Chapter 15

The Autonomic Nervous System

The Autonomic Nervous System

• The subconscious involuntary nervous system
• Regulates activity of smooth muscle, cardiac muscle & certain glands

ANS vs. SNS

• Somatic nervous system (SNS)
  – consciously perceived sensations
  – voluntary excitation of skeletal muscle
  – one motor neuron connects CNS to organ
• Autonomic nervous system (ANS)
  – unconsciously perceived visceral sensations
  – involuntary inhibition or excitation of smooth muscle, cardiac muscle or glandular secretion
  – two motor neurons needed to connect CNS to organ
  • preganglionic and postganglionic neurons

Autonomic Motor Pathways

• Consist of two motor neurons in series
  – The preganglionic neuron has its cell body in the CNS and its myelinated axon extends to an autonomic ganglion (or to the adrenal medulla)
  – The postganglionic neuron has its cell body in an autonomic ganglion and its nonmyelinated axon extends to an effector
ANS Divisions

- The motor (efferent) part of the ANS is divided into two principal parts:
  - the sympathetic division
  - the parasympathetic division
- organs that receive impulses from both sympathetic and parasympathetic fibers are said to have dual innervation
  - one speeds up organ; one slows down organ
    - sympathetic neurons increase heart rate
    - parasympathetic neurons decrease heart rate

Ganglia

- Sympathetic ganglia are adjacent or anterior to the spinal column
- Parasympathetic ganglia are the terminal ganglia that are located very close to or actually within the wall of a visceral organ
Sympathetic vs. Parasympathetic

Circuitry of Sympathetic NS

- Divergence = each preganglionic cell synapses on many postganglionic cells
- Mass activation due to divergence
  - multiple target organs
  - fight or flight response
- Adrenal gland
  - modified cluster of postganglionic cell bodies that release epinephrine & norepinephrine into blood

ANS Neurotransmitters

- Classified as either cholinergic or adrenergic neurons based upon the neurotransmitter released

Cholinergic Neurons and Receptors

- Cholinergic neurons release acetylcholine
  - all preganglionic neurons
  - all parasympathetic postganglionic neurons
  - a few sympathetic postganglionic neurons (to most sweat glands)
- Excitation or inhibition depending upon receptor subtype and organ involved
Cholinergic Neurons and Receptors

- Cholinergic receptors are integral membrane proteins in the postsynaptic plasma membrane
- The two types of cholinergic receptors are nicotinic and muscarinic receptors
  - Activation of nicotinic receptors always causes excitation of the postsynaptic cell
    • found in autonomic ganglia, in the adrenal medulla and at neuromuscular junctions
  - Activation of muscarinic receptors can cause either excitation or inhibition
    • found on plasma membranes of all parasympathetic effectors
    • found on cardiac muscle, smooth muscle and glands

Adrenergic Neurons and Receptors

- NE lingers at the synapse until enzymatically inactivated by monoamine oxidase (MAO) or catechol-O-methyltransferase (COMT)
- Effects triggered by adrenergic neurons typically are longer lasting than those triggered by cholinergic neurons

Adrenergic Neurons and Receptors

- Adrenergic neurons release norepinephrine (NE)
  - from postganglionic sympathetic neurons only
- Excites or inhibits organs depending on receptors
- The main types of adrenergic receptors are alpha ($\alpha_1, \alpha_2$) and beta ($\beta_1, \beta_2, \beta_3$) receptors

Receptor Agonists and Antagonists

- An agonist is a substance that binds to and activates a receptor, mimicking the effect of a natural neurotransmitter or hormone.
- An antagonist is a substance that binds to and blocks a receptor, preventing a natural neurotransmitter or hormone from exerting its effect.
- Drugs can serve as agonists or antagonists to selectively activate or block ANS receptors.
Physiological Effects of the ANS

- Most body organs receive dual innervation
  - innervation by both sympathetic & parasympathetic
- Hypothalamus regulates balance between sympathetic and parasympathetic activity levels
- Some organs have only sympathetic innervation
  - sweat glands, adrenal medulla, arrector pili muscles & many blood vessels

Sympathetic Responses

- Dominance by the sympathetic system is caused by physical or emotional stress -- “E situations”
  - emergency, embarrassment, excitement, exercise
- “Fight or flight response”
  - dilation of pupils
  - increase heart rate, force of contraction & BP
  - decrease in blood flow to nonessential organs
  - increase in blood flow to skeletal & cardiac muscle
  - airways dilate & respiratory rate increases
  - blood glucose level increases
- Long lasting due to lingering of NE in synaptic gap and release of norepinephrine by the adrenal gland

Parasympathetic Responses

- Enhance “rest and digest” activities
- Mechanisms that help conserve and restore body energy during times of rest
- Normally dominate over sympathetic impulses
- SLUDD type responses = salivation, lacrimation, urination, digestion & defecation and 3 “decreases” --- decreased HR, diameter of airways and diameter of pupil
- Paradoxical fear when there is no escape route or no way to win
  - causes massive activation of parasympathetic division
  - loss of control over urination and defecation

Autonomic or Visceral Reflexes

- An autonomic reflex adjusts the activity of a visceral effector, often unconsciously
  - changes in blood pressure, digestive functions, etc.
- Autonomic reflexes occur over autonomic reflex arcs. Components of that reflex arc:
  - sensory receptor
  - sensory neuron
  - integrating center
  - pre & postganglionic motor neurons
  - visceral effectors
Control of Autonomic NS

• Not aware of autonomic responses because control center is in lower regions of the brain
• Hypothalamus is major control center
  – input: emotions and visceral sensory information
    • smell, taste, temperature, osmolarity of blood, etc.

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  – involuntary inhibition or excitation of smooth muscle, cardiac muscle or glandular secretion
  – two neurons needed to connect CNS to organ
    • preganglionic and postganglionic neurons
  – 2 divisions:
    • Sympathetic (fight or flight)
    • Parasympathetic (rest and digest)