The Nervous System

peripheral nervous system

Organization of the Nervous System

Types of Reflexes and Regulation

- Autonomic reflexes
  - Smooth muscle regulation
  - Heart and blood pressure regulation
  - Regulation of glands
  - Digestive system regulation

Spinal Cord

- Extends from the foramen magnum of the skull to the first or second lumbar vertebra
- 31 pairs of spinal nerves arise from the spinal cord
- Cauda equina is a collection of spinal nerves at the inferior end

The Spinal Cord

- Together with brain forms the CNS
- Functions
  - spinal cord reflexes
  - integration (summation of inhibitory and excitatory) nerve impulses
  - highway for upward and downward travel of sensory and motor information

External Anatomy of Spinal Cord

- Flattened cylinder
- 16-18 inches long & 3/4 inch diameter
- In adult ends at L2
- In newborn ends at L4
- Growth of cord stops at age 5
- Cervical enlargement
  - upper limbs
- Lumbar enlargement
  - lower limbs
- End is the cauda equina

Spinal Cord Anatomy

Inferior End of Spinal Cord

- Caudae equinae (horse’s tail)
  - dorsal & ventral roots of lowest spinal nerves
- Spinal segment
  - area of cord from which each pair of spinal nerves arises

Spinal Cord Anatomy

Gray Matter of the Spinal Cord

- Gray matter is shaped like the letter H or a butterfly
  - contains neuron cell bodies, unmyelinated axons & dendrites
- paired dorsal and ventral gray horns
- gray commissure crosses the midline

11 **White Matter of the Spinal Cord**
- White matter covers gray matter
- Anterior, Lateral and Posterior White Columns contain axons that form ascending & descending tracts

12 **Spinal Cord & Spinal Nerves**
- Spinal nerves begin as roots
- Dorsal or posterior root is incoming sensory fibers
  - dorsal root ganglion (swelling) = cell bodies of sensory nerves
- Ventral or anterior root is outgoing motor fibers

13 **Spinal Cord Anatomy**
- Internal gray matter is mostly cell bodies
  - Dorsal (posterior) horns
  - Anterior (ventral) horns
- Gray matter surrounds the central canal
  - Central canal is filled with cerebrospinal fluid
- Exterior white matter—conduction tracts
  - Dorsal, lateral, ventral columns

14 **Spinal Cord Anatomy**

15 **Spinal Cord Anatomy**
- Meninges cover the spinal cord
- Spinal nerves leave at the level of each vertebrae
  - Dorsal root
    - Associated with the dorsal root ganglia—collections of cell bodies outside the central nervous system
  - Ventral root
    - Contains axons

16 **Spinal Cord Protection**

17 **Spinal tap or Lumbar Puncture**
- Technique
  - long needle into subarachnoid space
  - safe from L3 to L5
- Purpose
  - sampling CSF for diagnosis
  - injection of antibiotics, anesthetics or chemotherapy
  - measurement of CSF pressure

18 **Spinal Reflexes**
- Automatic response to change in environment
- Integration center for spinal reflexes is gray matter of spinal cord
- Examples
  - somatic reflexes result in skeletal muscle contraction
autonomic (visceral) reflexes involve smooth & cardiac muscle and glands.
- heart rate, respiration, digestion, urination, etc
- Note: cranial reflexes involve cranial nerves

### Pathways Between Brain and Spinal Cord

### Peripheral Nervous System (PNS)
- Nerves and ganglia outside the central nervous system
- Nerve = bundle of neuron fibers
- Neuron fibers are bundled by connective tissue

### PNS: Structure of a Nerve
- Endoneurium surrounds each fiber
- Groups of fibers are bound into fascicles by perineurium
- Fascicles are bound together by epineurium

### Connective Tissue Coverings
- Endoneurium = wrapping of each nerve fibers
- Perineurium = surrounds group of nerve fibers forming a fascicle
- Epineurium = covering of entire nerve
  - dura mater blends into it at intervertebral foramen

### PNS: Structure of a Nerve

### PNS: Classification of Nerves
- Mixed nerves
  - Both sensory and motor fibers
- Sensory (afferent) nerves
  - Carry impulses toward the CNS
- Motor (efferent) nerves
  - Carry impulses away from the CNS

### PNS: Cranial Nerves
- 12 pairs of nerves that mostly serve the head and neck
- Only the pair of vagus nerves extend to thoracic and abdominal cavities
- Most are mixed nerves, but three are sensory only

### PNS: Cranial Nerves
- I  Olfactory nerve—sensory for smell
- II  Optic nerve—sensory for vision
- III  Oculomotor nerve—motor fibers to eye muscles
- IV  Trochlear—motor fiber to eye muscles
- V  Trigeminal nerve—sensory for the face; motor fibers to chewing muscles
- VI  Abducens nerve—motor fibers to eye muscles
- VII  Facial nerve—sensory for taste; motor fibers to the face
- VIII  Vestibulocochlear nerve—sensory for balance and hearing

### PNS: Cranial Nerves
- IX  Glossopharyngeal nerve—sensory for taste; motor fibers to the pharynx
- X  Vagus nerves—sensory and motor fibers for pharynx, larynx, and viscera
- XI  Accessory nerve—motor fibers to neck and upper back
- XII Hypoglossal nerve—motor fibers to tongue

29 PNS: The Cranial Nerves

30 PNS: The Cranial Nerves

31 PNS: The Cranial Nerves

32 PNS: The Cranial Nerves

33 PNS: Distribution of Cranial Nerves

34 PNS: Spinal Nerves
  - There is a pair of spinal nerves at the level of each vertebrae for a total of 31 pairs
  - Formed by the combination of the ventral and dorsal roots of the spinal cord
  - Named for the region from which they arise

35 Spinal Nerves
  - 31 Pairs of spinal nerves
  - Named & numbered by the cord level of their origin
    - 8 pairs of cervical nerves (C1 to C8)
    - 12 pairs of thoracic nerves (T1 to T12)
    - 5 pairs of lumbar nerves (L1 to L5)
    - 5 pairs of sacral nerves (S1 to S5)
    - 1 pair of coccygeal nerves
  - Mixed sensory & motor nerves

36 PNS: Spinal Nerves

37 PNS: Anatomy of Spinal Nerves
  - Spinal nerves divide soon after leaving the spinal cord
    - Dorsal rami—serve the skin and muscles of the posterior trunk
    - Ventral rami—form a complex of networks (plexus) for the anterior

38 PNS: The Spinal Nerves

39 PNS: Distribution of Major Peripheral Nerves of the Upper and Lower Limbs

40 PNS: Distribution of Major Peripheral Nerves of the Upper and Lower Limbs

41 PNS: Distribution of Major Peripheral Nerves of the Upper and Lower Limbs

42 PNS: Autonomic Nervous System
  - Motor subdivision of the PNS
    - Consists only of motor nerves
  - Also known as the involuntary nervous system
    - Regulates activities of cardiac and smooth muscles and glands
  - Two subdivisions
- Sympathetic division
- Parasympathetic division

43  
PNS: Differences Between Somatic and Autonomic Nervous Systems
- Nerves
  - Somatic: one motor neuron
  - Autonomic: preganglionic and postganglionic nerves
- Effector organs
  - Somatic: skeletal muscle
  - Autonomic: smooth muscle, cardiac muscle, and glands

44  
PNS: Differences Between Somatic and Autonomic Nervous Systems
- Neurotransmitters
  - Somatic: always use acetylcholine
  - Autonomic: use acetylcholine, epinephrine, or norepinephrine

45  
PNS: Comparison of Somatic and Autonomic Nervous Systems

46  
PNS: Anatomy of the Autonomic Nervous System

47  
PNS: Autonomic Functioning
- Sympathetic—“fight or flight”
  - Response to unusual stimulus
  - Takes over to increase activities
  - Remember as the "E" division
    - Exercise, excitement, emergency, and embarrassment

48  
PNS: Autonomic Functioning
- Parasympathetic—“housekeeping” activities
  - Conserves energy
  - Maintains daily necessary body functions
  - Remember as the "D" division
    - digestion, defecation, and diuresis

49  
Effects of the Sympathetic and Parasympathetic Divisions of the ANS

50  
Effects of the Sympathetic and Parasympathetic Divisions of the ANS