Chapter 10
Brain Damage and Neuroplasticity

Can the Brain Recover from Damage?

Causes of Brain Damage

- Brain tumors
- Cerebrovascular disorders
- Closed-head injuries
- Infections of the brain
- Neurotoxins
- Genetic factors

Brain Tumors

- A tumor (neoplasm) is a mass of cells that grows independently of the rest of the body – a cancer
- 20% of brain tumors are meningiomas – encased in meninges
  - Encapsulated, growing within their own membranes
  - Usually benign, surgically removable
Brain Tumors Continued

- Most brain tumors are infiltrating
  - Grow diffusely through surrounding tissue
  - Malignant, difficult to remove or destroy
- About 10% of brain tumors are metastatic – they originate elsewhere, usually the lungs

Cerebrovascular Disorders

- Stroke – a sudden-onset cerebrovascular event that causes brain damage
  - Cerebral hemorrhage – bleeding in the brain
  - Cerebral ischemia – disruption of blood supply
- Third leading cause of death in the U.S. and most common cause of adult disability
Cerebrovascular Disorders Continued

- Cerebral Hemorrhage – blood vessel ruptures
  - Aneurysm – a weakened point in a blood vessel that makes a stroke more likely; may be congenital (present at birth) or due to poison or infection
- Cerebral Ischemia – disruption of blood supply
  - Thrombosis – a plug forms in the brain
  - Embolism – a plug forms elsewhere and moves to the brain
  - Arteriosclerosis – wall of blood vessels thicken, usually due to fat deposits

Damage Due to Cerebral Ischemia

- Does not develop immediately
- Most damage is a consequence of excess neurotransmitter release – especially glutamate
- Blood-deprived neurons become overactive and release glutamate
- Glutamate overactivates its receptors, especially NMDA receptors leading to an influx of Na⁺ and Ca²⁺

Damage Due to Cerebral Ischemia

- Influx of Na⁺ and Ca²⁺ triggers
  - the release of still more glutamate
  - a sequence of internal reactions that ultimately kill the neuron
- Ischemia-induced brain damage
  - takes time
  - does not occur equally in all parts of the brain
  - mechanisms of damage vary with the brain structure affected
Closed-Head Injuries

- Brain injuries due to blows that do not penetrate the skull – the brain collides with the skull
  - Contrecoup injuries – contusions are often on the side of the brain opposite to the blow
  - Contusions – closed-head injuries that involve damage to the cerebral circulatory system; hematoma (bruise) forms
  - Concussions – when there is disturbance of consciousness following a blow to the head and no evidence of structural damage

Closed-Head Injuries Continued

- While there is no apparent brain damage with a single concussion, multiple concussions may result in a dementia referred to as "punch-drunk syndrome"
Infections of the Brain

- Encephalitis – the resulting inflammation of the brain by an invasion of microorganisms
  - Bacterial infections
    - Often lead to abscesses, pockets of pus
    - May inflame meninges, creating meningitis
    - Treat with penicillin and other antibiotics
  - Viral infections
    - Some preferentially attack neural tissues
    - Some can lie dormant for years

Neurotoxins

- May enter general circulation from the GI tract or lungs, or through the skin
- Toxic psychosis – chronic insanity produced by a neurotoxin
- The Mad Hatter – hat makers often had toxic psychosis due to mercury exposure
Neurotoxins Continued

- Some antipsychotic drugs produce a motor disorder called tardive dyskinesia
- Some neurotoxins are endogenous (produced by the body)
  - e.g. Auto-immune disorders

Genetic Factors

- Most neuropsychological diseases of genetic origin are associated with recessive genes—why?
- Down syndrome
  - 0.15% of births, probability increases with advancing maternal age
  - Extra chromosome 21 created during ovulation
  - Characteristic disfigurement, mental retardation, other health problems

Programmed Cell Death

- All six causes of brain damage produce damage, in part, by activating apoptosis
Neuropsychological Diseases

- Epilepsy
- Parkinson’s disease
- Huntington’s disease
- Multiple sclerosis
- Alzheimer’s disease

Epilepsy

- Primary symptom is seizures, but not all who have seizures have epilepsy
- Epileptics have seizures generated by their own brain dysfunction
- Affects about 1% of the population
- Difficult to diagnose due to the diversity and complexity of epileptic seizures

Epilepsy Continued

- Types of seizures
  - Convulsions – motor seizures
  - Some are merely subtle changes of thought, mood, or behavior
- Causes
  - Brain damage
  - Genes – over 70 known so far
  - Faults at inhibitory synapses
- Diagnosis
  - EEG – electroencephalogram
  - Seizures associated with high amplitude spikes
Epilepsy Continued

- Seizures often preceded by an aura, such as a smell, hallucination, or feeling
  - Aura’s nature suggests the epileptic focus
  - Warns epileptic of an impending seizure
- Partial epilepsy – does not involve the whole brain
- Generalized epilepsy – involves the entire brain

Partial Seizures

- Simple
  - Symptoms are primarily sensory or motor or both (Jacksonian seizures)
  - Symptoms spread as epileptic discharge spreads
- Complex
  - Often restricted to the temporal lobes (temporal lobe epilepsy)
  - Patient engages in compulsive and repetitive simple behaviors (automatisms)
  - More complex behaviors seem normal

FIGURE 10.8 A cortical electroencephalogram (EEG) record from various locations on the scalp during the beginning of a complex partial seizure.
Generalized Seizures

- Grand mal
  - Loss of consciousness and equilibrium
  - Tonic-clonic convulsions
  - Rigidity (tonus)
  - Tremors (clonus)
  - Resulting hypoxia may cause brain damage
- Petit mal
  - Not associated with convulsions
  - A disruption of consciousness associated with a cessation of ongoing behavior

Parkinson’s Disease

- A movement disorder of middle and old age affecting about .5% of the population
- Tremor at rest is the most common symptom of the full-blown disorder
- Dementia is not typically seen
- No single cause
- Associated with degeneration of the substantia nigra; these neurons release dopamine to the striatum of the basal ganglia

Parkinson’s Disease

- Almost no dopamine in the substantia nigra of Parkinson’s patients
- Autopsies often reveal Lewy bodies (protein clumps) in the substantia nigra
- Treated temporarily with L-dopa
Parkinson’s Disease
Continued
• Linked to about ten different gene mutations
• Deep brain stimulation of subthalamic nucleus reduces symptoms, but effectiveness slowly declines over months or years

Huntington’s Disease
• A rare, progressive motor disorder of middle and old age with a strong genetic basis
  • Huntingtin gene
    • single, dominant gene
• Begins with fidgetiness and progresses to jerky movements of entire limbs and severe dementia
• Death usually occurs within 15 years
• Caused by a single dominant gene
• First symptoms usually not seen until age 40

Multiple Sclerosis
• A progressive disease that attacks CNS myelin, leaving areas of hard scar tissue (sclerosis)
• Nature and severity of deficits vary with the nature, size, and position of sclerotic lesions
• Periods of remission are common
• Symptoms include visual disturbances, muscle weakness, numbness, tremor, and loss of motor coordination (ataxia)
Epidemiological studies find that incidence of MS is increased in those who spend childhood in a cool climate.

MS is rare amongst Africans and Asians.

Only some genetic predisposition and only one chromosomal locus linked to MS with any certainty.

Recent focus on epigenetic mechanisms:
- Gene/environment interactions
- An autoimmune disorder – immune system attacks myelin
- Drugs may retard progression or block some symptoms.

FIGURE 10.11 Areas of sclerosis (see arrows) in the white matter of a patient with MS.
Alzheimer’s Disease

- Most common cause of dementia – likelihood of developing it increases with age
- Progressive, with early stages characterized by confusion and a selective decline in memory
- Definitive diagnosis only at autopsy – must observe neurofibrillary tangles and amyloid plaques

Alzheimer’s Disease Continued

- Several genes associated with early-onset AD synthesize amyloid or tau, a protein found in the tangles
- Which comes first, amyloid plaques or neurofibrillary tangles? Genetic research on early-onset AD supports amyloid hypothesis (amyloid first)
- Decline in acetylcholine levels is one of the earliest signs of AD
- Effective treatments not yet available
  - Immunotherapy is promising in animal models

FIGURE 10.13 The typical distribution of neurofibrillary tangles and amyloid plaques in the brains of patients with advanced Alzheimer’s disease. (Based on Goedert, 1993, and Selkoe, 1991.)