The Nervous System

Two body systems, the nervous and endocrine systems, share the responsibility for maintaining homeostasis. Their objective is the same – to keep controlled conditions within limits that maintain health. Their means of achieving that objective differs. Whereas the endocrine system uses hormones that respond relatively slow, the nervous system employs nervous impulses called action potentials to respond relatively rapidly to changing stimuli that affect the body.

Contents:
1. Individual Cells
   a) 
   b) 
2. Central Nervous System ( )
   a) 
3. Peripheral Nervous System ( )
   a) 
4. Sensory Receptors
   ex)

Functions:
1. Sensory Input
   a. Detects stimuli, both internal and external
   b. Afferent (toward the CNS)

2. Integration
   a. Analysis and interpretation of sensory input
   b. Make a decision as to appropriate response

3. Motor Output
   a. Response to a stimulus through a specific action taken
   b. Output goes to: muscle or gland
   c. *Efferent – away from CNS
1. Subdivisions of the nervous system
   - Subdivisions based on both structural and functional characteristics

   ![Diagram of the nervous system]

2. Glial cells: a review
   * The helper cells of neurons
   * Do not send/receive Action Potentials
   ex: astrocytes, ependymal cells, microglia, Schwann cells and oligodendrocytes
   Usually the source of tumors within nervous system
   Functions:
   a) Help, support, and nourish neurons
   b) Form myelin sheath
   c) Make memories

3. Neuron structure: a review

   Most neurons have 3 basic portions
   1) Cell body ( )
   2) Dendrite Usually short. Input (receiving part) of neuron
4. Action potential (A.P.) = nervous impulse
   = an electrochemical signal or message propagated along the cell membrane of a neuron or muscle cell

An Action Potential is all or none.
Thus, the strength or integrity of all AP’s is equal.

How is strength of stimulus interpreted
• It is encoded in frequency of AP’s sent

   ex: mild pain $\rightarrow$ 10-20 AP’s sent
       Severe pain $\rightarrow$ 50-60 AP’s sent

   a) Resting membrane potential = RMP

   a) Resting membrane potential = RPM

When axon is at rest (no AP’s being sent)
Unequal distribution of charges across cell membrane

<table>
<thead>
<tr>
<th>Segment of an Axon</th>
<th>Outside: Positive Ions</th>
<th>Inside: Negative ions</th>
</tr>
</thead>
</table>

Reasons why:
1. Membrane is selectively permeable
2. Na+ gates/pores are closed
3. Neuron actively pumping Na+ out of cell

b) Action potential = AP

The arrival of a stimulus at axon will change RMP. There are 2 steps

1. Stimulus causes Na+ gates to open in small areas
   a. *Na floods into axon from High $\rightarrow$ low
   b. *Cl- is repelled, so they exit axon.
2. Result:

Depolarization: a flip-flop of ions away from RMP

Eventually, Na⁺ gates close stop flow of Na⁺ ions
*ATP energy pumps all Na⁺ out of cell
*Cl⁻ is repelled, so they enter axon

Result: RMP is re-established. Repolarization (flip-flop back to RMP)
1. Resting Membrane Potential
- Neuron is at “rest”
- High concentration of Na⁺ outside of cell
- High concentration of Cl⁻ inside cell

2. Application of a Stimulus
- Stimulus causes Na⁺ gates to open; Na⁺ enters axon
- Cl⁻ is repelled and exits axon

3. Action Potential - beginning
- Opening of additional Na⁺ gates
  - Like a ‘wave’ along axon
- Riding the wave, Na⁺ enters axon
  - and Cl⁻ exits axon

4. Action Potential - continuation
- Wave of Na⁺ gates opening
  - and exchange of ions proceeds
- Behind wave, Na⁺ gates close;
  - Na⁺ pumped out and Cl⁻ reenters axon

5. Return to Rest. Membrane Potential
- Wave proceeds along axon
- Area of axon where action potential began is back to RMP
- Neuron now ready to send a new action potential while the first is still traveling along the axon
5. Types of neurons
   - based either on 1) anatomic structure or 2) function

   a) Anatomical classification
      
      **unipolar**
      
      Have 1 single axon and no dendrite
      *One end of axon acts as dendrite
      Commonly used as sensory neuron

      **Bipolar**
      
      Have 1 axon and 1 dendrite
      Commonly used in major sense organs
      
      ex: retina of eye, sense of smell and hearing

      **Multipolar**
      
      Have many dendrites and 1 axon
      Most numerous type of neuron
      Commonly used as motor neurons

   b) Functional classification
      
      **Sensory (= afferent) neuron**
      
      Brings sensory information from a sensory receptor towards CNS
      Cell bodies found in groups or clusters (ganglion)
      Common for several to link end-to-end to reach brain

      **Interneuron (= association neuron)**
      
      Any neuron contained entirely within the CNS
      Form various connections between parts of CNS
      ex: may link cerebrum to cerebellum
      Sensory or motor neurons together in a reflex arc
Motor (= efferent) neuron

Sends motor commands from CNS to all 3 muscles/glands
Cell body located within CNS and axon extends out into body
ex: innervates skeletal muscle

*neuropathway lab
6. Central nervous system: brain
   a) Cerebrum

The largest and most complex region of the brain
Superficial, gray matter (1-2 mm thick) cell bodies of neurons
Deeper= white matter – myelinated axons (traveling to and from cortex)
On each side, subdivided into 4 lobes:
   - Frontal
   - Parietal
   - Temporal
   - Occipital

Functions: higher level integration. ex: thinking, memory, decision, and personality

b) Diencephalon

Older “core” of brain where more “primitive” emotions (hunger, thirst, sex-drive). Consists of many named structures.

Functions:
   - Sensory relay center (lab on neural pathways)
   - Moods and emotions
   - Regulates many ANS functions
   - Hormone secretion (pituitary)

d) Cerebellum (little brain)
A rounded mass at inferior and posterior side of brain

Functions:
1. Regulates many motor activities
2. Balance and posture corrections
3. Remembers” repetitive motor patterns
   ex: free throw, musical instrument, signature
d) Midbrain
Small area of brain directly inferior to diencephalon
If damaged, can lead to Parkinson’s disease
Functions:
1. Visual integration
2. Auditory integration
3. Coordinates voluntary movements

e) Pons
Small, rounded area inferior to midbrain
Functions:
1. Location of same involuntary control centers
   a. ex: respiratory center
2. Contains sensory and motor neurons.

f) Medulla oblongata
Most inferior part of the brain
*Merges into spinal cord – boundary foramen magnum

Functions: location of many involuntary control centers
   - Blood pressure
   - 
   - 
   -
MATURE BRAIN: the basic parts

Cranium

Cerebrum

Corpus Callosum

Fornix

3rd Ventricle

Pineal Gland

Midbrain

Anterior Commissure

Optic Chiasma

Olfactory Lobe

Pituitary Gland

Pons

Cerebellum

Medulla Oblongata

Spinal Cord

Central Canal

Sheep brain dissection/Quiz 1
7. Central nervous system: spinal cord
   a) Introduction to the spinal cord

   About 16-18 inches long; ¾ to one-inch diameter
   Located within vertebral foramina of spine
   Functions:
   1. Contains ascending sensory and descending motor n=axons leading to and from brain
   2. Simple integration (reflex)

   b) Cross-sectional anatomy of spinal cord

   1. Posterior median fissure
   2. Anterior median fissure
   3. White matter (myelinated axons traveling up (sensory) or down (motor)
   4. Gray matter = cell bodies of neurons

   c) Reflex arcs

   A simple nervous pathway that produces a fixed response
   1. Sensory receptor
   2. Sensory neuron
   3. Interneuron
   4. Motor neuron
   5. Effector organ (any 3 muscle types or gland)
8. Meningeal layer
   = 3 layers of tissue that surround the CNS

   **Remember:** brain and spinal cord dorsal cavity/no parietal and visceral!
   **Functions:** 1. Surround and protect CNS
   If infected ➞ meningitis
   Consists of: cranial meninges and spinal meninges

   **Cerebrospinal fluid = CSF**
   Functions: acts as a shock absorber
   Keeps CNS moist
   CSF circulates around and within brain and spinal cord

   a) dura mater = superficial layer
   Made of dense irregular connective tissue
   Very strong and tough layer

   b) Arachnoid mater = middle layer
   Has a web-like or wispy appearance
   Made of areolar CT
   Spidery

   c) Pia mater = deep layer
   Lies directly on nervous tissue
   Made of areolar CT
   1 cell thick and transparent
   Contains capillaries for brain tissue
   Gentle
9. Peripheral nervous system = PNS

Consists of a total of 43 pairs of nerves that arise off brain and spinal cord
Function: connects all body tissues/organs to CNS

a) Cranial nerves

12 superior-most pairs of nerves. Attached to brain
Mainly involved with sensory and motor activities of head and neck structures
Can be:
   a) Sensory only
   b) Motor only
   c) Both sensory and motor

I. Olfactory
Sense of smell – sensory only

II. Optic
Sense of vision – sensory only

III. Oculomotor
Controls 4 muscles that move an eyeball in orbit. Motor only

IV. Trochlear
Controls 1 muscle that moves an eyeball – motor only

V. Trigeminal
Sensory of skin on head and face-motor for muscles of mastication

VI. Abducens
Controls 1 muscle that moves an eyeball – motor only
VII. Facial
Sensory for taste – motor for muscles of face and scalp

VIII. Vestibulocochlear
Sensory for hearing and inner ear balance – sensory only

IX. Glossopharyngeal
Sensory for taste – motor for muscles of pharynx/salivary glands

X. Vagus
Only CN to exit head and neck region-sensory and motor for thoracic/abdominopelvic organs

XI. Accessory
Controls muscles of pharynx and neck – motor only

XII. Hypoglossal
Controls muscles of tongue – motor only

On Old Olympus Towering Top, A Fat Visiting German Viewed A Hop
Some Say Marry Money But My Brother Says Bogus Bonds May Mature

Focus (Cranial Nerves)
b) Spinal nerves
- 31 pairs arising from the spinal cord
- All are mixed nerves = carry both sensory and motor neurons

1. Attachment to spinal cord

Dorsal root – contains only sensory axons entering ord. Has GANGLION (dorsal root ganglion)

Ventral root - Contains only motor axons exiting cord. No ganglion

2. Innervation of spinal nerves

Individual nerves “braid” together to form → plexus (new combinations of neurons)

Cervical plexus (C1 - C4)
- Innervates: neck, shoulder, and diaphragm

ex: phrenic nerve → diaphragm

Brachial plexus (C5 - T1)
- innervates: shoulder and entire upper extremity
ex: ulnar nerve → funny bone
Lumbosacral plexus (L1 - S4)
- innervates: pelvis and entire lower extremity

ex: sciatic nerve → largest nerve in body

Intercostal nerves (T1 - T12) (only watch last 5 min) http://www.youtube.com/watch?v=qvqcvYdv2ZQ
- Innervates: intercostal muscles

No plexus formed

Quiz #2

10. Autonomic nervous system = ANS

Part of nervous system that controls involuntary motor functions. Overseen by: diencephalon and control centers in pons and medulla oblongata
Sends motor commands to smooth muscle, cardiac muscle and all glands.

Somatic efferent = uses one motor neuron. VOLUNTARY

vs.

Autonomic efferent = uses two motor neurons in chain. INVOLUNTARY

a) Sympathetic division

“Fight or flight”

Stimulates the body into action
Ex: increased heart rate, inc breathing rate, inc. blood glucose, inc sweating, decreased digestion, inc. blood pressure

Associated with anger, stress, high anxiety, fear.
Causes the release of hormone epinephrine (adrenaline) from adrenal gland
b) Parasympathetic division

“"Rest and Digest”

Inhibits the body into inactivity.  
Ex: decreased heart rate, dec breathing, dec blood pressure, dec sweating, inc digestion, dec blood glucose

Readies the body for digestion of food/ sleep
Major control for urination and defecation

11. Disorders of the nervous system
   a) Epilepsy

   Short attacks of sensory/motor dysfunction of brain.
   Epileptic seizure – caused by massive electrical discharge of neurons
   During a seizure there is a loss off consciousness, uncontrollable convulsions

   Treatments: drugs to inhibit neurons.

   Triggered by: toxins, tumors, head trauma, infections, and genetic factors

   Most common type of neurologic disorder
   Caused by an interruption of blood flow to brain by: 1. Rupture of a BV, 2. Clot
within BV
Leads to death of neuron in brain
Typical symptoms: Paralysis on ½ of body, sensory deficits, difficulty speaking
Treatment: physical therapy, speech therapy

b) Cerebrovascular accident = CVA = stroke

Most common type of neurologic disorder
Caused by an interruption of blood flow to brain by
1. rupture of a blood vessel
2. clot within a blood vessel

Leads to death of neurons in brain.

Typical symptoms: paralysis on ½ of body, sensory deficits, difficulty speaking

Treatment: physical therapy, speech therapy

http://www.youtube.com/watch?v=wH7k5CFp4hI