INTRODUCTION TO THE NERVOUS SYSTEM

• STRUCTURE
  – BRAIN
  – SPINAL CORD
  – NERVES

Central Nervous System (CNS):

• Brain
• Spinal Cord
Peripheral Nervous System (PNS):

- Nerves
  - Cranial
  - Spinal

Cranial Nerves

Organization

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PRIME FUNCTIONS

• COMMUNICATION
  – Sending Messages, Cells in the NS Send Messages to Cells in Other Systems

• CONTROL
  – Regulation of Body Functions, The NS Regulates a # of Body Functions (Important in Maintaining Homeostasis)

• INTEGRATION
  – Unification of Body Functions, Allows the Body to Function as a Unit

Nervous & Endocrine Systems Share Functions:
Communication, Control, & Integration

Nervous & Endocrine Systems Share Functions

• NOTE: Both the Nervous and the Endocrine Systems Have Same Primary Functions, Communication, Control, and Integration

• The 2 Systems Differ in How They Communicate, Control, and Integrate
CELLS OF THE NERVOUS SYSTEM

• There Are 2 Major Types of Nervous System Cells
  – GLIA (NEUROGLIA)
  – NEURONS

Glia

– GLIA (NEUROGLIA)
  • DEFINITION/NUMBER
    – Supporting Cells in the Nervous System
    – 900 Billion
  • TYPES
    – Astrocytes
    – Microglia
    – Ependymal Cells
    – Oligodendrocytes
    – Schwann Cells

Types of Gli – Astrocytes

• ASTROCYTES
  – Found only in CNS
  – "Star Cells" (Star-Shaped)
  – Largest/Most Numerous Glia
  – Help Form the Blood-Brain Barrier
    • Protective Covering for Brain
    • Composed of Brain Capillaries And Astrocytes
Blood-Brain Barrier

- Protective Covering for Brain
- Composed of Brain Capillaries And Astrocytes

Types of Glia - Microglia

- MICROGLIA
  - “Small Glia” (Smallest)
  - Phagocytes in Brain Inflammation and other damaged CNS tissue

Types of Glia – Ependymal Cells

- EPENDYMAL CELLS
  - “Epithelial Cells” of the meninges/brain sinuses
  - Line Fluid Filled Spaces in the CNS
  - Help Produce/Keep Fluid Circulating (Cilia) Within the Spaces
Types of Glia - Oligodendrocytes

- OLIGODENDROCYTES
  - “Cells With Few Branches”
  - Functions:
    - Help Hold Together Nerve Fibers in the CNS (Nerve Fibers = Processes of Neurons)
    - Produce the Covering (Myelin) for Nerve Fibers (Axons) in the CNS (Many NF’s in the CNS Have 1 Covering:
      - Myelin Sheath, Formed by Oligodendrocytes)

Types of Glia – Schwann Cells

- SCHWANN CELLS
  - Located Only in the PNS
  - Functions
    - Hold Together Nerve Fibers in the PNS
    - Produces the Coverings for Many Nerve Fibers (Axons) in the PNS (Many NF’s in PNS Have 2 Coverings:
      - Myelin Sheath and Neurilemma, Formed by Schwann Cells;
        - The Myelin Sheath is the Schwann Cell’s Plasma Membrane and
        - The Neurilemma is the Schwann Cell’s Cytoplasm and Nucleus)
    - Cover and Support Neuron Cell Bodies in PNS

MS-Multiple Sclerosis

- Disease of the oligodendrocytes
- Affects CNS
- Results in demyelination of CNS white matter
- Nerve conduction is impaired
- Symptoms
  - Weakness
  - Loss of coordination
  - Visual impairment
  - Speech disturbances
- Most common in women between 20 and 40 years of age
- Normally a chronic disease characterized by relapses
- Some acute cases
- Cause unknown
  - Autoimmunity (lupus, arthritis)
  - Viral infections
  - Susceptibility is inherited in some cases
CELLS OF THE NERVOUS SYSTEM

- NEURONS
  - DEFINITION/NUMBER
  - Nerve Cells: Conduct NI
  - 100 Billion

Neuron Structure: Plasma Membrane & Cytoplasm

- PLASMA MEMBRANE
- CYTOPLASM

Neuron Structure: Cytoplasm

- CYTOSKELETON
  - Microtubules
  - Microfilaments
  - Neurofibrils:
    - Microscopic Threadlike Fibers that Extend Lengthwise Through the Neuron
    - Rapid Transport of Molecules From One End of the Neuron to the Other (i.e., Proteins)
Neuron Structure: Cell Body

- **CELL BODY**
  - Largest Part of Neuron
  - Contains Nucleus
  - Contains Typical Organelles
  - Contains Nissl Bodies
    - Rough ER of Neurons
    - Protein Synthesis

Neuron Structure: Processes

- **PROCESSES (NERVE FIBERS)**
  - Threadlike Extensions from Cell Body
  - 2 Types
    - DENDRITIC(S)
    - AXON

Neuron Structure: Processes

- DENDRITIC(S)
  - One or More/Neuron (Shorter)
  - Conduct NI Toward Cell Body
Neuron Structure: Processes

- AXON
  - One per Neuron (Longer)
  - Conduct Na Away from Cell Body

Neuron Structure: Axons

- AXON COLLATERAL(S)
  - Side Branches:
    - 1 or More
    - Divide into TELODENDRIA
    - TELODENDRIA (terminal branches) terminate into SYNAPTIC KNOBS (terminal ends-bulges)

Neuron Structure: Coverings

- COVERINGS
  - ONE COVERING: MYELIN SHEATH
    - (MYELINATED NERVE FIBERS)
  - TWO COVERINGS: MYELIN SHEATH & NEURILEMMA
  - NO COVERINGS
    - (UNMYELINATED NERVE FIBERS)
ONE COVERING: MYELIN SHEATH (MYELINATED NERVE FIBERS)

- Axons of Neurons in CNS Have 1 Covering, the Myelin Sheath
  - Formed by Oligodendrocytes
  - Known as Myelinated Nerve Fibers (White)

TWO COVERINGS: MYELIN SHEATH & NEURILEMMA (MYELINATED NERVE FIBERS)

- Many Axons of Neurons in PNS Have 2 Coverings, Myelin Sheath and Neurilemma, Formed by Schwann Cells
- Also Known as Myelinated Nerve Fibers (White)

NO COVERINGS (UNMYELINATED NERVE FIBERS)

- Some Axons of Neurons in PNS Have No Coverings
- Axons are Embedded in Schwann Cells, Rather than Schwann Cells Wrapping Around Axons
- Known as Unmyelinated Nerve Fibers (Gray)
Unmyelinated vs Myelinated Neuron Structure:

Axon Coverings: NOTES

- Neurilemma Functions in Repair of Neurons
  - Mature Neurons Are Not Capable of Mitosis
  - Repair of Neurons Requires Intact Cell Body and the Presence of a Neurilemma
    - Neurilemma Serves as the Guiding Tunnel
Neuron Structure:
Axon Coverings: NOTES

- Damage to Neurons in the CNS is Permanent*
  - Fetal tissue transplants
  - Presence of coverings
  - "Club Drugs" – see next slide

"Club Drugs"

Chronic abuse of MDMA (Ecstasy) appears to produce long-term damage to serotonin-containing neurons in the brain. The neurotransmitter serotonin plays in regulating emotion, memory, sleep, pain, and higher order cognitive processes. It is likely that MDMA use can cause a variety of behavioral and cognitive changes as well as impaired memory.

http://www.drugabuse.gov/Published_Articles/fundrugs.html

CLASSIFICATION OF NEURONS

STRUCTURAL CLASSIFICATION

- Neuron Classified According to Number of Processes that Extend Off the Cell Body
  - MULTIPOLAR NEURONS
    - Several Dendrites, 1 Axon
  - BIPOLAR NEURONS
    - 1 Dendrite ( Branched), 1 Axon
  - UNIPOLAR NEURONS
    - Several Dendrites, 1 Axon (Peripheral and Central Portions)
MULTIPOLAR NEURONS
Several Dendrites, 1 Axon

BIPOLAR NEURONS
1 Dendrite (Branched), 1 Axon

UNIPOLAR NEURONS
Several Dendrites, 1 Axon (Peripheral and Central Portions)
FUNCTIONAL CLASSIFICATION

- Neuron Classified According to Direction It Conducts Nerve Impulses

AFFERENT (SENSORY) NEURONS

- Conduct Nerve Impulses Toward CNS, Specifically From Receptors To CNS
- Receptors:
  - Distal Ends of Dendrites of Afferent (Sensory) Neurons
  - Receives a Stimulus
  - Converts Stimulus into a Nerve Impulse
  - Located in Sense Organs

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  - Receives a Stimulus
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  - Located in Sense Organs
FUNCTIONAL CLASSIFICATION

- EFFERENT (MOTOR) NEURONS
  - Conduct Nerve Impulses Away From CNS, Specifically from CNS to Effectors
  - Effector:
    • Structure that Shows Action
    • Muscle or Gland

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FUNCTIONAL CLASSIFICATION

- INTERNEURONS
  - "Between Neurons", Conduct Nerve Impulses From Afferent Neurons to Efferent Neurons
  - Located Entirely in CNS

Interneurons

Fast spiking cell (PV-positive interneuron)

FUNCTIONAL CLASSIFICATION

- MOST Afferent Neurons are Unipolar (A Few are Bipolar)
- Efferent Neurons are Multipolar
- Interneurons are Multipolar

- MULTIPOLAR NEURONS
  - Several Dendrites, 1 Axon

- BIPOLAR NEURONS
  - 1 Dendrite (Branched), 1 Axon

- UNIPOLAR NEURONS
  - Several Dendrites, 1 Axon (Peripheral and Central Portions)
**GRAY MATTER**

- **DEFINITION**
  - Gray
  - Neuron Cell Bodies (CNS, PNS) and/or Unmyelinated Nerve Fibers (PNS)
- **NUCLEI (us)**
  - Gray Matter in the CNS
- **GANGLIA (ion)**
  - Gray Matter in the PNS

**WHITE MATTER**

- **DEFINITION**
  - White
  - Myelinated Nerve Fibers
- **TRACTS (bundles of axons)**
  - White Matter in the CNS
- **NERVES (bundles of axons)**
  - White Matter in the PNS

**WHITE MATTER**

- **NERVES**
  - White Matter in the PNS
  - CONNECTIVE TISSUE COMPONENTS
    - **ENDONEURUM**
      - Connective Tissue that Wraps Around Each Individual Myelinated Nerve Fiber
    - **PERINEURUM**
      - Connective Tissue that Wraps Around Each Group of Myelinated Nerve Fibers (Fascicle)
    - **EPINEURUM**
      - Connective Tissue that Wraps Around the Entire Nerve
**WHITE MATTER**

- **TYPES**
  - MIXED NERVES
    - Contain Both Afferent and Efferent Nerve Fibers
    - Most Common
  - SENSORY NERVES
    - Contain Mainly Afferent Nerve Fibers
  - MOTOR NERVES
    - Contain Mainly Efferent Nerve Fibers

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**Nerve Types: Sensory & Motor**
NEURON PATHWAYS

• REFLEX ARC PATHWAYS (REFLEX ARCS)
  – DEFINITION
    • Neuron Pathway To/Away From the CNS
    • Nerve Impulse Always Begins in Receptors, Ends in Effector

NEURON PATHWAYS

• TYPES
  – THREE NEURON ARC
    • Involves 3 Neurons: Afferent Neuron, Interneuron, and Efferent Neuron
    • Most Common Type of Reflex Arc Pathway
  – TWO NEURON ARC
    • Involves 2 Neurons: Afferent Neuron and Efferent Neuron (No Interneurons)
    • Simplest Type of Reflex Arc Pathway

NEURON PATHWAYS

• REFLEX
  – Response Produced When a Nerve Impulse Travels Over a Reflex Arc Pathway
  – Involuntary (A Response to a Stimulus)
  – Types (Based on Effector)
    • Muscle Contraction
    • Gland Secretion
    • *Reflex: Mechanism of Communication, Control in Nervous System

*Reflex: Mechanism of Communication, Control in Nervous System
NEURON PATHWAYS

- OTHER PATHWAYS
  - Many Other Neuron Pathways Exist in the Nervous System
    - Examples:
      - Receptors → Brain
      - Brain → Skeletal Muscles
      - Within the Brain

Links

- Nerve healing
  - http://www.hucmlrc.howard.edu/neuroanat/Lectures/axoplasmtrans.htm
- Pictures and Animations