Chapter 6

Neurobiology in Mental Health and Disorder

CANDICE FRANCIS

“Between stimulus and response there is space. In that space is our power to choose our response. In our response lies our growth and our freedom.”

Viktor Frankl

OBJECTIVES

1. Identify the basic anatomic structures of the central nervous system.
2. Describe the physiologic functions of the central nervous system.
3. Describe the normal functioning of neurons.
4. Discuss the role of common neurotransmitters in the functioning of the central nervous system.
5. Describe the electrochemical mechanism of the central nervous system.
6. Identify criteria for client care related to neuroimaging testing.
7. Identify emerging technologies with a significant impact on the future of psychiatric nursing.
8. State uses for current neurobiologic findings in planning care for clients with a psychiatric disorder.
9. Identify potential areas for further nursing research related to neurobiology.

KEY TERMS

action potential, p. 177
alexia, p. 177
amygdala, p. 177
aphasia, p. 177
autonomic nervous system, p. 177
axon, p. 177
basal nuclei, p. 177
Broca’s area, p. 177
central nervous system, p. 177
cerebral cortex, p. 177
cerebrum, p. 177
corpus callosum, p. 177
cortex, p. 177
dendrites, p. 177
fissures, p. 177
frontal lobe, p. 177
gray matter, p. 177
gyr, p. 177
hippocampus, p. 177
hypothalamus, p. 177
limbic system, p. 177
neuroglia, p. 177
neuron, p. 177
neuroplasticity, p. 177
neurotransmitter, p. 177
occipital lobe, p. 177
parietal lobe, p. 177
peripheral nervous system, p. 177
premotor cortex, p. 177
primary motor cortex, p. 177
somatic association cortex, p. 177
stem cells, p. 177
sulci, p. 177
synapse, p. 177
temporal lobe, p. 177
thalamus, p. 177
Wernicke’s area, p. 177
white matter, p. 177

Visit the Neurology Review section of your Companion CD when you see this icon, to view an animation illustrating the concept described in the text.

The authors would like to thank Kathleen M. Walker, James M. Turnbull, and Chantal M. Flanagan for their contributions to this chapter in the third edition.
Neuroscientific discovery and developments continue to advance at a remarkable pace and contribute to the evolving understanding of brain function. This research provides new strategies for clinicians, clients, and families addressing mental disorders. Many now recognize mental disorders as brain-based illnesses. Although some still misunderstand mental disorders and stigmatize those clients, research on brain biology has helped reshape perceptions of mental illness. To understand treatment approaches to psychiatric illness, the psychiatric mental health nurse requires a firm foundation in the fundamentals of neurobiology, physiology, and genetics, and how these affect treatment of psychiatric disorders. Increased knowledge in this area has changed the way mental health care providers perceive and treat mental disorders. This chapter reviews the fundamentals of neurobiology and examines concepts and clinical approaches to the treatment of mental illness with regard to our growing knowledge of neuroscience.

UNDERSTANDING NEUROBIOLOGIC FUNCTIONS

The biologic model of psychiatric illness is not a new phenomenon, but the availability of new tools makes it increasingly more sophisticated. Science has advanced beyond merely making educated guesses about how the brain works and has developed scientific models that allow for testing brain-based interventions and developing new effective treatments (Gur, 2002). The best psychiatric mental health care begins with an understanding that the symptoms associated with psychiatric disorders are usually manifested behaviorally. Clients with psychiatric disorders frequently behave in ways society considers “not normal.” They often express their disorders through responses such as hearing voices, considering suicide, or wearing a winter coat on a hot summer day. These abnormal perceptions, thoughts, and behaviors usually have a neurobiologic basis. Knowledge of normal brain structure and function helps mental health care providers to offer an optimal level of treatment to people with brain-based illnesses. Understanding the structural or neurochemical defects that affect clients with psychiatric disorders helps psychiatric nurses to more effectively assess clients’ responses and plan interventions.

NEUROANATOMY AND NEUROPHYSIOLOGY OF THE HUMAN NERVOUS SYSTEM

Human thoughts, feelings, and actions begin in the central nervous system. The brain acts as the primary mediator-organ, controlling and determining how people interact with the world. All human responses are the result of the complex interaction between underlying neuroanatomy and neurophysiology, as well as the genetic, environmental, and developmental factors that influence those systems.

Neuroanatomy

The brain is one of the most important structures in the human body. Although it weighs only 3 to 5 pounds, the brain contains approximately 140 billion cells, making it the most complex and vital of human organs (Gribbin, 2002). The human nervous system is composed of two separate but interconnected anatomic divisions. The first division, the central nervous system (CNS), is composed of the spinal cord and brain. The second division, the peripheral nervous system (PNS), contains peripheral nerves, 12 pairs of cranial nerves that originate just outside of the brain stem, and 31 pairs of spinal nerves arising from the spinal cord. These peripheral nerves transmit sensory (incoming) information toward the CNS and motor (outgoing) information away from the CNS to muscles and glands that are controlled by the CNS.

Although the PNS and certain interactions with the autonomic nervous system (ANS) are of critical importance to human functioning, the understanding of psychiatric disorders depends on in-depth understanding of the structure and function of the CNS. For that reason, this chapter focuses on the CNS and how the nurse will use that knowledge to provide care to individuals who have psychiatric and neurologic disorders.

Brain cells are categorized as either neurons or neuroglia. Neurons generate and conduct electrical signals. Neuroglia provide the mechanical and physiologic support for neurons. White matter is composed of the axons of neurons that are insulated by myelin. White matter makes up the core of major brain structures such as the cerebrum and cerebellum. The gray matter, or cortex, typically covers the surface of these organs. The cortex is the functional area of the brain where neurons communicate with each other and where neurotransmitters are concentrated.

Cerebrum

The cerebrum is the largest part of the brain and it is divided into two halves called cerebral hemispheres. The cerebral hemispheres contain important functional areas such as the cerebral cortex, basal nuclei, and limbic system.

The cerebral hemispheres account for more than 70% of the neurons in the CNS and are responsible for functions such as hearing, vision, language, cognitive functions, control of muscles, and sensory interpretation. The left hemisphere is dominant in almost 95% of people and mainly controls motor and sensory functions on the right side of the body. The right hemisphere controls functions on the left side of the body. Most right-handed people, and half of left-handed people, have a dominant left hemisphere. In rare cases, some people have mixed dominance, with one side dominant for language expression and the other for motor functions such as handwriting.

Effective coordinated human activity requires a complex interrelationship and communication within and between the two hemispheres. A large bundle of white mat-
ter called the corpus callosum connects the two hemispheres. Sensorimotor information constantly flows between the two hemispheres via nerve pathways in the corpus callosum. The corpus callosum has to be intact for full, smooth, and coordinated communication between the hemispheres.

The outermost surface of the cerebral cortex contains corrugated wrinkles with many grooves and indentations. Shallow grooves are called sulci, and the deeper grooves extending deep into the brain are called fissures. The raised areas are called gyri. The sulci and gyri dramatically increase the overall surface area of the cerebrum. The cerebral cortex is typically composed of only six layers of cells, but it covers an area that, if spread out, equals almost 2.5 square feet. In contrast, the cortex of a chimpanzee would cover only a single sheet of paper, while a rat’s cortex occupies an area roughly equal to the size of a postage stamp (Gribbin, 2002). Most discussions on cerebral functions focus on the outer layer, the cerebral cortex.

The cerebrum is divided by the major fissures into four distinct functional regions called lobes. These are the frontal, temporal, occipital, and parietal lobes (Figure 6-1). Although these lobes often work together, each has distinct functions. The normal functions of each lobe, along with typical symptoms of disturbances in each cerebral cortical region of the brain, are described in Table 6-1. Many symptoms exhibited by clients with neurologic disorders and mental disorders are a disturbance in the normal functioning of one or more these cerebral lobes.

The frontal lobe is the largest lobe, and human beings as a species have the best-developed frontal lobes of all animals. Much of what makes human behavior unique is due to the functioning of the frontal lobe. The frontal lobe contains several important structures. The primary motor cortex lies in front of the large central sulcus and is also called the precentral gyrus. As a primary cortex, it is responsible for directly controlling voluntary motor activity of specific muscles. Neurons originating from the primary motor cortex are directly traced to peripheral nerves that innervate the muscles of the body. As they exit the brain, they form a pyramid-shaped bulge called the corticospinal nerve tract. Because of its unique shape, this system of nerves is also called the pyramidal tract. The pyramidal tract passes through the intersection of the medulla and spinal cord. It is at this point that the nerve tracts cross over, or decussate, to the opposite side of the body. This helps to explain why the right motor cortex actually controls voluntary motor activity on the left side.
of the body and the left motor cortex controls motor activity on the right side of the body.

The frontal lobe also contains two other important structures. The prefrontal cortex is responsible for the coordinated movement of multiple muscles, and the somatic association cortex integrates motor commands. Researchers have identified a number of brain regions as association regions. In fact, some estimate that 70% to 75% of all cortical regions are association regions that integrate functions in the primary region. The primary regions are generally involved in analysis, initiation, interpretation, and integrative activities. In the case of the frontal lobe, the somatic association cortex is the area of the brain responsible for coordinating learned motor skills. Cognition, memory, and analytic functions are largely functions of a third region of the frontal lobe known as the prefrontal cortex. Damage to this area of the frontal lobe causes changes in personality. Other functions of the prefrontal cortex, sometimes described as executive functions, include reasoning, planning, prioritizing, sequencing behavior, insight, flexibility, and judgment (Young and Pigott, 1999). Normal frontal cortical functions help suppress and moderate more primitive impulses and actions. The frontal cortex also allows a person to appropriately process incoming sensory stimuli, reason, focus on tasks, and respond to social cues. Difficulty in performing these activities often manifests as symptoms of psychiatric disorders. Two key functions, working memory and behavioral inhibition, have increasingly become targets of research interest as scientists explore the neurobiology of psychiatric disorders (Dubin, 2002). Another important area usually localized only in the left frontal lobe is Broca's area, which controls the muscles necessary to speak. Damage to Broca's area from causes such as accidents or stroke results in the inability to speak (motor aphasia). Speech is a vital part of communication and appropriate social interaction.

The temporal lobe is responsible for some functions of language, memory, and emotion. Wernicke's area is a specialized area of the temporal lobe responsible for organizing words so they will be recognized and express the correct emotional content. Written speech, verbal speech, and the visual recognition that is critical to communication are all functions of the temporal lobe. Language is one example where two distinct regions, Broca's area in the frontal lobe and Wernicke's area in the temporal lobe, work together to facilitate normal communication. Aphasia, a communication disorder, sometimes has several origins within the brain, most notably Wernicke's area of the temporal lobe and Broca's area in the frontal lobe. The auditory association area of the temporal lobe is involved with memory, especially those connected to visual and auditory cues.

The occipital lobe contains the primary visual cortex and is most responsible for visual functioning. Color recognition, the ability to recognize and name objects, and the ability to track moving objects are functions of the occipital lobe. The occipital lobe is sensitive to hypoxia, and trauma to this region of the brain sometimes results in blindness, even if the optic nerves and eyes remain in-

**TABLE 6-1**

<table>
<thead>
<tr>
<th>LOBE</th>
<th>LOCATION</th>
<th>NORMAL FUNCTION</th>
<th>SYMPTOMS OF ALTERATIONS IN BRAIN FUNCTIONING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frontal</td>
<td>Anterior, or front area, of brain</td>
<td>Programming and execution of motor functions</td>
<td>Changes in affect such as flattening</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Higher thought processes such as planning, ability to abstract, trial-and-error learning, and decision making</td>
<td>Alteration in language production</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Intellectual insight, judgment</td>
<td>Alteration in motor functioning</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Expression of emotion</td>
<td>Impulsive behavior</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sensory perception: taking in information from environment, organizing it, and communicating this information to rest of brain</td>
<td>Impaired decision making</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Association areas that allow for such things as accurately following directions on a map, reading a clock, building a birdhouse, or dressing oneself</td>
<td>Concrete thinking</td>
</tr>
<tr>
<td>Parietal</td>
<td>Posterior to central sulcus</td>
<td>Primarily responsible for hearing and receiving information via ears</td>
<td>Altered sensory perceptions such as decreased consciousness of pain sensation</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Difficulty with time concepts such as inability to keep appointment times</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Alteration in personal hygiene</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Alteration in ability to calculate numbers</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Inability to adequately perform common motor actions of writing</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mixing up right and left</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Poor attention span</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Auditory hallucinations</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Increased sexual focus</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Decreased motivation</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Alterations in memory</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Altered emotional responses</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Sensory aphasia</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Visual hallucinations</td>
</tr>
<tr>
<td>Temporal</td>
<td>Lies beneath skull on both sides; commonly called the temple</td>
<td>Primarily responsible for hearing and receiving information via ears</td>
<td></td>
</tr>
<tr>
<td>Occipital</td>
<td>Most posterior of brain lobes—back of head</td>
<td>Primarily responsible for seeing and receiving information via eyes</td>
<td></td>
</tr>
</tbody>
</table>
tact. Lesions of the occipital lobe can cause visual hallucinations and other abnormalities of visual functioning, such as alexia, or the inability to read.

The parietal lobe of the brain functions as the primary sensory processing center. The postcentral sensory gyrus area of the parietal lobe, or the somesthetic cortex, interprets sensory information. This includes visual, tactile, and auditory information. Posterior to the somesthetic cortex is the somesthetic association area. Again, as an association area, it is responsible for organizing, integrating, and analyzing sensory information that the primary sensory cortex in the postcentral gyrus will interpret more specifically.

**Basal Nuclei.** The basal nuclei, also known as basal ganglia, are concentrations of cell bodies closely involved with motor functions and association. Basal nuclei are concentrations of gray matter located within the white matter of the cerebrum and midbrain. They have many connections to both the superficial cortex above and the deep midbrain structures below. Among the most well known basal nuclei are the caudate lobe, putamen, globus pallidus, and substantia nigra. These basal nuclei translate movements such as walking while it is happening, and they also modulate and correct muscle functioning that allows movements to occur in a coordinated manner. The basal nuclei aid in the learning and programming of motor behavior. Activities that are well learned and rehearsed over the course of a person’s life often become automatic. Complex motor skills involved in walking, eating, or driving become so natural that a person does not have to think consciously to perform them. This helps to explain why some people with dementia retain some of these complex behaviors long after a severe memory or language loss.

Conditions such as Huntington’s disease and Parkinson’s disease are associated with basal nuclear dysfunction and their inability to effectively communicate with the cerebral cortex (Montoya, 2006). Some medications used to treat psychiatric disorders alter the basal nuclei (Box 6-1). For example, chlorpromazine (Thorazine) and haloperidol (Haldol) are two older neuroleptic antipsychotic medications that sometimes cause hypertonicity, or dystonia, a condition marked by excessive muscle tone.

**Limbic System.** Instincts, primitive drives, sexual arousal, fear, aggression, and other emotions are part of the functions of the structures deep within the brain called the limbic system or limbic lobe. It is often called a system because researchers believe its functions are a result of the interrelated, closely coordinated actions of its various structures. Table 6-2 and Figure 6-2 identify some of the structural components of the limbic system. Part of the limbic system, the amygduela, is instrumental in emotional functioning and in regulating affective responses to events. The amygdala modulates common emotional states such as feelings of anger and aggression, love, and comfort in social settings. The limbic system’s function of emotional regulation is linked with the olfactory pathways that connect to the amygdala. Some suggest that this explains why certain smells evoke strong emotional responses and memories in some individuals. The limbic system holds increasing interest for researchers trying to identify the biologic etiology of bipolar disorder. Some researchers have hypothesized that the rapid misfiring of neurons in the amygdala is instrumental in the development of the typical symptoms of bipolar disorder. Researchers are also studying the amygdala in an attempt to better understand abnormal fear reactions such as panic and violent-rage behaviors (Carlson, 2001).

The thalamus, a part of the brain collectively referred to as the diencephalon, is another part of the limbic sys-
Neurobiology in Mental Health and Disorder  Chapter 6  117

tem. It is primarily a structure that acts as gateway directing sensory information to the cerebral cortex. All sensory information, except smell, comes from the PNS to the cerebral cortex of the CNS via the thalamus. This critical structure helps to filter incoming sensory information and to direct it to specific regions of the cortex where it can be interpreted and evaluated more fully. This includes sensory information that influences emotions, mood, and memory.

The hypothalamus is another functional part of the limbic system that rests deep within the brain and helps regulate some of the most basic human functions including sleep-rest patterns, body temperature, thirst, and physical drives of hunger and sex. Research indicates that some symptomatic behaviors, such as appetite and sleep problems in the depressed client, the seasonal mood changes of seasonal affective disorder (SAD), and temperature regulation problems in clients with schizophrenia (e.g., wearing winter coats in the summer) are a hypothalamic dysregulation. Because of the close physical and physiologic association with the pituitary, hypothalamic activity influences hormonal regulatory events attributed to the pituitary as well.

The hippocampus is located deep within the temporal lobe below the thalamus (see Figure 6-2). It has direct connections with the hypothalamus and the amygdala, and it plays a major role in the encoding, consolidation, and retrieval of memories. Clients with Alzheimer’s disease have damage to the hippocampus, resulting in difficulties with short-term memory and learning ability.

**Neurophysiology**

Among the billions of cells that make up the human brain, approximately 10% are neurons. The neurons are directly responsible for impulse conduction that allows the brain to initiate signals and process information. Each neuron has thousands, if not hundreds of thousands, of connections to other neurons. The connections, called synapses, allow various areas of the brain to communicate with each other, to interpret sensory information, and to initiate stimuli to activate muscles. This constant brain nerve cell (neuronal) activity accounts for the complex perceptions and behaviors that make us human. The vast numbers of synaptic interconnections makes the brain far more complex and sophisticated than any computer.

There are several types of neurons in the brain. Nuclei and other major organelles are typically in a region of the cell known as the cell body or cyton. Two kinds of processes originate from the cell body region. Dendrites carry electrical impulses toward the cell body, while the axon carries impulses away from the cell body. Axons end at small presynaptic axon terminals. Figure 6-3 illustrates one common type of neuron, called a motor neuron, that stimulates glands and muscle cells.

**FIGURE 6-2** The limbic system.
Nerve Cell Electrical Function: Action Potential

All neurons are capable of detecting, processing, and conducting electrical signals known as action potential. Neurons in the CNS are also capable of generating their own electrical impulses. Cells conduct electricity by concentrations of ions such as sodium, potassium, and chloride. These ions differ inside and outside of the cell. Because these ions carry an electrical charge, the difference in the distribution of electrically charged ions on the two sides of the membrane creates an electrical potential, or ability to conduct an electrical current. The neuronal membranes allow selective movement of these ions across the membrane. An action potential occurs as a result of the movement of ions across the cell membrane, temporarily shifting the electrical charge on each side of the nerve cell membrane.

Many kinds of events initiate action potentials given sufficient stimulus strength. Typically, when an action potential reaches the synaptic terminal, it causes a change in the permeability of the membrane, allowing chemical neurotransmitter substances to be released into the gap or synaptic cleft between adjacent, or neighboring, neurons. Figure 6-4 illustrates a typical synaptic structure. The

---

**FIGURE 6-3** Structural features of neurons: dendrites, cell body, and axon. (From Lewis SM et al: Medical-surgical nursing: assessment and management of clinical problems, ed 7, St Louis, 2007, Mosby.)

---

**FIGURE 6-4** Electrical and chemical synapses. A, Electrical synapses involve gap junctions that allow action potentials to move from cell to cell directly by allowing electrical current to flow between cells. B, Chemical synapses involve transmitter chemicals (neurotransmitters) that signal postsynaptic cells, possibly inducing an action potential. (From Thibodeau GA, Patton KT: Anatomy & physiology, ed 6, St Louis, 2007, Mosby.)
movement of neurotransmitters across cell membranes plays a large role in mental health and mental disorders.

**Nerve Cell Chemical Function: Neurotransmitters**

As the depolarization of neurons reaches the synapse, the action potential is no longer effective in communicating directly with the next neuron in sequence. The space between the two cell membranes in most synapses is about 20 to 30 nanometers (nm). Although this is small, it is too large for most action potentials to cross directly. So communication between one neuron and another depends on the release of chemicals known as **neurotransmitters** by the presynaptic cell and their reception on the postsynaptic membrane. Neurotransmitter movement, while much slower than action potentials, is effective in sending and regulating signals from one neuron to the next. It is the specificity of neurotransmitter receptor sites on the postsynaptic membrane that forms the basis of chemical control of all neurologic functions.

Neurotransmitters are categorized several ways. For our purposes, we will classify them according to their chemical structure. Additionally, they are also identified as either excitatory or inhibitory in nature when reaching the postsynaptic membrane. Considerable research identifies brain regions with the highest concentrations of various transmitter substances and associates various brain functions and malfunctions with specific neurotransmitters. Although more than 100 substances are identified as neurotransmitters or probable neurotransmitters, Table 6-3 summarizes the most widely recognized neurotransmitter substances of the CNS. For a substance to qualify as a neurotransmitter, it will display the criteria described in Box 6-2.

Many synthetic and naturally occurring toxins, street drugs, anesthetics, and medications used to treat psychiatric disorders function at the level of the synapse where cell sites have specific receptors. Similarly, an increasing number of neurologic dysfunctions are attributed to abnormalities associated with neurochemical transmitter substances.

---

**TABLE 6-3**

**Common CNS Neurotransmitters**

<table>
<thead>
<tr>
<th>MOLECULAR CLASS</th>
<th>NAME OF NEUROTRANSMITTER</th>
<th>ACTIVITY</th>
<th>DISTRIBUTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biogenic amine (catechol amine)</td>
<td>Acetylcholine (ACh)</td>
<td>Excitatory</td>
<td>Motor neurons, pons, forebrain</td>
</tr>
<tr>
<td>Amino acids</td>
<td>Aspartate</td>
<td>Excitatory</td>
<td>CNS</td>
</tr>
<tr>
<td></td>
<td>Glutamate</td>
<td>Excitatory</td>
<td>Primary exciter in CNS</td>
</tr>
<tr>
<td></td>
<td>γ-Aminobutyric acid (GABA)</td>
<td>Inhibitory</td>
<td>Primary inhibitor in CNS</td>
</tr>
<tr>
<td></td>
<td>Glycine</td>
<td>Inhibitory</td>
<td>Spinal cord</td>
</tr>
<tr>
<td>Monoamines</td>
<td>Dopamine</td>
<td>Excitatory</td>
<td>Basal nuclei, limbic system</td>
</tr>
<tr>
<td></td>
<td>Serotonin (5-HT, 5 hydroxytryptamine)</td>
<td>Excitatory</td>
<td>Brain stem, pons, medulla</td>
</tr>
<tr>
<td></td>
<td>Norepinephrine</td>
<td>Excitatory</td>
<td>Pons, medulla</td>
</tr>
<tr>
<td>Neuropeptides</td>
<td>Many</td>
<td>Uncertain</td>
<td>CNS, PNS</td>
</tr>
<tr>
<td>Gases</td>
<td>Nitrous oxide (NO)</td>
<td></td>
<td>Brain, blood vessels</td>
</tr>
<tr>
<td></td>
<td>Carbon monoxide (CO)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**BOX 6-2**

**Criteria for a Substance To Be Labeled a Neurotransmitter**

The chemical is synthesized in the neuron.
The chemical is present in the presynaptic terminal and released in amounts sufficient to exert a specific effect on a receptor neuron.
When applied exogenously (as per drug) in a reasonable concentration, the drug mimics the action of the endogenously released neurotransmitter.
A specific mechanism exists for removing it from its site of action, the synaptic cleft.

Once a neurotransmitter is attracted to the postsynaptic membrane, typically at receptor sites that are specific to the particular neurotransmitter, it is deactivated. Deactivation happens by one of three primary means:

1. The neurotransmitter leaves the area through natural diffusion of a substance from an area of high concentration to one of low concentration.
2. The neurotransmitter is broken down by enzymatic degradation.
3. The neurotransmitter undergoes reuptake and is transported back into storage in the presynaptic neuron.

**Specific Neurotransmitters.** Specific neurotransmitters are located in different regions and areas of the brain, allowing for highly differentiated regional functions of the brain. The intricate interaction of nerve cells and distribution of various neurotransmitters in different areas of the brain form the basis for all complex activities of the CNS.

**Acetylcholine (ACh)** was the first substance discovered to be a neurotransmitter. It is almost everywhere in the brain, but particularly high concentrations occur in the basal nuclei and motor cortex of the brain. Neurons using ACh as a neurotransmitter are often called cholinergic. There are two types of acetylcholine receptors:
muscarnic and nicotinic. Many drugs, such as the older neuroleptic antipsychotics, interact with ACh and its receptor sites to produce anticholinergic side effects, which occur when muscarinic acetylcholine receptors are blocked. Side effects include dry mouth, blurred vision, constipation, and urinary retention. These side effects are troubling to clients and are a common reason why clients stop using their medications and fail to comply with the treatment regimen. In severe cases, muscarinic receptor blockade produces confusion and delirium in clients, especially in older clients. Nicotinic receptors respond positively to nicotine and are common in neuro-muscular synapses as well as in some CNS and PNS regions. Nicotine, found in tobacco, binds with the nicotinic receptor sites and is able to mimic the effects of ACh released in some centers of the brain that are associated with pleasure, making nicotine highly addictive. Exposure to excessive levels of nicotine will sometimes cause paralysis. Nicotine is also an effective insecticide and a common cause of poisoning in children. Good client teaching and nursing care designed to manage the side effects and adverse effects of drugs are significant aspects of psychiatric mental health nursing.

**Glutamate** (glutamic acid) is an amino acid and the most widely distributed excitatory neurotransmitter in the brain. Some theorize that excessive glutamate activity is a part of the neurodegenerative process seen in such illnesses as schizophrenia and Alzheimer’s disorder (Alexander et al., 2002; Goff and Coyle, 2001; Stahl, 2000). γ-Aminobutyric acid (GABA), chemically derived from glutamate, is the brain’s principal inhibitory neurotransmitter. Nerve cells stimulated by inhibitory neurotransmitters such as GABA will be turned off, which slows or stops actions completely in postsynaptic neurons.

**Dopamine** is a neurotransmitter well localized in the CNS. Dopaminergic neurons occur in several brain regions including the substantia nigra, midbrain, and hypothalamus. Dopamine-containing cells in the midbrain project to the limbic cortex. Researchers believe that these areas are the parts of the brain that malfunction in schizophrenia.

**Norepinephrine** or noradrenaline is concentrated in a small area of the brain known as the locus ceruleus. Many studies now indicate that clients suffering from mood disorders, particularly major depression, suffer from a deficit of norepinephrine. Sympathetic nerves that innervate smooth muscles in blood vessels have a heavy concentration of norepinephrine, which helps to explain its role in elevating blood pressure in the fight-or-flight response. When released directly into the bloodstream, norepinephrine acts as a hormone that enhances the effect of locally released norepinephrine at neuromuscular junctions. Both norepinephrine and its chemical relative, epinephrine, are synthesized from the amino acid tyrosine. Norepinephrine, epinephrine, dopamine, serotonin, and histamine belong to the class of neurotransmitters known as monoamines. Norepinephrine-producing neurons are sometimes referred to as adrenergic.

**Serotonin** has a pattern of action similar to norepinephrine and is made from tryptophan, another amino acid. Serotonin production occurs in the brain stem and is also widely dispersed throughout the cerebral cortex and the spinal cord. Serotonin helps to regulate a constant internal environment. Maintaining a normal body temperature, normal eating and sleep-rest patterns, and normal moods is dependent on adequate levels of serotonin. Clinically significant problems occur when clients have low levels of serotonin, and many behavioral symptoms common to depression occur when available serotonin is depleted.

Researchers suspect that two other gases—carbon monoxide (CO) and nitric oxide (NO)—function as neurotransmitter-like substances. NO and CO are both poisonous, unstable gases found in automobile emissions. Nitric oxide plays a role in the complex illness of major depression (McLeod, Lopez-Figueroa, and Lopez-Figueroa, 2001). Serotonin and its close chemical relatives, whose functions are still being researched, occur at multiple sites in the brain. Researchers believe these molecules play a role in the complex functioning of the brain.

**Clinical Significance of Neurotransmitters.** Extensive research has been directed toward developing new drugs that operate at the synaptic level within the brain. Any chemical that mimics, competes, destroys, or prevents a neurotransmitter from binding on specific receptor sites on the postsynaptic membrane alters the effectiveness of communication between neurons. Researchers have made countless advances in the treatment of psychiatric disorders. This is due to an increased understanding of neurotransmitters as well as an understanding of the way neurotransmitters are synthesized and deactivated. A brief discussion of some of the more common brain-related illnesses linked to neurotransmitter dysfunctions follows. Table 6-4 summarizes specific disorders and related neurotransmitters.

**Depression.** Serotonin and its close chemical relatives, dopamine and norepinephrine, are the neurotransmitters most widely involved in various forms of depression. The two major classes of antidepressants—tricyclic and selective serotonin reuptake inhibitors (SSRI) agents—differ primarily in their effects on either norepinephrine or serotonin levels. This explains why certain drugs, such as fluoxetine or paroxetine, that specifically target serotonin may not be effective for some clients but work well for others (see the case study presented later in the chapter). The selective serotonin reuptake inhibitor (SSRI) class of
Acetylcholine Decrease Alzheimer’s disease
in clients experiencing anxiety.

GABA synthesis, which then modulates the effect of excitatory neurotransmitters. This produces a calming effect. Many antianxiety medications such as diazepam (Valium) or alprazolam (Xanax) act by stimulating GABA neurotransmitters causing a hyperexcitability of the postsynaptic membrane. Catechol-O-methyl transferase (COMT), an enzyme normally responsible for deactivating norepinephrine, is sometimes present in excess in certain synapses. Too much of this enzyme prevents adrenergic neurons from effectively communicating with one another. Antidepressants that inhibit or reduce COMT levels restore neuronal communication ability. Because norepinephrine is also important in regulating activities such as heart rate and blood pressure, antidepressants operating on the norepinephrine system may have adverse side effects on these functions.

Anxiety. A number of conditions related to anxiety such as panic disorders and extreme phobias are triggered by an overproduction of some excitatory neurotransmitters causing a hyperexcitability of the postsynaptic membrane. GABA, one of the key inhibitory neurotransmitters in the CNS, normally counteracts the effect of these transmitters. Many antianxiety medications such as diazepam (Valium) or alprazolam (Xanax) act by stimulating GABA synthesis, which then modulates the effect of excitatory neurotransmitters. This produces a calming effect in clients experiencing anxiety.

Schizophrenia. A complex disorder such as schizophrenia most likely has multiple contributing factors including genetic predisposition, prenatal development, and the environment. The direct cause of symptoms manifested in schizophrenia is probably a disruption of normal neurotransmitter activity, particularly dopamine. One plausible explanation for schizophrenia is the dopaminergic theory, which hypothesizes that the dopamine levels in people with schizophrenia are elevated. Some maintain that at least six other neurotransmitters—glutamate, serotonin, norepinephrine, acetylcholine, GABA, and cholecystokinin—are also involved in schizophrenia. The most commonly prescribed antipsychotic drugs suppress dopamine and similar transmitter substances. Current treatment continues to focus primarily on the dopaminergic theory.

Parkinsonism. Most researchers agree that the immediate cause of parkinsonism is a deficiency of dopamine, particularly in the basal nuclei involved in motor coordination. Characteristically, patients suffering from Parkinson’s disease display tremors, a shuffling gait, and a progressive lack of motor control. Clients sometimes have a loss of facial motor control, slurring speech, and make facial expressions that are flat or masklike. Public figures such as the late Pope John Paul II, boxer Muhammad Ali, and actor Michael J. Fox displayed several of these symptoms, raising public awareness of the condition. The causes of dopamine deficiency in Parkinson’s patients appear to be both genetic and environmental. Currently, parkinsonism is treated with L-dopa, a dopamine precursor capable of crossing the blood-brain barrier of the brain. According to the theory, brain cells containing the appropriate enzymes will convert the L-dopa into dopamine.

Alzheimer’s Disease. Alzheimer’s disease is among the leading causes of disability and death of older adults in the United States, and the number of affected persons increases each year. Acetylcholine is the neurotransmitter primarily involved in Alzheimer’s disease. Decreased levels of ACh produce many of the behavioral manifestations of the disease, such as memory loss and disorientation. This helps to explain why drugs such as donepezil (Aricept) are useful in the treatment of Alzheimer’s disease. Aricept and other similar drugs inhibit the cholinesterase enzyme that breaks down ACh thus increasing the amount of available acetylcholine, therefore prolonging the onset of symptoms of Alzheimer’s disease (Stahl, 2000).

Both Parkinson’s and Alzheimer’s diseases are examples of recognized organic brain disorders. They are included in this discussion because of their relationship to specific transmitter substances and because the devastating effects of these degenerative conditions are clearly linked to mood disorders and dementia that psychiatric mental health nurses encounter. The Case Study is an example of a neurodegenerative disorder, multiple sclerosis, that frequently has associated symptoms of a mental disorder.

<table>
<thead>
<tr>
<th>NEUROTRANSMITTER</th>
<th>DYSFUNCTION</th>
<th>MENTAL DISORDER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dopamine</td>
<td>Increase</td>
<td>Schizophrenia</td>
</tr>
<tr>
<td>Serotonin</td>
<td>Decrease</td>
<td>Depression</td>
</tr>
<tr>
<td>Norepinephrine</td>
<td>Decrease</td>
<td>Depression</td>
</tr>
<tr>
<td>GABA</td>
<td>Decrease</td>
<td>Anxiety disorders</td>
</tr>
<tr>
<td>Acetylcholine</td>
<td>Decrease</td>
<td>Alzheimer’s disease</td>
</tr>
</tbody>
</table>
INTERRELATED SYSTEMS

Evidence is now clear that the CNS operates in delicate balance with other body systems. Research demonstrates that the CNS both affects and is affected by the immune system, the endocrine system, and the body’s natural biologic rhythms, as well as other systems. The following are some examples of the interactions between body systems and how the disruption of these systems sometimes results in mental, emotional, and behavioral dysfunction and disorder.

Psychoneuroimmunology

Psychoneuroimmunology (PNI) studies the relationship between the neurologic, endocrine, and immune systems and behaviors associated with these systems. Cytokines, chemical messengers between immune cells, signal the brain to produce changes of activity in the endocrine system as well as the immune system. Research studies focus on the relationship of cytokines and the pathophysiology of medical diseases such as cancer, allergies, and autoimmune diseases. More recent studies focus on psychiatric disorders such as major depression, schizophrenia, and Alzheimer’s disease (Kronfol and Remick, 2000).

Brain receptor sites for neuropeptides produced by the immune system are associated with changes in emotions and behaviors. Stress causes the discharge of corticotrophin-releasing factors that suppress the immune system. Studies indicate that negative emotions, anxiety, and psychiatric disorders such as schizophrenia and mood disorders are sometimes associated with a decreased functioning of the immune system. Posttraumatic stress syndrome is associated with long-term immunosuppression (Kawamura, Kim, and Asukai, 2001).

Neuroendocrinology

Neuroendocrinology studies the relationship between the nervous system and the endocrine system. A number of hormones, including epinephrine, actually function as neurotransmitter-like substances. This affects chemical communication between many cells, even ones that are distant from the source of the hormone. Several hormonally based disorders result in medical conditions that produce psychiatric symptoms, as described next.

Research studies correlate hypothyroidism with depressive symptoms and Addison’s disease with depression and fatigue. Other endocrine disorders are linked to autoimmune conditions such as Graves’ disease, which causes excessive thyroid secretion. This sometimes follows an acute infection suggesting an immunologic origin for Graves’ disease. People who suffer from Graves’ disease commonly report symptoms of emotional stress, nervousness, fatigue, weight loss, heat intolerance, and gastrointestinal symptoms. Also, because schizophrenia and other psychiatric disorders occur more frequently during the reproductive period of life when sex hormones are most active, this suggests an endocrine-related origin.

Chronobiology

Chronobiology is the study of the biologic rhythms of the body, such as the circadian rhythms. These rhythms manifest in metabolic rate, sleep-wakefulness cycles, blood pressure, hormone levels, and body temperature. Researchers believe the brain controls these rhythms and their interactions with various endocrine organs. Many psychiatric and medical disorders occur more frequently when sleep patterns and biologic rhythms are disrupted.

Many hypothesize that dreams result from the activation of electrical activity in brain regions that recall recent memories and reinforce long-term memories. One theory maintains that mental disorders are the result of brain circuits that are not activating competently because of abnormal brain wave patterns. When incompetent brain circuits are activated while the individual is awake, clients often report hallucinations and illusions. While sleeping, these incompetent brain circuits appear to produce bizarre or illusory dreams (Kavanau, 2000). Psychoactive drugs modify brain waves in psychotic clients, which temporarily restore more normal brain circuits. Antidepressants increase brain waves and suppress or reduce rapid eye movement (REM) sleep. Electroconvulsive therapy suppresses abnormal brain waves, allowing more normal slow waves to dominate. Additional information on sleep disorders is in Chapter 18.

Sundowning, or Sundowner’s syndrome, is the exacerbation, or worsening, of psychotic or depressive symptoms during the afternoon or evening resulting in confusion and disorientation. Some studies connect sundowning with a disturbance of circadian rhythms. Psychiatric and medical conditions such as Alzheimer’s disease also disrupt the client’s circadian rhythm (Volicer et al., 2001). Decreased exposure to light during the winter months has also shown to produce depressive symptoms in clients suffering from seasonal affective disorder (SAD). PMH nurses need to be aware of these examples of chronobiologic disruptions that produce symptoms of mental illnesses.

EMERGING CONCEPTS IN PSYCHOBIOLOGY

Genetic Research

Genetics is the study of genes and the role they play in the functioning of living organisms. The Human Genome Project that began in 1990 resulted in the identification of all of the genes contained on the 23 pairs of human chromosomes. The knowledge of precise locations of genes responsible for every human biologic characteristic, as well as their biochemical structure, has opened up endless possibilities for research into the genetic causes of nearly every human disease or condition. This includes psychiatric disorders. However, recognizing that genes only determine the potential to develop any normal or abnormal condition significantly complicates the problem of identifying genetic causes of specific psychiatric disorders. Excellent evidence attributes disorders such as Huntington’s
disease and Parkinsonism to specific genes. For example, both diseases are located on chromosome number 4, but evidence for genetic causes of some other specific neurologic disorders is not so clear.

Because there appear to be familial tendencies in some disorders, researchers are attempting to specify schizophrenia genes. According to the most current literature, there are as many as 150 genes on nearly a dozen different chromosomes that contribute to the causes of schizophrenia, making the situation more complex (Badner and Gershon, 2002; Lewis et al., 2003). Research indicates that schizophrenia results from the interaction of multiple genes rather than a single gene. In theory, defective genes code for incorrect synthesis of neurotransmitters, or their deactivating enzymes, or other factors interfere with the proper transmission of vital chemical agents.

Research has also identified genes that are linked to bipolar disorder and substance dependence (Schindler et al., 2001). This helps to explain why certain psychiatric disorders recur in families and why first-degree relatives of individuals with psychiatric disorders have increased risk for developing the same or similar disorders. The genetic origins of other psychiatric dysfunction and disorders, namely attention deficit hyperactivity disorder, antisocial personality disorder, and violent behaviors, are being explored (Doyle, Roe, and Faraone, 2001; Raine et al., 2000).

Although few researchers believe that a single gene causes a psychiatric illness, genetics clearly plays a significant role in influencing mental health and disorder. The interaction of genes is highly complex, and the link of genes to behavior remains controversial. It appears that many genes influence psychiatric illness and the dysfunctional behaviors that are symptomatic of those illnesses (Petronis et al., 2003). There is also increased evidence that environmental and developmental conditions in utero contribute to the expression of these genes that subsequently manifest as abnormal behavior.

**Stem Cell Technology**

Stem cell technology is perhaps the most controversial and promising technique that will lead to treatments and cures for neurobiologic disease and injury. Stem cells are cells that have the complete genome intact and have not yet differentiated, or developed, into a specific cell type. A fertilized egg is totipotent, or has total potential to develop into an entire human being. As embryonic cells replicate, some become specialized genes while others are turned off. Adult stem cells have already differentiated, or begun to develop to a certain degree. For example, some adult stem cells have already developed into epithelia rather than connective tissue cells or muscle or nervous tissues. Although there are adult stem cells in a variety of tissues including bone marrow, some connective tissues, and even brain tissue, the ability to successfully culture them and use them for therapeutic purposes is currently limited.

The reason why stem cell technology is so promising is because undifferentiated stem cells from embryos have the potential to develop into any type of cell, so researchers are able to control gene expression deliberately. Specialized stem cells can be developed into organs for transplants and have fewer complications from tissue rejection. The controversy surrounding stem cell research is an ethical issue, primarily regarding the source of embryos that provide undifferentiated stem cells. Many public figures have taken seemingly rational and passionate but opposing points of view increasing the intensity of the debate. These points of view will shape public policy and the direction of stem cell research, which will determine matters of life and death. Debate continues for or against the use of embryos or amniotic fluid as researchers seek cures and treatments for conditions and diseases and remedies that stem cells might provide.

Regardless of the source of stem cells, adult or embryonic, numerous technical challenges remain, but the potential therapeutic applications for this research seem unlimited at the moment. Active research continues on numerous neurobiologic conditions including brain and spinal cord injury, neurogenetic disorders affecting brain development, and degenerative conditions such as amyotrophic lateral sclerosis (ALS), Parkinson’s disease and Alzheimer’s disease, among others (Shihabuddin et al., 1999). The implications of stem cell research for the future of psychiatric nursing are promising as is the potential of stem cell therapy itself.

**Diagnostic and Evaluation Procedures**

**Neuroimaging**

Before modern neuroimaging techniques were available, clinicians had few noninvasive tools to examine the human brain, with the exception of the x-ray. The brain remained a mystery. The development of imaging techniques since the early 1980s has dramatically changed the understanding of brain structure and function. Brain anatomy and physiology has now been mapped in exquisite detail, providing valuable information using a variety of techniques. Useful neuroimaging techniques available today include ultrasonography (US), computed tomography (CT), magnetic resonance imaging (MRI), functional magnetic resonance imaging (fMRI), positron emission tomography (PET), and single photon emission computed tomography (SPECT) (Figure 6-5). Unlike older x-ray technology that uses film, these techniques use computers to generate images. Table 6-5 identifies common nursing considerations for clients undergoing neuroimaging tests.

**Ultrasonography**

Ultrasonography, also known as echoencephalography, uses high-frequency sound waves to form images of brain spaces and masses. Because ultrasonography does not use
harmful radiation, many prefer this technique to examine developing brains. It was developed for medical purposes following World War II and has been widely used to create images of developing fetuses as well as various organs within the body, including the brain.

**Computed Tomography**

Following the development of sonography, a new neuroimaging technique based on x-rays was developed in 1972. Scientists conducted research to develop this technology at Electronic Music Industry, a branch of Capitol Records. Money from the sale of Beatles records partly funded the research. This technique used to be called computerized axial tomography (CAT). A CT scan of the brain provides a three-dimensional view of brain structures by imaging serial thin sections through the brain or other anatomic structure. These multiple sections help differentiate fine densities, unlike a normal x-ray film. Anatomic abnormalities in the brain as revealed in CT scans are not specific to any type of psychiatric disorder and do not serve as a specific test for disorders. However, they do provide suggestive evidence of brain-based problems. Clients with schizophrenia, bipolar disorder, other mood disorders, alcoholism, multi-infarct dementia, and Alzheimer’s disease have shown nonspecific brain abnormalities in CT scans. Many use the CT scan because it is available and cost effective. Disadvantages include lack of screening sensitivity, underestimation of brain atrophy, and inability to image in the sagittal and coronal views.

**Magnetic Resonance Imaging**

Formerly known as nuclear magnetic resonance (NMR), MRI has become an excellent tool and a substitute for actual exploratory surgery. It is also advantageous because it uses radio waves instead of harmful radiation and provides images that are sharper than CTs. MRI is unaffected by bone, and, unlike CT, it is able to view brain structures close to the skull. It also differentiates between white matter and gray matter tissue.

MRI is not appropriate for all clients because of several contraindications to its use. Box 6-3 indicates the client groups who must avoid MRIs. Clients with claustrophobia are often unable to complete the study because the MRI machine is enclosed and clients are required to remain motionless. Because of the confining environment and excessive noise of the equipment, nurses need to focus on client teaching before the test and closely monitor the client’s anxiety levels during testing. Newer open-structured MRI equipment has made MRI testing easier for clients. MRIs show neuroanatomic changes in clients with schizophrenia that include increased size of ventricles, temporal lobe reductions, hippocampal reductions, and cortical atrophy as evidenced in Figure 12-1.

**Functional MRI**

fMRI is a modification of the basic MRI and detects brain activity by measuring oxygen consumption and metabolic differences in various parts of the brain. fMRI reveals that clients with Alzheimer’s disease often have lower glucose metabolism in the cortical regions (Alexander et al., 2002). fMRI is an effective tool for identifying specific functional areas of the brain associated with behaviors. The science of neuroinformatics, which includes techniques such as fMRI, has become the equivalent of the Human Genome Project of the twenty-first century by helping to map the human brain.

**Positron Emission Tomography and Single Photon Emission Computed Tomography**

Positron emission tomography (PET) is based on the basic principles of CT scanning. PET scanning remains at the forefront in neuroimaging procedures because of the information it provides regarding brain function in addition to structure. Patients undergoing a PET scan have radioactive substances such as glucose introduced into the blood supply of the brain. When positron-emitting radionuclei interact with electrons, an image is produced. Both particles cease to exist and are converted into two photons that travel in opposite directions and are detected as color variations indicated on a screen. The machine and procedure require a support team of physicists, chemists, and computer experts and are expensive.

SPECT and PET are also called radionucleide scanning techniques, because both involve the introduction of radioactive substances into the blood supply of the brain. SPECT is particularly useful in visualizing vascular struc-
tures in the brain and in diagnosing disorders such as cerebrovascular accidents (CVAs).

These techniques are particularly useful for demonstrating variable levels of brain activity and associated blood flow within the brain. SPECT scans have detected abnormalities in the frontal cortex, occipital, and temporal lobes, and parahippocampal gyrus in clients with panic disorders.

**TABLE 6-5**

<table>
<thead>
<tr>
<th>TEST</th>
<th>GENERAL CONSIDERATIONS</th>
<th>COMMON NURSING CARE</th>
<th>COMMON CONTRAINDICATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ANATOMIC IMAGING</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computed tomography (CT)</td>
<td>Three-dimensional view of brain structures</td>
<td>Explain purpose of test and all procedures. Reassure client that test is safe and that radiation exposure is not a concern. Assess client’s anxiety level and monitor for symptoms of claustrophobia. Reassure client that hearing monotonous noise is common. Instruct client to lie still to ensure good imaging.</td>
<td>Allergy to iodine (not all CT requires iodine) Inability to lie completely still Claustrophobia</td>
</tr>
<tr>
<td>Magnetic resonance imaging (MRI)</td>
<td>Separates view of white matter from gray matter tissue</td>
<td>Explain purpose of test and all procedures. Reassure client that test uses magnets, not radiation; radiation exposure is not a concern. Assess client’s anxiety level and monitor for symptoms of claustrophobia. Instruct client to lie still to ensure good imaging. Instruct client that a clear plastic helmet with antenna will be put over head. Reassure client that hearing monotonous noise is common.</td>
<td>Inability to lie completely still Claustrophobia Pacemakers Metallic implants, plates, or screws Life support equipment needed for client Infusion pumps Generally not used when client is pregnant</td>
</tr>
<tr>
<td><strong>FUNCTIONAL IMAGING</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Positron emission tomography (PET)</td>
<td>Two-dimensional view of brain structures</td>
<td>Explain purpose of test and all procedures. Inform client that isotopes are radioactive and discuss concerns. Assess client’s anxiety level and monitor for symptoms of claustrophobia. Explain that there will be time interval of about 45 min between injection of isotope and scanning procedure. Explain that client may be blindfolded and have earplugs to decrease environmental stimulus during testing. Instruct client to lie still to ensure good imaging. Make sure client does not fall asleep during procedure—this will affect test results. As for PET above.</td>
<td>Inability to lie completely still Claustrophobia Severe anxiety level Recent use of sedating/tranquilizing medication because these medications alter cellular glucose use patterns Breast-feeding Requires expensive cyclotron</td>
</tr>
<tr>
<td>Single photon emission computed tomography (SPECT)</td>
<td>Two-dimensional view of brain structures</td>
<td></td>
<td>Breast-feeding Inability to lie completely still Claustrophobia</td>
</tr>
<tr>
<td></td>
<td>Measures physiologic and chemical functioning such as glucose uptake by cells in brain, as well as information on anatomic structures</td>
<td>Long half-life isotopes used</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Explain purpose of test and all procedures. Reassure client that test uses magnets, not radiation; radiation exposure is not a concern. Assess client’s anxiety level and monitor for symptoms of claustrophobia. Instruct client to lie still to ensure good imaging.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>No onsite cyclotron required</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Client and Family Teaching Guidelines

**Biologic Basis of Psychiatric Disorders**
- Determine a mutually acceptable time and location for the teaching session.
- Select an environment that is favorable for learning.
- Identify the client's readiness for learning.
- Identify the client's motivation for learning.
- Identify the client's knowledge about the topic and accuracy of that knowledge.
- Identify with the client the specific content that is requested and required.
- Define a measurable outcome with the client to determine that learning has occurred.
- Define the evaluation method used to determine the effectiveness of teaching.
- Use multiple teaching-learning approaches, such as visual and auditory, based on client's needs.
- Monitor the client's anxiety level during the teaching session, as increased anxiety will decrease information processing.
- Identify alternative resources available to the client to increase learning potential.
- Identify the process that the client will follow to access support persons if the client requires more reinforcement.

### Neurobiology and Psychiatric Nursing

Psychiatric mental health nursing provides care to clients with brain-based illnesses. Increasingly, a strong background in neurobiology is part of the standards of practice for psychiatric mental health nursing (American Nurses Association, 2006). By synthesizing the findings of the nursing assessment discussed in Chapter 3 and the nurse's understanding of psychobiologic issues, effective nursing care will assist clients in achieving wellness.

As we are learning, each structure and each neurochemical produced and used by the brain has a specific function. The brain is a dynamic, continually changing environment, and researchers are discovering more of the complexities of the brain. In adults, the brain seems less able to repair itself after injury or replace degenerative cells when compared with other parts of the body. This *neuroplasticity*, or the ability of the brain to change its structure and function, is providing insights into the role of certain brain areas in the development of illness (Mohr and Mohr, 2001). New understanding and application of concepts such as the neuroplastic nature of brain tissue are also leading to new approaches for treating disorders. Until now, many believed that the capacity of the brain to repair itself after injury or to replace degenerative cells was minimal, particularly in adults, but current research reveals brain cell regeneration in several conditions.

Genetics and stem cell research are just two emerging technologies that are opening the door to potential treatments for psychiatric illnesses. Much of the stigma attached to psychiatric illness was due to a lack of understanding regarding the biologic basis of these disorders. Therefore, effective client and family teaching is an important function of the role of the psychiatric mental health nurse as researchers discover new information regarding the structures and functioning of the CNS. The Client and Family Teaching Guidelines box displays the highlights of effective client teaching regarding the biologic basis of psychiatric disorders. Psychiatric mental health nurses will continue to play an important part by directly assisting clients with brain-based disorders and by teaching and informing clients, families, and the general public about advances in neurobiology.

New research findings continue to change the way people with psychiatric disorders are cared for and treated. The Research for Evidence-Based Practice box highlights the importance of critical thinking as psychiatric mental health nurses approach and plan modifications of care based on new research findings.

Knowledge of the neurobiologic basis of psychiatric disorders is essential in effective psychiatric mental health nursing practice. Nurses need to include biologic principles in all aspects of nursing care, from assessment to evaluation, to ensure comprehensive and quality nursing. More and more information will be available regarding structure and functioning of the brain, and because of this, the role and function of the psychiatric mental health nurse will continue to change. Staying current with dynamic development in the field will continue to stimulate and positively challenge the truly professional psychiatric mental health nurse.

### Research for Evidence-Based Practice


Some research has reported that the brains of individuals who commit suicide are different from the brains of individuals who have died of natural causes. Postmortem examination of the receptor/transporter binding sites of the brain tissue of suicide victims and of individuals who have died of natural causes show that the brains of suicide victims have unique, specific neurochemical characteristics that make “suicide brains” different from the brains of individuals who have died of natural causes. Scientists are using such studies to formulate a hypothesis of molecular markers that will possibly help define and identify individuals at risk for suicidal behavior. Researchers are developing tests to measure identified markers. When these markers are specifically identified and prove to be reliable in their ability to predict suicidal behavior, the test will likely become a routine aspect of mental health evaluation.

### Chapter Summary
- Current knowledge about the brain and its functions is continually changing.
- The brain is the most complex and one of the most important organs in the human body because of its multiple functions.
Psychiatric disorders are brain-based illnesses with anatomic or physiologic components.

It is imperative for nurses to understand the anatomy and physiology of the brain and other systems that interact with the nervous system. Nurses also will become familiar with psychobiologic approaches to treat psychiatric disorders.

One key to understanding treatment strategies for psychiatric disorders is to recognize the role that neurotransmitter substances play in neural communication.

Nurses will become familiar with psychobiologic approaches to treat psychiatric disorders.

Modern neuroimaging techniques help explain structure and function and their relation to brain differences and psychiatric illnesses.

Emerging fields in neuroscience such as genetics and stem cell research will continue to bring advanced technologies that lead to improved care for patients suffering from neurobiologic disorders.

### REVIEW QUESTIONS

1. Which statement by a family member of a person with schizophrenia demonstrates effective learning about the disease?
   1. “The disease was probably caused by problems with several genes. These genes cause changes in how certain brain chemicals work.”
   2. “The disease could be cured if our politicians and laws allowed for more stem cell research. Adult stem cells hold so much promise.”
   3. “The disease probably resulted from the mother’s smoking during pregnancy. Nicotine is actually a neurotransmitter.”
   4. “If our family had more money, we could afford the promising psychoneuroimmunologic treatments available in other countries.”

2. Which assessment finding best indicates release of norepinephrine?
   1. Pulse rates changes from 70 to 62
   2. Pupil size changes from 8 mm to 3 mm
   3. Client begins complaining of “intestinal cramping”
   4. “If our family had more money, we could afford the promising psychoneuroimmunologic treatments available in other countries.”

3. These clients are scheduled to have magnetic resonance imaging (MRI). For which client(s) should additional assessment information be gathered before the diagnostic procedure? You may select more than one answer. A client with the following conditions:
   1. A history of wounds from exploding shrapnel during military service
   2. A comorbid diagnosis of bleeding peptic ulcers for the past 3 years
   3. Current complaints of extreme sensitivity to loud noises
   4. Reports of allergies to iodine, eggs, and shellfish
   5. A 3-year history of Parkinson’s disease

4. An adult has panic attacks. Which neurotransmitter is most implicated in this problem?
   1. Norepinephrine
   2. Acetylcholine
   3. Serotonin
   4. Gamma aminobutyric acid (GABA)

5. A nurse plans the care for an adult with a tumor in the brain’s frontal lobes. Initial interventions should focus on the client’s anticipated problems with the following:
   1. Motor function and judgment
   2. Sensory and calculation abilities
   3. Interpretation of visual stimuli
   4. Hearing and hygiene

Additional self-study exercises and learning resources are available to you on the Companion CD at the back of the book and on the Evolve website at http://evolve.elsevier.com/Fortinash/.

### REFERENCES


**ONLINE RESOURCES**
American Academy of Sleep Medicine: www.aasmnet.org
American Society of Neuroimaging: www.asnweb.org
Center for Sleep and Circadian Biology: www.northwestern.edu/cscb
Encyclopedia of Psychology: Psychobiology: www.psychology.org/links/Publications/
Psychobiology
International Society of Developmental Psychobiology: www.oswego.edu/isdp
National Institute of Mental Health: The Human Brain Project: www.nimh.nih.gov/neuroinformatics/
National Sleep Foundation: www.sleepfoundation.org
Society for Light Treatment and Biological Rhythms: www.sltbr.org