

Peripheral Nervous System (PNS)

I. Overview of the PNS

The PNS provides the link to the outside world -- both in terms of reception of stimuli, but also in our responses to them. Refer to Figure 13-1 for an overview of PNS organization.

The peripheral nervous system (PNS) includes all neural structures outside the brain and spinal cord: sensory receptors, peripheral nerves, their associated ganglia, and efferent motor endings.

For now we will not discuss receptor function -- this will be covered shortly in our discussion of sensory systems and receptor physiology.

The main goals of this discussion are to understand the general anatomical scheme for processing of sensory information, its integration at the level of the CNS, and the anatomical basis for the ensuing response.

II. Functional anatomy of the PNS -- nerves and associated ganglia

A. Structure and classification:

1. Nerve: parallel bundles of peripheral axons (myelinated and unmyelinated) enclosed by successive wrappings of connective tissue.

- endoneurium: a delicate layer of loose connective tissue surrounding each axon, its myelin sheath and neurilemma.

- perineurium: coarse connective tissue layer wrapping bundles of axons into fascicles.

- epineurium - a tough fibrous sheath enclosing bundles of fascicles and blood vessels.

- recall that the PNS has sensory (afferent) and motor (efferent) divisions; nerves containing both sensory and motor fibers and transmitting impulses both to and from the CNS are called mixed nerves.

- nerves with only sensory fibers are sensory nerves, with only motor fibers are motor nerves; peripheral nerves are classified as either cranial or spinal nerves.

2. Ganglia: collections of neuron cell bodies associated with nerves of PNS; ganglia associated with afferent nerve fibers contain cell bodies of sensory neurons; ganglia associated with efferent nerve fibers contain cell bodies of autonomic motor neurons.

3. Motor endings - PNS elements that activate effectors by releasing neurotransmitters.

B. Cranial Nerves

- 12 pairs of nerves associated with the brain, pass through several foramina in the skull.
- first two pairs attach to forebrain, rest originate in brainstem.
- with one exception, the cranial nerves only serve the neck/head structure; the exception is the vagus nerve which extends well into the body cavity.
- most cranial nerves are mixed nerves; three pairs purely sensory, five pairs purely motor
- cranial nerves are: olfactory, optic, oculomotor, trochlear, trigeminal, abducens, facial, vestibulocochlear, glossopharyngeal, vagus, accessory, and hypoglossal

C. Review structure of the spinal cord

1. Gray matter is a mix of neuron cell bodies, unmyelinated processes and neuroglia, has appearance of an "H", two lateral gray masses connected by gray commissure.

- the two anterior projections of gray matter are the anterior (ventral) horns, the lateral projections are the lateral horns, and the posterior gray matter projections are the posterior (dorsal) horns.

a. anterior (ventral) horns: contain nerve cell bodies of somatic motor neurons, send their axons via ventral roots of SC to skeletal muscles.

b. lateral horns: are autonomic (sympathetic division) motor neurons that serve visceral organs, their axons leave SC via ventral roots along with those of somatic motor neurons (see above).

c. afferent fibers carrying impulses from peripheral sensory receptors form the dorsal roots of SC; nerve cell bodies of these sensory fibers form enlarged portion of dorsal root, dorsal root ganglion; after entering SC their axons can enter the posterior white matter directly and travel to synapse at higher cord/brain levels; or their axons can synapse with interneurons in posterior (dorsal) horns.

d. note that dorsal and ventral roots fuse laterally to form spinal nerves.

2. White matter: composed of myelinated/unmyelinated nerve fibers, run in ascending and descending directions, and also can be commissural

- all spinal tracts are part of multineuron pathways that connect brain to periphery; most pathways decussate, and consist of two to three neuron chains; all pathways are paired, 1 per side of SC.

D. Spinal nerves

- 31 pairs of spinal nerves arise from the spinal cord and supply all parts of the body except the head and some areas of the neck; all are mixed nerves.
- there are 8 pairs of cervical nerves; 12 pairs of thoracic; 5 pairs of lumbar; 5 pairs of sacral; and 1 pair of coccygeal
- each spinal nerve is formed by both dorsal and ventral roots; recall ventral roots contain motor (afferent) fibers and dorsal roots contain sensory (afferent) fibers.
- a spinal nerve divides into dorsal ramus, ventral ramus; the dorsal rami supply the posterior body trunk; ventral rami supply the rest of the body trunk and limbs.
- ventral rami of the thoracic nerves course anteriorly deep to each rib.
- ventral rami of other spinal nerves branch profusely and form networks of nerves called plexuses; major plexuses occur in the cervical, brachial, lumbar, and sacral regions.
- within each plexus the fibers of the ventral rami crisscross each other and become redistributed so that each resulting branch of the plexus contains fibers from several spinal nerves; fibers from each spinal nerve carried to body periphery via several routes.

III. Reflex Activity

- a reflex is a rapid, predictable motor responses to a stimulus.

A. Components of a reflex arc

- receptor - site of stimulus action.
- sensory neuron - transmits afferent impulses to the CNS.
- integration center - in the CNS.
- motor neuron - conducts efferent impulses from integration center to effector organ.
- effector region - muscle fiber, gland unit, responds to efferent impulse.
- reflexes can be somatic reflexes (activate skeletal muscles) or autonomic reflexes (visceral effector activated)

B. Spinal reflexes

- are somatic reflexes mediated by the SC.

1. Stretch reflex

- state of muscles is conveyed to CNS by sensory input from muscle spindles and Golgi tendon organs.
- tone of muscles depends on stretch reflexes initiated by muscle spindles.

a. Functional anatomy of muscle spindles

- each spindle is a group of 3 - 10 intrafusal muscle fibers, nuclear bag fibers, nuclear chain fibers, enclosed in CT capsule.
- intrafusal fibers lack contractile proteins in central regions; these regions wrapped by two types of afferent endings that send impulses to CNS

- primary sensory endings: endings of Type Ia fibers, stimulated by both rate and amount of stretch, innervate center of intrafusal fibers.
- secondary sensory endings: endings of Type II fibers, stimulated only by amount of stretch, associated with ends of intrafusal fibers.
- ends of intrafusal fibers are contractile, innervated by gamma-efferent fibers which originate in motor neurons in ventral horn of SC; this innervation maintains sensitivity of spindle, do not confuse with alpha efferent motor fibers that innervate extrafusal muscle fibers.

b. The stretch reflex.

- muscle stretch, spindles activated, sensory input to SC via afferent fibers; sensory neuron synapses directly with alpha motor neuron, excites extrafusal fibers of stretched muscle, reflex contraction of stretched muscle.
- branches of the afferent fiber also synapse with interneurons which inhibit motor neurons controlling antagonistic muscles - reciprocal innervation.
- gamma motor neurons allow us to "modify" and manipulate stretch reflex, allows for smooth, sustained contractions, and are responsible for basal muscle tone.
- example of stretch reflex is knee jerk.

2. Deep tendon reflex.

- opposite to stretch reflex, muscle relaxation/lengthening in response to muscle contraction: muscle tension increases during contraction, Golgi tendon organs in muscle's tendons are activated; afferent impulses to SC via sensory fibers, synapse with interneurons that inhibit motor neurons serving contracting muscle, and stimulate motor neurons activating antagonistic muscle group -- important in activities involved in rapid switching between flexion and extension.
- ensures smooth onset and termination of muscle contraction

Note: so far talked of mono- and polysynaptic ipsilateral reflexes.

3. Flexor reflex.

- ipsilateral, polysynaptic; painful stimulus causes withdrawal of threatened part.

4. Crossed extensor reflex.

- contralateral, polysynaptic; includes an ipsilateral withdrawal reflex and a contralateral extension.