I. Introduction

A) General Function:
   (1) Master controller and communication system of the entire body
       (a) includes every thought, emotion and action
       (b) all carried out by electrical or nervous impulses

   (2) Specifically, there are three overlapping functions

       (a) _
           (1) sensory receptors monitor environmental stimuli
           (2) nervous impulses take information to integration center/brain and spinal cord

       (b) _
           (1) neurons of the brain and spinal cord receive sensory information
           (2) determine an appropriate response based on current information and past experience
           (3) issue commands through nervous impulses to motor neurons

       (c) _
           (1) motor neurons signal effectors to carry out a response
           (2) muscle contract or a gland secrete

B) Organization
   (1) structural classification

       (a) _
           (1) brain and spinal cord within dorsal body cavity
           (2) processes sensory information, integrates and determines an appropriate response

       (b) _
           (1) all nerves that extend from CNS to all body parts
           (2) links/connects body to CNS
           (3) only sensory and motor function

   (2) Functional Classification

       (a) _
           (1) sensory information going TO brain and spinal cord (continuous)
           (2) somatic sensory information—skin and joints
           (3) viscera

       (b) _
           (1) motor output—information/commands issued to effectors
           (2) somatic/voluntary/conscious responses
           (3) autonomic/involuntary/unconscious responses
C) (Slide 6) Neurons

(1) General
   (a) >100 years old
   (b) amitotic
   (c) excitable—membrane sensitive to stimuli and conducts nervous/electrical impulses
   (d) high metabolism (glucose and oxygen)
   (e) many dendrites/single axon (may branch)
   (f) nervous impulse travels in one direction

(2) Membrane Transport Proteins

   (a) 
      (1) facilitated diffusion (Na\(^+\) and K\(^+\))
   (b) 
      (1) active transport (Na\(^+\) and K\(^+\))

(3) (Slide 7) Neurons categorized by function

   (a) 
      (1) afferent division: transmit nervous impulse TO CNS
      (2) specialized to monitor specific stimuli—special senses, cutaneous, proprioception
   (b) 
      (1) located entirely within CNS
      (2) integrate information and determine response
   (c) 
      (1) efferent division
      (2) carry message to effector cells—muscles and glands
D) (Slide 9) CNS Glial Cells
   (1) General Characteristics
       (a) support neurons of the CNS
       (b) smaller
       (c) numerous
       (d) provide scaffolding/framework
       (e) do not conduct nervous impulses
       (f) mitotic
       (g) ‘gliomas’

   (2) (Slide 10) Astrocytes
       (a) structure:
           (1) ‘star’ shaped
           (2) approximately ½ nervous tissue
       (b) functions:
           (1) __
           (2) __
           (3) mop up/recapture Na+

   (3) (Slide 11) Microglial Cells
       (a) structure: ‘thorny’
       (b) function: immune

   (4) (Slide 12) Ependymal Cells
       (a) structure:
           (1) ciliated epithelial cells
           (2) line cavities
       (b) function: cilia circulate cerebrospinal fluid (CSF)

   (5) __

       (a) structure: form myelin sheath around axons of CNS
       (b) function: speed up nervous impulses

E) __

   (1) structure: form myelin sheath over axons of PNS
   (2) function: speed up nervous impulses
II. (Slide 14) **Physiology of the Nervous Impulse (Action Potential)**

A) Two main functional properties of neurons
   (1) ___ ability to respond to a stimulus
   (2) ___ ability to transmit a nervous impulse to another cell

B) (Slide 15) **Generation of a Nervous Impulse**
   (1) Overview
      (a) ___ membrane at rest/not generating an impulse
      (b) ___ minimum amount of a stimulus required to generate an action potential
      (c) ___ an electrical event occurring when a stimulus of sufficient intensity is applied to a neuron (or muscle cell) allowing sodium ions to move into the cell and reverse the polarity.
      (d) ___ time required to return neuronal membrane to its resting potential/capable of generating the next impulse/action potential

C) (Slide 16) **Neuron Membrane at Rest**
   (1) impulse being generated
   (2) extracellular environment:
      (3) cytoplasm
         (a) negatively charged proteins
         (b) few potassium ions K+
      (4) membrane impermeable to Na+ and K+

(a) **Resting membrane electrical conditions.** The external face of the membrane is slightly positive; its internal face is slightly negative. The chief extracellular ion is sodium (Na+), whereas the chief intracellular ion is potassium (K+). The membrane is relatively impermeable to both ions.

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D) (Slide 17-20) **Stimulus initiates an action potential**

1. (a) energy-pressure, vibration, stretch, light, heat
   (b) chemical-molecules (taste, smell, neurotransmitters)
2. membrane receptors respond to a specific stimulus

E) (Slide 21) **AP propagates along axon in a series of depolarization and repolarization events**

1. **Depolarization**
   
   (a) 
   (b) 
   (c) charge difference across membrane decreases
   (d) (Slide 22) continues along length of axon towards axonal terminus

(b) **Stimulus initiates local depolarization.** A stimulus changes the permeability of a “patch” of the membrane, and sodium ions diffuse rapidly into the cell. This changes the polarity of the membrane (the inside becomes more positive; the outside becomes more negative) at that site.

(d) **Propagation of the action potential.** Depolarization of the first membrane patch causes permeability changes in the adjacent membrane, and the events described in (b) are repeated. Thus, the action potential propagates rapidly along the entire length of the membrane.
(2) **Repolarization**

(a) 

(b) 

(c) charge difference across membrane increases  
(d) restore the charge difference 
(e) continues/propagates along axonal length

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F) **Refractory Period**

(1) return resting membrane potential ion concentrations 

(a) 

(b) 

(2) Sodium-Potassium Pump  

(a) active transport-requires ATP  

(b) 

(c) 

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G) **Can measure the difference in voltage across the membrane during an action potential**

H) **Myelinated versus Nonmyelinated axons**

(1) nonmyelinated  

(a) 

(b) 

(2) myelinated  

(a) 

(b) 

(c) 

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I) (Slide 27) **Synapse or Synaptic cleft**

1. junction/space between the pre-synaptic neuron and the post-synaptic neuron

2. **pre-synaptic neuron**

3. **post-synaptic neuron**

J) (Slide 28) **Neurotransmitters**

1. >50 have been identified
   
   a) _ reduces perception of pain or stress--‘runners high’

   b) _ skeletal muscle contractions

   c) _ ‘feel good’--tricyclic antidepressents keep it in the synapse

   d) _ excitatory neurotransmitter important in learning and memory

2. (Slide 29) **Effects on post-synaptic neuron**

   a) _ move post-synaptic neuron closer to threshold → AP

   b) _ move post-synaptic neuron away from threshold → no AP

   c) _

3. (Slide 30) **Fate of neurotransmitters in synaptic cleft**

   a) reabsorbed by endocytosis and resused

   b) enzymatically destroyed
      
      1. example: acetylcholinesterase and ACh

K) (Slide 31) **Conductive Cells**

1. capable of generating an AP

2. _

3. _ ACh binding ACh receptor stimulates SR to release Ca+ along entire length of the muscle fiber due to the AP generated along sarcolemma
III. CNS Central Nervous System

A) Organs: brain and spinal cord

B) Protection:

(1) Bone
   (a) cranium and facial bones
   (b) vertebrae

(2) Meninges
   (a) _
       outer, tough, fibrous
   (b) _
       weblike filled with cerebrospinal fluid
   (c) _
       inner, delicate membrane covers surface
   (d) meningitis: inflammation of the meninges

(3) CSF Cerebrospinal Fluid
   (a) composition
      (1) similar plasma—watery broth
      (2) fewer proteins
      (3) more vitamin C
      (4) no blood cells
   (b) produced by
      (1) capillary network
   (c) function: cushion

(4) Blood-Brain Barrier
   (a) requirement: CNS neurons do not tolerate fluctuations of their internal environment
   (b) CNS capillaries impermeable
   (c) astrocytes--living barrier—connect blood vessels to neurons
      (1) permeable substances:
      (2) impermeable substances
   (d) no effect on lipid-soluble substances
      nicotine, alcohol, anesthetics, O\textsubscript{2} and CO\textsubscript{2}
B) Brain

(1) Cerebrum

(a) Structure:

(1) 

(2) 

(3) lobes named after cranial bones
(4) longitudinal fissure divides right and left hemispheres

(5) 
outer gray matter

(6) 
inner white matter

(7) 
tract of white matter connects right and left hemispheres

(b) Function:

(1) higher thought processes
(2) learning, memory, emotions
(3) integration and processing sensory information

(2) Limbic System

(a) structure: deep within cerebrum

(b) function:
(a) links smells to emotions/events
(b) blends emotions with mental function
(c) example: ↑stress → ↑BP ; emotions cloud judgment

(3) Diencephalon

(a) 
integration and relay visual, auditory and somatosensory (joint/skin) information

(b) 
direct link to pituitary gland by infundibulum

(c) 
(1) hunger and thirst
(2) water balance
(3) body temperature
(4) **Cerebellum**

(a) structure:
   (1) outer gray matter

   (2) inner white matter

(b) function:
   (1) 

   (2) 

   (3) monitors body position and tension

(c) directly affected by alcohol
(d) ataxia—damaged ➔ clumsy/drunken

(5) **Brainstem**

(a) General
   (1) ascending (sensory)/descending (motor) tracts

   (2) many nuclei

   (macroscopic) rigidly programmed with autonomic behaviors necessary for survival

   (3) bundle of nerve fibers/axons of CNS

(b) **Midbrain**

   (1) structure: tracts

   (2) function: relay information

(c) **Pons**

   (1) structure: ‘bridge’

   (2) function:
      (a) relay
      (b) reflex centers for head movements (sight/sound)
      (c) breathing
(d) **Medulla Oblongata**

(1) structure:
   (a) connects pons and spinal cord
   (b) tracts and nuclei (control centers)

(2) function: regulate visceral function

(6) **Reticular Activating System**

(a) structure: system of neurons running through cerebellum, cerebrum and extending into brainstem

(b) function:

   (1) arouse cerebrum/alert (alarm clock)

   (2) ____________
      (a) inactive → asleep
      (b) injured → coma

C) **Spinal Cord**

(1) General
   (a) about 17 inches long
   (b) continuation of brain stem
   (c) 2-way path of fiber tracts
      ascending—sensory
      descending—motor

(2) Protection
   (a) ____________
   (b) ____________
   (c) ____________

(3) Structure:
   (a) central canal with CSF
   (b) ependymal cells circulate with cilia
   (c) gray matter: cell bodies/nonmyelinated fibers
   (d) white matter: myelinated tracts

(4) Function:
   (a) relay information to/from brain and body
   (b) 1000’s of reflex arcs

(5) sever and stop flow of information
IV. PNS Peripheral Nervous System

A) Includes all nerves that extend from brain and spinal cord

(1) _
group of axons/bundles of processes outside CNS

(2) _
group of cell bodies outside CNS

(3) **Types of Nerves**

(a) _
all processes/axons carrying sensory information to CNS regarding current conditions

(b) _
all processes/axons carrying commands from CNS to effector cells

(c) _
includes processes that convey sensory/ascending information, as well as, motor/descending information between body and CNS

(4) 12 pair of **Cranial Nerves**

(a) optic nerve
(b) olfactory nerve
(c) trigeminal nerve (mixed)

(5) Spinal Nerves (mixed)
(a) emerge laterally from spinal cord
(b) dorsal root
(c) ventral root
(d) ganglion

B) PNS Nerves can be categorized

(1) **Somatic Nervous System**

(a) sensory information from sensory receptors
(b) motor information to effector cells (muscles/glands)

(c) _

(d) involuntary responses (reflexes)

(2) **Autonomic Nervous System**

(a) affect internal organs/viscera and reflexes, smooth muscles, glands
(b) 2 divisions
   (1) sympathetic nervous system
   (2) parasympathetic nervous system
(c) Sympathetic Nervous System
(1) commonly active: stress

(2) characteristics
(a) inhibit tears, digestion, urination
(b) dilate pupils, bronchi
(c) increase heart, rate
(d) stimulate adrenal gland

(d) Parasympathetic Nervous System
(1) commonly active: nonstress
(2) characteristics
(a) stimulate tears, digestion, urination
(b) constrict pupils, bronchi
(c) decrease heart rate

C) reflex
(1) rapid, predictable involuntary response to a stimulus

(a) always follows the same pathway/reflex arc

(b) somatic reflexes: stimulate skeletal muscle contraction (ex: hand on hot stove)

(c) autonomic reflexes: stimulate smooth muscle, cardiac muscle, or gland secretions (ex: saliva production, tears)

(2) Reflex arc

(a) light, pressure, sound, taste, small, CO2

(b) responds to a change in stimulus (threshold) and transmits information as an AP to CNS

(c) integrate incoming information and determine/issue an appropriate response

(d) (1) carries out the response by transmitting an AP
(2) stimulates an effector cell to carry out response

(e) (1) muscle contract
(2) gland secrete (sweat, hormones)