CHAPTER 7

NEUROLOGICAL DISORDERS

The normal functioning of the central nervous system can be affected by a number of disorders, the commonest of which are headaches, tumors, vascular problems, infections, epilepsy, trauma from head injury, demyelinating diseases, and metabolic and nutritional diseases. The following is a brief overview of those disorders that a neuropsychologist is most likely to encounter either clinically or in the literature.

VASCULAR DISORDERS

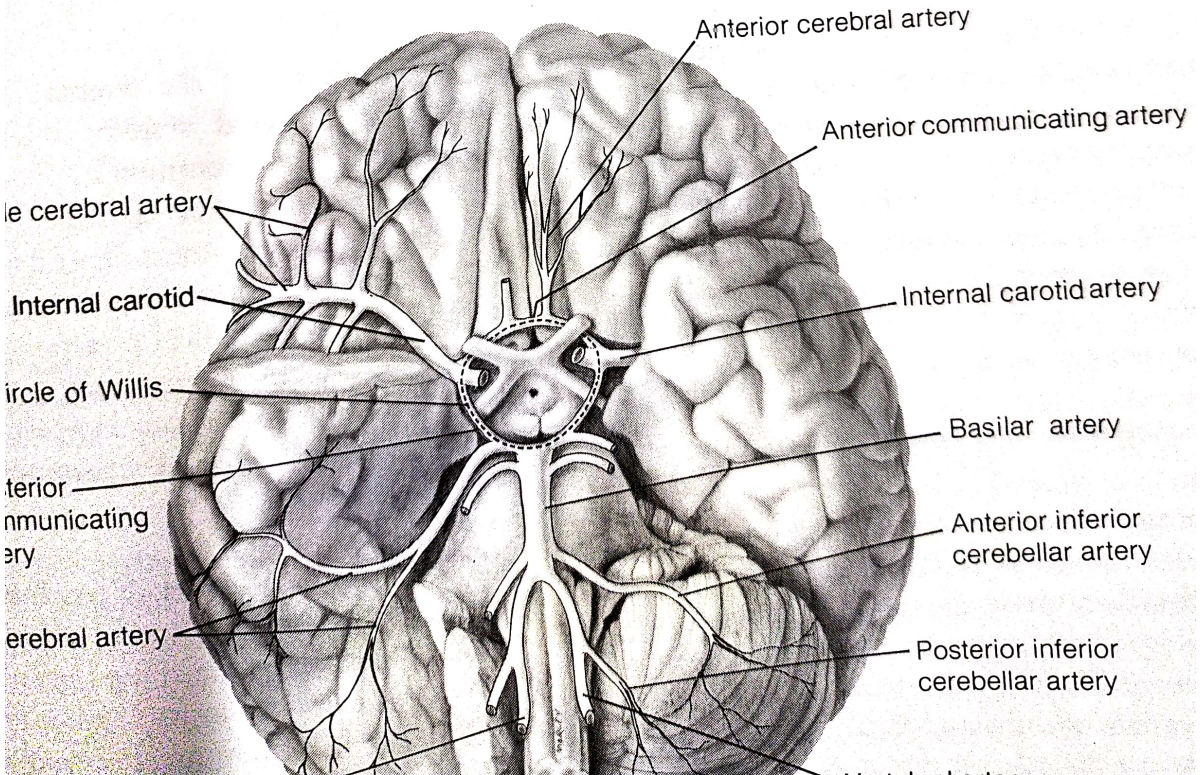
A neuron or glial cell can be damaged by any process that interferes with its energy metabolism, whether it be a reduction in oxygen or glucose, an introduction of some poison or toxic substance, or, more importantly, an interruption in blood supply. Vascular disease can produce serious—even total—reduction in the flow of both oxygen and glucose, resulting in a critical interference wit cellular metabolism. If such interference las longer than 10 minutes, all cells in the affecte region die. Cerebral vascular diseases are amor the most frequent causes of death and chron disability in the Western world. They are of parti ular concern to the neuropsychologist, becau neuropsychology plays an important role in asse ing the effect of vascular disorders on cogniti functioning. The neuropsychologist's role is esp cially important in the planning and assessment rehabilitation for victims of these diseases.

The brain receives its blood supply from t *internal carotid* and two *vertebral arteries;* one each is in either side of the body, as shown Figure 7-1. The internal carotid arteries enter skull at the base of the brain, branching off int number of smaller arteries and two major arter the *anterior cerebral artery* and the *middle cere artery,* which irrigate the anterior and middle p

. The vertebral arteries enter at
ın and then join together to form
After branching off into several
ıat irrigate the cerebellum, the
divides into the *posterior cerebral*
gates the medial temporal lobe
occipital lobe (Figure 7-2*C*).
rebral and posterior cerebral ar-
joined together on each side by
municating artery, and the two
ıre joined by the *anterior commu-*
These interconnections of arteries
f Willis, which may compensate
brain has lost flow from one of its
ɔral arteries. In swimming mam-
ıf Willis may also rapidly equalize
arterial pressure in the two hemispheres during diving.

The distribution zones of the anterior, middle, and posterior cerebral arteries are shown in Figure 7-2. Notice, however, that these arteries irrigate not only the cortex but also subcortical structures, as shown in Figure 7-3. Thus, a disruption of blood flow to one of these arteries has serious consequences for subcortical as well as cortical structures. As we shall see in ensuing chapters, the occurrence of both cortical and subcortical damage following vascular accident (stroke) is a major reason why studying stroke victims is such a difficult way to study brain function.

The veins of the brain are classified as external and internal cerebral veins and cerebellar veins



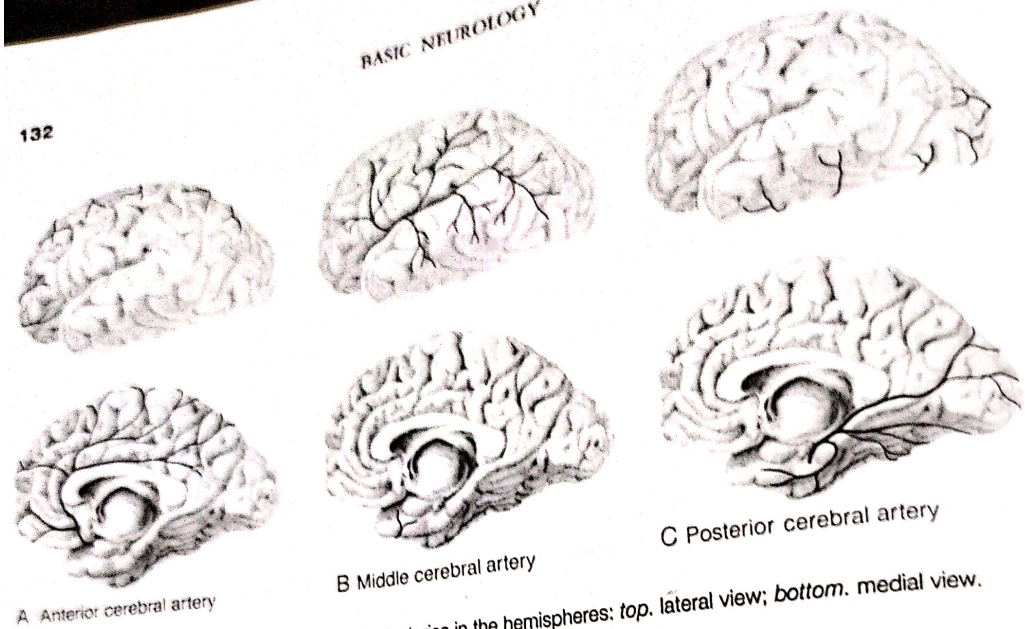


FIGURE 7-2. Distribution of the major cerebral arteries in the hemispheres: *top*, lateral view; *bottom*, medial view.

The venous flow does not follow the course of corresponding arteries but follows a pattern of its own, eventually flowing into a system of venous sinuses, or cavities, that drain the dura mater. Because adequate illustration of the venous-sinal drainage system requires more technical detail than is appropriate for this book, the interested reader is referred to more advanced discussions for more detail.

Symptoms and Diagnosis of Vascular Disorders

A common term used in discussion of cerebral vascular disorder is **stroke,** or **cerebral vascular accident.** A stroke is a sudden appearance of neurological symptoms as a result of severe interruption of blood flow. Stroke can result from a wide variety of different vascular diseases, but not all vascular disorders produce stroke, because the onset of dysfunction can be insidious, spanning months and even years. Stroke often produces an **infarct,** an area of dead or dying tissue resulting from an obstruction of the blood vessels normally supplying the area.

Most disease of the cerebral vascular system affects the arterial system, disease of venous drainage being uncommon in the central nervous system. The type of damage, or **lesion,** its extent, and its symptoms depend on a number of factors, including especially: the size of the blood vessel involved, the health of the remaining vessels, the presence of preexisting vascular lesions, the location of the tissue involved, the type of disorder, the presence of anastomoses, and individual differences.

Size of Blood Vessel. If small blood vessels, such as capillaries, are interrupted, the effects are more limited than the often devastating consequences of damage to such large vessels as the major arteries diagrammed in Figure 7-2. Disturbance of these arteries can result in lesions that include large portions of the brain and produce serious deficits in behavior.

Health of Remaining Vessels. If a stroke or

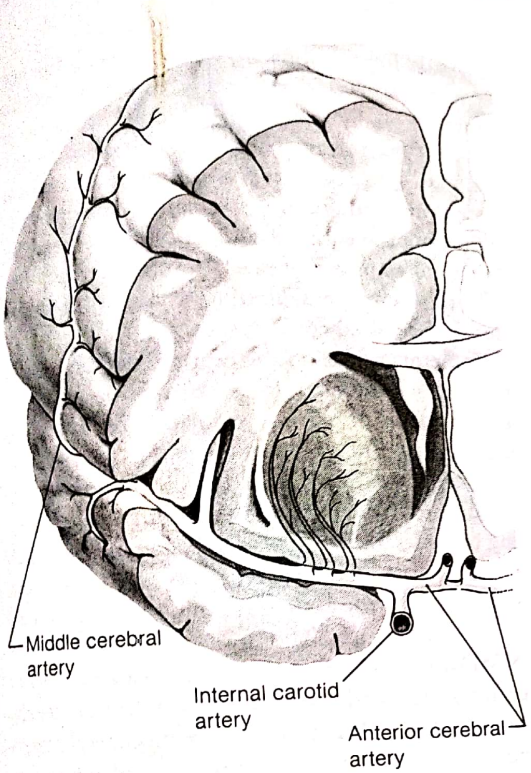


FIGURE 7-3. Irrigation of the deep structures of the brain by the same arteries as irrigate the surface structures. Interruption of the blood supply can thus produce both cortical and subcortical damage. (After Raichle, et al., 1978.)

nosis may be rather good, because vessels in surrounding zones are often able to supply blood to at least some of the deprived area. On the other hand, if a stroke affects a region surrounded by weak or diseased vessels, the effects may be much more serious, because there is no possibility of compensation. In addition, the surrounding weak zones may be at an increased risk of stroke themselves.

Presence of Preexisting Vascular Lesions. A small vascular lesion in a healthy brain will, in the long run, have a good prognosis for substantial recovery of function. However, in the event of preexisting vascular lesions, the effects of the second lesions may be extremely variable. The lesions can be cumulative and obliterate a functional zone of brain tissue, producing serious consequences. Or, less commonly, the lesions can produce what is known as a **serial lesion effect**, in which case there is remarkably little chronic effect from the second lesion. Although the mechanism of the serial lesion effect is unknown (see Chapter 26), the phenomenon is assumed to result from the process of recovery from the first lesion.

Location of Tissue Involved. The behavioral symptoms following vascular lesions depends, as with other lesions, on the exact location of damage. For example, a lesion in the primary visual cortex can produce an area of blindness, a lesion in the hippocampus can produce an impairment in memory, and a lesion in the medulla can produce arrest of breathing, resulting in death. Thus, the behavioral symptoms resulting from vascular disorder are important clues to the neurologist in locating the area of brain damaged and assessing the extent of the damage.

Type of Disorder. Exact symptoms of vascular disorder depend on the precise nature of the disorder. Slowly developing disorders can be expected to produce symptoms that differ from those of disorders of sudden onset. Warning symptoms of many disorders may be similar, however, and can include headache (if there is compression of the brain), as well as dizziness and vomiting.

Presence of Anastomoses. An **anastomosis** is a connection between parallel blood vessels that allows them to mingle their blood flows. The presence of an anastomosis in the brain allows cerebral blood supply to take more than one route to a given region. If one vessel is blocked, a given region might be spared an infarct because the blood has an alternative route to the affected zone. The presence of anastomoses is highly idiosyncratic among individuals, making it very difficult to

edict the extent of damage resulting from a
oke to a given vessel. The difficulty is exacer-
ed by substantial variation in the exact route of
n major blood vessels in the brain.

vidual Variation. The precise organization
e blood vessels differs considerably from per-
n person, as illustrated in Figure 7-4. Thus,
ge to the same vessel in different people can
ce symptoms that vary considerably al-
h the differences tend to be quantitative
than qualitative.

Types of Vascular Disorders

numerous vascular disorders that affect the
nervous system, the commonest are ische-
igraine stroke, cerebral hemorrhage, an-
and arteriovenous aneurysms.

al Ischemia. Ischemia includes a group
ers in which the symptoms are due to an
te supply of blood to the brain. The is-
ay occur suddenly (in which case the
e is often used) or they may appear grad-
creases in blood flow can have any of
s: (1) a **thrombosis:** a plug or clot in a
el, which has coagulated and remains at
f its formation; (2) an **embolism:** a
plug brought through the blood from
el and forced into a smaller one, where
circulation (an embolism can be a
bubble of air, a deposit of oil or fat, or
of cells detached from a tumor; cur-
lisms most frequently affect the mid-
ntery of the left side of the brain); or
of blood flow such that not enough
lucose are supplied (this reduction in
n result from a variety of factors that
wing of the vessels; the commonest
ch narrowing is **cerebral arterio-**
ndition marked by thickening and
e arteries; other causes of narrowing
nation of the vessels (*vasculitis*) or
essels).

Aside from embolism, which occurs suddenly, **encephalomalacia** *(literally "softening of the brain") usually develops gradually, taking hours or sometimes days. The disease may also be episodic, in which case it may be termed* **cerebral vascular insufficiency** *or* **transient ischemia,** *indicating the variable nature of the disorder. The onset of transient attacks is often abrupt, frequently occurring as fleeting sensations of giddiness or impaired consciousness.*

Ischemia results in the death of neurons, or an infarct. Neural death from ischemia was once believed to result directly from the loss of blood supply, but it now appears that this is not the case. Rather, when cells are deprived of blood, toxins are produced that act to overstimulate cells, leading to their death. For example, there are NMDA (*N*-methyl-D-aspartate) receptors on cells that are stimulated by the excitatory amino acids produced by the ischemia. The overstimulation of the NMDA receptors is toxic because neurons are literally stimulated to death. There are currently clinical trials of NMDA-receptor blockers that appear to reduce significantly the area of infarction resulting from stroke. It may seem odd that cells would have a "suicide" mechanism, but it appears that the NMDA receptors (and other similar receptors) play a major role in the neural mechanisms of learning. It is an unfortunate accident that when overstimulated they are self-destructive.

Migraine Stroke. People with classic **migraine** experience a transient ischemic attack with a variety of neurological symptoms, including impaired sensory function (especially vision), numbness of the skin (especially in the arms) difficulties in moving, and aphasia. The precise symptoms depend on the vessels involved; however, the posterior cerebral artery is most commonly affected. Although relatively rare, it has been known since the late 1800s that migraine attacks may lead to infarcts and permanent neurological deficits. **Migraine strokes** are believed to account for a significant proportion of

the distribution of the calcarine (*A*) and parieto-occipi-
particular blood distribution pattern.

(under 40 years of age), especially women. The cause of these strokes is likely some form of vasospasm, but the reason remains a mystery.

Cerebral Hemorrhage. **Cerebral hemorrhage** is a massive bleeding into the substance of the brain. The most frequent cause is high blood pressure *(hypertension)*. Other causes are congenital defects in cerebral arteries, blood disorders such as leukemia, or toxic chemicals. Onset of cerebral hemorrhage is abrupt and may quickly prove fatal. It usually occurs during waking hours, presumably because the person is more active and thus has higher blood pressure. Prognosis is poor in cerebral hemorrhage, especially if the patient is unconscious for more than 48 hours.

Angiomas and Aneurysms. **Angiomas** are congenital collections of abnormal vessels, including capillary, venous, or **arteriovenous (A-V) malformations,** that result in abnormal blood flow. Angiomas are composed of a mass of enlarged and tortuous cortical vessels that are supplied by one or more large arteries and are drained by one or more large veins, most frequently in the field of the middle cerebral artery. By causing abnormal blood flow, angiomas may lead to stroke, because they are inherently weak, or to inadequate distribution of blood in the regions surrounding the vessels. In some cases arterial blood may actually flow directly into veins after only briefly, or sometimes not at all, servicing the surrounding brain tissue.

Aneurysms are vascular dilations resulting from localized defects in the elasticity of the vessel. These can be visualized as balloonlike expansions of vessels, which are usually weak and prone to rupture. Although aneurysms are usually due to congenital defects, they may also develop from hypertension, arteriosclerosis, embolisms, or infections. Symptoms of aneurysm especially include severe headache, which may be present for years because of pressure on the dura from the aneurysm.

Treatment of Vascular Disorders

Most vascular disorders have no specific treatment, although the commonest remedies include drug therapy and surgery. Supportive therapies include such drugs as anticoagulants (to dissolve clots or prevent clotting), vasodilators to dilate the vessels, drugs to reduce blood pressure, and salty solutions or steroids to reduce cerebral edema (swelling). Surgical techniques have been greatly improved in recent years but are practical only for some disorders. For example, the only certain cure for aneurysm is total removal, which is usually not feasible. Aneurysms are sometimes painted with various plastic substances, but the efficacy of this treatment is disputed. In the case of cerebral hemorrhage it may be necessary to operate to relieve the pressure of the blood from the ruptured vessel on the rest of the brain.

TRAUMATIC HEAD INJURIES

Brain injury is an all too common result of automobile and industrial accidents; **cerebral trauma** is the commonest form of brain damage in persons under the age of 40. Cerebral trauma may significantly affect brain function in a number of ways. (1) The trauma may result in direct damage to the brain, such as in a gunshot wound, in which neurons and support cells are damaged directly. (2) Trauma may disrupt blood supply, resulting in ischemia and, if the interruption is prolonged, infarction. (3) Trauma may cause bleeding within the skull, leading to increased intracranial pressure and subsequent additional damage. (4) Like most tissues in the body, the brain swells when traumatized, leading to increased intracranial pressure and the possibility of brain damage. (5) Compound fracture of the skull opens the brain to infection. (6) Head trauma can produce scarring of brain tissue; the scarred tissue becomes a focus for later epileptic seizures. Indeed, the sud-

den appearance of epileptic seizures in adulthood can frequently be traced to head injury (particularly from automobile accidents) in preceding months or years.

Open-Head Injuries

Open-head injuries include traumatic brain injuries in which the skull is penetrated, as in gunshot or missile wounds, or in which fragments of bone penetrate the brain substance. Open-head injuries show striking differences from closed-head injuries. Many people who have open-head injuries do not lose consciousness, and there is a tendency for them to have distinctive symptoms that may undergo rapid and spontaneous recovery. Neurological signs are often highly specific, with the effects of the injuries often closely resembling those of surgical excision of a small area of cortex, as illustrated in the following case:

> J. S. was injured in November 1944 by a bullet which penetrated the brain in the left parietal region. He did not lose consciousness and walked about two miles to meet the stretcher bearers. For about an hour after the injury he was unable to speak and thereafter his speech was slurred and hesitant [dysphasia]. On examination, during which he was fully conscious and co-operative, he had slight right facial weakness and arm and leg reflexes were brisker on the right. The operation took place in a mobile Neurosurgical Unit 44 hours after wounding. . . . Five days after wounding, he was admitted to the Oxford Head Injuries Centre and was found to be in good general condition but had some numbness of the right hand, chiefly of the third and fourth digits although this had improved since injury. . . . Three months after injury, the hypalgesia [reduced pain sensitivity] of the right side of the face had persisted with slight loss to pin prick over the fingers and palm of the right hand as far as the wrist, and also slight decrease of vibration sense at the fingers and wrist of the right hand. His dysphasia was described as "not very marked" but he was hesitant in spontaneous speech. He read fairly well and retained the content of his reading "very well." (Newcombe, 1969, p. 6)

The specificity of neurological symptoms following open-head injuries makes these patients especially good research subjects. Three thorough investigations of World War II veterans with open-head injuries have been published by Newcombe; Luria; and Teuber and his associates.

Closed-Head Injuries

These injuries result from a blow to the head, which subjects the brain to a variety of mechanical forces. First, there is damage at the site of the blow called a *coup*. The brain is compacted by molding of the bone inward, even if the skull is not fractured. Second, this pressure on the brain at the time of the coup may force the brain against the opposite side of the skull, producing an additional bruise (contusion) known as a *countercoup* (see Figure 7-5 and the CT scan in Figure 6-5). Third, the movement of the brain may cause a twisting or shearing of nerve fibers in the brain, producing microscopic lesions. These may occur throughout the brain but are commonest in the frontal and temporal lobes. In addition, the twisting and shearing may produce damage to the major fiber tracts of the brain, especially those crossing the midline, such as the corpus callosum and anterior commissure. As a result, connection between the two sides of the brain may be disrupted, leading to what is known as a **disconnection** syndrome (see Chapter 20). Fourth, the bruises and strains caused by the impact may produce bleeding (hemorrhage). Since the blood is trapped within the skull it acts as a growing mass (hemotoma), which exerts pressure on surrounding structures. Finally, as with blows to other parts of the body, blows to the brain produce *edema*, which is a collection of fluid in and around damaged tissue, producing another source of pressure on the brain tissue. Closed-head injuries are commonly accompanied by a lack of consciousness resulting from strain o

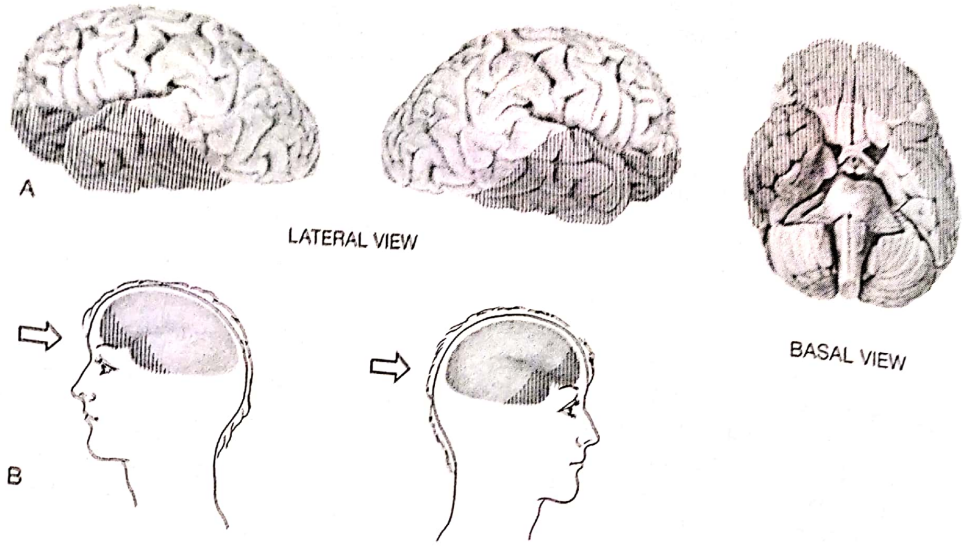


FIGURE 7-5. *A*, Shading represents regions of the cerebral hemispheres most frequently damaged in cerebral contusion. *B*, Demonstration of how a blow (arrow) to the forehead or occiput can produce a cerebral contusion on the frontal and temporal lobes. Left, the blow directly damages the brain. Right, the blow causes the brain to be compressed forward, producing a countercoup injury. (Illustrations after Courville, 1945.)

fibers in the brainstem reticular formation. These fibers often sustain permanent damage, even in cases of simple concussion. According to Lezak, the duration of loss of consciousness—or length of coma—can serve as a measure of the severity of damage, because it correlates directly with mortality, intellectual impairment, and deficits in social skills. The longer lasting the coma the greater the possibility of serious impairment and death.

Closed-head injuries resulting from traffic accidents are particularly severe because the head is moving when the blow is struck, thereby increasing the velocity of the impact and hence multiplying the number and severity of small lesions throughout the brain. CT scans of accident victims suffering prolonged coma show diffuse brain injury and enlarged ventricles—signs associated with poor outcomes.

Two kinds of behavioral effects result from closed-head injuries: discrete impairment of those functions mediated by the cortex at the site of the coup or the countercoup lesion, and more generalized impairments from damage widespread throughout the brain. Discrete impairment is most commonly associated with damage to the frontal and temporal lobes, those areas most susceptible to closed-head injuries (see Figure 7-5). More general impairment, resulting from minute lesions and lacerations scattered throughout the brain, is characterized by a general loss of complex cognitive functions, including reductions in mental speed, ability to concentrate, and overall cognitive efficiency. These difficulties are usually reflected in patients' complaints of inability to concentrate or to do things as well as they could before the accident, even though the intelligence rating may still be well above average. Indeed, in our experience, bright people are the most affected by closed-head

injuries because they are acutely aware of a loss of cognitive skill that prevents them from returning to their previous competence level.

Closed-head injuries that damage the frontal and temporal lobes also tend to have significant effects on people's personality and social adjustment. According to Lezak, relatively few victims of traffic accidents who have sustained severe head injuries ever resume their studies or return to gainful employment, or if they do reenter the work force, they do so at a lower level than before.

> Despite residual capacities that are often considerable, one combination or another of impaired initiative and apathy, lack of critical capacity, defective social judgement, childishness and egocentricity, inability to plan or sustain activity, impulsitivity, irritability, and low frustration tolerance is likely to render these patients unemployable or only marginally employable. These same qualities also make a person who has sustained moderate to severe head injuries at best a nuisance at home, at worst a terror. By virtue of these qualities, and again despite their residual capacities, these patients are rarely able to form or maintain close relationships, so that those who have not been rendered silly and euphoric or apathetic by their injuries, are often lonely and depressed as well. (Lezak, 1983, p. 170).

The diffuse nature of the chronic effects of closed-head injuries is often not associated with any neurological signs, and patients are often referred for psychiatric evaluation. Psychological assessments are especially useful here, because seriously handicapping cognitive deficits may become immediately apparent in the course of a thorough assessment, even though they are not obvious in casual conversation. Many of these patients appear normal in a psychological examination with standard intelligence tests, or even commercial neuropsychological test batteries, but careful neuropsychological investigation may reveal severe cognitive deficits, a result that underscores the need for a careful and competent neuropsychological assessment (see Chapters 27 through 32).

EPILEPSIES

Epilepsy is a condition characterized by recurrent electrographic seizures of various types that are associated with a disturbance of consciousness. Although epileptic episodes have been termed convulsions, seizures, fits, and attacks, none of these terms is entirely satisfactory, since the episodes can vary greatly in nature. Epileptic seizures are very common; 1 person in 20 will experience at least one seizure during his or her lifetime. Most of these people are not truly epileptic, however, for the seizures do not recur. The prevalance of multiple seizures is much lower, about 1 in 200.

The cause of epileptic seizures was unknown until the development of the EEG by Hans Berger in 1929. The technique made it possible to demonstrate that different varieties of epilepsy are associated with different abnormal electrical rhythms in the brain (see Figure 7-6*B–D*). Sometimes epileptic seizures are classifiable as **symptomatic seizures;** that is, they can sometimes be identified with a specific cause, such as infection, trauma, tumor, vascular malformation, toxic chemicals, very high fever, or other neurological disorders. But other seizure disorders, called **idiopathic seizures,** appear to arise spontaneously and in the absence of other diseases of the central nervous system. The cause of the abnormal electric discharge within the cell is poorly understood, although it is likely that it creates some type of abnormality in the neuronal membranes.

Although it has long been known that epilepsy runs in families, it is unlikely that there is a single gene responsible for the seizures, because the incidence is lower than would be predicted from genetic models. It is more likely that certain genotypes have a predisposition to seizure problems given certain environmental circumstances.

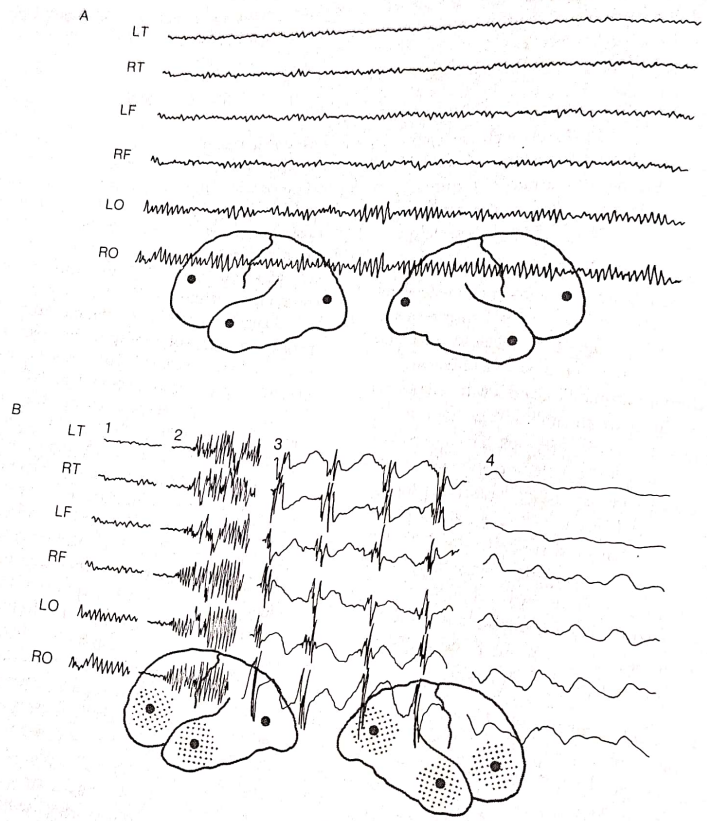


FIGURE 7-6. Examples of EEG recordings from different forms of epilepsy. LT: left temporal. RT: right temporal. LF: left frontal. RF: right frontal. LO: left occipital. RO: right occipital. The black dots on the hemispheres indicate the approximate recording sites. *A*. Normal adult EEG. *B*. Brief excerpts from an EEG taken during a grand mal seizure: (1) Normal recording preceding the attack. (2) Onset of attack. (3) Clonic phase of the attack. (4) Postictal period of coma. Shaded areas represent regions picked up by scalp electrodes. *C*. An episode of a 3/sec spike-and-wave EEG characteristic of petit mal seizures. *D*. Hypsarrhythmia in the EEG of a child. Notice diffuse slow waves with occasional spikes. (From W. B. Hardin, 1978. Copyright © 1978 by Oxford University Press, Inc. Reprinted with permission.)

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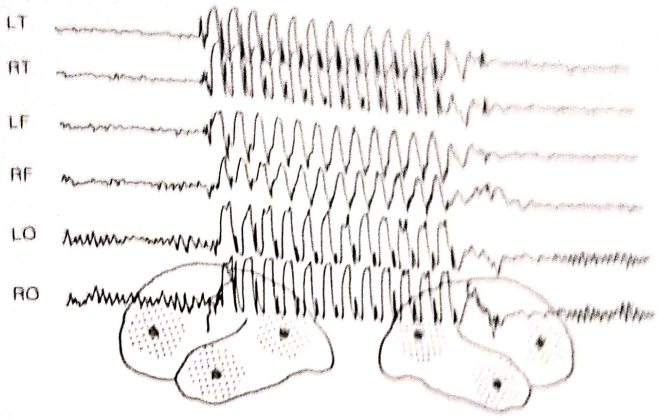

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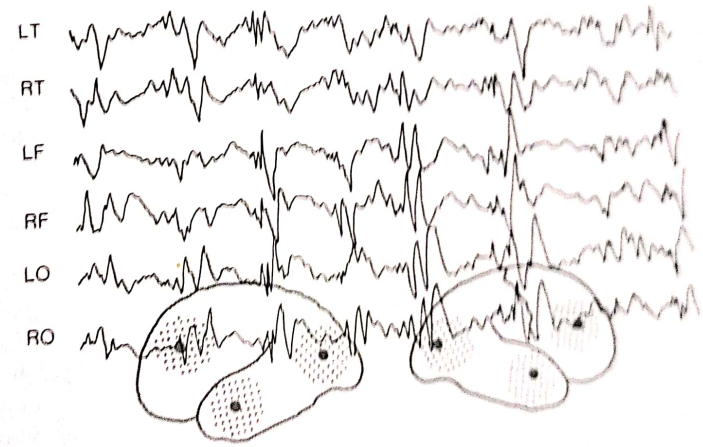

Symptoms and Diagnosis

The most remarkable clinical feature of epileptic disorders is the widely varying intervals between attacks—anywhere from minutes, hours, weeks, or even years. Thus, it is almost impossible to describe a basic set of symptoms to be expected in all, or even most, people with the disease. Three symptoms, however, are found in many types of epilepsy. (1) An aura, or warning, of impending seizure. This may take the form of sensations such as odors, noises, and the like, or may simply be a

"feeling" that the seizure is going to occur. (2) Loss of consciousness. This may take the form of complete collapse or simply staring off into space. There is often **amnesia**, the victim forgetting the seizure itself and the period of lost consciousness. (3) Movements. It is common for seizures to have a motor component, although the characteristics vary considerably. In some cases there are shaking movements; in others, automatic movements such as rubbing the hands or chewing.

The diagnosis of epilepsy is usually confirmed by EEG. However, in some epileptics, seizures are difficult to demonstrate except under special circumstances (e.g., an EEG recorded during sleep), and not all persons with an abnormal EEG actually have seizures. In fact, some estimates suggest that 4 people in 20 actually have abnormal EEG patterns! Recently PET has provided a more reliable measure of functional abnormalities, although the cost for this method remains prohibitive. Studies of cerebral blood flow (see Chapter 15) may provide a less expensive alternative (see Engle).

TABLE 7-1. Classification of the epilepsies

Partial seizures (focal)
- Simple partial seizures
  - Motor (Jacksonian)
  - Sensory (Jacksonian)
  - Autonomic
- Complex partial seizures (temporal lobe, psychomotor)
  - Absences
  - Complex hallucinations
  - Affective symptoms
  - Automatism
- Partial seizures secondarily generalized

Generalized seizures
- Bilaterally symmetrical without local onset
  - Absence attacks (petit mal)
  - Tonic-clonic (grand mal)
  - Bilateral myoclonic
  - Drop attacks (akinetic)

Unclassified seizures
- Because of incomplete data, includes many persons with apparently generalized seizures.

Types of Epilepsies

Several classification schemes have been published for epilepsy. Table 7-1 summarizes the ones in common use.

Focal seizures are those that begin locally and then spread. For example, in **Jacksonian seizures** the attack begins with jerks of single parts of the body, such as finger, a toe, or the mouth, and then spreads. If it were the finger, the jerks might spread to other fingers, then the hand, arm and so on, producing the so-called Jacksonian march. Jackson made the prediction in 1870 that such seizures probably originated from the point (focus) in the neocortex representing that region. He was later proved correct.

Complex partial seizures most commonly originate in the temporal lobe, and somewhat less frequently in the frontal lobe. Complex partial seizures are characterized by three common manifestations: (1) subjective feelings, such as forced, repetitive thoughts, alterations in mood, feelings of déjà vu, or hallucinations; (2) **automatisms**, repetitive stereotyped movements such as lip smacking or chewing, or the repetition of acts such as undoing buttons and the like; (3) postural changes, afflicted persons sometimes assuming catatonic, or frozen, postures.

Generalized seizures are bilaterally symmetrical without local onset. The **grand mal attack** is characterized by loss of consciousness and stereotyped motor activity. Typically, patients go through three stages: (1) a tonic stage, in which the body stiffens and breathing stops; (2) a clonic stage, in which there is rhythmic shaking; and (3) a post seizure (also known as postictal) depression, in which the patient is confused. About 50% of these seizures are preceded by an aura.

In the **petit mal, or absence attack,** there is loss of awareness during which there is no motor activity except blinking or turning the head or rolling the eyes. These attacks are of brief duration, seldom exceeding about 10 sec. The EEG record of a petit mal seizure has a typical pattern known as 3/sec spike and wave.

Akinetic seizures are ordinarily only seen in children. Usually the child collapses suddenly and without warning. These seizures are often of very short duration, and the child may get up after only a few seconds with no postictal depression. The falls that these children have can be quite dangerous in themselves, and it is not uncommon for the children to wear football helmets until the fits can be controlled by medication.

Myoclonic spasms are massive seizures that basically consist of a sudden flexion or extension of the body and often begin with a cry.

As mentioned earlier, seizures are not continual in any epileptic patients, even though the EEG may be chronically abnormal. Table 7-2 summarizes the great variety of circumstances that appear able to precipitate seizures. Although one is struck by the wide range of factors that may precipitate seizures, a consistent feature is that the brain is most epileptogenic when it is relatively inactive and the patient is sitting still.

TABLE 7-2. Factors that may precipitate seizures in susceptible individuals

Hyperventilation	
Sleep	
Sleep deprivation	
Sensory stimuli:	Flashing lights
	Reading-speaking, coughing
	Laughing
	Sounds: music, bells, etc.
	Reading
Trauma	
Hormonal changes:	Menses
	Puberty
	Adrenal steroids
	Adrenocorticotrophic hormone (ACTH)
Fever	
Emotional stress	
Drugs:	Phenothiazines
	Analeptics
	Tricyclic mood elevators
	Alcohol
	Excessive anticonvulsants

Source: After Pincus and Tucker, 1974.

Treatment of Epilepsy

The treatment of choice for epilepsy is an anticonvulsant drug, such as diphenylhydantoin (DPH, Dilantin), phenobarbital, and several others. Although the mechanism by which these drugs act is uncertain, they presumably inhibit the discharge of abnormal neurons by stabilizing the neuronal membrane. If medication fails to alleviate the seizure problem satisfactorily, surgery can be performed to remove the focus of abnormal functioning in patients with focalized seizures.

The surgical treatment of epilepsy dates back to the late 1800s, when W. Horsley and others removed the cortex in an attempt to alleviate seizures. The modern technique of surgery for epilepsy was pioneered by Otfrid Foerster in the 1920s in Germany. Wilder Penfield, stimulated by his studies with Foerster, began a prolonged scientific study of the surgical treatment of epilepsy in 1928, when he founded the Montreal Neurological Institute for that purpose. Penfield was soon joined by Herbert Jasper, who introduced EEG to the operating room, and by D. O. Hebb and Brenda Milner, who introduced the neuropsychological assessment of Penfield's surgical patients. Together these four and their colleagues developed a technique of cortical removal of the epileptogenic tissue from victims of focal epilepsy. The technique has been remarkably successful for this form of epilepsy. Their team approach to the treatment of a neurological disease provides a model of the marriage of basic and applied disciplines in developing an effective treatment for a neurological disorder.

Today, epilepsy is a particularly important disease for the neuropsychologist, because patients treated surgically for the relief of epilepsy form one of the best populations for neuropsychological study. Because the extent of surgical removal can be carefully charted at surgery and correlated with both preoperative and postoperative behavior, neuropsychologists have an excellent source of information on brain-behavior relations in humans.

TUMORS

A tumor (or neoplasm) is a mass of new tissue that persists and grows independently of its surrounding structures and has no physiological use. Brain tumors do not grow from neurons but rather from glia or other support cells. The rate at which tumors grow varies widely, depending on the type of cell that gives rise to the tumor. Tumors account for a relatively high proportion of neurological disease, and next to the uterus, the brain is the commonest site for tumors. It is possible to distinguish between benign (those not likely to recur after removal) and malignant (those likely to recur after removal and that frequently progress, becoming a threat to life) tumors. Although the distinction between benign and malignant tumors is well founded, the benign tumor may be as serious as the malignant one, since many benign tumors in the brain are inaccessible to the surgeon without risk to life. The brain is affected by many types of tumors, and no region of the brain is immune to tumor formation.

Tumors can significantly affect behavior in a number of ways. A tumor may develop as a distinct entity in the brain, a so-called *encapsulated tumor*, and put pressure on the rest of the brain (Figure 7-7). Encapsulated tumors are also sometimes *cystic*, which means they produce a fluid-filled cavity in the brain, usually lined with the tumor cells. Since the skull is of fixed size, any increase in its contents will functionally compress the brain, resulting in dysfunctions. Other tumors, so-called *infiltrating tumors*, are not clearly marked off from the surrounding tissue; they may either destroy normal cells and occupy their place or surround existing cells (both neurons and glia) and interfere with their normal functioning (Figure 7-8).

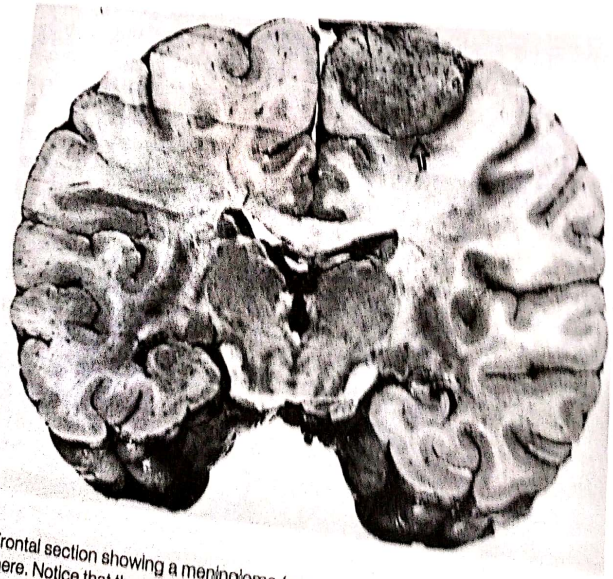

FIGURE 7-7. Frontal section showing a meningioma (arrow) arising in the dura and compressing the right cerebral hemisphere. Notice that the tumor has not infiltrated the brain. (From S. I. Zacks, 1971. Copyright © 1971 by Harper & Row. Reprinted with permission.)

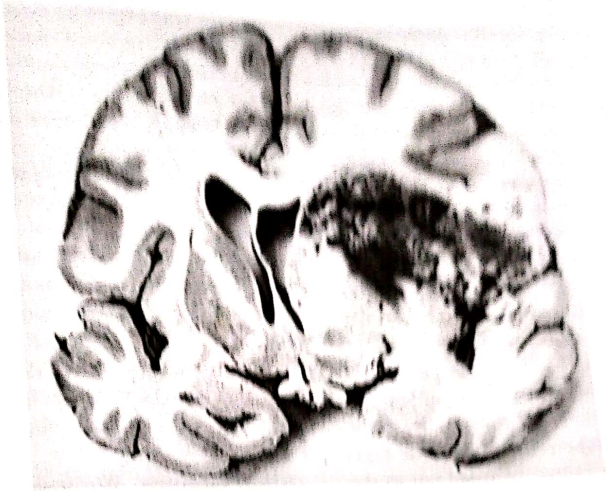

FIGURE 7-8. Frontal section showing a glioblastoma in the right cerebral hemisphere. Note the displacement of the ventricular system and the invasion of brain tissue (dark area). (From R. Bannister, 1978. Copyright © 1978 by Oxford University Press, Inc. Reprinted with permission.)

Symptoms and Diagnosis of Brain Tumors

The recognition of a brain tumor may be divided into three phases: (1) the suspicion that a tumor may be present, (2) the diagnostic confirmation of the tumor, and (3) the precise location of the tumor within the nervous system. The generalized symptoms of brain tumors, which result from increased intracranial pressure, include headache, vomiting, swelling of the optic disk (papilledema), slowing of the heart rate (bradycardia), mental dullness, double vision (**diplopia**), and, finally, convulsions. It would be rare indeed for a patient to exhibit all these symptoms, most of which result from a marked increase in intracranial pressure. Other signs and symptoms depend on the exact location of the tumor. Thus, a tumor in the speech zones would be more likely to disrupt speech than would a tumor in the visual cortex.

Types of Brain Tumors

There are three major types of brain tumors, distinguished on the basis of where they originate: gliomas, meningiomas, and metastic tumors.

Gliomas. **Glioma** is a general term for those brain tumors that arise from glial cells and infiltrate the brain substance. Roughly 45% of all brain tumors are gliomas. Gliomas, ranging from the relatively benign to the highly malignant, vary considerably in their response to treatment. Because the detailed description of types of gliomas is more important to the neurologist and neurosurgeon than to the neuropsychologist, we shal briefly describe only the most frequently occurrin types of gliomas: astrocytomas, glioblastomas, ar medulloblastomas.

Astrocytomas. These tumors result from the growth of astrocytes and are usually slow growing. Astrocytomas account for about 40% of gliomas, being commonest in adults over 30 years of age. Because they are not very malignant, and because of their slow growth rate, they are relatively safe once treated. Thus, the prognosis for patients with this type of tumor is relatively good, with postoperative survivals occasionally being over 20 years.

Glioblastomas. These are highly malignant, rapidly growing tumors commonest in adults, especially men, over 35 years of age. **Glioblastomas** account for roughly 30% of gliomas. This tumor may result from the sudden growth of *spongioblasts,* cells that are ordinarily formed only during development of the brain, although some texts suggest that astrocytes cannot be ruled out as the source of glioblastomas. The tumor may be made up of a variety of cell types (glioblastoma multiforme) or of a single-cell type (glioblastoma unipolare). Because these tumors grow so rapidly, a patient's life expectancy is usually short, seldom extending beyond one year after surgery.

Medulloblastomas. These tumors are highly malignant and found almost exclusively in the cerebellum of children. **Medulloblastomas** account for about 11% of all gliomas. The tumor results from the growth of germinal cells that infiltrate the cerebellum or underlying brainstem. The prognosis for children with these tumors is poor; the postoperative survival period ranges from 1.5 to 2 years.

Meningiomas. **Meningiomas** are growths attached to the **meninges,** or protective outer layer of the brain. They grow entirely outside the brain, are well encapsulated, and are the most benign of all brain tumors. Although meningiomas do not invade the brain, they are often multiple and disturb brain function by producing pressure on the brain, often producing seizures as a symptom. Although most meningiomas lie over the hemispheres, some occur between them. The latter location makes removal more complicated. It is not uncommon for these tumors to erode the overlying bone of the skull. If meningiomas are removed completely, they tend not to recur.

Metastatic Tumors. **Metastasis** is the transfer of disease from one organ or part to another not directly connected with it. Thus, a **metastatic tumor** in the brain is one that has become established by a transfer of tumor cells from some other region of the body, most commonly lung or breast. Indeed, it is not uncommon for the first indication of lung cancer to be evidence of brain tumor. Metastases to the brain are usually multiple, making treatment complicated and prognosis poor.

Other Tumors. We have considered only the major types of primary brain tumors; there are, however, many more less common types. One of these, the *pituitary adenoma,* is a tumor of the pituitary region. Although the pituitary is not really part of the brain, tumors there produce pressure on the brain, and owing to the close relation between the hypothalamus and the pituitary, such tumors can produce significant functional abnormalities in the hypothalamus. For a detailed discussion of other brain tumors, we recommend Baker and Baker's extensive text.

Treatment of Brain Tumors

The most obvious treatment of brain tumors is surgery, which is the only way to make a definite histological diagnosis. If feasible, tumors are removed, but, as with tumors elsewhere in the body, success depends on early diagnosis. Radiation therapy is useful for treating certain types of tumors, such as glioblastomas and medulloblastomas, as well as for some metastatic tumors. Chemotherapy has not yet been very successful in the treatment of brain tumors, owing in part to the difficulty in getting drugs to pass the blood-brain barrier and distribute in the tumor.

CSF and reduce pressure where there is edema or a build-up of pus.

Neither mycotic nor parasitic infections can be satisfactorily treated, although antibiotics are often used to treat associated disorders.

DEGENERATIVE DISORDERS

Many diseases of the nervous system involve a progressive deterioration of brain tissue and behavior. In most cases there is a specific loss of some region or system in the brain, which produces a distinctive behavioral syndrome. The commonest degenerative disorders and their probable causes are summarized in Table 7-3. We shall consider only the dementias (Alzheimer's, Pick's, and Creutzfeldt-Jakob's diseases) here, as the other disorders are described in detail elsewhere in the book. Parkinson's disease, Huntington's chorea, multiple sclerosis, myasthenia gravis are discussed in Chapter 13; Korsakoff's syndrome is considered in Chapter 21. Alzheimer's disease is further detailed in Chapter 31.

TABLE 7-3. Summary of common degenerative diseases

Disorder	Probable cause
Alzheimer's disease	Loss of cholinergic neurons in nucleus basalis of Meynert leading to development of senile plaques and neurofibrillary tangles
Pick's disease	Atrophy of frontal and temporal lobes from unknown causes
Cruetzfeldt-Jakob's disease	Generalized cortical atrophy from unknown causes
Korsakoff's syndrome	Atrophy of medial thalamus and mamillary bodies from chronic excessive alcohol consumption
Huntington's chorea	Degeneration of basal ganglia, frontal cortex, and corpus callosum due to a genetic abnormality
Parkinson's disease	Loss of striatal dopamine due to degeneration of the substantia nigra
Multiple sclerosis	Abnormal neural activity due to loss of myelin
Myasthenia gravis	Autoimmune disorder causing motor muscle receptors to decrease

Alzheimer's disease accounts for about 65% of the patients diagnosed as demented and has generated a great deal of interest recently because it may provide a good model for the study of senility in general. Although a distinction was once made between the onset of senility prior to age 65 (presenile dementia of the Alzheimer type) and onset over 65 (senile dementia), there are no longer strong grounds for distinguishing between these disorders, since the pathology is similar. The term *Alzheimer's disease* is now commonly used to refer to both presenile and senile dementia. The disease begins insidiously, eventually afflicting about 5% of the population over age 65. Postmortem study of the brains of Alzheimer's patients has recently led to a major breakthrough in our understanding of this and related diseases. It has been known for some time that the brains of these persons are characterized by abnormal **neurofibrils** (neurofibrillatory tangles), **neuritic plaques,** and the loss of nerve cells, but recent neurochemical studies have suggested that there are other changes, including the amount of serotonin, dopamine, and norepinephrine in cells. Careful study of the brains of Alzheimer's patients suggests that the plaque density in the cortex correlates with reductions in these transmitter systems. In addition, cells in the cortex, particularly in the **entorhinal cortex** and hippocampus, degenerate, and cells in tertiary areas of the cortex lose their dendrites.

Behaviorally, Alzheimer's disease is characterized by marked deficits in memory, language, and perception as well as by symptoms of depression. Indeed, it is not uncommon for Alzheimer's patients to be initially treated for depression. It is the loss of memory, however, that has generated the most research interest; research on this is possible because memory can be easily studied in nonhuman species following the administration of drugs that are antagonistic to acetylcholine and appear to interfere with performance in tests of memory.

Pick's and Creutzfeldt-Jakob's diseases are also dementias, although they are less common than Alzheimer's. The cause of the first disease is unknown, and the second is thought to be produced by a virus. *Pick's disease* is characterized by symptoms that are virtually indistinguishable clinically from those of Alzheimer's disease, but at autopsy the diseases can be distinguished. In Pick's disease the cellular degeneration and atrophy are confined to the frontal and temporal cortex, and the plaques and tangles characteristic of Alzheimer's disease are not evident. *Creutzfeldt-Jakob's disease* differs from the other two in that its course is very rapid, leading in just a few months to stupor, coma, and death. Memory loss is prominent from the outset, but deterioration can be measured nearly day to day. At autopsy, there is a generalized thinning of the cortex in addition to generalized abnormalities in subcortical structures.

MENTAL DISORDERS

The *Diagnostic and Statistical Manual of Mental Disorders* (DSM-III) of the American Psychiatric Association lists 16 different types of behavioral disorders (see Table 7-4); it can be safely assumed that some of these disorders result from abnormal brain function. However, the current limitations in our knowledge about brain function make it impossible to ascertain whether a given behavioral disturbance results directly from abnormal brain functioning or from a response to environmental or social factors.

TABLE 7-4. DSM-III categories of mental disorders

Disorders usually first evident in infancy, adulthood, or adolescence
Organic mental disorders
Substance use disorders
Schizophrenic disorders
Paranoid disorders
Psychotic disorders not elsewhere classified
Affective disorders
Anxiety disorders
Somatoform disorders
Dissociative disorders
Psychosexual disorders
Factitious disorders
Disorders of impulse control not elsewhere classified
Adjustment disorder
Psychological factors affecting physical condition
Conditions not attributable to a mental disorder that are a focus of attention or treatment

Source: American Psychiatric Association. *Diagnostic and Statistical Manual of Mental Disorders*, 3rd ed. Washington, D.C.: American Psychiatric Association, 1980.

Two types of disorders likely to result from neurological abnormalities are the schizophrenic and affective disorders, although even in these an environmental influence cannot be ruled out. Both of these disorders have been alleged to result, in part, from abnormalities in the levels of neurotransmitters in the brain (dopamine for schizophrenia and norepinephrine and serotonin for depression); the principal treatment for both disorders is thus pharmacological. We shall consider current neurological theories of schizophrenia and affective disorders in detail in Chapter 23 in the broader context of the neurological control of affective behavior.