1. **Common Causes of Brain Damage**
   - Cerebrovascular Disorders = “Stroke”
   - Tumors
   - Closed-head injuries
   - Infections
   - Neurotoxins
   - Genetic Factors

2. **Cerebrovascular Disorders = “Stroke”**
   - May result from:
     - Cerebral hemorrhage
     - Bursting of an aneurysm (balloon-like dilation of a weak area of a blood vessel)
       - Aneurysms can be congenital (present from birth) or the result of infection, toxins, etc.
     - Cerebral ischemia
       - Thrombosis – a plug (ex. A blood clot, fat, cancerous cells, air bubbles) becomes lodged at site of formation
       - Embolism – a plug travels from the site of formation and becomes lodged in smaller blood vessels
       - Arteriosclerosis – blood vessel walls thicken and the space inside narrows

3. **Arteriosclerosis**

4. **Ischemia and Excitotoxicity**
   - Brain damage during ischemia believed to result part from excessive release of glutamate
   - Over-activates postsynaptic glutamate receptors, triggering an excessive influx of Na\(^+\) and Ca\(^{++}\)
   - Damage produced by ischemia takes a while to develop and spread

5. **Mechanisms of Neuronal Death After Stroke**

6. **Stroke Damage**

7. **What Can Be Done to Preserve Neurons?**
   - Remove clot
• Surgically
  – Use tPA (tissue plasminogen activator) to break up the clot –
    must be given within 3 hrs of the stroke
• Experimental:
  – Block excitatory synapses
  – Stimulate inhibitory synapses
  – Block flow of calcium and zinc
  – Cool the brain

Brains On Ice
Brain Tumors
Brain Tumors
Closed-head Injuries
  • Contusion – damage to the cerebral circulatory system
    producing internal bleeding, and ultimately a hematoma
  • Contusions occur when the brain slams against the inside of
    the skull
  • Contusions frequently occur on the side of the brain opposite
    side of the head where the blow occurs
  • Blood can accumulate in the subdural space (between the
dura mater and the arachnoid membrane)
Trepanation – Boring a Hole Through the Skull
Closed-head Injuries
  • Concussion - a disturbance of consciousness with no evidence
    of contusion or other structural damage
  • Coma - a complete loss of consciousness
Dementia Pugilistica or Punch-drunk Syndrome
  • Progressive neurodegenerative disease linked to multiple
    blows to the head
  • Symptoms include light-headedness, depression, memory
    impairment, emotional instability and erratic behavior - can
    progress to dementia
  • Has been found in professional athletes participating in
    football, ice hockey, professional wrestling and other contact
    sports
• NFL Players Association collaborating with the Center for the Study of Traumatic Encephalopathy (CSTE) at Boston University School of Medicine

16 Unanswered questions about chronic traumatic encephalopathy:
• How many concussions does it take to cause CTE?
• What severity of concussions causes CTE?
• How many years of repetitive concussions does it take to cause CTE?
• How many years after an athlete receives his/her last concussion does CTE begin to deteriorate the brain?
• Is CTE manifested uniquely in each individual athlete?
• Do different athletes have different tolerances?

17 Brain Infections - Encephalitis
• Bacterial Infections
  – E.g. Syphilis - infecting bacteria may go dormant for several years before they become virulent and attack many parts of the body including the brain – a syndrome of insanity and dementia may result if left untreated

18 Brain Infections - Encephalitis
• Viral Infections
  – Viruses with a particular affinity for the nervous system
    • E.g. Rabies - takes time to attack the brain (at least a month) - produces fits of rage and ultimately death
    • E.g. Polio - preferentially attacks motor neurons
  – Viruses that can attack the nervous system, but have no special affinity for it
    • E.g. Mumps, measles, herpes
  – Some mosquito- and tick-borne illnesses
    • E.g. West Nile

19 Neurotoxins
• Brain damage can be produced by a variety of toxins in the environment
– E.g. Mercury - “Mad hatters” were the victims of mercury poisoning
– E.g. Lead - “Crackpots” were originally those who drank tea from cracked ceramic pots with lead cores

• Sometimes drugs used to treat a disease can have neurotoxic effects
  – Tardive dyskinesia (tremors and other involuntary movements) can be produced by exposure (ranging from a few days to more than 20 years) to certain antipsychotic medications

20 Genetic Factors
  • Some genetic disorders are accidents of cell division (ex. In Down syndrome an extra chromosome in pair 21 is present in all cells – produces retarded intellectual development)
  • More commonly, genetic disorders are products of abnormal genes (these are usually recessive)

21 Neuroplastic Responses to Nervous System Damage
  • Degeneration
  • Regeneration
  • Reorganization

22 Mechanisms of Recovery After Brain Damage
  • Promoting Regeneration
    – Regeneration of spinal cord
      • Transplantation of myelinated PNS nerves promoted growth of spinal cord neurons through the implanted Schwann cell myelin sheaths (make growth factors and cell adhesion molecules)
  • Neurotransplantation
    – Fetal Tissue
      • Fetal substantia nigra cells have been implanted in striatum
of Parkinson’s patients – Stem Cells
• Still in early stages
• Cells are pluripotent (can develop into many types of mature cells)

28 Neurotrophic (Nerve Growth) Factors
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30 What Are Stem Cells?
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• Rehabilitative Training

**Phantom Limb Sensation & Rehabilitative Training**
• About 50% of amputees experience a continuing sensation of the amputated body part
• Until the 1990’s, it was generally believed that the sensations were coming from the stump
• We now know that reorganization of the somatosensory cortex is responsible - the greater the reorganization the more likely and more intense the phantom sensations

**The MAP of the Somatosensory Cortex Explains Why Touch In Some Locations Can Elicit Phantom Limb Sensation**

**Training Can Facilitate Additional Reorganization Of The CNS**
• Phantom limb sensation can range from occasional tingling to intense pain
• Sometimes the sensation fades within days or weeks, but it can last a lifetime
• If the phantom sensation is painful, training can help
• E.g. Sensation of fingernails digging into the palm - relax the “phantom hand” by relaxing the image of the hand