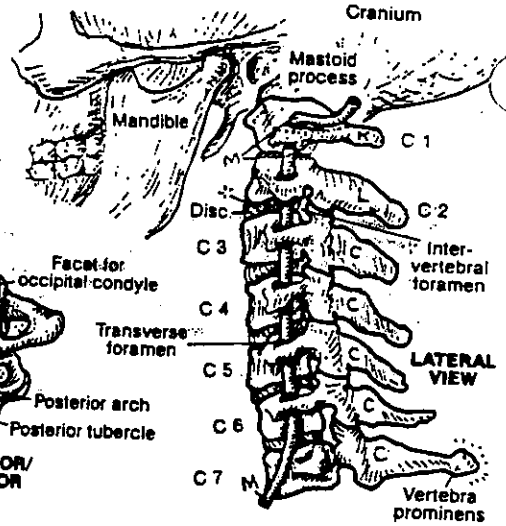
See 21, 23

CERVICAL AND THORACIC VERTEBRAE

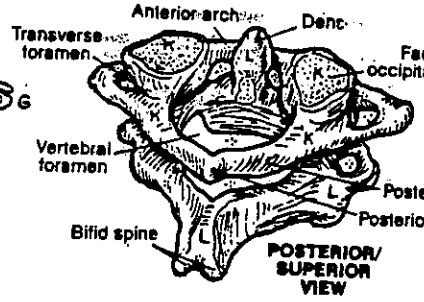
CN: Use red for M and use the same colors as were used on Plate 21 for C and T. Use dark colors for N, O, and P. (1) Begin with the parts of a cervical vertebra. Color the atlas and axis and note they have been given separate colors to distinguish them from other cervical vertebrae. (2) Color the parts of a thoracic vertebra and then the thoracic portion of the vertebral column. Note the three different facet/demifacet colors.



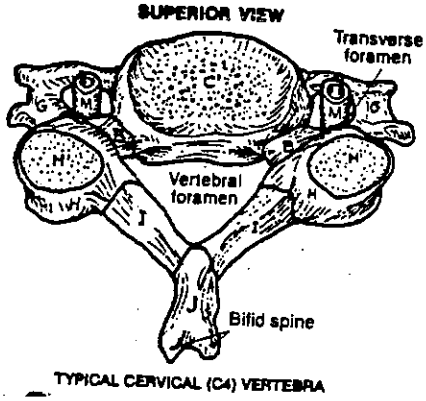
ATLAS K
AXIS L



CERVICAL VERTEBRA C
BODY C'
PEDICLE B
TRANSVERSE PROCESS G
ARTICULAR PROCESS H
FACET H'
LAMINA I
SPINOUS PROCESS J

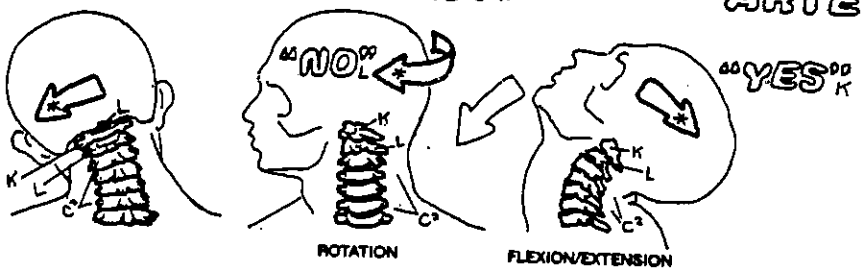


VERTEBRAL ARTERY M

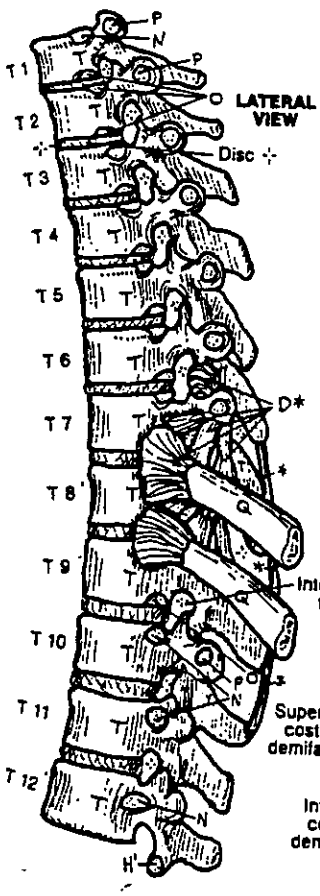


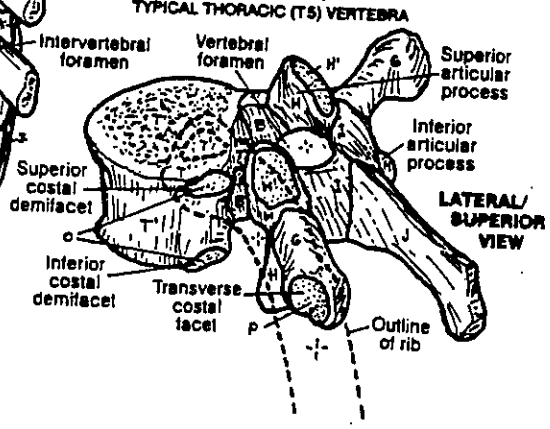
TYPICAL CERVICAL (C4) VERTEBRA

MOVEMENT *



The small seven *cervical vertebrae* support and move the head and neck, supported by ligaments and strap-like paracervical (paraspinal) muscles. The ring-shaped *atlas* (C1) has no body; thus there are no weight-bearing discs between the occiput and C1, and between C1 and C2 (the *axis*). Head weight is transferred to C3 by the large *articular processes* and *facets* of C1 and C2. The atlantooccipital joints, in conjunction with the C3-C7 facet joints, permit a remarkable degree of flexion/extension ("yes" movements). The dens of C2 projects into the anterior part of the C1 ring, forming a pivot joint, enabling the head and C1 to rotate almost 90° ("no" movements). Such rotational capacity is permitted by the relatively horizontal orientation of the cervical facets. The C3-C6 vertebrae are similar; C7 is remarkable for its prominent *spinous process*, easily palpated. The anteriorly directed cervical curve and the extensive paracervical musculature preclude palpation of the other cervical spinous processes. The *vertebral arteries*, enroute to the brain stem, pass through foramina of the *transverse processes* of the upper six cervical vertebrae. These vessels are subject to stretching injuries with extreme cervical rotation of the hyperextended neck. The cervical vertebral canal conducts the cervical spinal cord and its coverings (not shown). The C4-5 and C5-6 motion segments are the most mobile of the cervical region and are particularly prone to disc/facet degeneration.



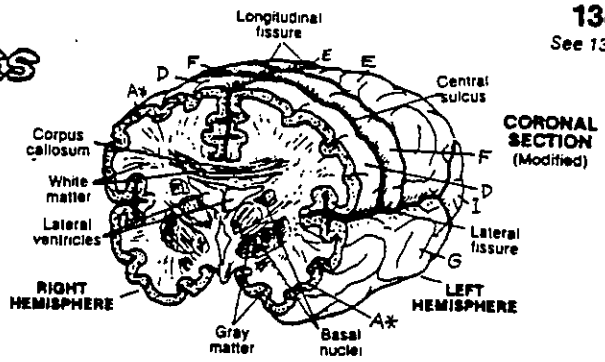


THORACIC VERTEBRA T
BODY T'
FACET N
DEMIFACET O
TRANSVERSE FACET P
RIB Q
LIGAMENT D*

The twelve *thoracic vertebrae*—characterized by long, slender spinous processes, heart-shaped *bodies*, and nearly vertically oriented *facets*—articulate with *ribs* bilaterally. In general, each rib forms a synovial joint with two *demifacets* on the bodies of adjacent vertebrae and a single *facet* on the transverse process of the lower vertebra. Variations of these costovertebral joints are seen with T1, T11, and T12.

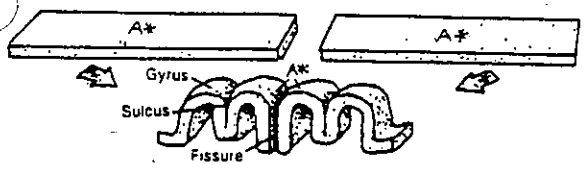
XIV. NERVOUS SYSTEM
CNS: CEREBRAL HEMISPHERES

CN: Use light colors for B, E, I, and J. (1) Color the two large hemispheres first. Note that the stippled areas of specialized function are parts of lobes, but receive their own colors. Color the arrows identifying the major fissures (sulcus. (2) Color the coronal section and posterior portion of the brain. (coronal section of the cerebral cortex is colored gray. (3) Color gray the stretched-out cortex and the convoluted cortex illustrating how the latter provides increased surface area in a smaller space.

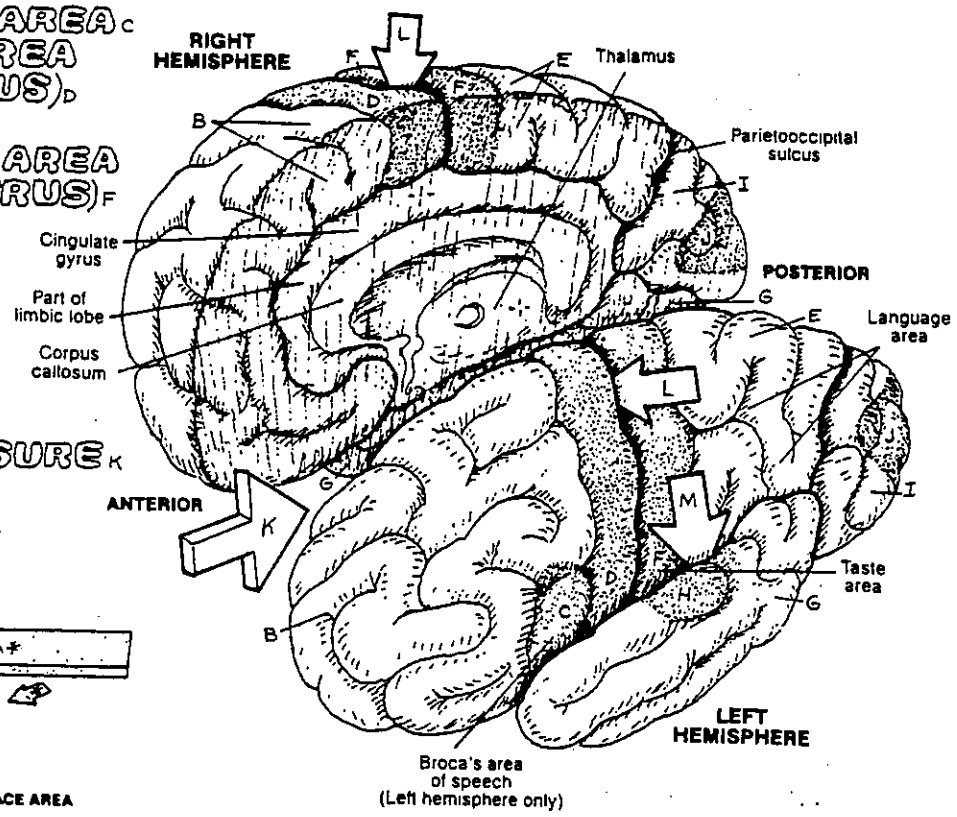


CEREBRAL CORTEX: A*
- **FRONTAL LOBE** B
  - PRINCIPAL SPEECH AREA C
  - PRIMARY MOTOR AREA (PRECENTRAL GYRUS) D
- **PARIETAL LOBE** E
  - PRIMARY SENSORY AREA (POSTCENTRAL GYRUS) F
- **TEMPORAL LOBE** G
  - AUDITORY AREA H
- **OCCIPITAL LOBE** I
  - VISUAL AREA J

MAJOR FISSURES/ SULCUS: *
- LONGITUDINAL FISSURE K
- CENTRAL SULCUS L
- LATERAL FISSURE M



CORTICAL CONVOLUTIONS: INCREASED SURFACE AREA



The paired cerebral hemispheres (cerebrum), derivatives of the embryonic telencephalon, consist of four major elements: (1) an outer cerebral cortex of gray matter, the topography of which reveals fissures (deep grooves), gyri (hills), and sulci (furrows); (2) underlying white matter consisting of numerous tracts destined for or leaving the cortex and oriented along three general directions; (3) discrete masses of gray matter at the base of the cerebrum (basal nuclei) that subserve motor areas of the cortex; (4) paired cavities called lateral ventricles. The cerebral cortex is the most highly evolved area of the brain. About 2-4 mm (roughly 1/6 inch) thick, the cortex is divided into lobes distinctly bordered by sulci; the lobes are generally related to the cranial bones that cover them: frontal, parietal, temporal, occipital. The exception is the limbic lobe (part of which is shown); it incorporates parts of other (frontal, temporal, parietal) lobes.

Cortical mapping experiments (based on electrical stimulation) and clinical/pathologic data have been the principal methods by which functions of the cortex have been discovered. All parts of the cortex are concerned with storage of experience (memory), exchange of impulses with other cortical areas (association), and the two-way transmission of impulses with subcortical areas (afferent/efferent (ctions).

Frontal lobe is concerned with intellectual functions such as reasoning and abstract thinking, aggression, sexual behavior, olfaction or smell, articulation of meaningful sound (*speech*), and voluntary movement (*precentral gyrus*). The *central sulcus* separates the frontal lobe from the parietal lobe. The *parietal lobe* is concerned with body sensory awareness, including taste (*postcentral gyrus*), the use of symbols for communication (language), abstract reasoning (e.g., mathematics), and body imaging. The *temporal lobe* is partly limbic and here is concerned with the formation of emotions (love, anger, aggression, compulsion, sexual behavior); the non-limbic temporal lobe is concerned with interpretation of language, awareness and discrimination of sound (hearing; *auditory area*), and constitutes a major memory processing area. The *occipital lobe* is concerned with receiving, interpreting, and discriminating visual stimuli from the optic tract, and associating those visual impulses with other cortical areas (e.g., memory).

In evolutionary terms, the limbic lobe or system is the oldest part of the cortex. It is the center of emotional behavior. The limbic neurons occupy parts of the inferior and medial cortices of each hemisphere, and some subcortical areas as well. Certain limbic areas are closely related topographically to the olfactory tracts.

The cerebral hemispheres appear structurally as mirror images of one another; functionally they are not. The speech area develops fully only on one side, usually the left. In general, the left hemisphere tends to deal with certain higher functions (mathematical, analytical, verbal) while the right concentrates on visual, spatial, and musical orientations. The matter of cerebral "dominance" (left hemisphere, left speech center, right handed) or vice versa is quite controversial.

See 130, 136

XIV. NERVOUS SYSTEM

CNS: BRAIN STEM / CEREBELLUM

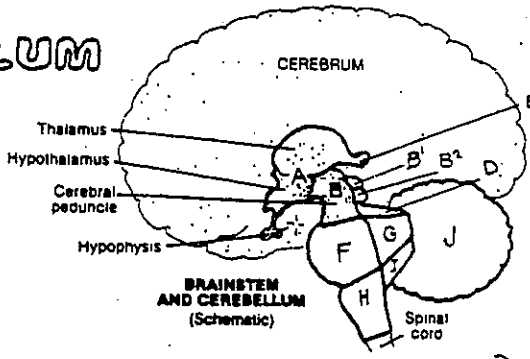
CN: Use darker colors for C, E, M, and the lightest for K. (1) As you color each structure in as many views as it is shown, take particular note of of the orientation of the view. (2) Note that the fourth ventricle is located in both parts of the hindbrain and receives the same color in both parts. The diencephalon has been presented on the previous plate and is shown here only for orientation.

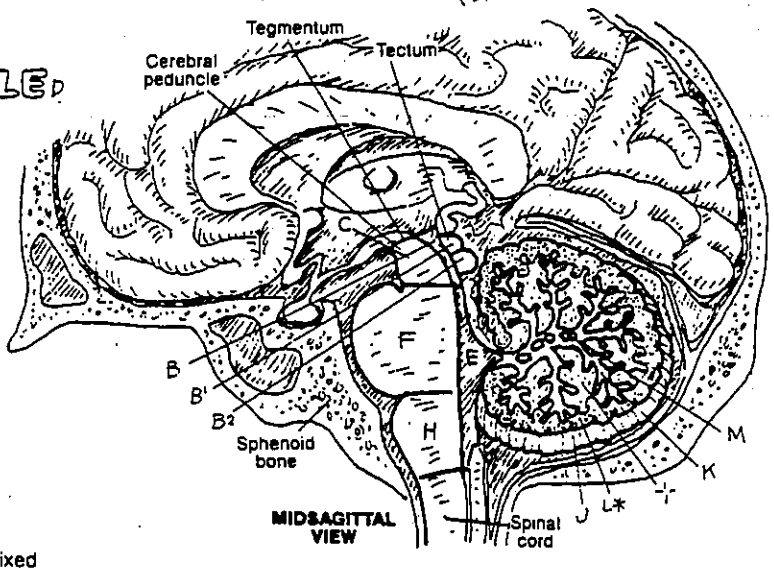
DIENCEPHALON A

MIDBRAIN: B
- CEREBRAL AQUEDUCT C
- SUPERIOR COLLICULUS B'
- INFERIOR COLLICULUS B²
- SUP. CEREBELLAR PEDUNCLE D

HINDBRAIN: *
- 4TH VENTRICLE E
- PONS F
  - MID. CEREBELL. PED. G
- MEDULLA H
  - INF. CEREBELL. PED. I

CEREBELLUM J
- ARBOR VITAE K
- CEREBELLAR CORTEX L*
- DEEP CEREB. NUCLEUS M

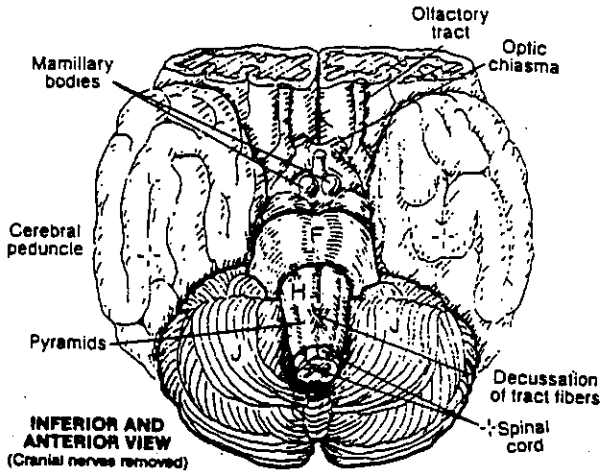




The *brainstem* consists of all portions of the brain less the cerebrum and cerebellum.

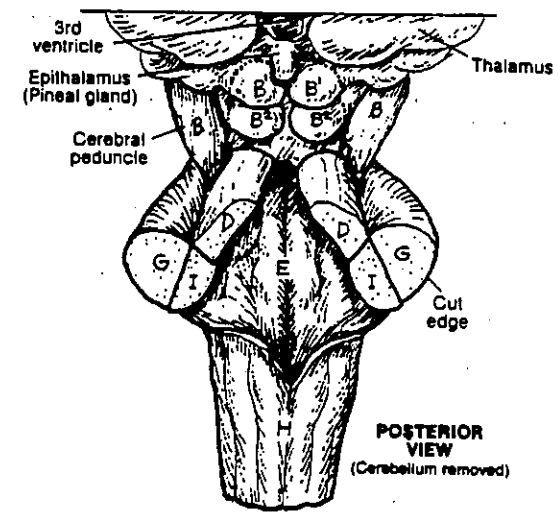
The *midbrain* includes two columns of tracts (cerebral peduncles) and mixed nuclei/tracts posterior to these columns (tegmentum), the *cerebral aqueduct*, *superior cerebellar peduncles* (conducting tracts from thalamus, midbrain, and medulla), and the more posterior *superior and inferior colliculi* (tectum of the midbrain). The peduncles consist of descending axons continuous with the internal capsule above and destined for lower motor neurons in the brain stem (cranial nerve) and spinal cord (spinal nerves) below. The deeper tegmentum contains nuclei of the reticular formation, nuclei/tracts concerned with cranial nerves III and IV, relay of impulses between lower and higher centers, and other centers/tracts concerned with somatic and visceral motor-related impulses. The superior colliculi are centers for visual reflexes; the inferior colliculi make possible auditory reflexes (e.g., involuntary movements in response to visual and auditory stimuli, respectively).

The upper hindbrain is the *pons*. Massive stalks of white matter, the *middle cerebellar peduncles*, cross the *fourth ventricle* (pons, bridge) to reach the cerebellum. The pons consists of (1) tracts descending from the midbrain to lower centers; (2) masses of cell bodies that synapse with certain tracts of cortical origin and whose axons constitute the middle cerebellar peduncle; (3) nuclei that relate to cranial nerves V, VI, VII, and VIII; (4) several ascending tracts arising from the medulla and spinal cord; and (5) a network of polysynaptic neurons (part of the reticular formation) that facilitate/inhibit (mediate) somatic and visceral reflexes and form a mechanism for arousal, wakefulness, and alertness.



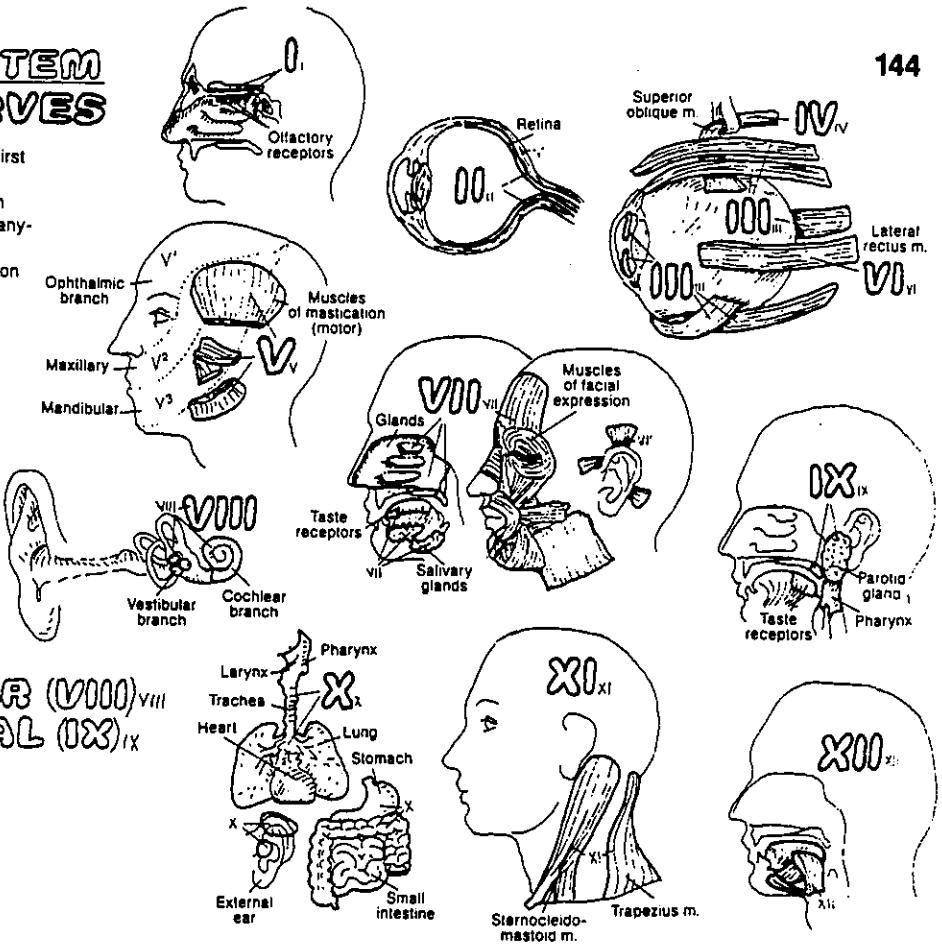
The *medulla*, continuous with the deep pons above and the spinal cord below, consists of much the same organization as the pons. Life-sustaining control centers for respiration, heart rate, and vasomotor function exist here. It contains nuclei concerned with cranial nerves VIII, IX, X, XI, and XII. The *inferior cerebellar peduncle* carries tracts from the spinal cord and vestibular centers (head balance) in the medulla. Two particularly evident bundles of fibers are seen on the anterior surface of the medulla. These pyramids consist of corticospinal fibers conducting voluntary movement-related impulses to lower motor neurons of the spinal cord. 80% of these fibers cross (decussate) to the contralateral side.

The *cerebellum* consists of two hemispheres, with a cortex of gray matter on its surface (*cerebellar cortex*), central masses of motor-related (*deep cerebellar*) *nuclei*, and bands of white matter forming a treelike appearance (*arbor vitae*, tree of life) when the cerebellum is cut in section. The cerebellum is attached to the brain stem by the three cerebellar peduncles. The cerebellum is concerned with equilibrium and position sense, fine movement, control of muscle tone, and overall coordination of muscular activity in response to proprioceptive input and descending traffic from higher centers.



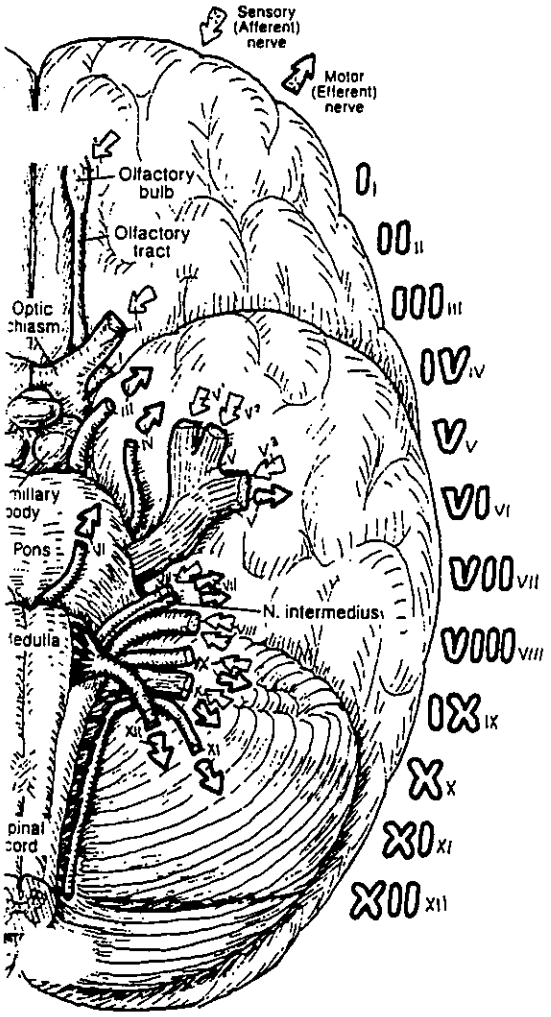
XIV. NERVOUS SYSTEM
PNS: CRANIAL NERVES

CN: Use light colors throughout. (1) Beginning with the first cranial nerve, color the title on the left; the large Roman numeral, the cranial nerve (cut), and the related function at lower left; and the roman numeral and accompanying illustration at upper right. The illustrations generally depict target organs/areas. (2) Note carefully the direction of the function arrows at lower left (sensory/afferent is incoming; motor/efferent is outgoing).



CRANIAL NERVES:*

OLFACTORY (I) I
OPTIC (II) II
OCULOMOTOR (III) III
TROCHLEAR (IV) IV
TRIGEMINAL (V) V
ABDUCENS (VI) VI
FACIAL (VII) VII
VESTIBULOCOCHLEAR (VIII) VIII
GLOSSOPHARYNGEAL (IX) IX
VAGUS (X) X
ACCESSORY (XI) XI
HYPOGLOSSAL (XII) XII



ANTERIOR-INFERIOR SURFACE
(Left brain, brainstem, and cerebellum)

Here cranial nerves and their general target organs/areas are shown. All motor nerves include proprioceptive (sensory) fibers as well. Cranial nerves I and II are derived from the forebrain; all others are brain stem-derived. Cranial nerve nuclei (neuronal cell bodies) are arranged into seven longitudinal columns in the brain stem. Functionally, these columns are general somatic afferent *(GSA)* or efferent *(GSE)*, general visceral afferent *(GVA)* or efferent *(GVE)*, special visceral afferent *(SVA)* or efferent *(SVE)*, and special somatic afferent *(SSA)*. General columns also exist in the spinal cord for spinal nerves; special columns do not. Somatic includes skin, eye, fascial, and musculoskeletal structures; visceral includes smooth muscle and glands of organs with hollow cavities.

- **I** SVA: smell-sensitive (olfactory) receptors in roof/walls of nasal cavity.
- **II** SSA: light-sensitive (visual) receptors in retina of eye.
- **III** GSE: to extrinsic eye muscles (exc. lat. rectus and sup. oblique); GVE: parasympathetic to ciliary and pupillary sphincter (eye) muscles via ciliary ganglion in orbit.
- **IV** GSE: to superior oblique muscle of the eye.
- **V** GSA: from face via three divisions indicated; SVE: to muscles of mastication, tensor tympani, tensor veli palatini, mylohyoid, and digastric muscles.
- **VI** GSE: to lateral rectus muscle of the eye.
- **VII** SVA: from taste receptors ant. tongue; GSA: from ext. ear; GVE: parasympathetic to glands of nasal/oral cavity, lacrimal gland (via pterygopalatine ganglion in fossa of same name), submandibular/sublingual salivary glands (via submandibular ganglion in region of same name); SVE: to facial muscles, stapedius (mid. ear), stylohyoid, post. digastric muscles.
- **VIII** SSA: cochlear part is sound-sensitive; vestibular part is sensitive to head balance and movement (equilibrium).
- **IX** SVA: from taste receptors post. one-third tongue; GSA: from ext. ear and ext. auditory canal; GVA: from mucous membranes of posterior mouth, pharynx, auditory tube, and middle ear; from pressure and chemical receptors in carotid body and common carotid artery; SVE: to sup. constrictor m. of the pharynx, stylopharyngeus; GVE: parasymp. to parotid gland (via otic ganglion in infratemporal fossa).
- **X** SVA: from taste receptors at base of tongue and epiglottis; GSA: from ext. ear and ext. aud. canal; GVA: from pharynx, larynx, thoracic and abdominal viscera; SVE: to muscles of palate, pharynx, and larynx; GVE: parasymp. to muscles of thoracic and abdominal viscera (via intramural ganglia).
- **XI** Cranial root: joins vagus (GVA to laryngeal muscles); spinal root (C1–C5): innervates trapezius and sternocleidomastoid muscles.
- **XII** GSE: to extrinsic and intrinsic muscles of tongue.

IV. NERVOUS SYSTEM ORGANIZATION

CN: Use very light colors for A and C. (1) The spinal cord has been placed behind the vertebral column in the main illustration to show the length of the cord and corresponding spinal cord regions in relation to the length and regions of the vertebral column. Note the descending spinal nerve roots (arrows coming off the cord) in the lumbar regions and below. (2) In coloring the spinal nerves and their peripheral branches at lower right, color over the lines representing them. (3) Color the motor ganglia of the autonomic nervous system (L and M) in the lower right drawing.

CENTRAL (CNS) NERVOUS SYSTEM: *

BRAIN: -/-
- CEREBRUM A
- BRAINSTEM B
- CEREBELLUM C

SPINAL CORD D / REGIONS: D
- CERV. G THOR. H LUM. I SAC. J CO K

The nervous system consists of neurons arranged into a highly integrated central part (central nervous system, or CNS) and bundles of neuronal processes (nerves) and islands of neurons (ganglia) largely outside the CNS making up the peripheral part (peripheral nervous system, or PNS). These neurons are supported by neuroglial cells, and a rich blood supply. Neurons of the CNS are interconnected to form centers (nuclei; gray matter) and axon bundles (tracts; white matter). The brain is the center of sensory awareness and movement, emotions, rational thought and behavior, foresight and planning, memory, speech, language and interpretation of language.

The *spinal cord*, an extension of the brain beginning at the foramen magnum of the skull, traffics in ascending/descending impulses, and is a center for spinal reflexes, source of motor commands for muscles below the head, and receiver of sensory input below the head.

PERIPHERAL (PNS) NERVOUS SYSTEM: *

CRANIAL NERVES (12 PAIR) E

SPINAL NERVES/BRANCHES F
- CERVICAL (8) G'
- THORACIC (12) H'
- LUMBAR (5) I'
- SACRAL (5) J'
- COCCYGEAL (1) K'

AUTONOMIC NERV. SYS. L M *
- SYMPATHETIC DIV. L
- PARASYMPATHETIC DIV. M

The PNS consists largely of bundles of sensory and motor axons (nerves) radiating from the brain (*cranial nerves*) and spinal cord (*spinal nerves*) segmentally and bilaterally and reaching to all parts of the body (visceral and somatic) through a classic pattern of distribution. *Branches* of spinal nerves are often called peripheral nerves. Nerves conduct all sensations from the body to the brain and spinal cord, and conduct motor commands to all the skeletal muscles of the body. The *autonomic nervous system* (ANS) is a subset of ganglia and nerves in the PNS dedicated to visceral movement and glandular secretion, and the conduction of visceral sensations to the spinal cord and brain.