Biology 325, Fall 2004
Peripheral nervous system -- efferent division

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.

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.

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 commissura

- 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.

II. Overview of ANS

A. Introduction

- ANS vs. the somatic nervous system (SNS): have fibers that differ in effectors, efferent pathways, responses of the target organs.

1. Effectors: SNS stimulates skeletal muscle; ANS stimulates cardiac and smooth muscle, and some glands.

2. Efferent Pathways: SNS cell bodies of motor neurons are in the CNS, their axons give rise to spinal nerves, rami, associated plexuses, and travel to effector organs that they serve.

- in the ANS, two motor neuron chain; cell body of the first motor neuron, preganglionic neuron, in the CNS; cell body of postganglionic neuron in ganglion outside CNS, postaganglionic axon extends to the effector organ.

3. Effects on target organs: all somatic motor neurons release ACH at the neuromuscular junction; all preganglionic autonomic motor neurons release ACH at axon terminals; postganglionic motor neurons release norepinephrine or ACH at synapse with effector organs.

B. Divisions of the ANS.

- sympathetic and parasympathetic.

- serve same visceral organs, cause essentially opposite effects - dual innervation.

1. Parasympathetic division: "resting and digesting"; keeps energy use low while maintaining vital functions; fibers originate in the brain and sacral spinal cord; long

preganglionic fibers, short postganglionic fibers (ganglia are close to or on the effector organs innervated).

2. Sympathetic Division: "fight or flight" takes over during stressful or emotional situations; fibers originate in the thoracolumbar region of SC; short preganglionic fibers, and long post ganglionic fibers; ganglia are close to the spinal cord.

III. Parasympathetic division of ANS

- preganglionic axons extend from CNS nearly all the ways to structure being innervated; they synapse with the postganglionic neurons very close to or within the target organ.

A. Cranial outflow.

- some cranial nerves have parasympathetic fibers.

- preganglionic fibers run in the oculomotor, facial, glossopharyngeal, and vagus nerves.

- cell bodies in motor nuclei in the brain steam.

B. Sacral flow

- arises form neurons located in the lateral gray matter of spinal cord segments.

- axons of those preganglionic neurons run in ventral roots of spinal cord to ventral rami, then branch to form pelvic splanchnic nerves.

- postganglionic fibers are found in the intramural ganglia of innervated organs (large intestines, bladder).

IV. Sympathetic division of ANS

- besides internal organs, innervates certain visceral structures in the skin (sweat glands, pili muscles).

A. General

- all preganglionic fibers arise from cell bodies located in lateral horns of spinal cord segments.

- leave spinal cord via a ventral root, enters a paravertebral ganglion of sympathetic chain, three things can happen:

1. Synapses with a postganglionic neuron at that paravertebral ganglion.

2. Ascends or descends sympathetic chain to synapse with postganglionic neuron in another paravertebral ganglion.

3. Can pass through paravertebral ganglion without synapsing; synapses with postganglionic neurons in prevertebral ganglion associated with the aorta; postganglionic fibers travel to target organs.

V. ANS physiology.

A. Nervous tissue and their receptors.

- ACH and norepinephrine (NE) are major neurotransmitters released by ANS neurons.

- all preganglionic axons of the ANS release ACH.

- parasympathetic system postganglionic axons release ACH.

- sympathetic postganglionic axons release NE.

- remember that ACH and NE effects on effectors are not consistent with either excitation or inhibition; response depends on NT receptors present in the effectors.

B. NT receptors.

a. Cholinergic receptors --bind ACH.

- two types, nicotinic and muscarinic.

b. Adrenergic receptors -- bind NE.

- two major classes are alpha (usually stimulatory), and beta (usually inhibitory).

V. Interactions of ANS divisions/ Unique roles of each division.

- recall that visceral organs innervated by both the parasympathetic and sympathetic divisions of the ANS, dual innervation, usually antagonistic; however some structures exclusively innervated by one division or the other.

A. Sympathetic.

- vascular system is mostly innervated by the sympathetic fibers, keeps blood vessels in a state of partial constriction, vasomotor tone.

- adrenal medulla, sweat glands, arrector pilli muscles only receive sympathetic input.

- sympathetic division mediated reflexes help regulate body temperature.

- release of renin from kidneys, increases blood pressure.

- metabolic effects: increases basal metabolic rate, blood glucose, mental alertness.

B. Parasympathetic.

- parasympathetic division effects dominate heart and all smooth muscle of digestive, urinary and respiratory tracts.

- prevents unnecessary heart acceleration

- determines normal activity levels of the gastrointestinal and urinary tracts.

C. Localized versus diffuse effects.

- pattern of parasympathetic division innervation is very specific -- ganglia located in the walls of effector organs.

- pattern of sympathetic innervation is more diffuse, fibers going to many different effectors originate in the same ganglia, therefore, sympathetic effects are more diffuse and the parasympathetic effects are more specific.

- ACH: NT of all postganglionic parasympathetic neurons quickly destroyed, parasympathetic effects are short lived.

- NE: NT of most postganglionic sympathetic neurons, inactivated slowly; acts via second messengers; effects are more diffuse and long-lasting.