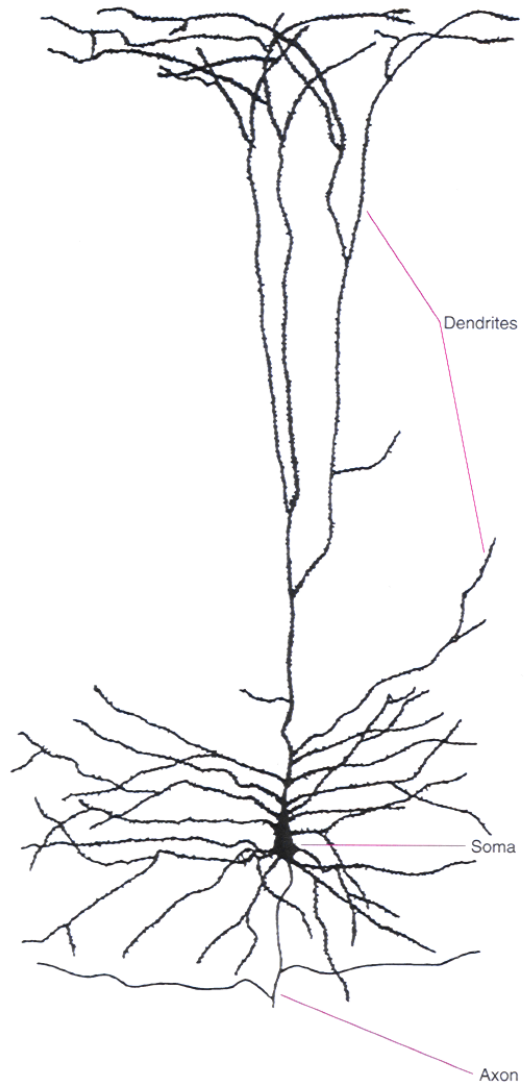
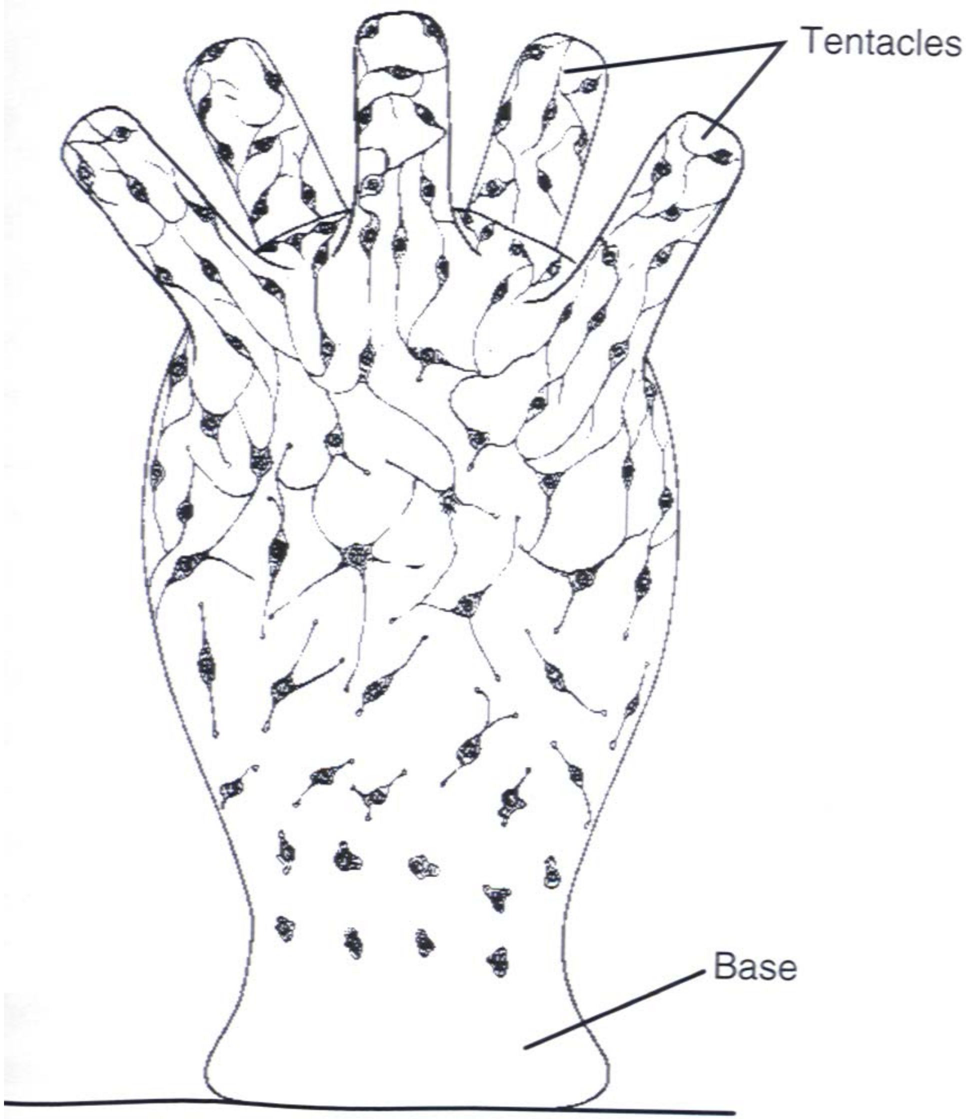


FIGURE 2.2 A typical neuron in the cerebral cortex. The soma gives rise to a single apical dendrite that branches, and many basal dendrites that emerge, near the base of the soma. A single branched axon with smooth contours is also observed. The jagged appearance of the dendrites is due to tiny protrusions termed "spines" where the synaptic apparatus is located. Adapted from Cajal.[3]



URE 2.4 The nerve net of the hydra, a simple cnidarian, is
d diffusely around the animal. This drawing shows maturation
nerve net in a hydra bud, starting near the base and finishing
he tentacles. Refer to McConnell.[5]

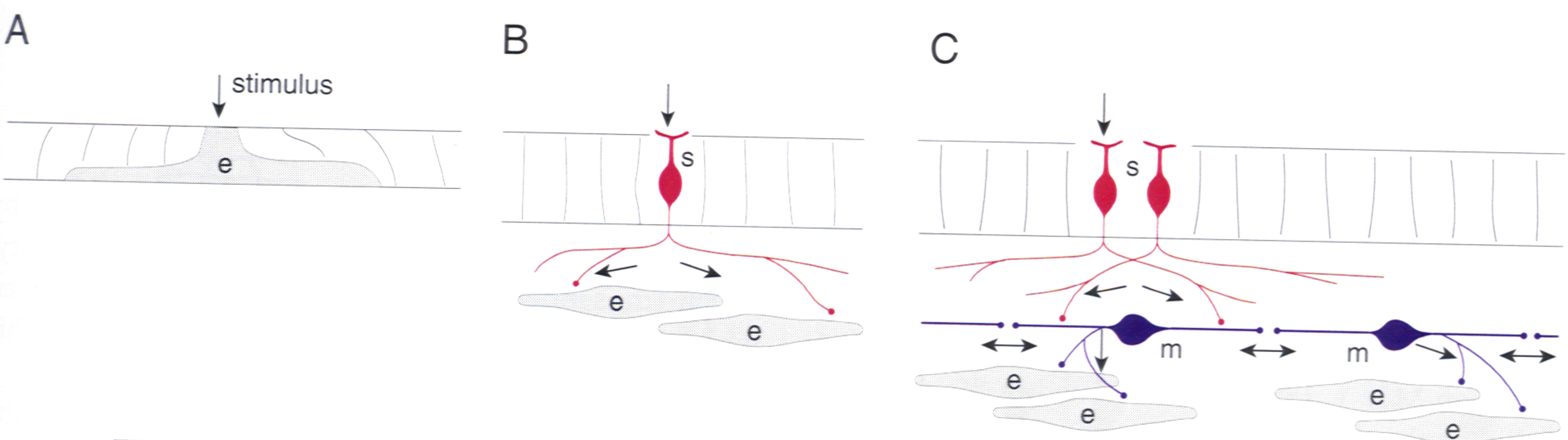


FIGURE 2.3 Activation of effector cells in simple animals. (A) Sponges lack a nervous system; stimuli act directly on effector cells (e), which are thus called independent effectors. (B) In cnidarians, bipolar sensory neurons (s) differentiate in the ectoderm (outer body layer). The outer process of the sensory neuron detects stimuli and is thus a dendrite. The inner process of some sensory neurons transmits information directly to effector cells and is thus an axon. Because this type of sensory neuron directly innervates effector cells, it is actually a sensorimotor neuron. (C) Most cnidarian sensory neurons send their axon to motor neurons (m), which in turn send an axon to effector cells. The motor neurons also have processes that interact with other motor neurons; these processes typically conduct information in both directions. Arrows show the direction of information flow.

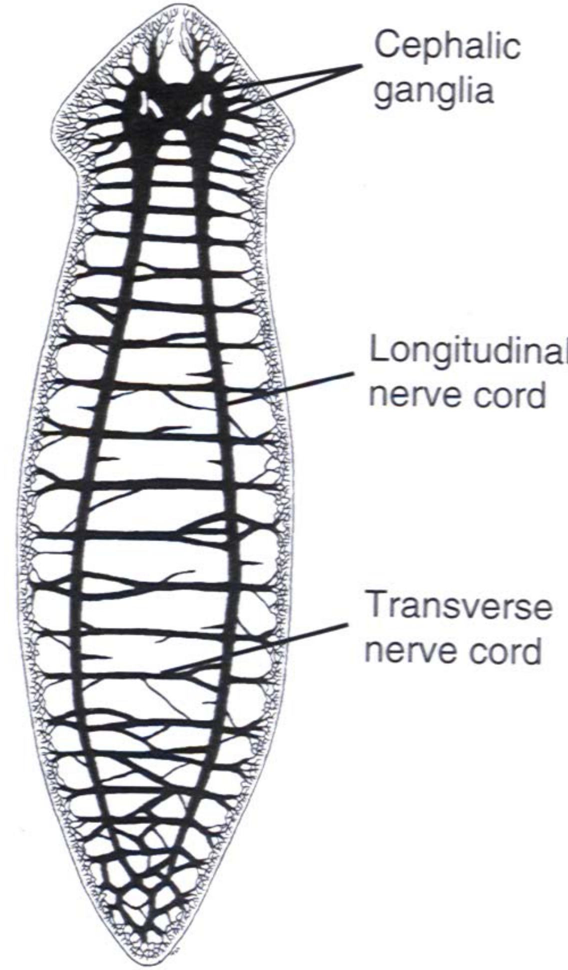


FIGURE 2.5 The nervous system of the planarian, a flatworm, includes longitudinal and transverse nerve cords associated with centralization and two fused cephalic ganglia in the rostral end associated with cephalization. Centralization and cephalization are probably related to the flatworm's bilateral symmetry and ability to swim forward rapidly. Refer to Lentz.[6] Reproduced with permission from Yale University Press.

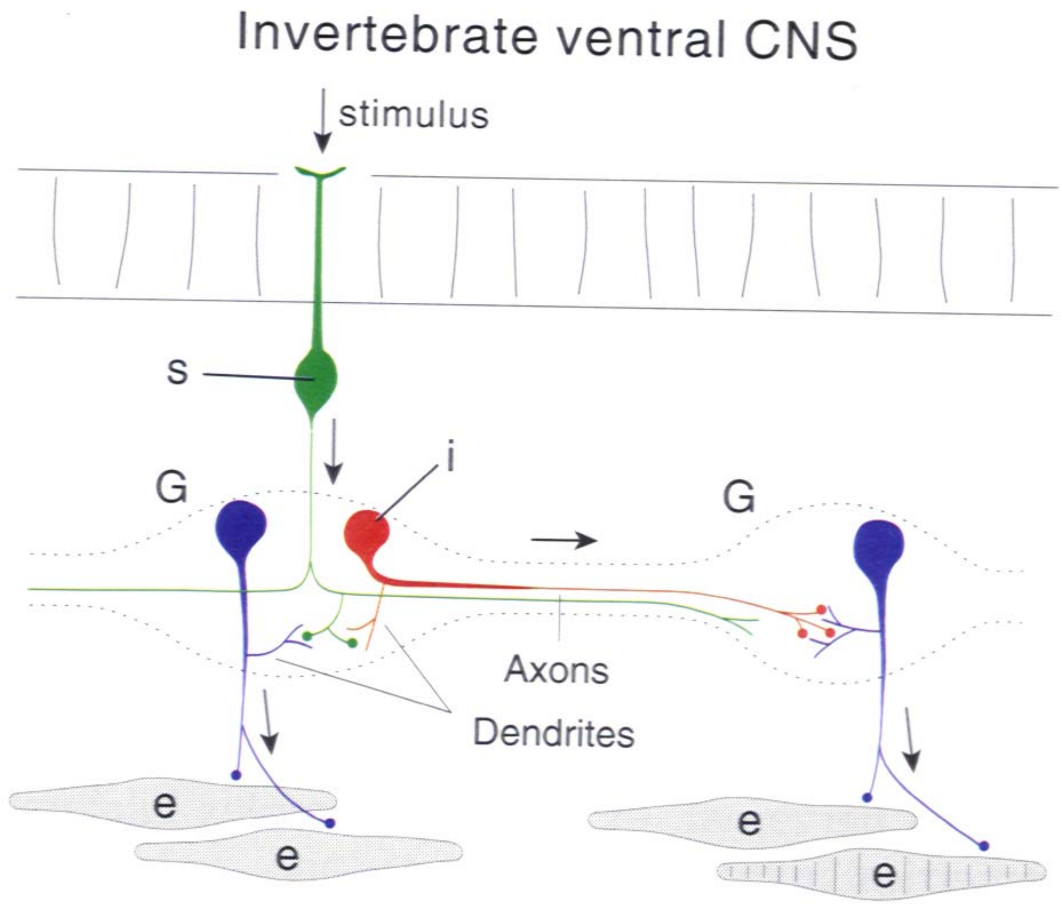


FIGURE 2.6 There are usually two kinds of neurons in invertebrate ganglia (G): motor neurons (m) and interneurons (i), both of which are typically unipolar, with dendrites arising from a single axon. In a typical invertebrate ganglion, neuronal somata are arranged around the outside and synapses occupy the central region, or neuropil. Sensory neurons (s) usually innervate motor neurons and interneurons but not effectors (e). Arrows show the direction of information flow.

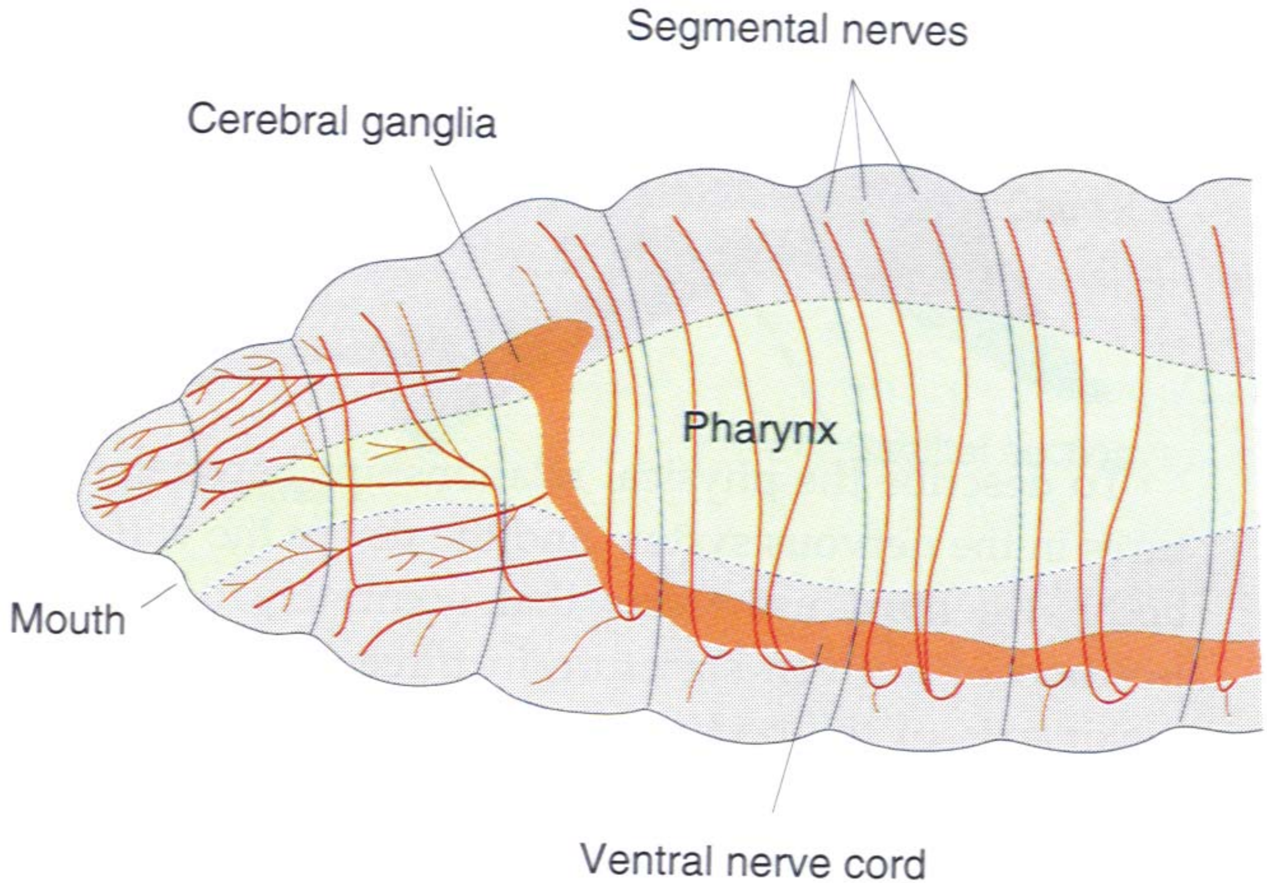


FIGURE 2.7 Organization of the nervous system in the rostral end of an annelid worm. A ventral nerve cord that contains more or less distinct ganglia connects with a fused pair of cerebral ganglia, which lie dorsal to the pharynx. Note the nerves arising from the ventral nerve cord and cerebral ganglia. Refer to Brusca and Brusca.[7]

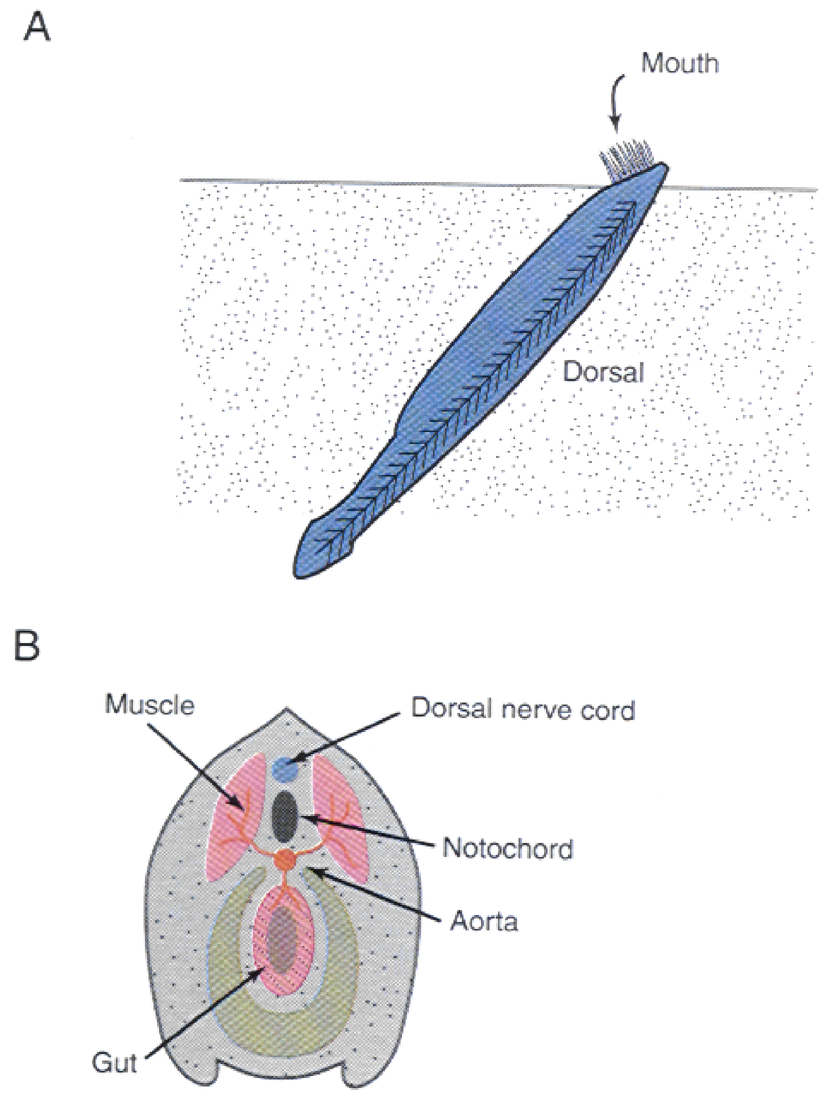


FIGURE 2.9 The lancelet is a prototypic vertebrate. (A) Lateral view of the animal in its native environment under the ocean floor, with its mouth protruding above the sand. (B) A cross-section of the lancelet showing the relationship between the dorsal nerve cord, the notochord, and the gut. Adapted from Cartmill *et al.*[8]

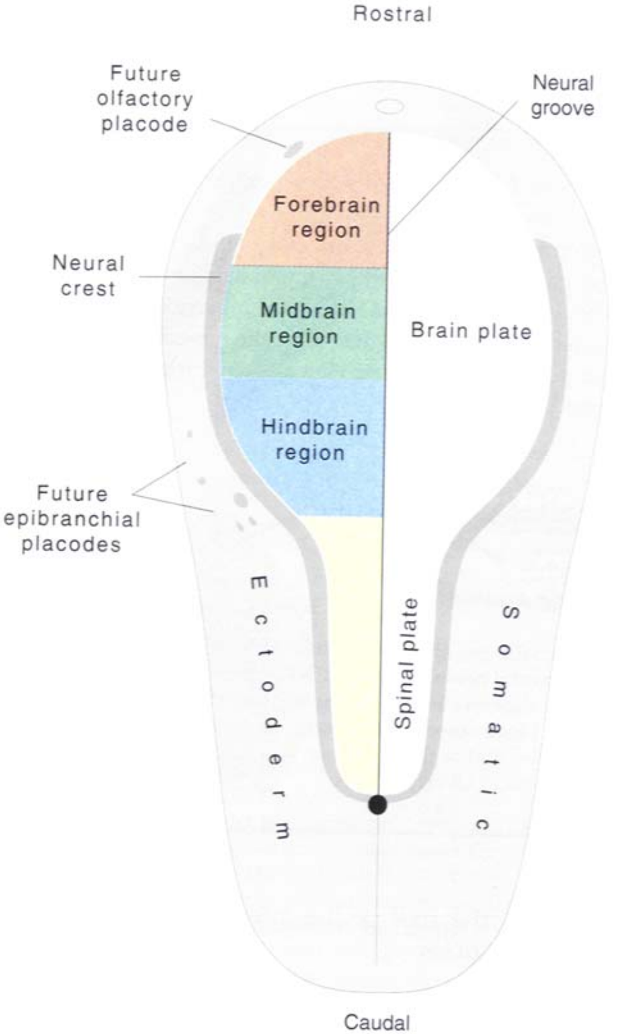


FIGURE 2.10 The neural plate is a spoon-shaped region of ectoderm (neural ectoderm) that forms the CNS. Ectoderm that lies outside the neural plate is called somatic ectoderm. The neural plate is polarized (the rostral end is wider than the caudal end), bilaterally symmetrical (divided by the neural groove), and regionalized (the rostral end forms the brain, and the caudal end forms the spinal cord). The neural crest lies along the junction between somatic and neural ectoderm, and a series of placodes develop as "islands" within the somatic ectoderm. The neural crest and placodes form the peripheral nervous system. The approximate location of future major brain divisions in the neural plate is shown in color on the left. The same color scheme is used in Figs. 2.11 and 2.12. Refer to Swanson.[12]

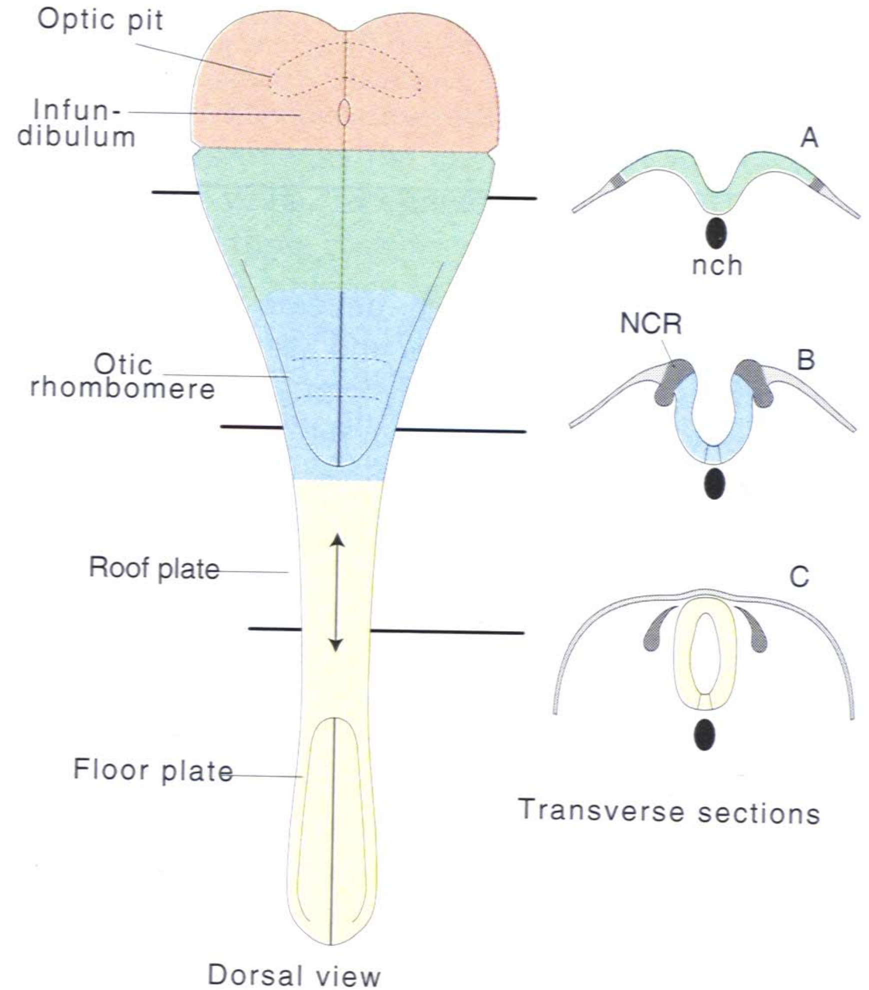
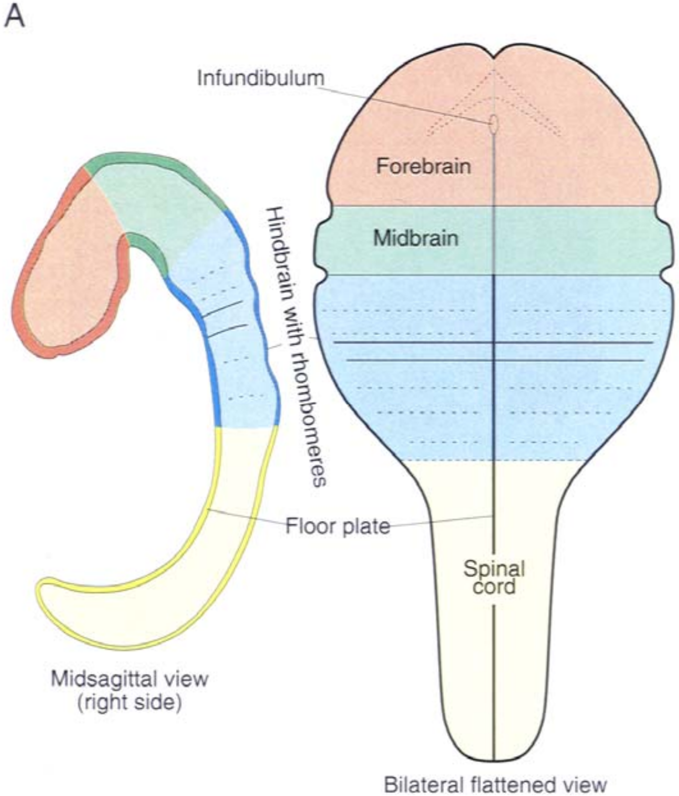


FIGURE 2.11 The optic pits, infundibulum, and otic rhombomere (dorsal view on left) are the earliest clear differentiations of the neural plate. The neural tube is formed by invagination of the neural ectoderm (transverse sections A and B), followed by fusion of the lateral edges of the neural plate (transverse section C). Fusion begins near the center of the neural plate (roughly the cervical region) and proceeds both rostrally and caudally (double arrow in roof plate). Note how the neural crest (NCR) pinches off in the process. Also note the position of the notochord (nch) just ventral to the neural groove. Refer to Swanson.[12]



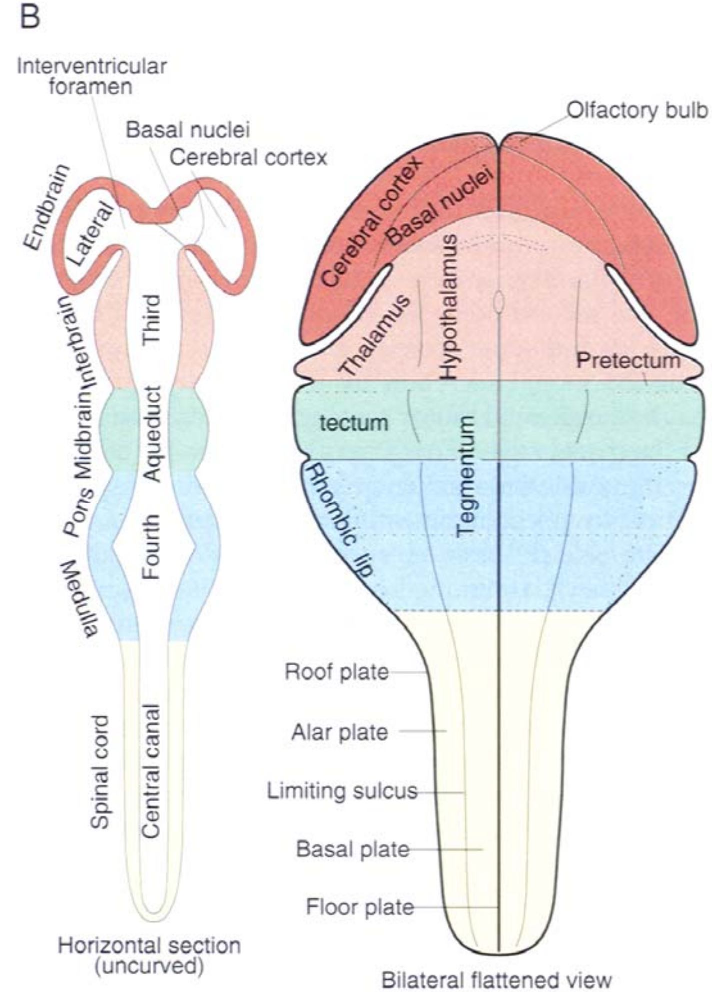


FIGURE 2.12 Formation and subdivision of the neural tube. (A) The brain region of the early neural tube develops three swellings: the forebrain, midbrain, and hindbrain vesicles. The hindbrain vesicle develops a series of transverse swellings called rhombomeres. (B) As neurulation continues, the forebrain vesicle differentiates into the right and left endbrain vesicles and a midline interbrain vesicle; the hindbrain vesicle differentiates into pontine and medullary regions. The endbrain vesicle further divides into the cerebral cortex (including the olfactory bulb) and basal nuclei; the interbrain vesicle divides into the thalamus, hypothalamus, and pretectum; the midbrain vesicle divides into the tectum and tegmentum; and the hindbrain divides into the basal plate (tegmentum), alar plate, and rhombic lip. At this stage of development, the major components of the adult ventricular system can be seen in the lumen of the neural tube. Refer to Swanson[12] and Alvarez-Bolado and Swanson.[15]

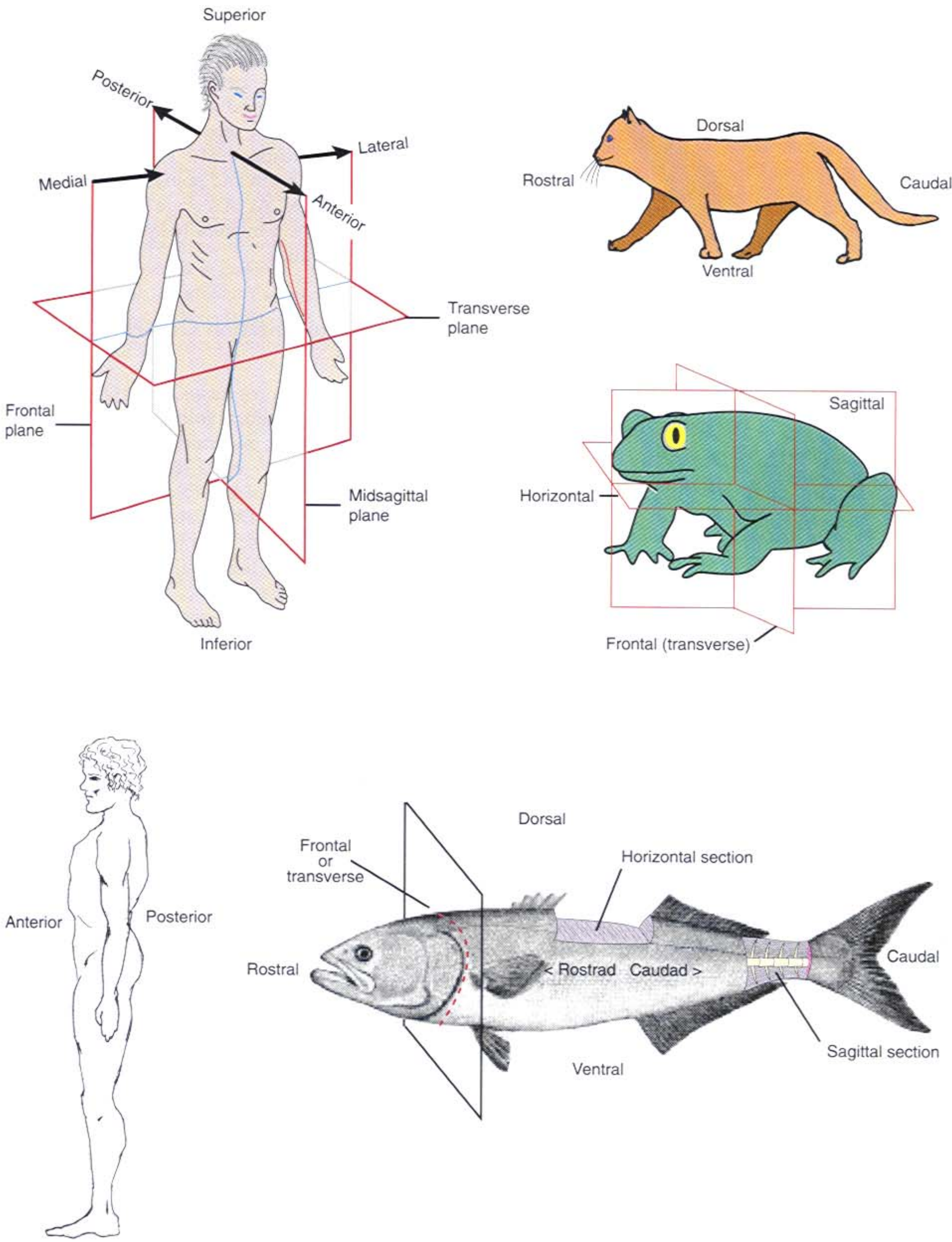


FIGURE 2.8 Orientation of the vertebrate body. Orientation planes for fish, quadrupeds, and bipeds are depicted.

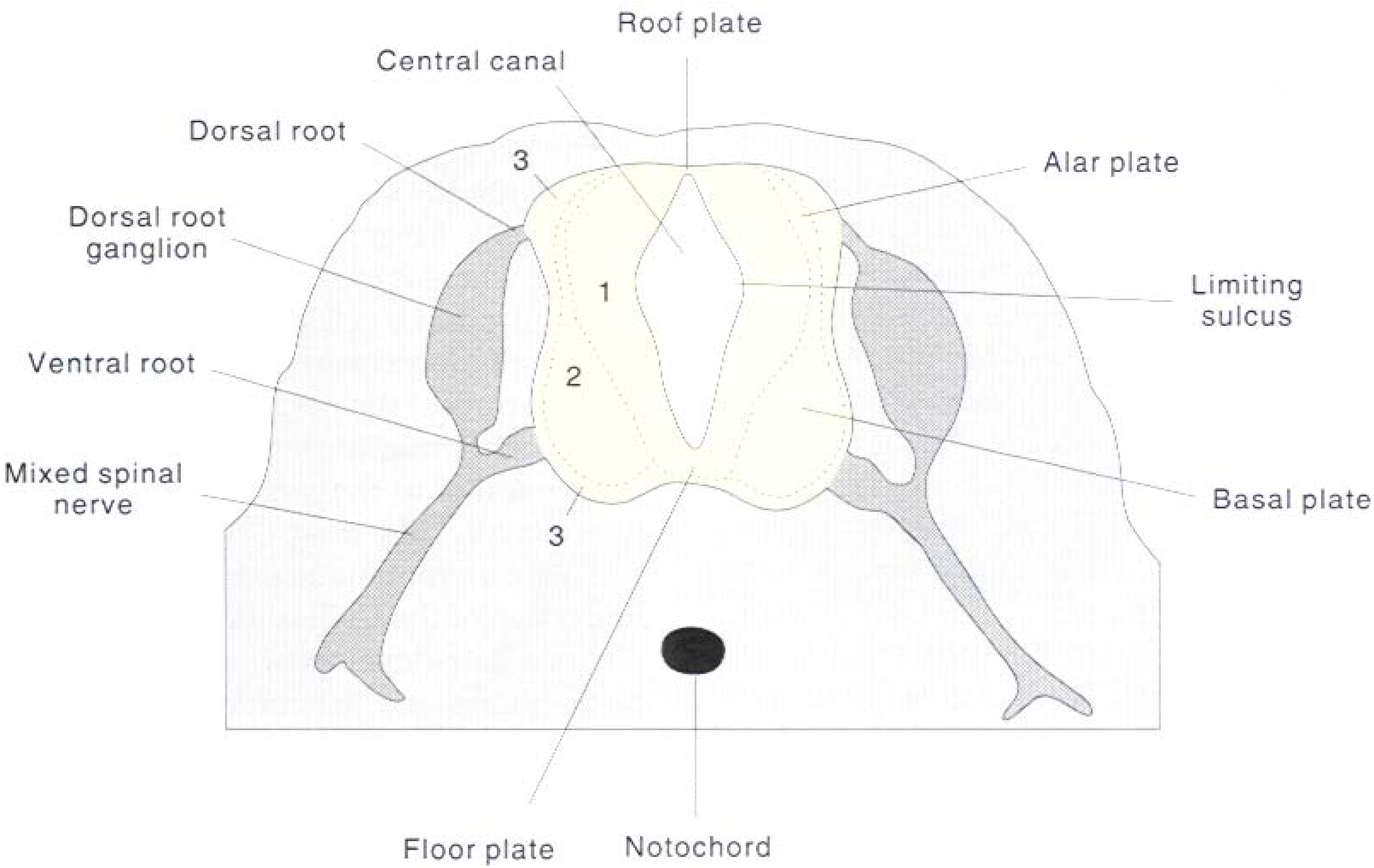
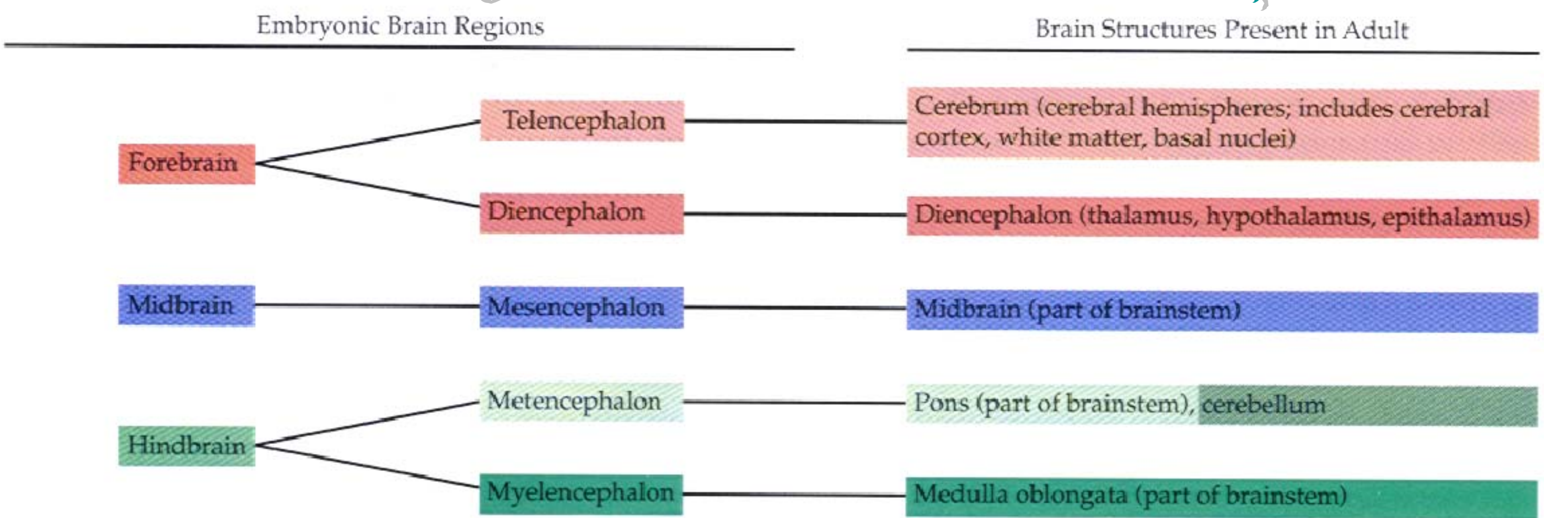


FIGURE 2.13 The early spinal cord and hindbrain are divided into dorsal (alar) and ventral (basal) plates by the limiting sulcus. This morphology reflects early ventral differentiation of the mantle layer (2), which is accompanied by an early ventral thinning of the ventricular (1) layer. This schematic drawing, which was traced from a transverse section of the spinal cord, also shows the dorsal (sensory) and ventral (motor) roots of the spinal cord; the dorsal root ganglia, which contain the somata of sensory neurons; and the mixed (sensory and motor) spinal nerves distal to the ganglia. The peripheral area (3) is called the marginal zone and develops into the spinal cord funiculi, which contain ascending and descending fiber tracts.

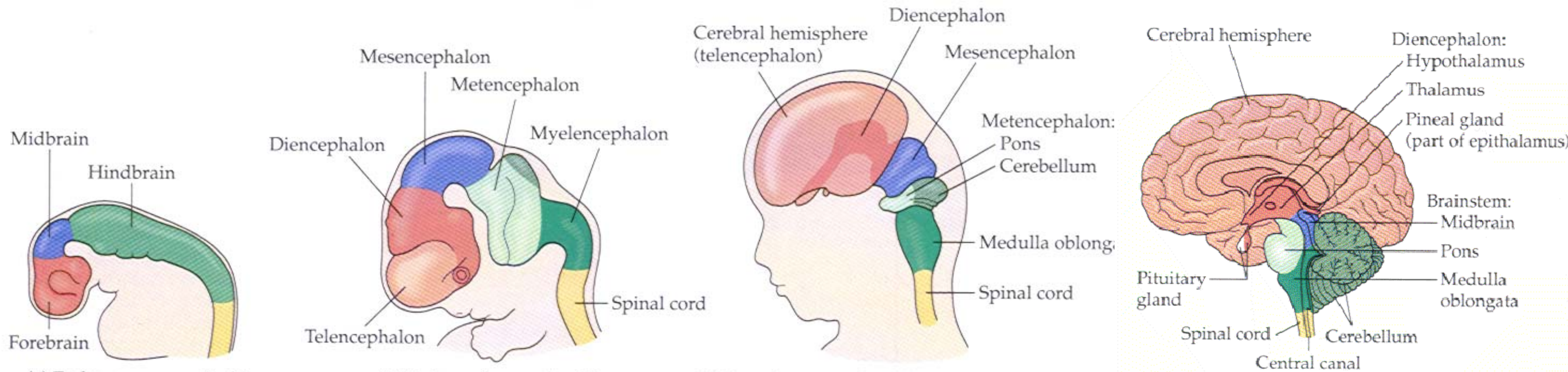
Nervous System

- Central Nervous System
  - Brain
  - Spinal cord
- Peripheral Nervous System
  - Sensory
  - Motor

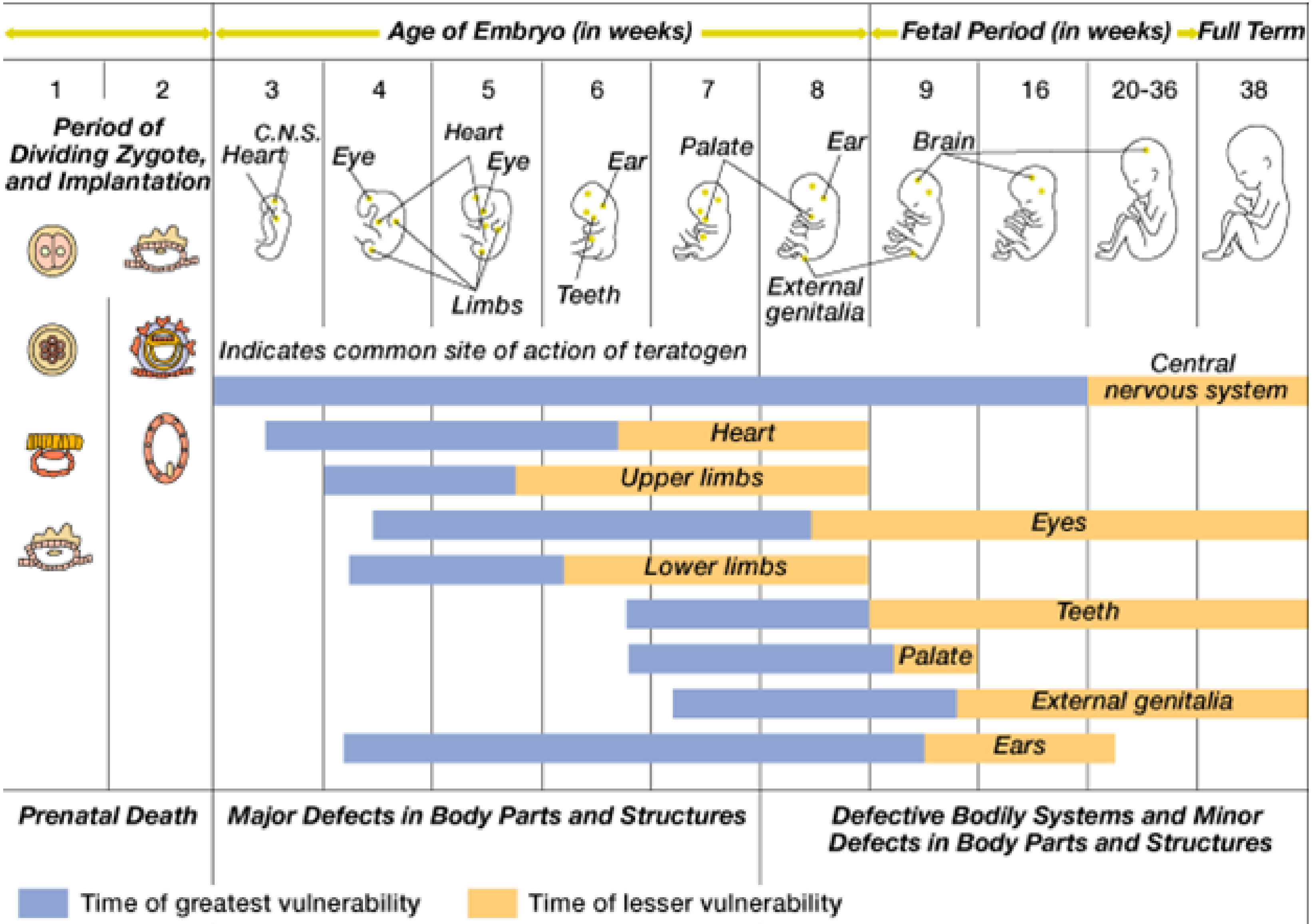
Summary of Brain Development



- The starts off with three simple parts and develops into five complex regions with their own functions.



(a) Embryo one month old **(b)** Embryo five weeks old **(c)** Fetus three months old **(d)** Adult



http://www.msu.edu/course/asc/333/casby/NeuroPrimer.html

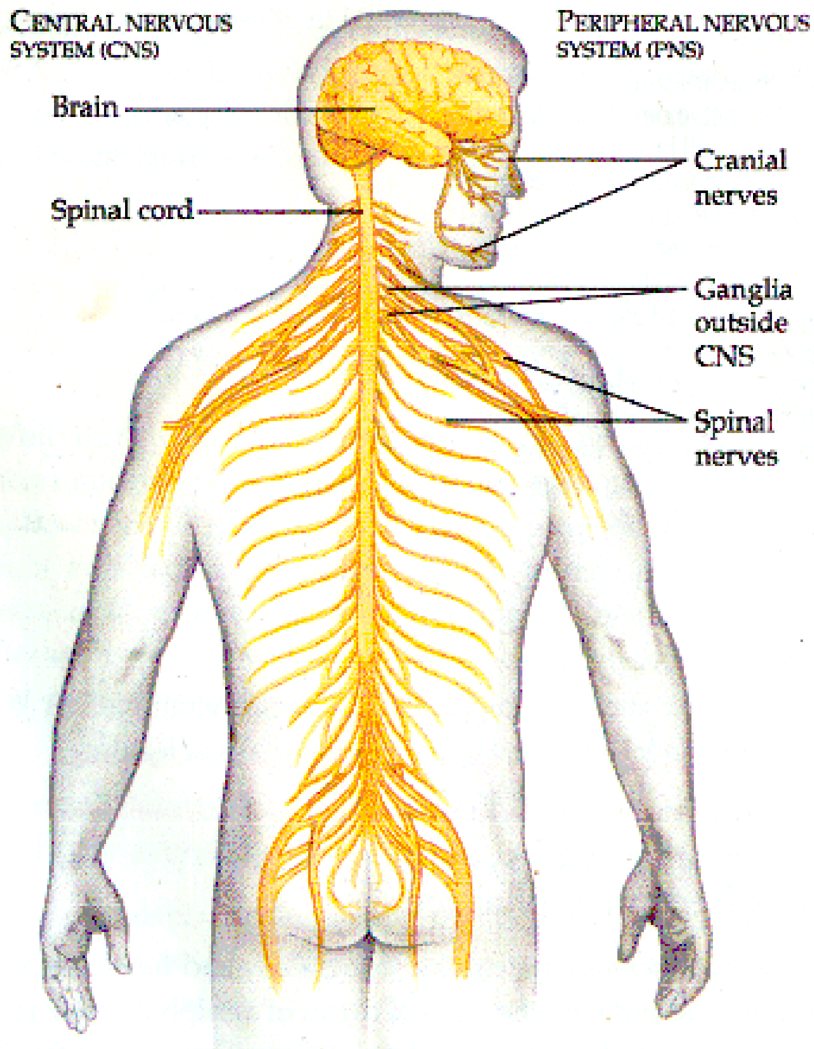


FIGURE 48.14 • The nervous system of a vertebrate. The vertebrate nervous system is highly centralized. The components of the central nervous system (brain and spinal cord) develop from the dorsal, hollow nerve cord, a hallmark of chordates. Cranial nerves (originating in the brain), spinal nerves (originating in the spinal cord), and ganglia outside the central nervous system make up the peripheral nervous system.

Human Brain

- Largest Brain to body ratio (w/w)
- Average weight 1.4 kg
- Over 1 billion neurons
- Cerebral Spinal Fluid (CSF) with a half life of about 3.5 hours

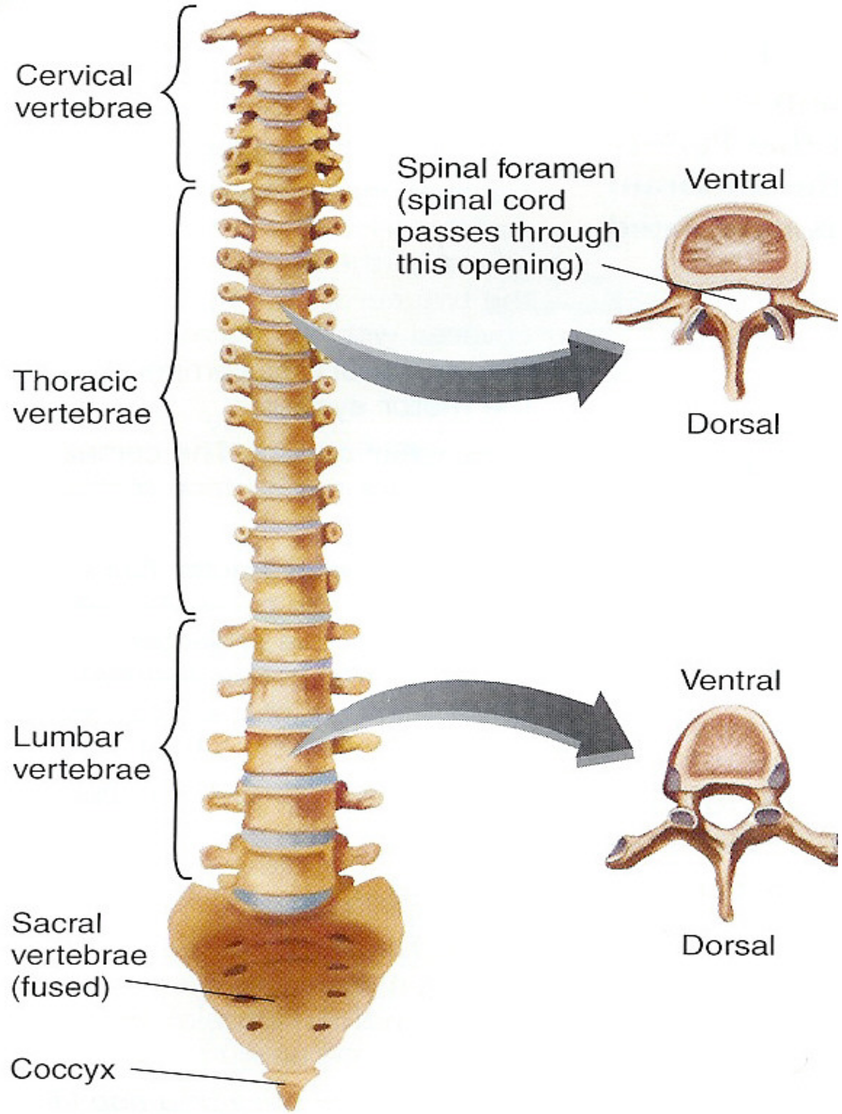


FIGURE 3.17

A ventral view of the human spinal column, with details showing the anatomy of the vertebrae.

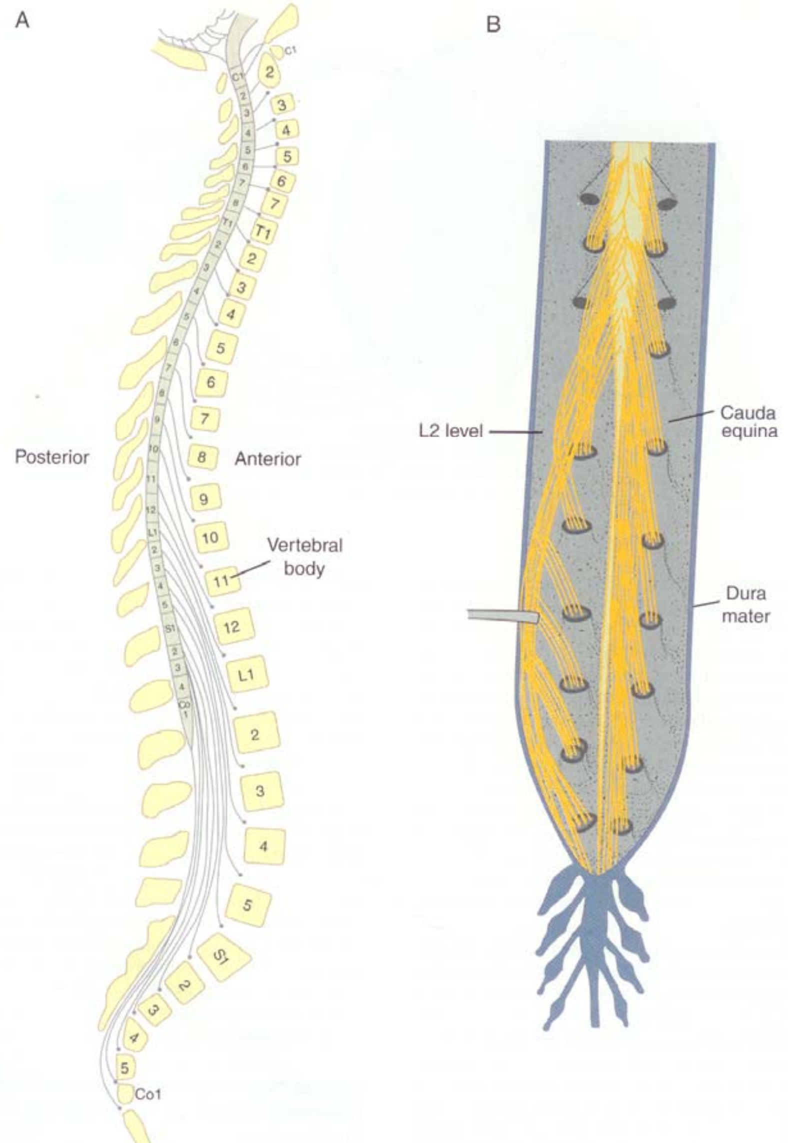
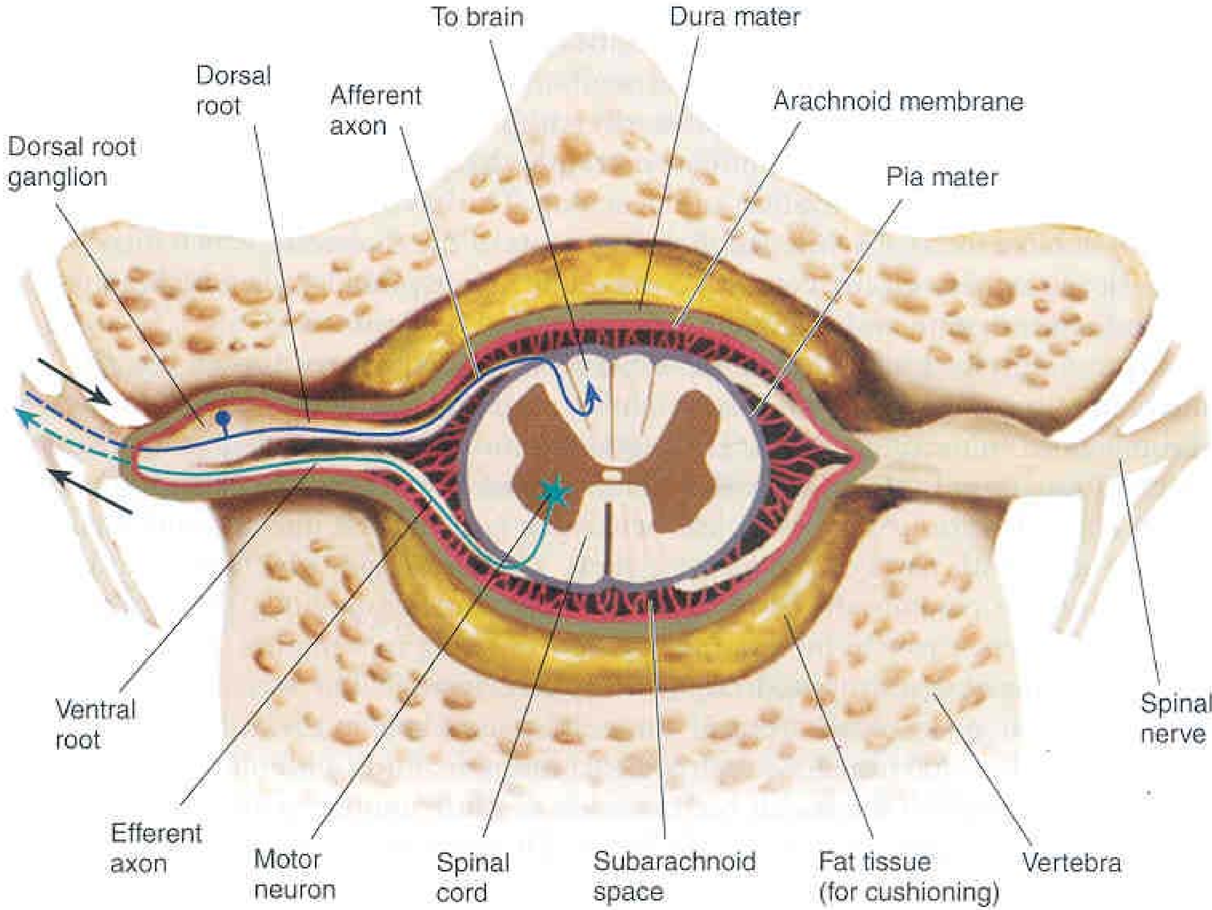
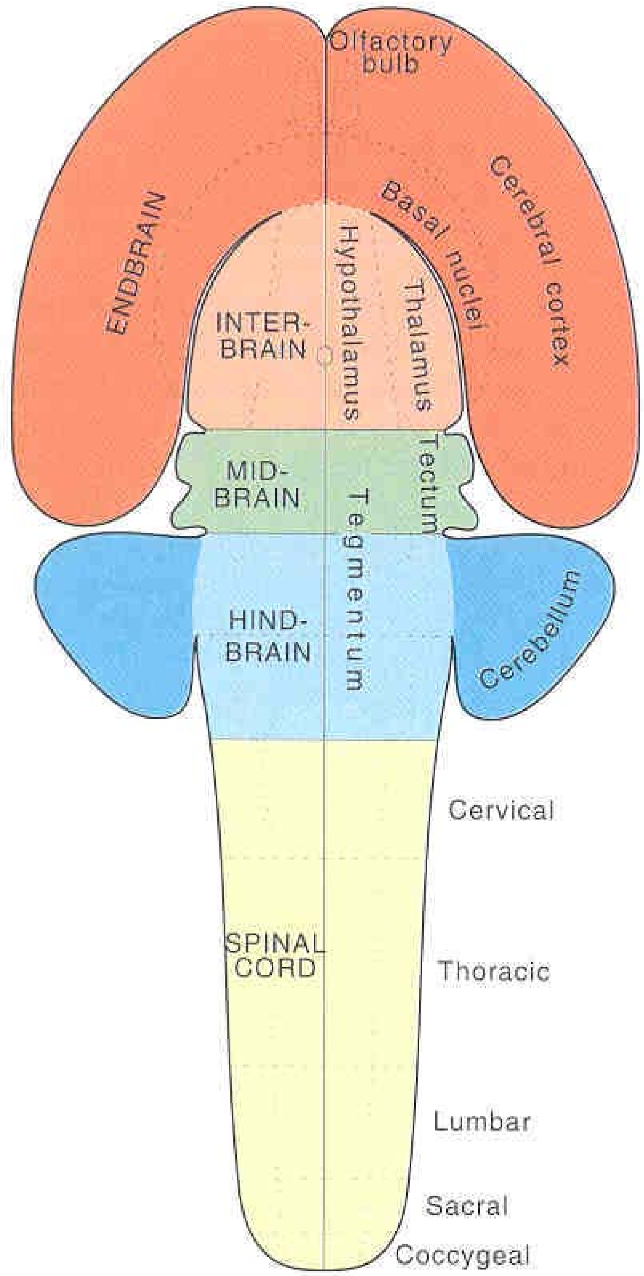


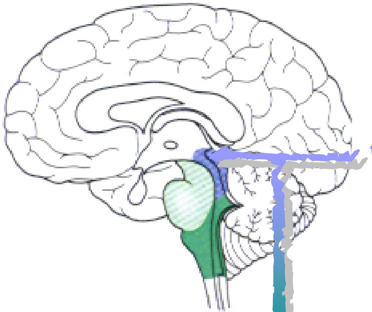
FIGURE 2.21 The spinal cord within the spinal column. (A) Mid-sagittal section of the back in the human. The spinal cord is considerably shorter than the vertebral column that encases it. The spinal cord extends only to level L1–L2, but the nerve rootlets emanating from each segment continue down to the appropriate vertebral column exit point. (B) The cauda equina ("horse tail") is formed from the collected nerve roots. The cauda equina exits the vertebral canal through the dura mater, which surrounds the spinal column.



To brain
Dura mater
Dorsal root
Afferent axon
Arachnoid membrane
Dorsal root ganglion
Pia mater
Ventral root
Spinal nerve
Efferent axon
Motor neuron
Spinal cord
Subarachnoid space
Fat tissue (for cushioning)
Vertebra



Olfactory bulb
ENDBRAIN
Cerebral cortex
Basal nuclei
INTER-BRAIN
Hypothalamus
Thalamus
MID-BRAIN
Tectum
Tegmentum
HIND-BRAIN
Cerebellum
SPINAL CORD
Cervical
Thoracic
Lumbar
Sacral
Coccygeal



The Brainstem

- Functions: data conduction &

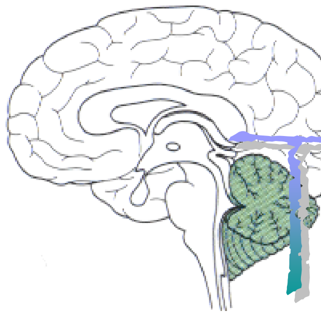
  : automatic activities essential for survival

- Made up of: the medulla oblongata, pons, & midbrain

- Medulla & pons: conduct sensory & motor signals between the spinal cord & upper brain

  : control involuntary actions

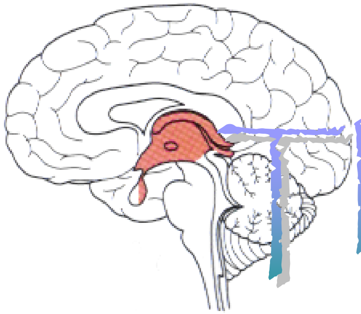
- Midbrain: receives, integrates, & projects sensory information upper brain



The Cerebellum

- Functions: controls coordination of movement & balance

: helps vertebrate learn and memorize motor responses



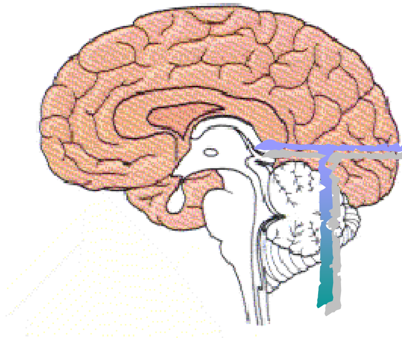
The Diencephalon

- Function: site of prominent neural processing & integrating centers
- Made up of: the epithalamus, hypothalamus, & thalamus
- Thalamus: directs neural input from the body to specific areas of the cerebral cortex (the outer, gray area)
- Hypothalamus: produces hormones

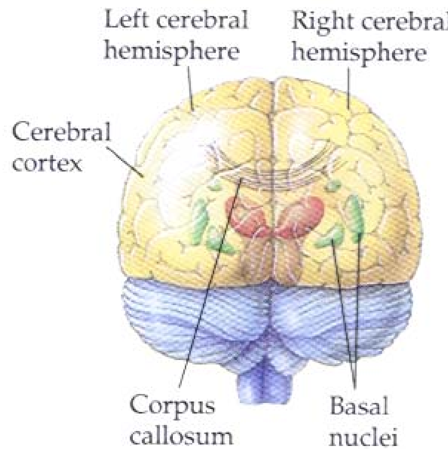
: regulates - survival mechanisms

- circadian rhythms

- sexual & fight-or-flight responses



The Cerebrum

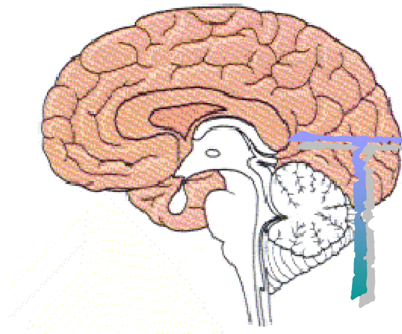


- Function: has the most complex integrating centers
- Divided into the left & right cerebral hemispheres, which consist of

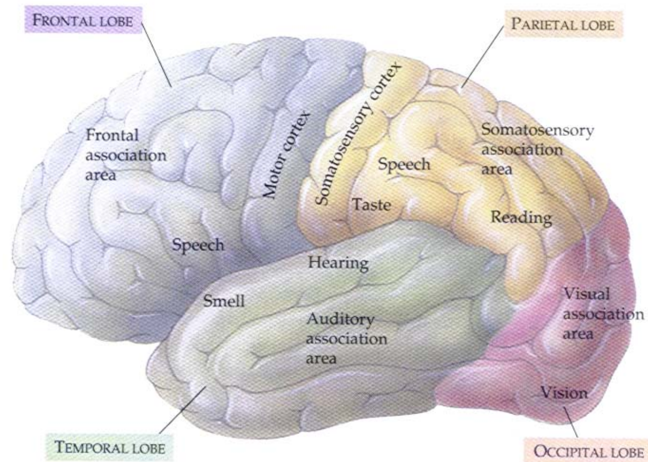
: the cerebral cortex (right & left sides held together by corpus callosum)

: white matter

: basal nuclei (motor coordination centers)



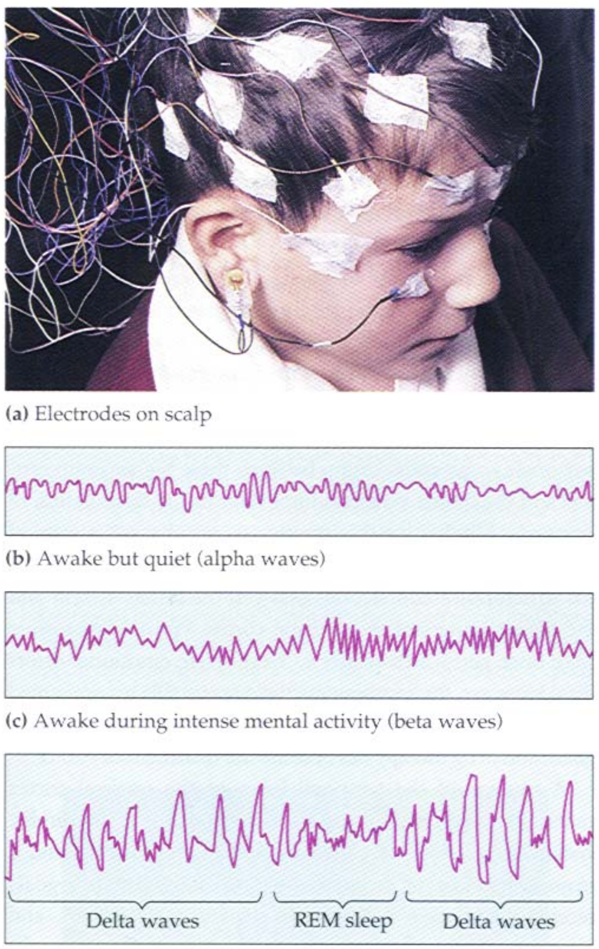
The Cerebrum



(b) Left side of brain

- The right & left sides of the cerebral cortex each have four lobes.
- Somatosensory and motor areas of different lobes directly process info. and association areas integrate info.
- Our sensory perceptions are produced by a complicated interchange of signals among receiving centers and association centers.

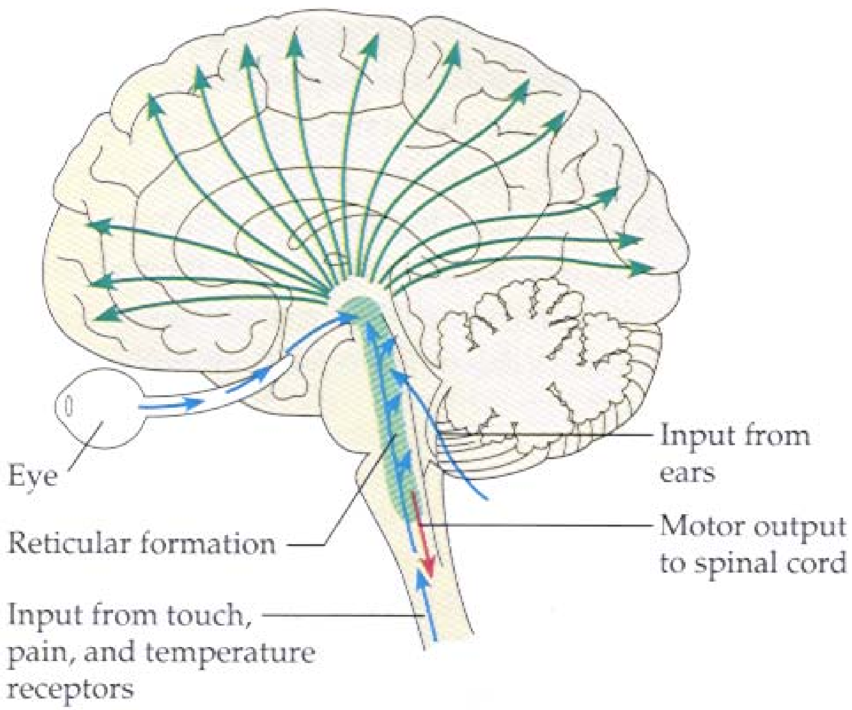
Research on the Brain



(a) Electrodes on scalp
(b) Awake but quiet (alpha waves)
(c) Awake during intense mental activity (beta waves)
(d) Asleep

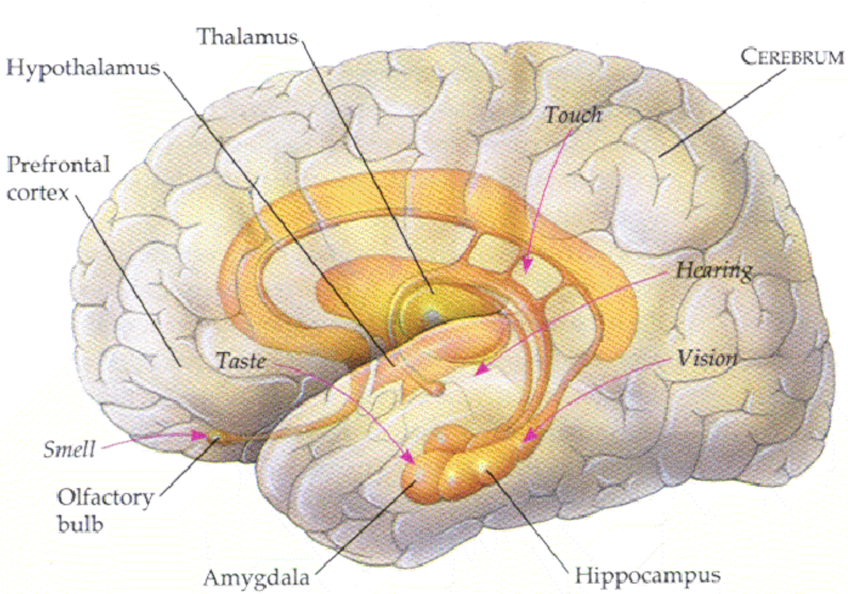
- Some aspects of brain research that are interesting include: arousal & sleep; lateralization, language, & speech; emotions; memory & learning; and consciousness.
- An electroencephalogram records the different patterns in the electrical activity of the brain produced during sleep and arousal.

Research on the Brain



- Several cerebellum and brainstem centers control sleep and arousal, such as the reticular system that filters sensory input sent to the cortex.
- The two hemispheres of the brain are specialized for different functions; the left hemisphere contains processes supporting speech, language, & analytical ability, while spatial perception and artistic ability predominate the right.

Research on the Brain



- Parts of the diencephalon and inner portions of the cerebral cortex (amygdala & hippocampus) form the center where human emotions arise and memory is retrieved and processed.
- There is long-term & short-term memory.
- Consciousness is when you can be aware of your surroundings and make conscious judgments about it.

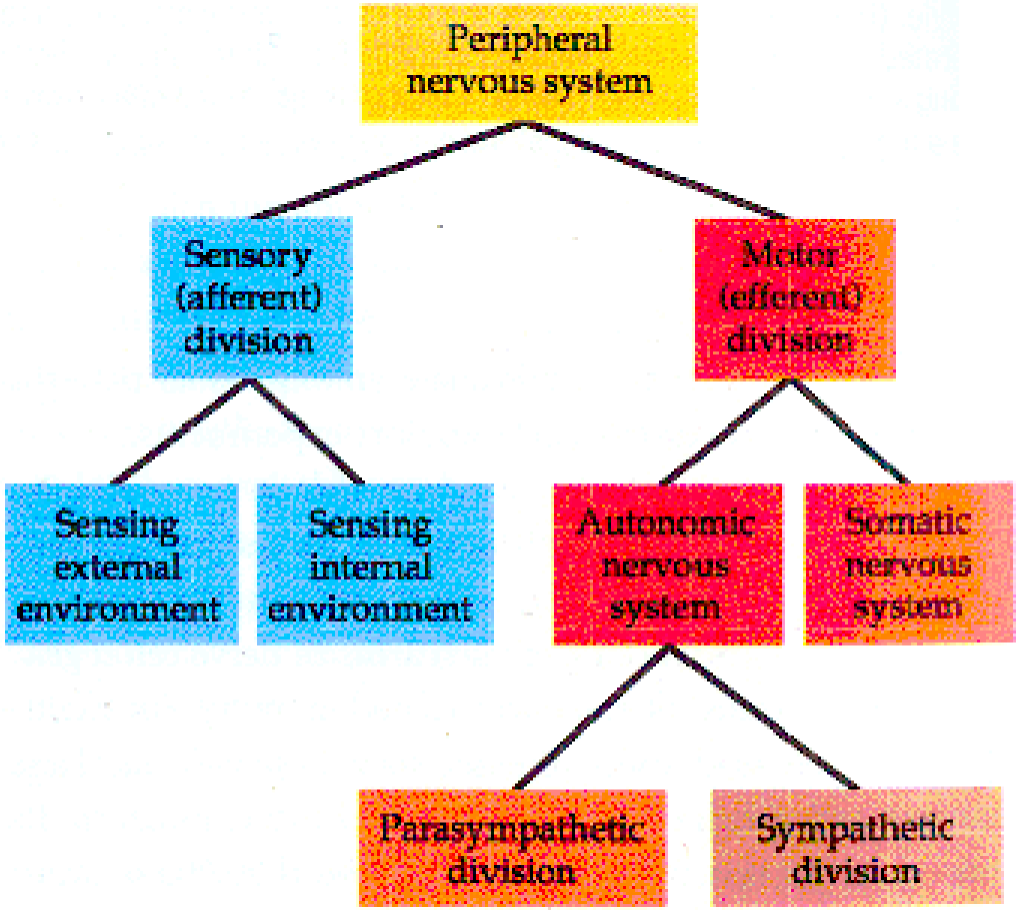
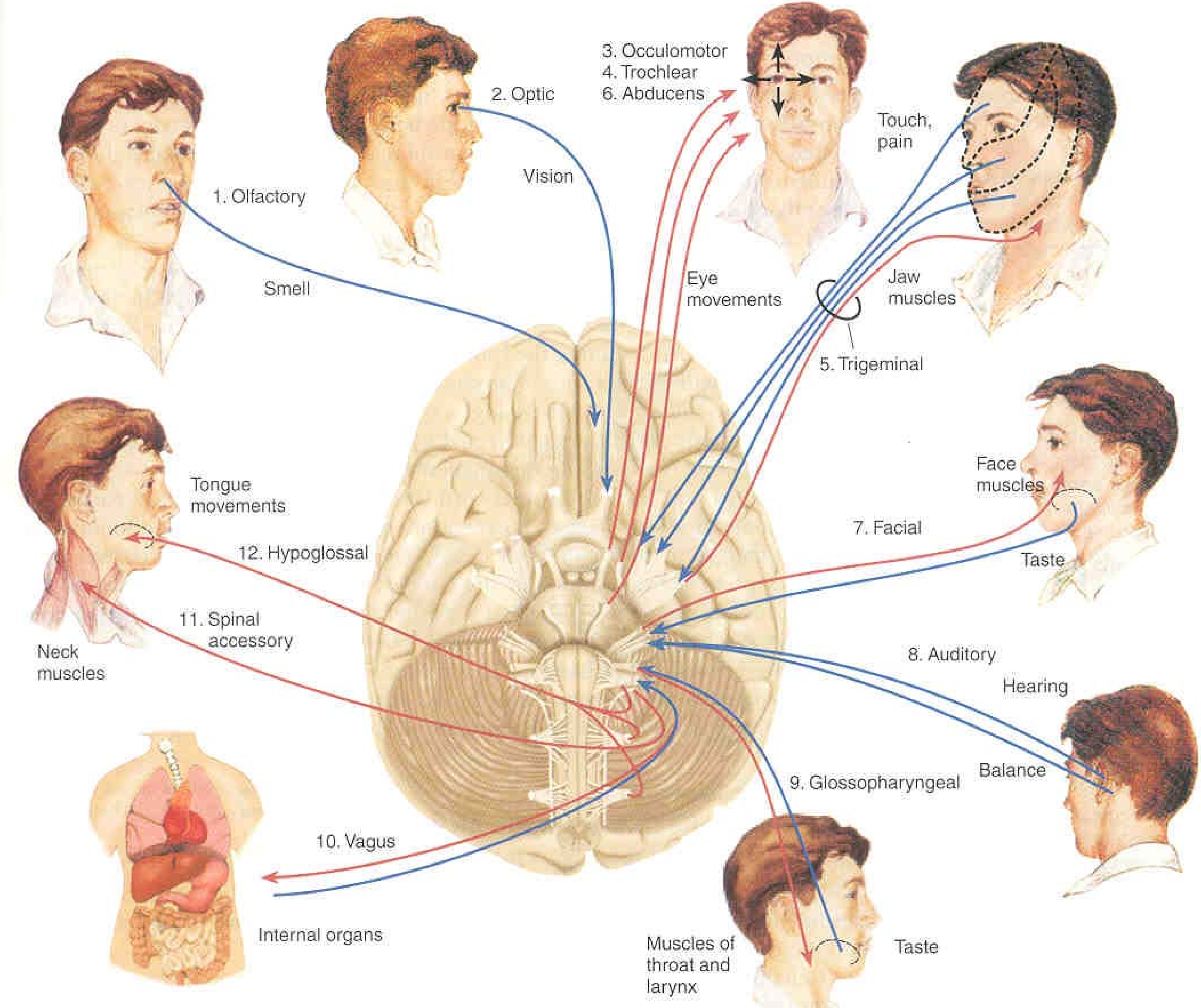


FIGURE 48.15 • Functional hierarchy of the peripheral nervous system. The nerves and ganglia of the vertebrate PNS convey information throughout the body. Sensory and motor divisions of the PNS are organized into a functional hierarchy.


1. Olfactory
Smell
2. Optic
Vision
3. Occulomotor
4. Trochlear
6. Abducens
Eye movements
Touch, pain
Jaw muscles
5. Trigeminal
Tongue movements
12. Hypoglossal
11. Spinal accessory
Neck muscles
Face muscles
7. Facial
Taste
8. Auditory
Hearing
Balance
9. Glossopharyngeal
10. Vagus
Internal organs
Muscles of throat and larynx
Taste

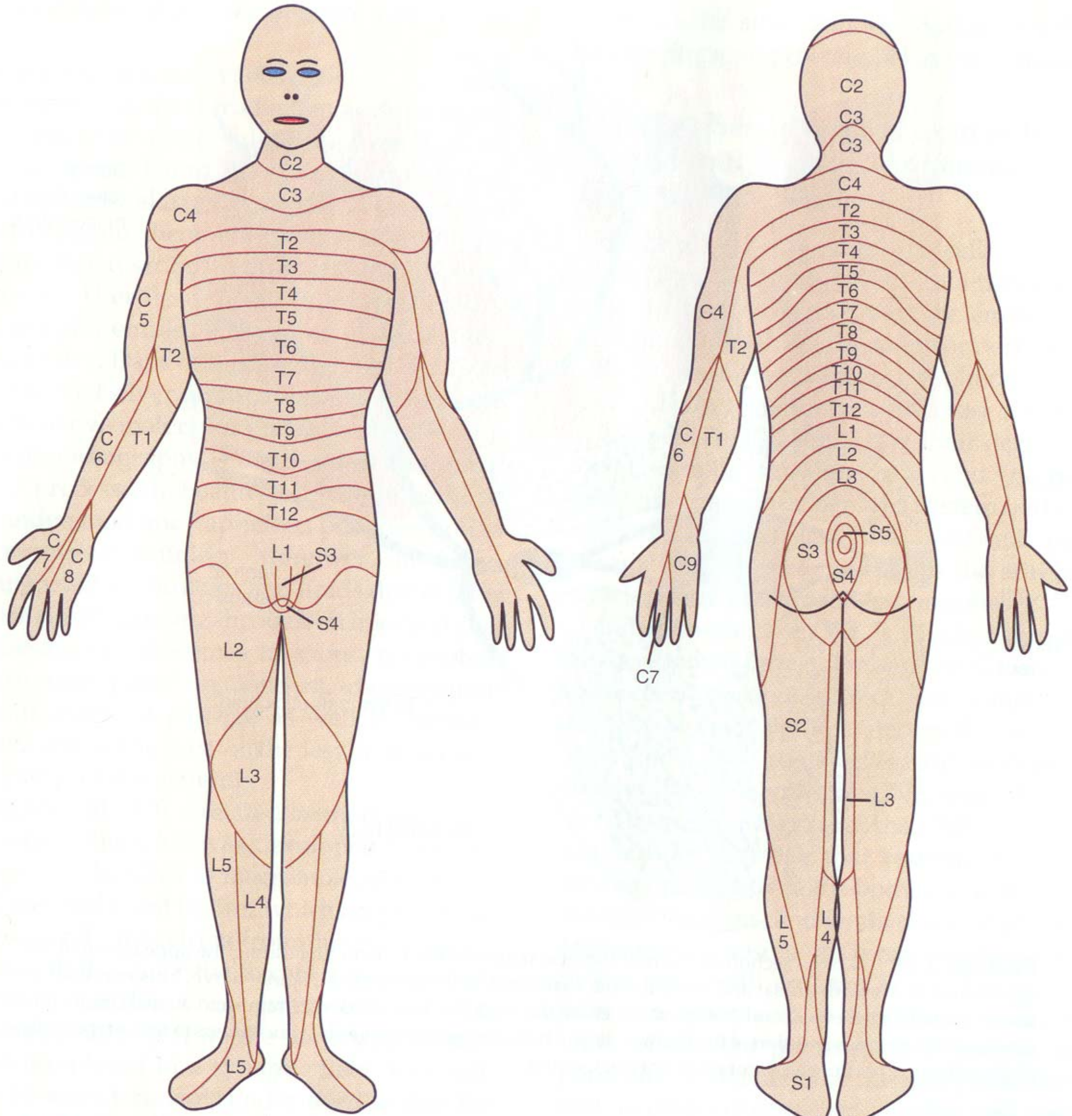
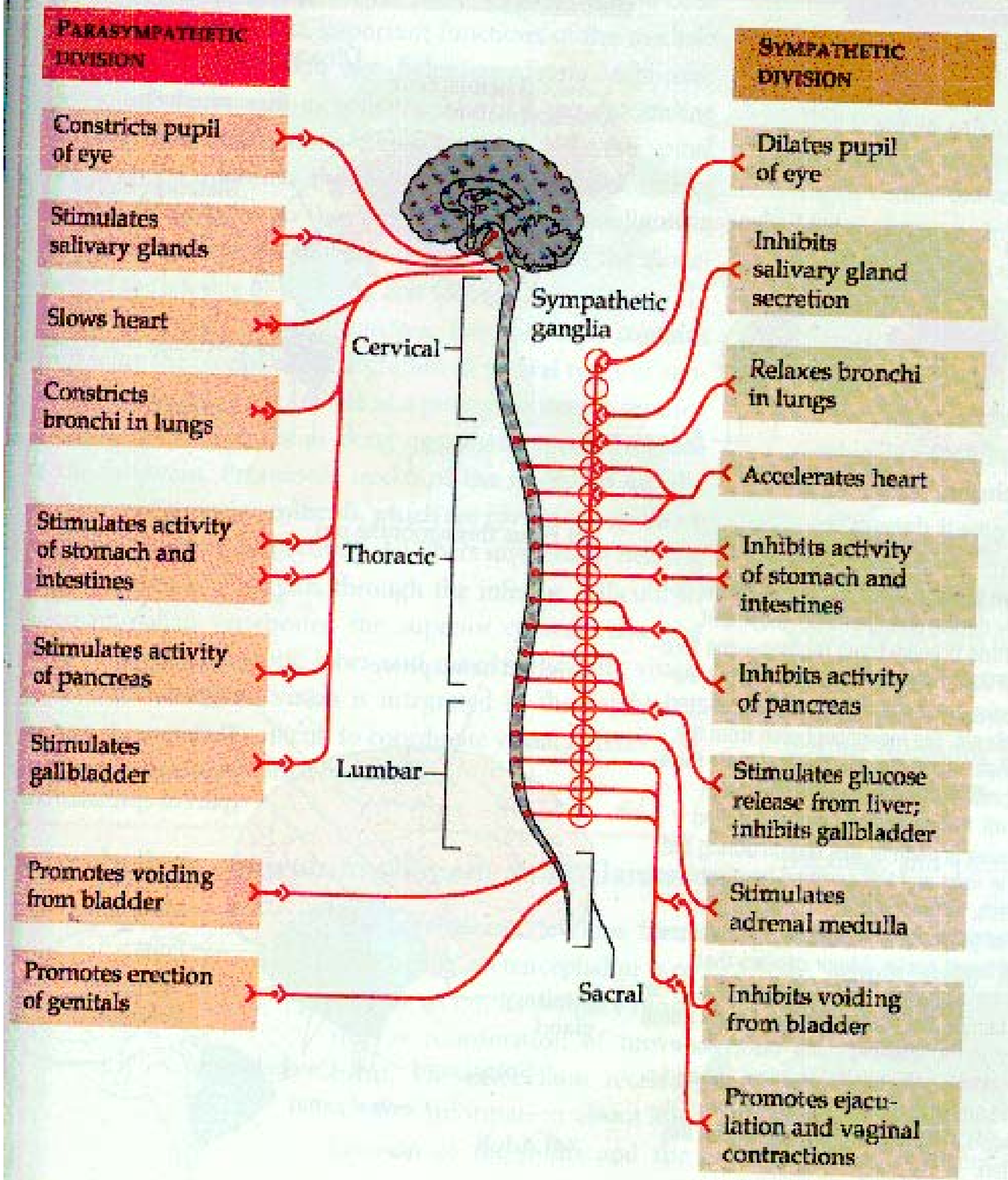


FIGURE 2.19 A dermatome map of the human body. The spinal cord level that selectively innervates each dermatome is indicated. Note the twisting of the dermatomes of the lower limb, which arises from rotation of that limb as it develops to accommodate bipedal motion.



PARASYMPATHETIC DIVISION
SYMPATHETIC DIVISION
Constricts pupil of eye
Stimulates salivary glands
Slows heart
Constricts bronchi in lungs
Stimulates activity of stomach and intestines
Stimulates activity of pancreas
Stimulates gallbladder
Promotes voiding from bladder
Promotes erection of genitals
Dilates pupil of eye
Inhibits salivary gland secretion
Sympathetic ganglia
Relaxes bronchi in lungs
Accelerates heart
Inhibits activity of stomach and intestines
Inhibits activity of pancreas
Stimulates glucose release from liver; inhibits gallbladder
Stimulates adrenal medulla
Inhibits voiding from bladder
Promotes ejaculation and vaginal contractions
Cervical
Thoracic
Lumbar
Sacral

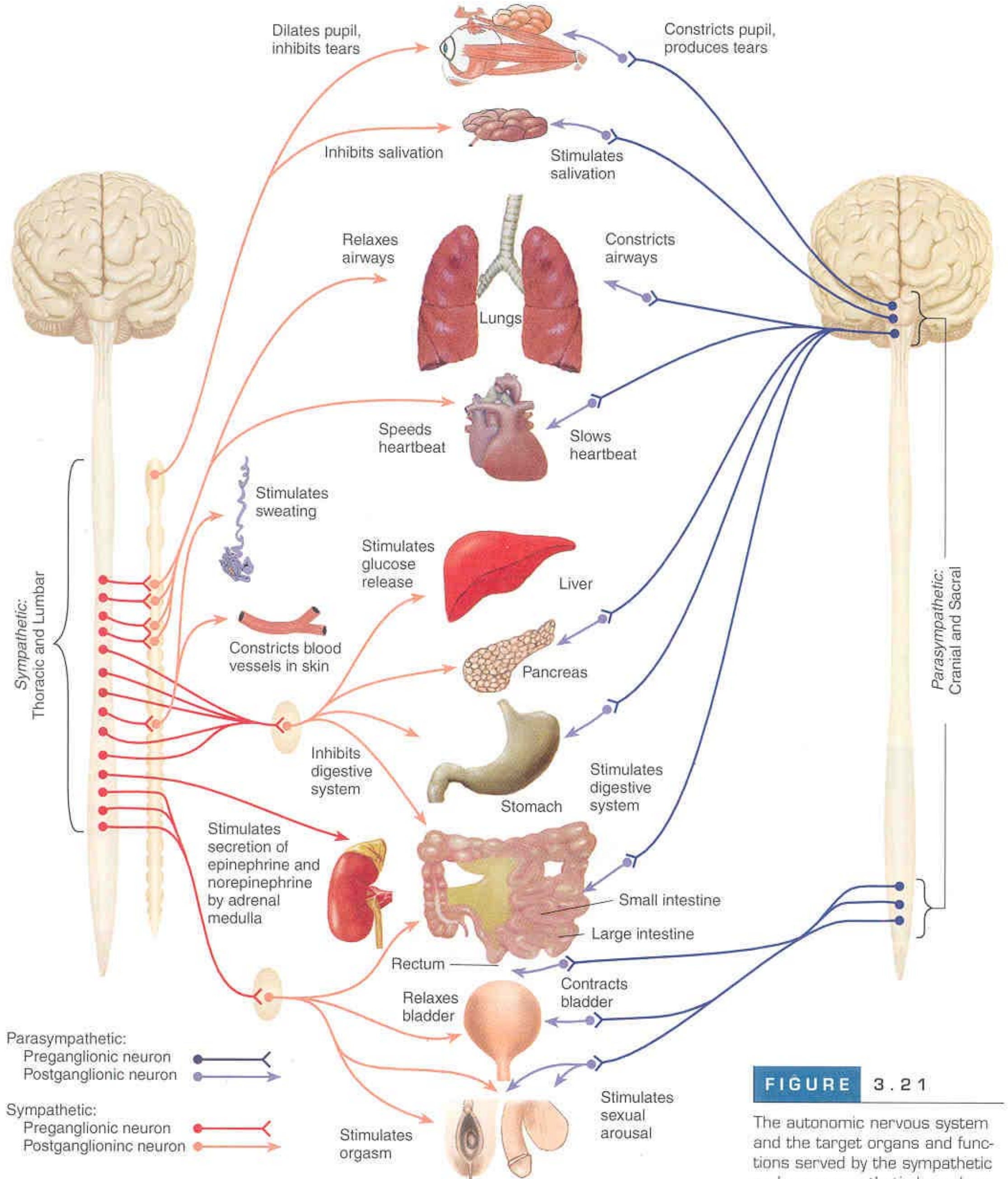
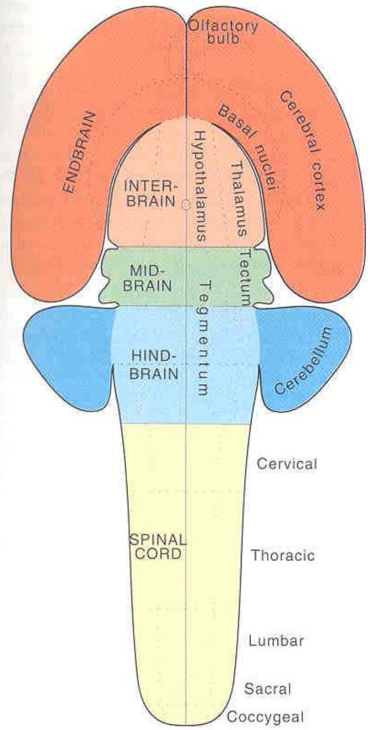


FIGURE 3.21

The autonomic nervous system and the target organs and functions served by the sympathetic and parasympathetic branches.



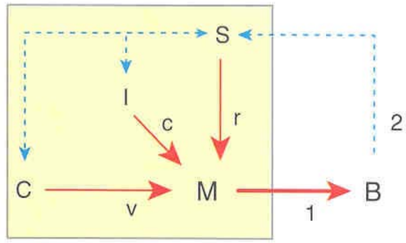


FIGURE 2.15 This model of information flow through the nervous system (inside the box) postulates that behavior (B) is determined by the motor system (M), which is influenced by three neural inputs: sensory (S), intrinsic (I), and cognitive (C). Sensory inputs lead to reflex responses (r), cognitive inputs produce voluntary responses (v), and intrinsic inputs act as control signals (c) to regulate the behavioral state. Motor system outputs (1) produce behaviors whose consequences are monitored by sensory feedback (2). Sensory feedback may be used by the cognitive system for perception and by the intrinsic system to generate affect. The cognitive, sensory, and intrinsic systems are all interconnected, hence the arrowheads at the end of each dashed line within the box (nervous system). Refer to Swanson.[16] Reprinted by permission of Oxford University Press.

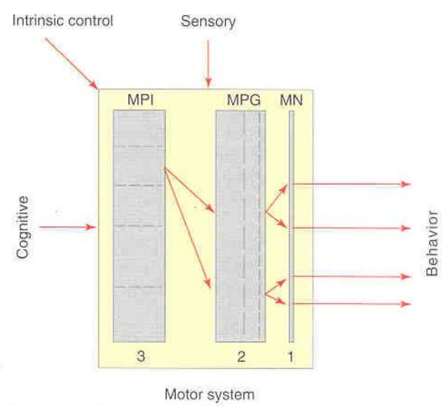


FIGURE 2.16 Hierarchical organization of the skeletal motor system. At the simplest level (1), pools of motor neurons (MNs) innervate individual muscles that generate individual components of behavior. At the next higher level (2), pools of interneurons referred to as motor pattern generators (MPGs) innervate specific sets of motor neuron pools. At the highest level (3), additional pools of interneurons referred to as motor pattern initiators (MPIs) innervate specific sets of MPGs. The MPIs can produce complex behaviors when they receive specific patterns of sensory, intrinsic, and cognitive inputs. Note that MPGs and MPIs may themselves be hierarchically organized as indicated by the dashed lines, and that sensory, intrinsic, and cognitive inputs may go directly to any level of the motor system. Refer to Swanson.[16] Reprinted by permission of Oxford University Press.