The Brain and Cranial Nerves

Lecture Overview

• Brain
  – Function
  – Organization
  – Protection and support
  – Brain Regions - Anatomy
  – Brain regions - Physiology
    • Location
    • Associated structures
    • functions
  – Limbic system
• Cranial Nerves

Functions of Brain

• Integration center
  – Registers sensations
  – Correlates sensations with one another and with stored information
  – Makes decisions
  – Initiates taking action
• Center for intellect, emotions, behavior, memory
• Directs behavior towards others
An Introduction to the Organization of the Brain

Protection and Support of the Brain
Protection of Brain

- Cranial bones
- Cranial meninges
  - Dura mater
    - Periosteal layer
    - Dural sinuses
      » Superior sagittal sinus
  - Meningeal layer
    - Subdural space
    - Arachnoid mater
    - Subarachnoid space
      » Arachnoid villi (arachnoid granulations)
    - Pia mater
Fluid and ventricles

- Ventricles
  - Lateral ventricles
    - Septum pellucidum
    - Interventricular foramen (foramen of monroe)
  - Third ventricle
    - Cerebral aqueduct
  - Fourth ventricle
    - Lateral and median apertures
    - Choroid plexus
• Can you trace a drop of CSF from the right ventricle to the superior sagittal sinus?
  – Be sure to list all structures it passes through

Cerebrospinal Fluid

• Protection: cushions neural structures
• Buoyancy: supports the brain
• Chemical stability: transports
  – Nutrients
  – Chemical messengers
  – Waste products

Cerebrospinal Fluid

You produce ~500 ml/day. The total volume of CSF is replaced about every 8 hours.

• Jack has stenosis of the left interventricular foramen….
  – Where would there be fluid and pressure build up?
Lots of blood vessels…

- Brain is about 2% of your total body weight.
- It utilizes ~20% of ALL oxygen inhaled.
  - Remember O2 is used to make ATP.

The brain is the most metabolically active organ in the body

<table>
<thead>
<tr>
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<th>CSF</th>
<th>Blood Plasma</th>
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<tr>
<td>Na⁺ (mEq/L)</td>
<td>140–145</td>
<td>135–147</td>
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<tr>
<td>K⁺ (mEq/L)</td>
<td>3</td>
<td>3.5–5.0</td>
</tr>
<tr>
<td>Cl⁻ (mEq/L)</td>
<td>115–120</td>
<td>95–105</td>
</tr>
<tr>
<td>HCO₃⁻ (mEq/L)</td>
<td>20</td>
<td>22–28</td>
</tr>
<tr>
<td>Glucose (mg/dL)</td>
<td>50–75</td>
<td>70–110</td>
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<tr>
<td>Protein (g/dL)</td>
<td>0.05–0.07</td>
<td>6.0–7.8</td>
</tr>
<tr>
<td>pH</td>
<td>7.3</td>
<td>7.35–7.45</td>
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Blood Brain Barrier

Areas where the blood brain barrier is not intact:
- Portions of hypothalamus
- Posterior pituitary gland
- Pineal gland
- Choroid plexus

Brain vulnerable to infection
Ex: HIV
Major Brain Regions

- Brain Stem
  - Medulla oblongata
  - Pons
  - Midbrain
- Cerebellum
- Diencephalon
  - Thalamus
  - Hypothalamus
  - Epithalamus
- Cerebrum
Brain Stem

- Medulla oblongata
- Pons
- Midbrain
  - Superior colliculi
  - Inferior colliculi
  - Red nucleus
  - Substantia nigra
Cerebellum

- Cerebellar hemispheres
- Arbor vitae
- Cerebellar cortex
Diencephalon

- Thalamus
- Hypothalamus
  - Pituitary gland
  - Mammillary bodies
  - Optic chiasm
- Epithalamus
  - Pineal gland (body)
Cerebrum

- Left and right cerebral hemispheres
  - Cerebral cortex
  - White matter
    - Mostly myelinated axons
      - Association tracts: same hemisphere
      - Commissures: between hemispheres
      - Projection tracts: ascending and descending
    - Corpus callosum
  - Nuclei
    - Basal ganglia
The Brain and Cranial Nerves

Melissa Gonzales McNeal
Cerebrum

- Lobes
  - Frontal lobe
  - Parietal lobe
  - Occipital lobe
  - Temporal lobe
  - Hippocampus
- Folds and grooves
  - Precentral gyrus
  - Postcentral gyrus
  - Central sulcus
  - Lateral sulcus
  - Longitudinal fissure
  - Transverse fissure
The Brain and Cranial Nerves

Melissa Gonzales McNeal

**THE MEDULLA OBLONGATA**

- Cardiac center
- Vasomotor centers
- Respiratory centers
- Reflex centers (cough, sneeze, swallow, vomit)
- Sensory and motor nuclei for cranial nerves (VIII, IX, X, XI, XII)
- Relay stations along sensory and motor pathways

**THE PONS**

- Respiratory centers
- Sensory and motor nuclei for cranial nerves (V, VI, VII, VIII)
- Relay information to and from cerebellum
The Midbrain (Mesencephalon)

- **Superior colliculi**: receives visual input
  - Visual reflex movement
- **Inferior colliculi**: receives auditory data
  - Auditory reflex movement
- **Red nucleus**
  - Righting reflexes
- Nuclei for cranial nerves (III and IV)
- Substantia nigra...

Substantia Nigra

- Movement and balance
- Cells produce dopamine
  - Acts on other neurons to control/regulate their firing.
- Parkinson’s Disease
Reticular Formation

- Network of gray matter in brainstem
  - Ascending (RAS) and descending components
- ~25 specific behaviors
  - Somatic motor control
    - Adjust muscle tension for muscle tone, balance, and posture
    - Central pattern generators
      - Breathing, chewing, swallowing
  - Pain modulation (neuropeptides)
  - Cardiovascular control
  - Sleep and consciousness
    - Sleep, alertness, fatigue, motivation
  - Habituation
    - Attention, focus

- Possibly involved with
  - Introversion versus extroversion
  - Chronic fatigue syndrome
  - ADHD (attention deficit hyperactive disorder)
- Oldest portion of brain

Extensive dendrites of each neuron receive input from up to 200,000 synapses

The Cerebellum
The Cerebellum

- Adjusts postural muscles of body
  - Uses information provided by receptors in inner ear
- Programming and fine-tuning movements controlled at conscious and subconscious levels
  - Trajectory and end point
  - What muscles should be doing vs what they are doing
  - Sends corrective feedback via thalamus
- Alcohol impairs

Hypothalamus

- Part of limbic system: involves emotional response
  - Somatic motor patterns associated with rage, pleasure, pain, sexual arousal
- Behavioral drives: hunger, food intake, thirst
- Controls autonomic function
- Coordination of nervous and endocrine systems
- Secretion of hormones
  - Oxytocin, antidiuretic hormone (ADH), plus others that control the pituitary gland
- Regulation of body temperature
- Controls circadian rhythms
- Memory

Thalamus

- Suppresses "unimportant conscious sensation"
- Integrates sensation
The Brain and Cranial Nerves

Corpus Callosum
- Band of nerve fibers that connect the right and left hemispheres
- Corpus Callosotomy
  - “split-brain surgery”

**Diffuse Axonal Injury**
Due to Motor Vehicle Accident

**Basal Nuclei (Ganglia)**
- Subconscious aspects of voluntary movement
  - Ex: shoulder position and arm stabilization when writing
- Huntington’s Chorea

**Hippocampus**
A memory forming center in the temporal lobe

Caudate nucleus
Putamen
Globus pallidus
Amygdala
Substantia nigra

THE CEREBRUM

The corpus callosum contains about 200 million neuron fibers
The Brain and Cranial Nerves

Functional areas of cerebral cortex

- Motor areas
  - Primary motor cortex
  - Broca’s speech area - left hemisphere

- Sensory areas
  - Primary somatosensory cortex
  - Primary auditory cortex
  - Primary gustatory cortex
  - Primary olfactory cortex
  - Primary visual cortex

- Association areas
  - Premotor cortex (motor association area)
  - Somatosensory association area
  - Somatosensory visual areas (visual association area)
  - Somatosensory auditory areas (auditory association area)

- Integrative centers
  - Wernicke’s area - left hemisphere
  - Prefrontal cortex
  - Frontal eye field

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Broca's Speech center

Frontal eye field

Wernicke's General Interpretive area

Cannot physically form words

Aphasia – still able to understand written/spoken work

Language comprehension

Thought the precedes speech

Damage

- sit on chair – unable to follow the command
- Unable to produce meaningful sentences

Ex: reading, sports

Intellect

Complex learning

Recall

Temporal relationships

Personality

Judgment

Consequences

1. Prim older woman stripping in public
2. Tiger Woods (professional golfer)
3. Translator who speaks English, French, and Japanese
4. Congenitally blind person reading Braille
5. Concert pianist who was in a car accident. She can still physically play the piano but cannot remember how.

A. Which Functional Region(s) are involved?
B. Well developed or damaged (disease or trauma)?
Identify the functional areas: A-K

Phineas Gage
1848
What specific brain regions are involved in walking?

Higher Order Functions

- Cerebral cortex involved
- Involve both conscious and subconscious information processing
- Subject to modification and adjustment over time

Limbic System

- Emotional brain
  - Motor responses to emotion
  - Control and expression of emotions
  - Important roles in personality
- Facilitates memory storage and retrieval
- Associations with reward/pleasure and punishment/aversion
Limbic System

- Major structures
  - Prefrontal cortex
  - Hippocampus
  - Thalamus
  - Hypothalamus
    - Mammillary bodies
  - Amygdala
  - Basal nuclei

Memory

- Memories: stored bits of information gathered through experience
  - Memory trace (engram): pathway in brain where new synapses were formed or modified
- Synaptic plasticity: ability of synapses to change
- Types
  - Fact (declarative) memory: specific bit of information
  - Skill (procedural) memory: learned motor behavior

Memory consolidation: conversion from short term to long term memory
  - Hippocampus
Memory

Formation and storage

- Increased neurotransmitter release
- Facilitation at synapses
  - Potentiation
  - Build up of $\text{Ca}^{2+}$ in synaptic end bulb causes larger burst of neurotransmitter release
- Formation of additional synaptic connections or neurotransmitter receptors

When I study matters?!

Symptoms include

- Short term memory loss
- Changes in personality

What brain regions are affected and why?
States of Consciousness

- Conscious: awareness of and attention to external stimuli
- Unconscious
  - Sleep
    - Deep sleep: cerebral cortex activity minimum
    - Rapid eye movement (REM): dreaming, less receptive than deep sleep
  - Coma
- Arousal: awaking from sleep
  - Reticular activating system
    - Alermness
    - focus

Brain Waves

- Beta waves
  - Mental activity and sensory stimulation
- Alpha waves
  - Awake and resting with eyes closed
- Theta waves
  - Children
  - Drowsy or sleeping adults
- Delta (slow) waves
  - Infants
  - Deep sleep in adults

Sleep

- 4 stages of non-REM sleep
  - Stage 1: relaxation, light sleep, alpha waves
  - Stage 2: brain waves slow down
  - Stage 3: theta and delta waves appear, vital signs fall
  - Stage 4: deep sleep
    - Delta waves
    - Decreased metabolism, decreased temperature
    - Restorative sleep
    - Difficult to wake
Sleep

• REM (rapid eye movement)
  – Increased HR, BP, O₂ consumption
  – Brain activity begins in pons and midbrain
    • Turns off motor neurons (temporary paralysis)
    • Strongly activate inhibitory center in medulla
    • Deepest stage (hardest to awaken)
  – Thalamus
  – Cerebral cortex
  – Reticular formation
• Dreaming occurs in stage 4 and REM

Cranial Nerves

12 pairs – for each you need to know
➢ Name and number
➢ Sensory*, motor*, mixed (both)
➢ General function

* Predominately sensory or motor
The Brain and Cranial Nerves

Olfactory Nerve I
- Sensory
- Smell

Optic Nerve II
- Sensory
- Vision

Oculomotor Nerve III
- Motor
- Moves eyeball
- Raises upper lid
- Constricts pupil

Trochlear Nerve IV
- Motor
- Moves eyeball
The Brain and Cranial Nerves

Trigeminal Nerve V
- Mixed
- Sensory information
  - Face, scalp, teeth
- Motor instructions
  - Mastication

Abducent Nerve VI
Abducens
- Motor
  - Moves eyeball

Facial Nerve VII
- Mixed
- Sensory information
  - Face
  - Taste
- Motor instructions
  - Scalp and face
  - Lacrimal glands
  - Salivary glands
  - Glands nose and throat

Vestibulocochlear Nerve VIII
Acoustic, Auditory, Stato-acoustic
- Sensory
- Vestibular
  - Balance
  - Orientation and head movement
- Cochlear
  - Hearing
The Brain and Cranial Nerves

Glossopharyngeal Nerve IX
- Mixed
- Sensory information
  - Blood pressure
  - Dissolved gases
- Motor instructions
  - Salivary glands
  - Swallowing

Vagus Nerve X
- Mixed
- Larynx
- Esophagus
- Bronchial tubes
- Heart
- Stomach
- Intestines
- Pancreas

Accessory Nerve XI
- Motor
- Muscles of neck and upper back
- Speech

Hypoglossal Nerve XII
- Motor
- Movement of tongue
Memory Devices

• Cranial nerve names
  – Old Opie occasionally tries trigonometry and feels very gloomy vague and hypoactive
  – on occasion our trusty truck act funny, very good vehicle any how

• Cranial nerve functions
  – Some say marry money but my brother says big brains matter more