Chapter 1

# The Brain and the Nervous System

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Pharmaceutical agents are chemicals that interact with chemical processes within the body to produce changes. Psychiatric medications are no exception in that they interact with chemical processes in the brain and nervous system. In order to comprehend these processes, it is critical to have a basic understanding of the structures and functions of the brain and nervous system.

This chapter discusses the principles of neuroanatomy and physiology that are essential to the understanding of the functions of psychiatric medication. Reference will be made in later chapters to the specific areas discussed in this chapter related to the actions of various drugs. It should be noted, however, that this chapter in no way represents a compendium of the information regarding neuroanatomy or psychophysiology. There are numerous sources addressing these issues and all the related components critical to their understanding. For a further reference, see Gardner (1975), Gilman and Newman (1987), Kolb and Whishaw (1980), or Liebman and Tadmor (1986).

In considering the brain and nervous system, the discussion is focused on three areas. To begin, the anatomy and physiology of the brain, and specifically the core structures and the ways in which they are affected by the introduction of various psychiatric medications, are examined. The second area of emphasis is the spinal cord and peripheral nervous system. In addition to the anatomy and physiology of these systems, the discussion also includes the neuron, which is the basic unit of communication within the brain and nervous system. The interactions of the brain, spinal cord, and peripheral nervous system structures are explained. Finally, the processes of neural transmission within the brain and nervous system are described. These reactions within the nervous system form the basis of most theories of psychopharmacological action.

## THE BRAIN

With the advent of transplants and artificial organs, it is clear that medical science has come a long way in understanding the structure and mechanics of the human body. Even with this fundamental understanding, however, knowledge of the brain is still in its infancy. New advances and theories regarding this frontier are being reported, but there still remains a void in the understanding of this vital organ, which lies at the root of all human behavior.

Levinthal (1983) describes the brain in terms of three fundamental areas—the hindbrain, the midbrain, and the forebrain. For the purposes of the present discussion, each area is considered separately. It is important to remember that the brain is more than the sum of its parts. There is a tremendous amount of overlap and interaction between each of its structures.

## The Hindbrain

The hindbrain, also called the brain stem, is the lowest portion of the brain relative to the top of the head and is composed of three areas: the medulla, the pons, and the cerebellum (Figure 1-1). These three areas play an important role in the basic functioning of the body.

The medulla is the link between the brain and the spinal cord. Many of the basic life support functions, including maintenance of blood pressure, heartbeat, and breathing rate, are regulated at this point. A number of the cranial nerves discussed later in this chapter are found within these structures.

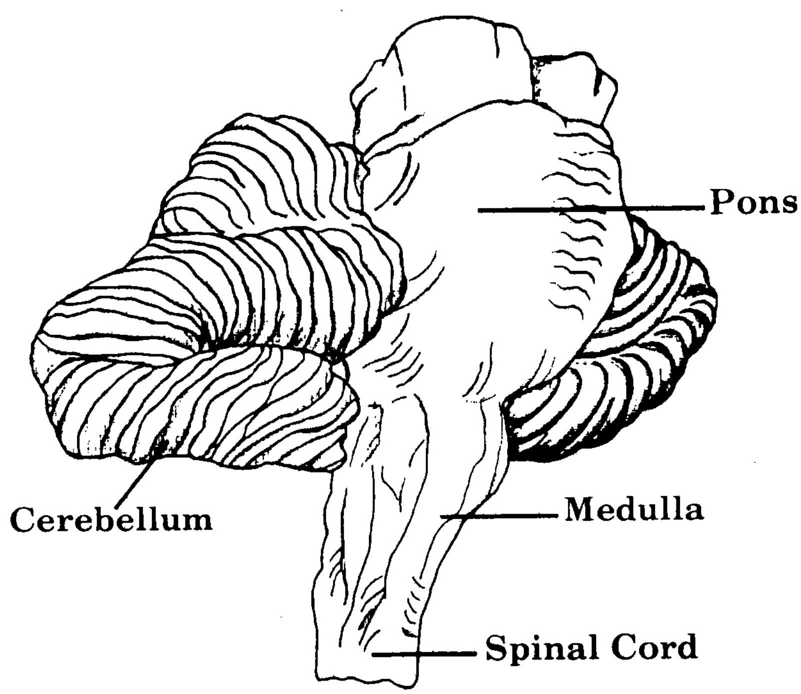


**Figure 1-1** The Hindbrain (Brain Stem) and Its Component Parts

At the upper portion and in front of the medulla is the pons. It is here that various nerve fibers come together, linking different parts of the brain to other parts of the brain and to the nervous system.

Directly behind the medulla lies the cerebellum, which has the function of integrating body movement, position, and balance. Input comes to the cerebellum from receptors in the inner ear and the various joints within the body. When the cerebellum is coordinating body movement and position, the result is smooth integrated body motion.

Goldsmith (1977) points out that damage to the cerebellum results in clumsy, jerky movements. Alcohol is the drug that most affects the cerebellum, and its effects are seen in the drunken gait, slurred speech, impaired balance, and limited dexterity and motion of an intoxicated person. Barbiturates also have these effects.

## The Midbrain

Surrounding the upper and lower portions of the medulla and the pons are the two structures that compose the midbrain: the tectum and the tegmentum. Figure 1-2 shows a medial view (view from the middle) of the brain and points out the location of these structures relative to some of the hindbrain structures discussed above.

The tectum contains two structures referred to as the superior colliculus and inferior colliculus, which mediate visual and auditory sensory data, respectively.

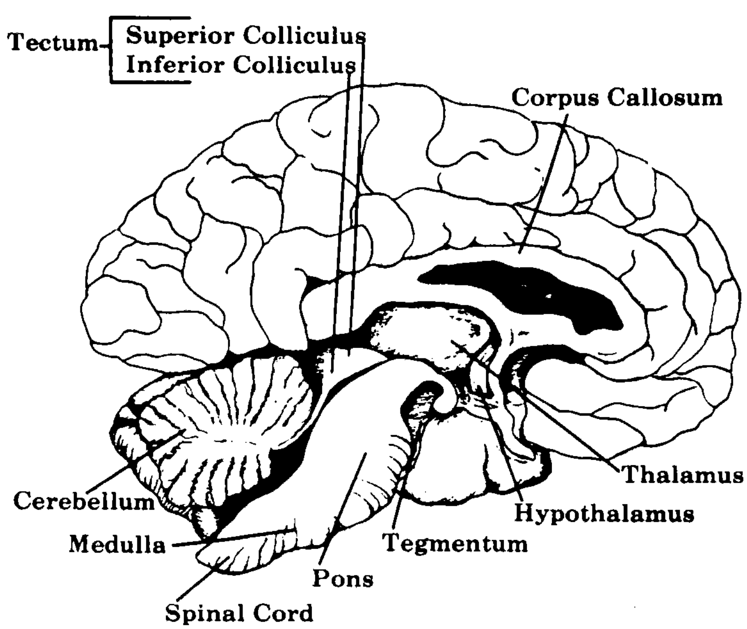


**Figure 1-2** Medial View of the Brain Featuring Associated Forebrain, Midbrain, and Hindbrain Structures

They are particularly concerned with whole-body orientation to visual and auditory stimuli.

The tegmentum consists of a number of sensory and motor nerves. Also found there are the nuclei of the oculomotor and trochlear cranial nerves, which will be discussed later in this chapter.

One other important structure is the reticular formation or the reticular activating system, which runs from the thalamus (part of the forebrain) through the midbrain and extends into the brain stem. The reticular formation is directly involved in the maintenance of arousal and supplies information concerning this state to and from the cortex (part of the forebrain). It is also important in the study of psychopharmacology because some of the major body chemicals affected by psychiatric medications are actively present and used in this system.

### The Forebrain

In terms of the study of psychopharmacology, the activity in the forebrain is of central importance. It is here that centers of emotion, memory, reasoning, and judgment are found. The forebrain involves structures surrounding the midbrain as well as the brain's outer layer, referred to as the cerebral cortex.

At the upper end of the medulla is the thalamus (see Figure 1-2). Its function within the brain and nervous system is extremely important in that it serves as a relay of sensory information to the different areas of the cerebral cortex. This information is received from various systems within the body and is passed to areas within the cortex. Some of the sensory data received include visual and auditory stimuli, tactile sensation, pressure, pain, and temperature.

Just beneath the thalamus is the hypothalamus. Its main functions are in the areas of motivational and emotional expression, feeding, drinking, sexual activity, and temperature regulation. Hypothalamus functions also extend to some control of the pituitary gland, which regulates many of the other endocrine glands within the body. This area will be examined in more detail in Chapter 2.

The limbic system (Figure 1-3) is composed of a number of subcortical structures that are closely related to the cortex and also the thalamus and hypothalamus. Three main areas in the limbic system are the amygdala, the septum, and the hippocampus. Gardner (1975) emphasizes that little is known about the physiology of the limbic system. Furthermore, it is difficult to make generalizations from research with animals; it seems that the limbic system has different functions in different animals. It is believed that the limbic system is one of the main structures involved in the expression of emotion in humans and has a number of links with endocrine functioning. It also plays a major role in memory. The limbic system and its component parts are discussed frequently in relation to various psychiatric illnesses and in regard to the action of various tranquilizers.

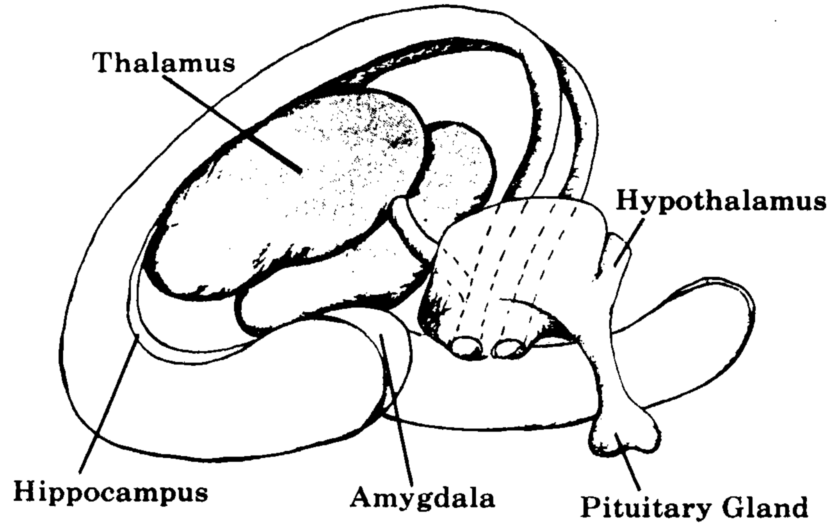


**Figure 1-3** The Limbic System

In the area of the limbic system structures and around the thalamus are the basal ganglia (Figure 1-4). These are nuclei that are involved in muscular activities. The basal ganglia receive input from the cerebral cortex and pass it on to nerves within the brain stem. Included among the basal ganglia are the caudate nucleus and the lenticular nucleus, which is composed of the globus pallidus and the putamen. The lenticular nucleus is of particular importance because of its involvement with certain nervous system chemicals associated with schizophrenia and Parkinson's disease. Understanding of these structures is still very limited and speculative, however.

The final major area in the forebrain is the neocortex (Figure 1-5), which is a layer of tissue that covers the areas of the forebrain and midbrain discussed above. This tissue gives the brain its many convolutions.

The neocortex is divided into four areas, referred to as lobes: the frontal lobes, the temporal lobes, the parietal lobes, and the occipital lobes. The lobes consist of

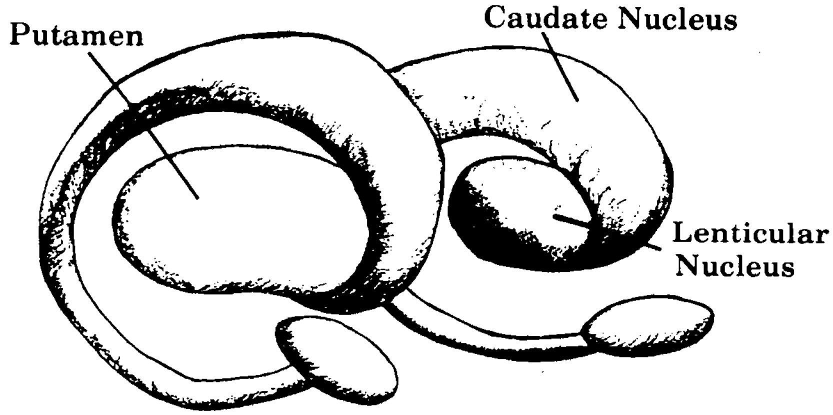


**Figure 1-4** Basal Ganglia

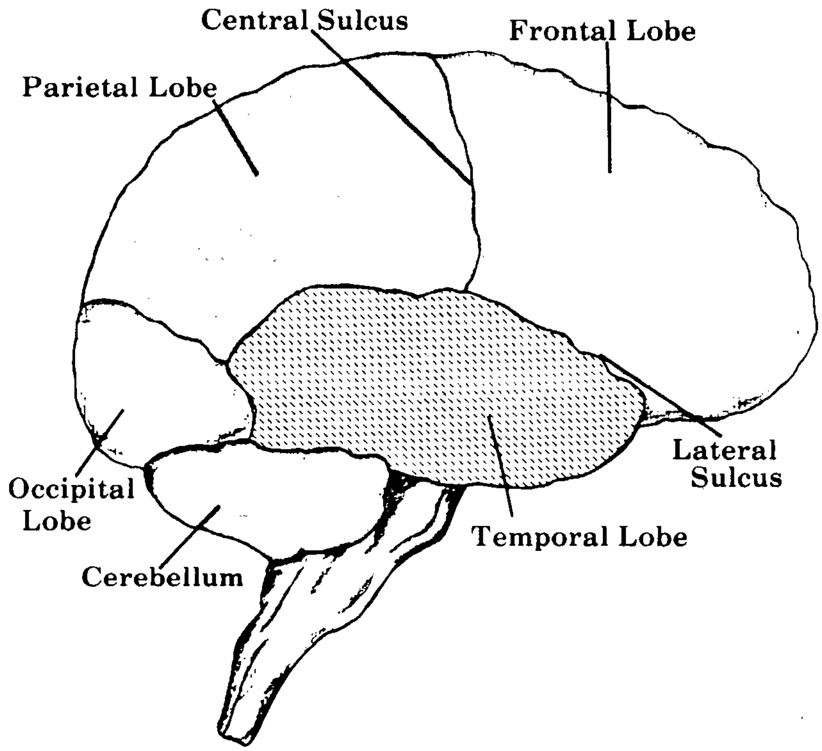


**Figure 1-5** The Neocortex

large masses or bulges of tissue referred to as gyri, which are separated by grooves called sulci. One major sulcus, known as the central sulcus, runs from side to side and separates the frontal lobes from the parietal lobes. It is also referred to as the fissure of Rolando. The other major sulcus is the lateral sulcus, which runs from the frontal lobe to the occipital lobe and separates the parietal and temporal lobes. It is often referred to as the fissure of Sylvius.

The frontal lobes compose the area of the cerebral cortex from the forehead to the front of the central sulcus. It has been argued for many years that the human frontal lobe is special in that it houses the high mental processes not seen in other animals. Kolb and Whishaw (1980) dispute this idea, however, on the basis that there is no evidence that human frontal lobes have any special characteristics. It is difficult to pinpoint the functions of the frontal lobes. It seems to be true that the frontal lobes do have responsibility for various personality and emotional traits, planning and organizational skills, speech and language, and control of motor functioning.

Directly behind the frontal lobes are the parietal lobes, which share a number of functions with other areas of the brain. They have primary responsibility for receiving various somatic sensations and perceptions while at the same time integrating sensory data from a number of sources, including visual, auditory, and somatic sensations. The parietal lobes are also believed to play a role in gross motor functioning, in contrast to the frontal lobes, which are involved in fine motor functioning.

Immediately below the parietal lobes are the temporal lobes; these seem to be directly involved with auditory processing of information and long-term memory.

The occipital lobes are located at the back of the cortex, directly behind the parietal and temporal lobes. Their primary responsibility is in visual processing.

The cerebral cortex is divided down the middle from front to back into two hemispheres, the left brain and the right brain. Each side has one of the four corresponding lobes discussed above. Although the brain may look symmetrical, as shown in the view in Figure 1-6, the lobes on each side control different areas of functioning related to the functions noted previously. Also, just because the brain is separated into right and left hemispheres does not mean that the right brain does not know what the left brain is doing (and vice versa). The two sides are linked beneath the surface of the cortex by a system of nerve fibers referred to as the corpus callosum, which is located just above the midbrain structures.

## THE SPINAL CORD AND PERIPHERAL NERVOUS SYSTEM

The brain is only half of what is called the central nervous system; the other half is the spinal cord. Beyond the nerves within the central nervous system are those

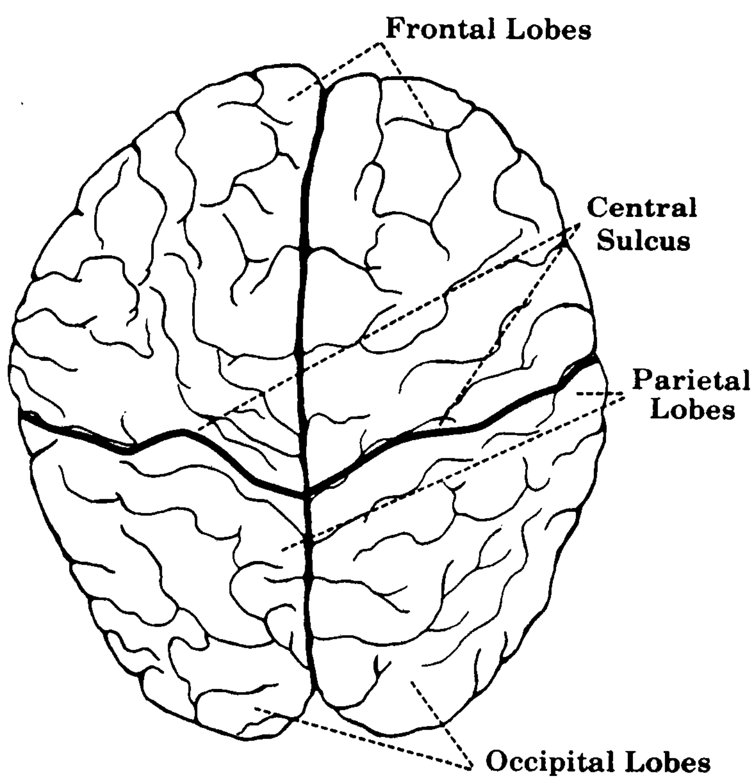


**Figure 1-6** View from Top of the Brain

which extend to all parts of the body, referred to collectively as the peripheral nervous system.

The spinal cord extends from the brain stem downward through the vertebral column. It serves a dual function: it carries information from the brain to peripheral nerves in the body, and it transfers information from peripheral nerves from various places in the body to a number of sites in the brain. Thus the spinal cord contains both ascending (sensory) pathways and descending (motor) pathways.

## The Peripheral Nervous System

For the purpose of discussion, this section focuses on motor nerves (i.e., those nerves that transfer information from the central nervous system to the various organs and muscles).

The motor nerves are either voluntary or involuntary (autonomic). Primarily, the function of voluntary motor nerves is to provide information from the central nervous system to the various muscles that are involved in voluntary movement. The autonomic nerves carry information to the organs and glands, where movement is involuntary. This information originates in either spinal or cranial nerves. Spinal nerves are those directly connected to the spinal cord. Their location is the point at which they leave the spinal cord and relates to the particular type of vertebra found at that point (i.e., cervical, thoracic, lumbar, or sacral). The cranial nerves comprise 12 pairs of nerves that originate in the brain (see Table 1-1).

**Table 1-1** The Cranial Nerves

| *Cranial Nerve* | *Point of Origin* | *Function(s)* |
|---|---|---|
| Olfactory | Olfactory cortex | Sense of smell |
| Optic | Thalamus and superior colliculus | Vision |
| Oculomotor | Midbrain | Eye movements; pupil size and accommodation |
| Trochlear | Midbrain | Eye movements |
| Trigeminal | Pons | Chewing movements |
| Abducens | Pons | Abduction of eyes |
| Facial | Pons | Facial expressions; saliva secretion |
| Auditory vestibular | Pons and medulla | Equilibrium; hearing |
| Glossopharyngeal | Medulla | Movements of tongue and pharynx |
| Vagus | Medulla | Movements of heart, blood vessels, viscera; voice production |
| Spinal accessory | Medulla | Neck muscle control |
| Hypoglossal | Medulla | Tongue muscle control |