Unit 5: *5-1*, *5-2*, 5-3, *5-13*, 5-20, 5-24, *5-29*, 5-30, 5-33, 5-38, *5-44* (11)
Unit 6: *6-1*, 6-6, 6-7, 6-11, 6-25 (5)
Unit 7: *7-1*, 7-3, *7-4* (3)
Unit 8: *8-1* (1)
Unit 9: *9-1*, *9-2*, *9-3*, *9-10*, *9-11*, *9-12* (6)

c. The plates recommended for consideration in lower-division undergraduate courses of instruction, as well as related courses in schools of nursing, physical therapy, and so on, are listed below. The 81 plates listed represent approximately 55 hours of work, equivalent to 5 hours per week in an 11-week quarter or 3 to 4 hours per week in a 15- to 17-week semester. For reduced loads, consider the recommendations in paragraph b.

Unit 1: all (6)
Unit 2: 2-1 through 2-9, 2-12 (10)
Unit 3: 3-1, 3-2, 3-6 through 3-12 (9)
Unit 4: 4-1 through 4-5, 4-9 (6)
Unit 5: 5-1, 5-2, 5-3, 5-12, 5-13, 5-16, 5-20, 5-24, 5-26, 5-29 through 5-34, 5-35, 5-37, 5-40, 5-41, 5-44, 5-46 (21)
Unit 6: 6-1, 6-2, 6-4, 6-6, 6-7, 6-8, 6-11, 6-15, 6-17, 6-18, 6-19 (11)
Unit 7: 7-1, 7-3 through 7-6 (5)
Unit 8: all (4)
Unit 9: 9-1 through 9-4, 9-9 through 9-13 (9)

d. For upper-division students and students of graduate or professional schools such as medicine, chiropractic, psychology, and dentistry, who are all presumed to have had a solid background in biological science, the more detailed plates may be particularly applicable. Plates of particular significance to these students include 2-5 through 2-8, 2-10 through 2-12, 3-11, 4-4 through 4-13 (CNS pathways), and all of Units Five through Nine (115 plates, representing approximately 60 to 70 hours of work).

e. Professionals in the neurosciences or related fields, with neuroanatomy experience, may find useful Plates 2-5, 2-11, 3-11, 5-12, 5-19, 5-27, 5-28, 5-32, 5-34, and 9-4 through 9-8. An excellent review of the brain stem and cerebral hemispheres can be had by coloring Plates 5-4 through 5-11 and 5-35 through 5-48. For a review of circuits among brain stem and cerebral structures, see the table of contents and the index.

f. Frequent use of the index is strongly recommended for all users.

3. TIPS FOR COLORING THE PLATES

a. As you come to each plate, look over the entire illustration to get your bearings. Note the arrangement and order of titles. Contemplate a number of color arrangements before starting. Count the number of subscripts to find the number of colors you will need. Subscripts with exponents may receive the same color as the parent subscript, a shade of the same color, or a different pattern of the same color. Scan the coloring instructions on the text page for further guidance on choosing colors. In some cases, you may want to color related forms with different shades of the same color; in other cases, contrast is desirable. The more thought you put into the use of colors, the more information you will derive from the plate.

b. Read the coloring instructions. Follow the directions. These instructions have been developed after many coloring trials, and they work. The most important consideration is to link a structure and its title (printed in large outline or blank letters) with the same color. It is recommended that you color the title first and then its corresponding structure.

c. It is wise to scan the text before coloring. After coloring according to the directions, read the related text for color-reinforced learning. Then go to the next set of coloring instructions and continue as before. In the text, certain words are set in *italics*. The title of any structure to be colored will be set this way when it is first discussed in the text. This is to enable you to spot quickly the title of a structure to be colored. New terms may also be italicized when they are introduced.

d. In some cases, a plate of illustrations will require more colors than you have in your possession. Forced to use a color twice or three times on the same plate, you must take care to prevent confusion in identification and review by employing such a color on areas well separated from one another. Consider the use of different patterns of the same color (dots, dashes, etc.) to eliminate confusion.

e. On some plates, structures will require colors that were used for the same structures on a previous plate (this is especially true in Unit Three). In such cases, color the titles of the repeated structures first, regardless of where they appear on the plate. Then go back to the top of the title list and begin coloring in the usual sequence. In this way, you will be prevented from using a color already specified for another structure.

f. Now turn to any plate in the book and note the following aspects:

(1) Areas to be colored are bounded by heavy lines, and each such area usually has a pointer (leader) with a letter (subscript). Some boundaries between coloring zones may be represented by a dot or two or dotted lines. These represent a division of names (titles) and indicate that an actual structural boundary may not exist or, at best, is not

clearly visible. Lighter lines represent background, suggest texture, or define form and should be colored over if they exist within the confines of a heavier line. A light-line structure outside a heavy-line boundary, often marked with a no-color sign (-¦-), should not be colored.

(2) Any outline-lettered word followed by a subscript should be colored. The main title of the plate receives a black color, indicated by the symbol (●). Subheadings, which are used for organizational reasons, are indicated by a (★) and should be colored gray. An outline-lettered word followed by a subscript and parentheses, as A( ), is not represented by a single structure to be colored but by a composition of parts whose titles are listed below it with the same letter but different exponents. This word can be colored with a mixture of the colors used for its parts.

(3) If structures are duplicated on a plate, as in left and right parts, branches, or serial (segmented) parts, only one may be labeled with a subscript. If you come upon a structure bounded by a heavy line without a subscript, look for its complementary structure above it, below it, or on the other side of the midline: you will find the subscript there.

g. Throughout this book, and others of the Coloring Concepts Series, the following symbols are employed:

●	=	color black; generally reserved for headings and subheadings
★	=	color gray; generally reserved for subheadings
-¦-	=	do not color
A( )	=	as a subscript, signals that this structure is composed of the parts whose titles are listed below it with the same subscript but different exponents; receives same color or mosaic of colors used for parts; only its parts are labeled in the illustration
A^1, A^2, etc.	=	identical letter with different exponents implies parts so labeled are sufficiently related to receive same color or shade of the same color
N.S.	=	not shown

h. As a general rule, large areas should be colored with light colors, and dark colors should be used for small areas. Test your colors before you use them on this book. Take care with very dark colors; they obscure detail, texture lines, stippling, and subscripts (in the event they are located within the area to be colored).

i. In some cases, a structure will be identified by two subscripts (e.g., A + D). This indicates you are looking at one structure overlying another. In such a case, consider using two light colors or a pattern of lines or dots of one color superimposed over another.

1–1 INTRODUCTION TO THE HUMAN BRAIN

The human brain is the most complex mass of protoplasm on earth—perhaps even in our galaxy. A product of heredity and environment, operative for many tens of millions of years, this three-pound collection of cells is still of virtually unknown potential; yet what a history of achievement and what incredible promise for the future! Certainly no other group of cells sends travelers to the moon and soon beyond, creates the Declaration of Human Rights, reengineers genes, produces a Mozart sonata or a Turner landscape. In our search to understand the brain, we cannot expect simple answers to our questions.

What is the most significant achievement of this organ small enough to be held in one's hands? Perhaps it includes the ability to conceive of a universe a billion light-years or more across or a microcosmic world out of reach of our senses—in other words, to model worlds completely separate from the reality we can see, hear, feel, and smell.

Certainly one significant achievement is the ability of the brain to change in response to cultural diversity—with measurable chemical and structural changes! Indeed, our brains literally add nerve cell branches in response to training and learning, no matter what our age. Conversely, the brain is learning to reshape the environment in which we live and will both benefit from and suffer the consequences as it does.

The brain and its expressions are unique for every individual who has ever lived. Almost every organ of the body has the potential for being transplanted into another person. With the acceptance of each organ, the "persona" of the individual remains the same—except in the case of the brain. Transplant the brain, transplant the person, for the brain is the person. However, the brain does not carry out its functions alone; it is part of a total unit, the human body. The body is the support system for the brain and the brain for the body. The brain is dependent on the heart, liver, kidneys, lungs, and the immune system all working together.

Color the earth (A), in the upper left corner of the plate, and its title, Outer World. Then color the title Inner World (★) gray.

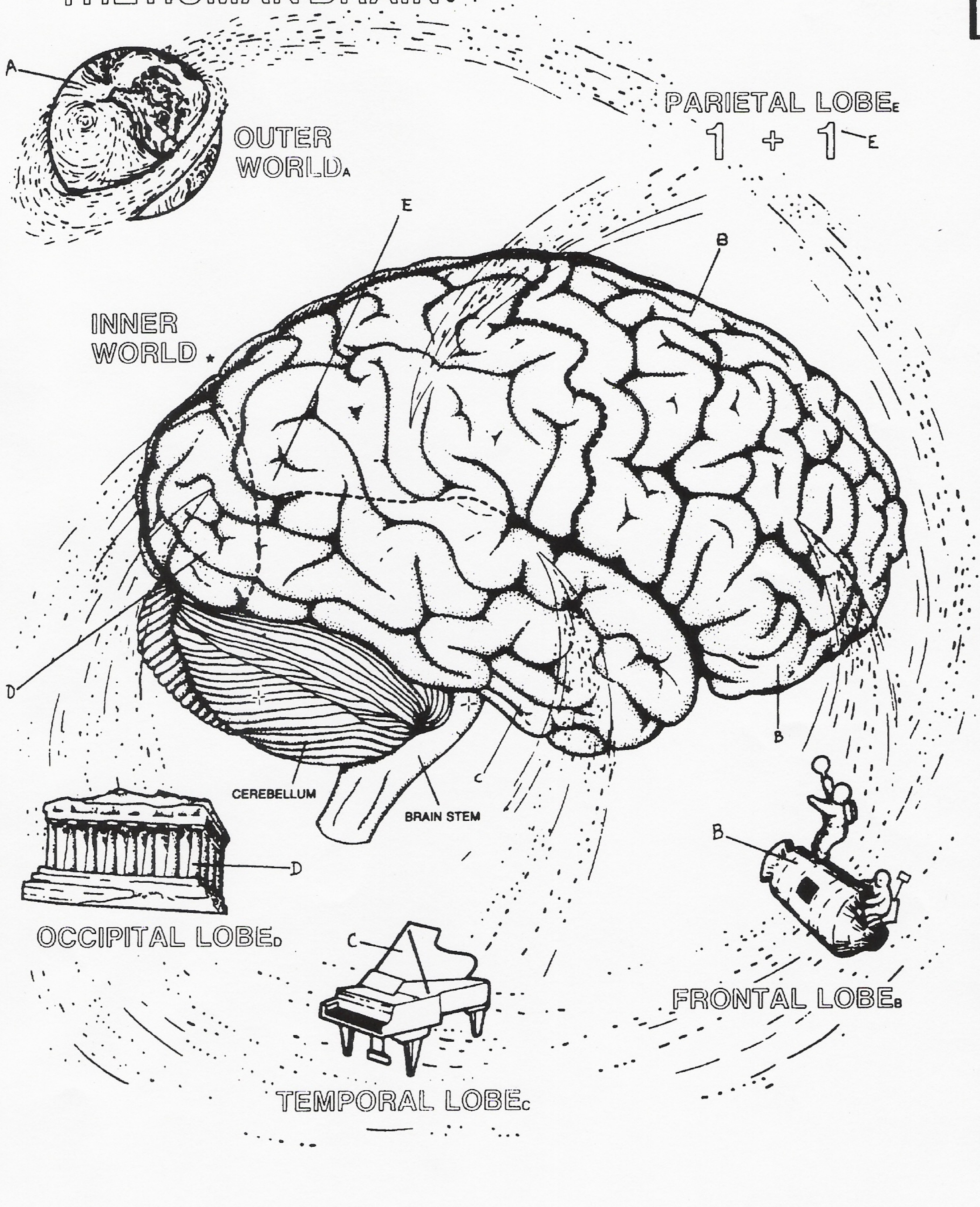
The *outer world* (A), represented by the globe, is the world of our external reality experienced by our sense organs and reported to our brain. The activity of our brain, in turn, constructs the inner world. It is the constant interaction between events in the two worlds that determines our survival. The concepts and ideas created in the inner world of the brain are translated into the realities of the outer world, and it is within the cerebral hemispheres that such activities take place.

Color the lobes of the cerebral hemisphere (B through E) and the related titles and activity representations.

The external surface of one cerebral hemisphere is seen here from the side. The hemispheres are subdivided into lobes, each of which is characterized by unique functional capacities. The planning of the future, represented here by the exploration of space, utilizes the *frontal lobes* (B). Musical masters have created concerti that are heard and appreciated through the action of the *temporal lobes* (C). The *occipital lobes* (D) of the hemispheres are responsible for the visual capacities necessary to construct the architectural monuments of the world. The logic of mathematics, representing perhaps the most abstract of neural functions, is derived in part from the *parietal lobes* (E).

In the next plate, the external, undissected structure of the brain as seen from the side is introduced as a means of further orientation.

INTRODUCTION TO THE HUMAN BRAIN.



1–2 INTRODUCTION TO BRAIN STRUCTURE I

This plate elaborates on some structural landmarks and functional areas of the hemispheres, which are part of the forebrain, and describes some major parts of the hindbrain, as a further introduction to the brain. A more complete treatment is provided in Unit Five. Structures in this illustration that were shown in the previous plate have been given the same subscripts and should be colored identically to those in Plate 1-1.

Reserve the colors used for B, C, D, and E in the previous plate and use them here for the same structures. Color the heading Forebrain, titles A through D, and related structures. Different shades of the same color are recommended for structures that have the same subscript but different exponents. The fissures A and G and sulcus (F) are exaggerated in size for coloring.

The cerebral hemispheres are separated into right and left halves by a deep groove called the *longitudinal fissure* (A). Other prominent grooves (fissures or sulci) separate the hemispheres into lobes. Two such grooves are the *central sulcus* (F; also called *fissure of Rolando*) and the *lateral fissure* (G; also called *fissure of Sylvius*). The central sulcus runs from the top (vertex) of the hemisphere downward and forward about midway between the front and rear poles of the hemisphere. The lateral fissure runs backward and slightly upward, appearing as a deep groove between the temporal and parietal lobes.

The part of the hemisphere in front of the central sulcus is the *frontal lobe* (B). It constitutes about one third of the hemispheric surface. A major part of the frontal lobe is concerned with planning ahead, prediction, and programming for an individual's needs. The lower portion of the frontal lobe, primarily on the left side, is specialized for articulation of speech (*speech area,* B^1). A thin strip of frontal lobe just in front of the central sulcus (*motor area,* B^2) specifically controls discrete movements of the body. Injury to this area can cause paralysis of the opposite side of the body.

The part of the hemisphere below the lateral fissure is the *temporal lobe* (C), the uppermost part of which is concerned with the sense of hearing. Damage to this part of the brain results in impaired hearing or deafness. The inner surface of the temporal lobe plays a role in memory processing. Much of the remaining temporal lobe may be involved with the integration of multiple sensory functions such as auditory, visual, and touch.

The part of the hemisphere behind the central sulcus is the *parietal lobe* (E), the precise boundaries of which are difficult to delineate. Nerve impulses related to the sensations of pain, temperature, touch, and pressure enter the portion of the parietal lobe just behind the central sulcus (*primary sensory area,* E^1). Investigators have demonstrated that structural abnormalities localized in the lower regions of the parietal lobe are associated with reading disabilities. Stimulation of parts of this lobe in conscious patients produces gustatory (taste) sensations.

The *occipital lobe* (D) is behind the parietal and temporal lobes and is separated from them on the illustration by a vertical dotted line drawn between a fissure above and a notch below. A dotted line drawn from the end of the lateral fissure back to this vertical line completes the separation of parietal and temporal lobes. Visual information is processed in the occipital lobes; damage to this area results in partial or complete blindness. Visual mechanisms in the brain constitute one of the most intensely studied subjects in neuroscience.

Color the heading Hindbrain, titles H, I, and J, and related structures.

The lowest part of the hindbrain, the *medulla oblongata* (J), is continuous with the spinal cord. This 2.5-centimeter-long region controls such vital functions as respiration and heart rate. Just above the medulla is the *pons* (H; pons, bridge), which serves as part of a relay between the cerebral hemispheres and the *cerebellum* (I). The cerebellum can be identified clearly from the overlying cerebral hemispheres by its more finely folded surface. The cerebellum deals with muscle coordination and balance involved in such action as writing and walking.

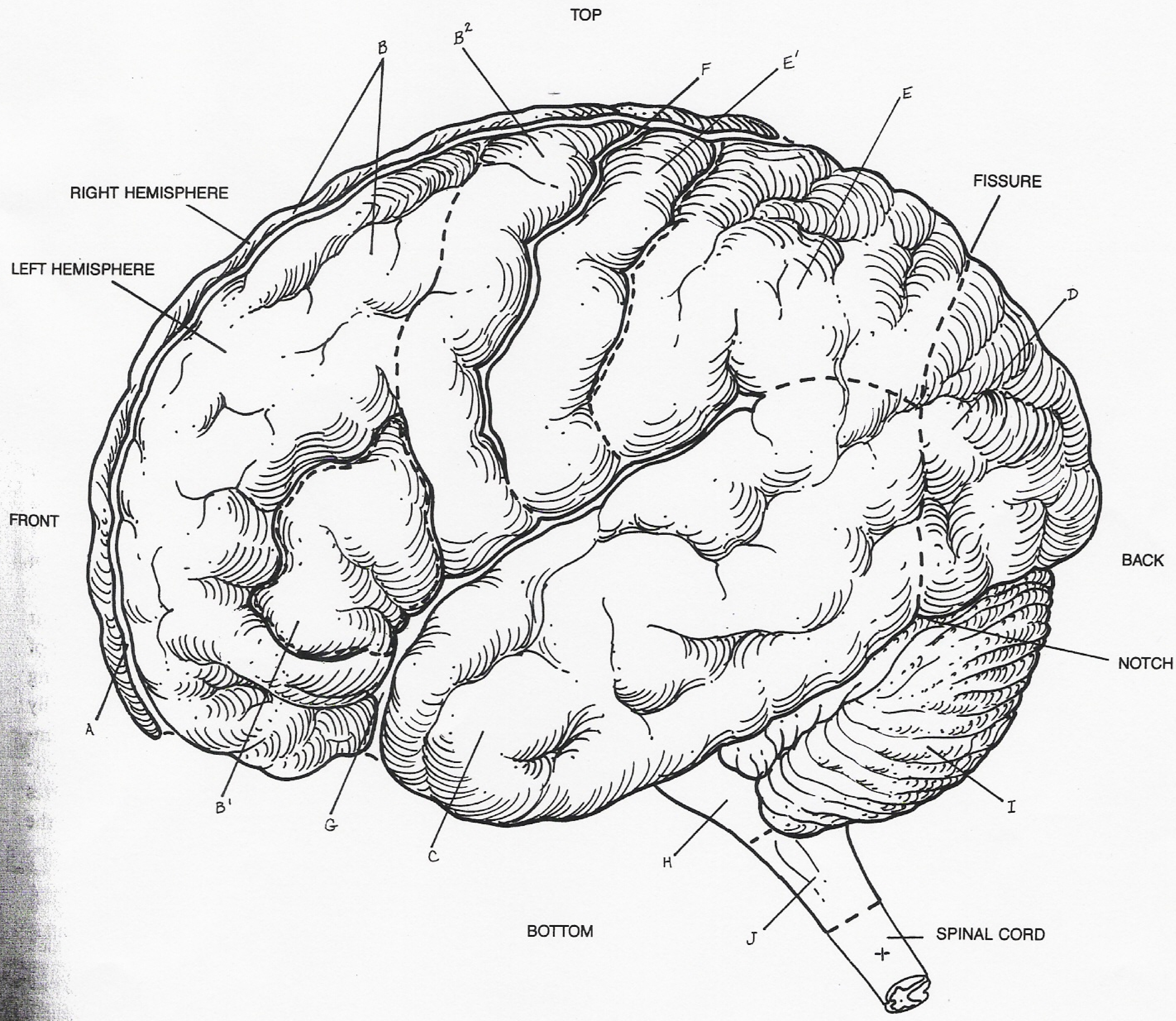
INTRODUCTION TO BRAIN STRUCTURE I.

FOREBRAIN ★
- LONGITUDINAL FISSURE A
- CENTRAL SULCUS F
- LATERAL FISSURE G
- FRONTAL LOBE B
  - SPEECH AREA B¹
  - MOTOR AREA B²
- TEMPORAL LOBE C

PARIETAL LOBE E
- PRIMARY SENSORY AREA E¹

OCCIPITAL LOBE D

HINDBRAIN ★
- PONS H
- CEREBELLUM I
- MEDULLA OBLONGATA J



1–3
INTRODUCTION TO BRAIN STRUCTURE II

The introduction to the brain continues with this "exploded" view of the brain and upper spinal cord. You have become acquainted with the cerebral hemispheres on the two previous plates, and here you can visualize them in relation to the rest of the brain. Again, structures in this illustration that were shown earlier have been given the same subscripts and should be colored as before.

Reserve the colors used for B, C, D, E, H, I, and J in the previous plate and use them here for the same structures. Color the heading Cerebral Hemisphere, titles B through F, and related structures in the two upper illustrations.

The cerebral hemispheres consist of five lobes, four of which you have colored in a side view of the brain. Here you see those lobes as you look into the inside (medial) surface of the right hemisphere. In this case, the left hemisphere has been completely removed to permit such a view. Moving backward from the front one can see the medial surfaces of the *frontal* (B), *parietal* (E), and *occipital* (D) lobes, overlapping from the outer or lateral surface. The view also shows the underside of the *temporal lobe* (C) and the collarlike *limbic lobe* (A; *limbic*, "of a margin or border") arranged around the junction of the cerebral hemisphere with the brain stem. Some functions of the frontal, temporal, parietal, and occipital lobes have been presented on Plates 1-1 and 1-2. The limbic lobe is involved with sexual and emotional aspects of behavior and with the processing of memory.

Beneath the surface of the hemispheres are great masses of fibers (not shown) conducting impulses in all directions and large groups of cells forming discrete bodies at the base of each hemisphere: these are the *basal ganglia* (F; sing. *ganglion*, "knot"). Their major role seems to be the programming and execution of movement (motor activity). Diseases of the basal ganglia are manifested by tremors and uncontrolled movements.

Color the heading Upper Brain Stem, titles G through L, and related structures.

The uppermost part of the brain stem (tucked away into the concave bases of the hemispheres) consists largely of the *thalamus* (G), *hypothalamus* (K; *hypo-*, "below"), and *pineal gland* (L). The thalamus serves as the sensory gateway to the cerebral hemispheres. The pathways for all senses except smell stop in the thalamus before proceeding into the hemispheres. The hypothalamus packs a remarkable roster of functions into its small size (barely larger than four peas). It controls the visceral nervous system, which stimulates contraction of muscle fibers and glandular secretions in the internal organs; it regulates appetite, thirst, and temperature; and it controls the hormonal secretions from the pituitary gland and, thereby, many of the endocrine glands of the body.

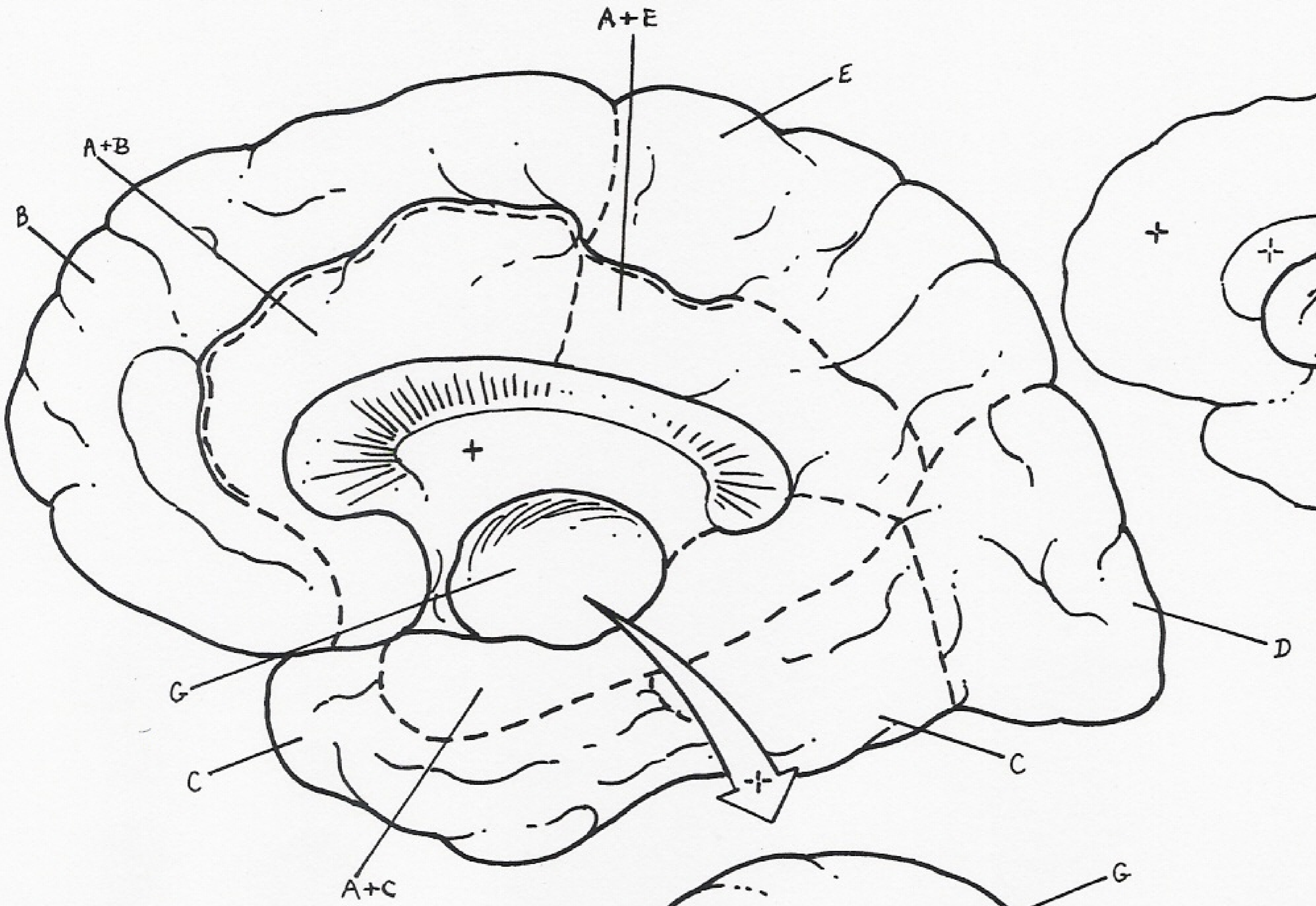
The small pineal gland, located behind the thalamus, functionally resembles a biological clock, regulating body rhythms and sexual activity.

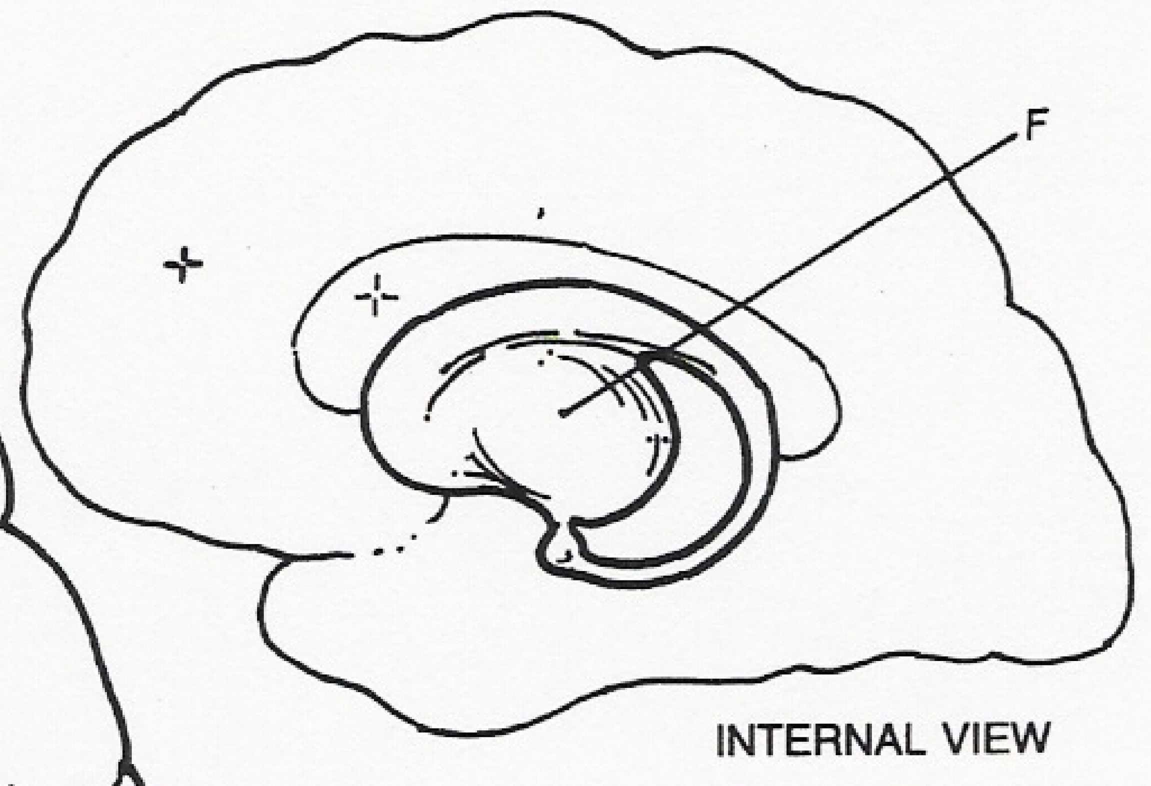
Color the rest of the headings, titles M through N, and related structures.

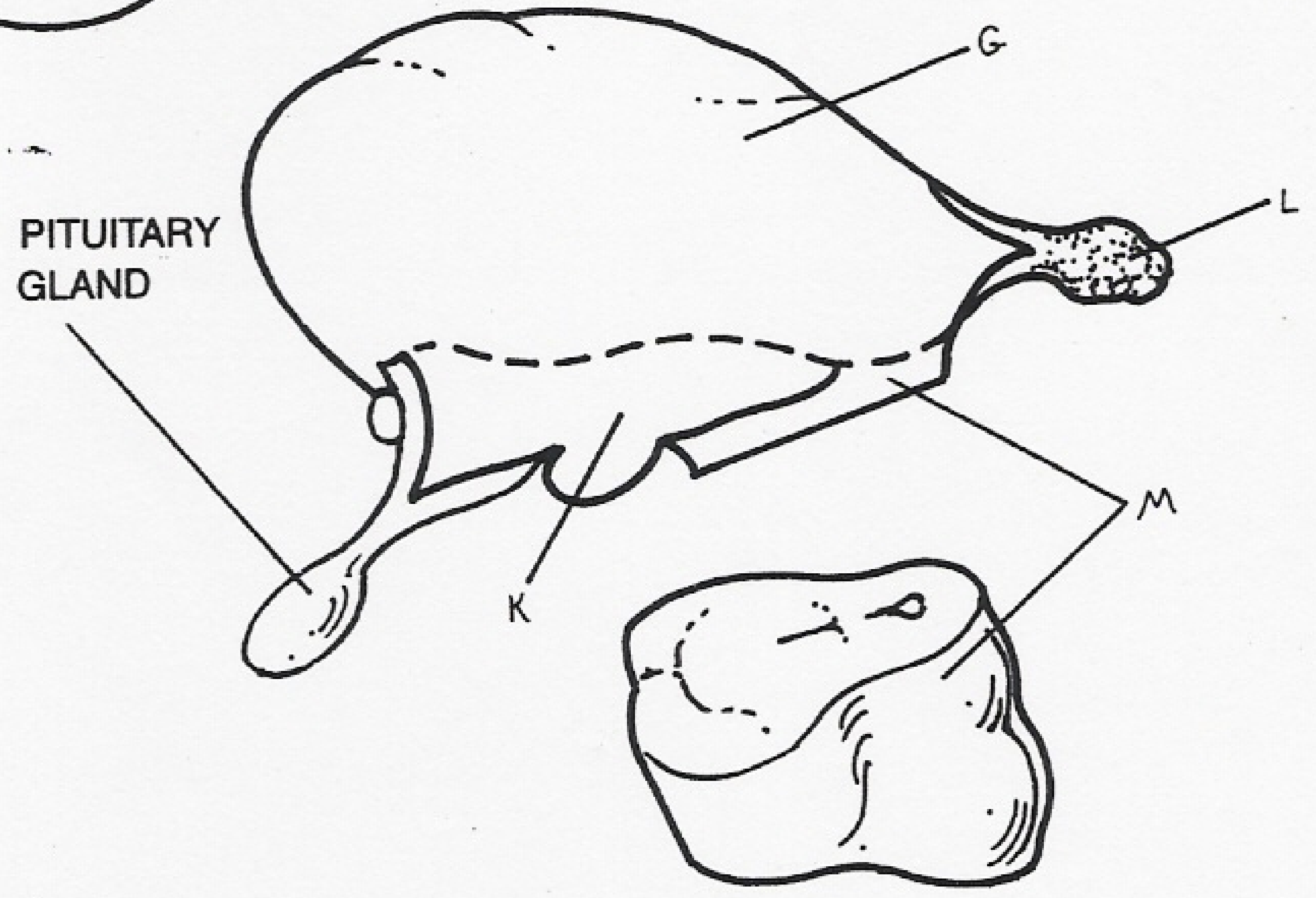
The middle portion of the brain stem is the *midbrain* (M), which, in part, controls automatic (reflex) patterns associated with the visual and auditory systems. Its deeper parts are concerned with other important movement patterns. The lower brain stem is a part of the hindbrain and consists of the *medulla* (J) and *pons* (H), which have been presented in Plate 1-2. The *cerebellum* (I) is the other part of the hindbrain, and its function has been described in Plate 1-2 as well.

The *spinal cord* (N) is continuous with the medulla at the base of the skull and is enclosed in the neural canal of the spine or vertebral column. It includes both ascending (generally sensation-related) and descending (generally movement-related) pathways for the conduction of impulses to and from the brain. As the most primitive portion of the human nervous system, the spinal cord receives sensory information from all parts of the body (except the face) and sends commands for motor activity.

INTRODUCTION TO BRAIN STRUCTURE II.







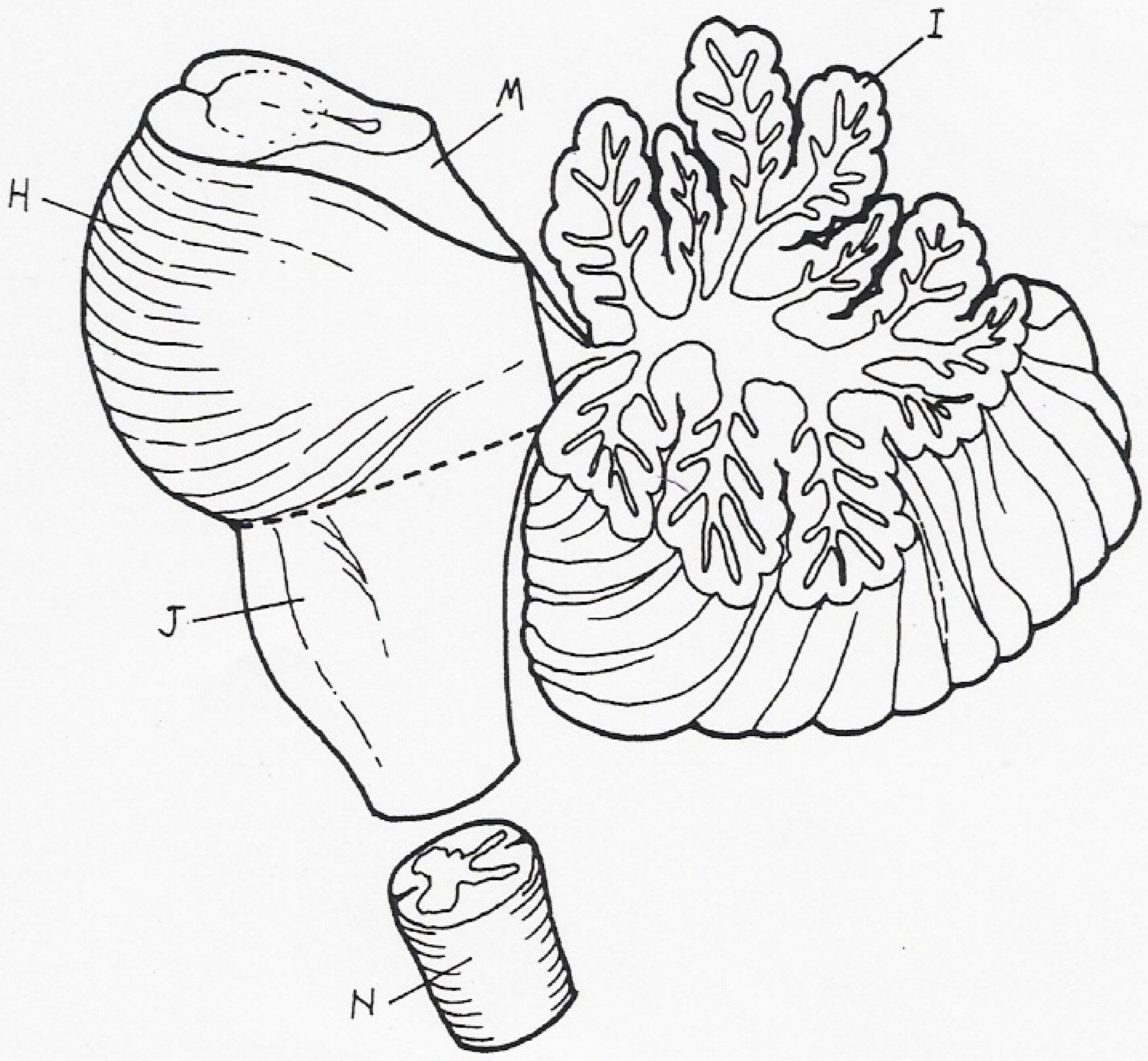
CEREBRAL HEMISPHERE ★
- FRONTAL LOBE B
- TEMPORAL LOBE C
- PARIETAL LOBE E
- OCCIPITAL LOBE D
- LIMBIC LOBE A
- BASAL GANGLIA F

UPPER BRAIN STEM ★
- THALAMUS G
- HYPOTHALAMUS K
- PINEAL GLAND L

MIDDLE BRAIN STEM ★
- MIDBRAIN M

LOWER BRAIN STEM ★
- PONS H
- MEDULLA J

CEREBELLUM I
SPINAL CORD N



1–4
ORGANIZATION OF THE NERVOUS SYSTEM

It is important to recognize that the cerebral hemispheres, though exciting structures in their own right, are not the entire human nervous system. In this plate, as an aid to orientation, we introduce the scheme of the entire nervous system: central, peripheral, and visceral.

Color the titles and structures A through C, contrasting the colors among the three systems.

The human nervous system consists of both central and peripheral parts. The *brain* (A^1), reposing in the cranial vault, and the *spinal cord* (A^2), encased within the neural arches of the vertebral column, constitute the *central nervous system,* or *CNS.* Not only are they centrally located, but they are also the centers of neural functions. The brain is the focus of Unit Five. The major components or areas of the brain have been introduced in the previous plate. The cerebral hemispheres are certainly the largest structures of the brain, but they are still only a part. The hemispheres are dependent on other components of the nervous system to receive information and to transmit and modify its commands.

The junction of the brain with the spinal cord occurs at the foramen magnum (not shown but see Plate 6-2), the large hole (foramen) at the base of the skull. The spinal cord is the subject of Unit Four. Pathways that transit both spinal cord and brain are also included in that unit.

The *peripheral nervous system,* or *PNS,* consists of *cranial* (B^1) and *spinal nerves* (B^2), and their components are located outside the CNS. Of the 12 paired cranial nerves (only three examples are shown), all but the first and second arise from the brain stem. Cranial nerves are largely concerned with the head and are the subject of Unit Six.

The 31 paired spinal nerves (of which only a few are shown) arise from the spinal cord and, like cranial nerves, consist of nerve cell processes conducting sensory-related impulses and/or processes conducting movement-related (motor) impulses. Spinal nerves are concerned with the entire body except the areas of the head that are supplied by the cranial nerves; they are the topic of Unit Seven.

The *visceral nervous system,* or *VNS* (C; also called *autonomic nervous system,* or *ANS*), is concerned with the motor innervation (nerve supply) of cardiac muscle and of glands and smooth muscles of cavity-containing body organs (viscera), as well as with the sensory innervation of viscera. Viscera include the organs of the thoracic, abdominal, and pelvic cavities, certain structures of the head and neck, as well as blood vessels, sweat glands, and hair-raising muscles throughout the skin. Components of the VNS include parts of the brain and spinal cord, cranial and spinal nerves, as well as their own specialized parts. Shown here is a part of a chain of VNS nerve cells located in the thoracic, abdominal, and pelvic cavities and connected to the spinal cord by parts of spinal nerves. Processes of these VNS motor nerve cells are directed to visceral structures. The motor component of the VNS is the subject of Unit Eight. The sensory component of the VNS is more diffusely arranged than the motor component and cannot be structurally distinguished from sensory axons to somatic (musculoskeletal and skin) structures. See the index, under VNS, for a complete list of plates considering both sensory and motor components.

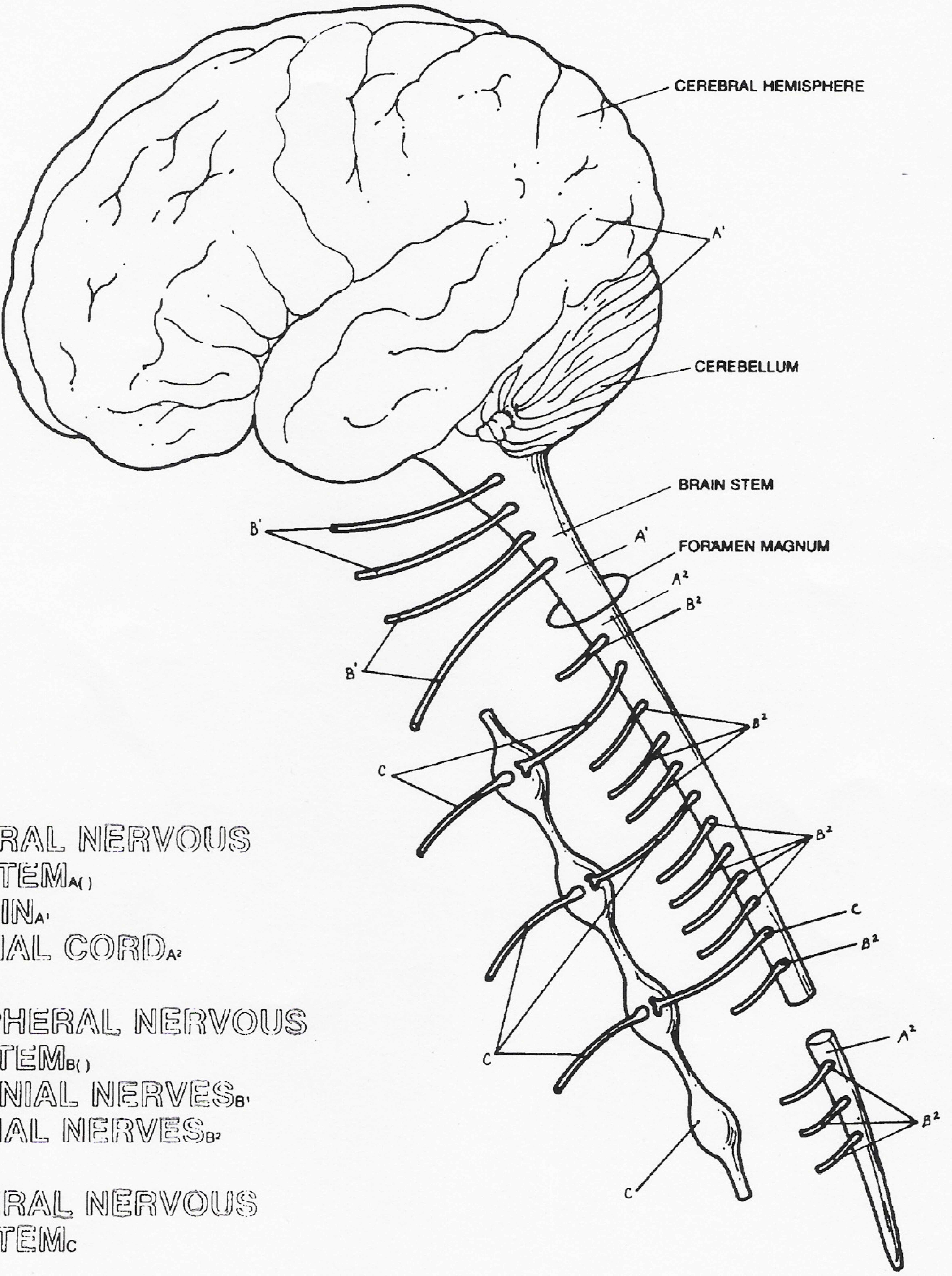
In essence, all three divisions of the nervous system are constantly interacting with each other. They are presented separately only because each has some specific characteristics.

C

P

V

ORGANIZATION OF THE NERVOUS SYSTEM.

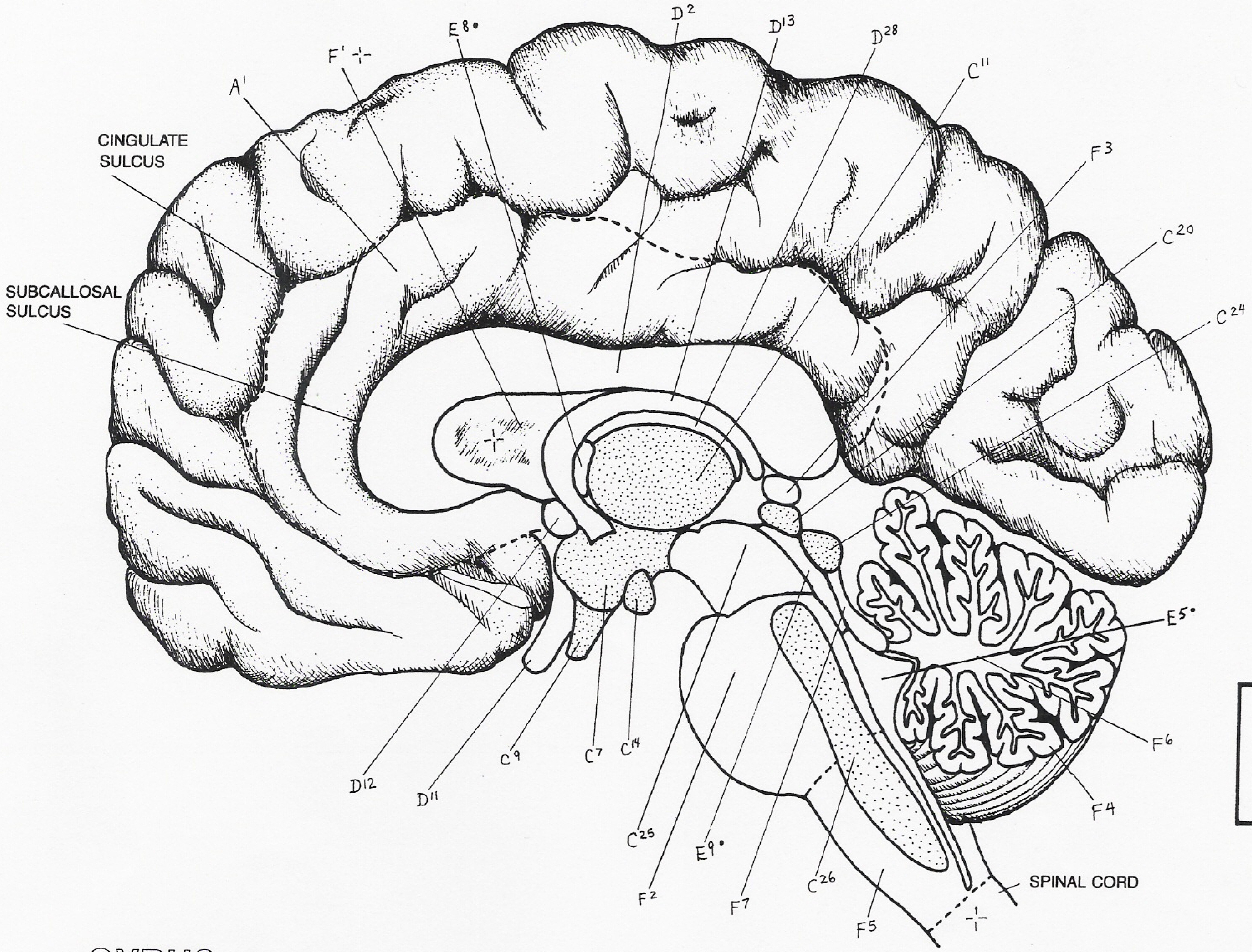


CENTRAL NERVOUS SYSTEM$_{A()}$
BRAIN$_{A^1}$
SPINAL CORD$_{A^2}$

PERIPHERAL NERVOUS SYSTEM$_{B()}$
CRANIAL NERVES$_{B^1}$
SPINAL NERVES$_{B^2}$

VISCERAL NERVOUS SYSTEM$_C$

MEDIAN SECTION.



GYRUS A( )
CINGULATE A1

HYPOTHALAMUS C7
INFUNDIBULUM C9
MAMMILLARY BODY C14
MED. NUC. THAL. C11
SUP. COLLICULUS C20
INF. COLLICULUS C24
MIDBRAIN TEGMENTUM C25
RETIC. FORM. C26

TRACT/NERVE D( )
OPTIC TR. D11

VENTRICLE E( )
FOURTH VENTRICLE E5
INTERVENTRIC. FOR. E8
CEREB. AQUEDUCT E9

PONS F2
PINEAL GLAND F3
CEREBELLAR CORTEX F4
MEDULLA OBLONG. F5