TOPIC 6: CENTRAL NERVOUS SYSTEM

I. Introduction to the Nervous System

A. Objective: We've discussed mechanisms of how electrical signals are transmitted within a neuron (Topic 4), and how they are transmitted from neuron to neuron (Topic 5). For the next 3 Topics, we will discuss how neurons are organized into a functioning unit that allows you to think, walk, smell, feel pain, etc.

B. Organization of nervous system. Note that this is a subdivision of a single integrated system, based on differences in structure, function and location (Fig 7.1). Such a subdivision allows easier analysis and understanding than trying to comprehend the system as a whole.
   1. Central Nervous System (integrates and issues information)
      a) brain
      b) spinal cord
   2. Peripheral Nervous System
      a) Afferent Division (sends information to CNS)
      b) Efferent Division (receives information from CNS)
         (1) Somatic nervous system
         (2) Autonomic nervous system
            (a) Sympathetic nervous system
            (b) Parasympathetic nervous system

C. Three classes of neurons (Fig 7.4)
   1. afferent neurons
      a) have sensory receptors
      b) axon terminals in CNS
      c) send information to CNS from body
   2. efferent neurons
      a) cell body in CNS
      b) axon terminals in effector organ
      c) send information from CNS to body
   3. interneurons
      a) lie within CNS
      b) some connect afferent neurons and efferent neurons
         (1) integrate peripheral responses and peripheral information
      c) some connect other interneurons
         (1) responsible for activity of the "mind", i.e., thoughts, emotions, motivation, etc.
      d) 99% of all neurons are interneurons

II. The Brain: Gross Structure and Associated Functions (Fig 9.11)

A. Brain Stem
   1. Critical connecting link between entire brain & spinal cord
   2. Cardiovascular, respiratory, digestive control
   3. Regulation of muscle reflexes: equilibrium & posture
   4. Reception & integration of spinal cord input; arousal and activation of cerebral cortex
   5. Sleep/wake cycle control

B. Cerebellum
   1. Maintenance of balance
   2. Enhancement of muscle tone

3. Coordination of voluntary muscle activity

C. Hypothalamus
   1. Regulation of many homeostatic functions & associated behaviors
      a) body temperature
      b) thirst & urine output
      c) food intake
      d) uterine contraction & milk production
   2. Link between nervous and endocrine systems
      a) smooth & cardiac muscle control
      b) exocrine gland control
   3. Involved in emotion and basic behavior patterns

D. Thalamus
   1. Relay station and filter for all input to the cerebral cortex
   2. Crude awareness of sensation
   3. Some degree of consciousness
   4. Role in motor control

E. Cerebrum
   1. Basal nuclei
      a) Inhibition of muscle tone
      b) Coordination of slow sustained movement
      c) Suppression of useless movement patterns
   2. Cerebral cortex
      a) Sensory perception
      b) Voluntary control of movement
      c) Language
      d) Personality
      e) Consciousness & sophisticated mental events (thinking, memory, etc.)

F. Limbic System (Fig 9.17)
   1. Not a separate structure
   2. Includes interconnected portions of
      a) cerebral cortex
      b) basal nuclei
      c) thalamus
      d) hypothalamus
   3. Involved in generating emotions

G. Neural basis of some human behaviors
   1. Language and speech
      a) Processed in multiple areas of cerebral cortex
   2. Emotions
      a) Generated by the Limbic system which attaches “feelings” to basic survival-related programs of the brainstem including feeding, aggression and sexuality
      b) At birth primates have sufficient emotional circuits to bond to a caretaker, recognize a face, have visual & vocal interactions with caretaker. As child develops and emotional memories laid down more complex emotions become possible

3. Memory
    a) Short term memory in frontal lobes of cortex, rely on rapid changes in strength of existing nerve connections
    b) Long term memory involves limbic system and requires new connections among neurons; this is accomplished by practice and consolidation

III. Support of the Brain: Glial Cells
- A. 90% of cells in CNS are not neurons but are glial cells
- B. But occupy only 50% of brain volume
- C. Do not initiate or conduct nerve impulses
- D. Support CNS neurons physically, metabolically & homeostatically

IV. Nourishment of the Brain and the Blood Brain Barrier
- A. Brain carefully shielded from harmful blood changes
    1. Prevents changes in blood ions & molecules from adversely affecting brain
- B. A normal capillary has pores in its walls for easy passage of materials
- C. Brain capillaries have tight junctions (Fig 9.4) that prevent passage of materials
- D. Only small lipid soluble substances (O_2, CO_2, alcohol, steroid hormones) can diffuse through capillary membrane
- *E. All other molecules must be transported into brain by carrier proteins*
- F. NOTE: A portion of hypothalamus is not subject to Blood Brain Barrier
    1. Monitors blood directly for levels of hormones, etc.
- G. Glucose and Oxygen
    1. The brain can only make ATP:
        a) from glucose (no other sugars or fats)
        b) in presence of O_2
    2. Hence the brain is dependent on constant supplies of glucose & O_2
        a) 4-5 min without O_2 or 10-15 min without glucose = brain damage and then death

V. Spinal Cord
- A. Structure
    1. Whole cord (Figs 9.6 & 9.7)
        a) 31 pairs of nerves
    2. Cross section (Fig 9.8)
        a) gray matter
            (1) cell bodies, dendrites, short interneurons, glial cells
        b) white matter
            (1) mylenated axons organized into tracts (bundles of axons)
            (2) some are ascending (to brain) and some are descending (from brain)
            (3) like packaged phone lines
- B. Function
    1. Carries and supports neurons (both afferent and efferent) between brain and body (Fig 9.10)
    2. Simple spinal reflex (Fig 9.20)