Topic 13: PERIPHERAL NERVOUS SYSTEM: AFFERENT DIVISION – SPECIAL SENSES II

I Vestibular apparatus

A organs that sense position and acceleration

B 2 major vestibular organs in inner ear

1 semicircular canals
- a 3 semicircular canals: 1 for each dimension (X/Y; Y/Z; X/Z)
- b at base of each canal, the ampulla contains an array of hair cells
- c tips of hair cells embedded in a gelatinous matrix called cupula
- d detect rotational/angular acceleration of the head (spinning, turning the head, doing somersaults)
- e hair cells depolarize/hyperpolarize depending on how the stereocilia are bent

2 otolith organs
- a utricle and saccule: saclike structures between the cochlea and semicircular canals
- b hair cells also embedded in gelatinous matrix
- c otolith ($CaCO_3$ crystals) are suspended in the matrix, making it heavier and giving it more inertia
- d detect linear acceleration of the head and changes in head position

C integration

1 several senses contribute to maintain positional equilibrium and balance
- a vestibular apparatus
- b vision — cues about position relative to environment
- c proprioception — stretch receptors in muscles

2 absence of or defects in one of these senses can lead to balance problems

II Smell (olfaction)

A Olfactory epithelium

1 thin layer of neural tissue that lines the upper sinus

2 olfactory receptor cells mediate smell

3 receptors send axons to olfactory bulb, between brain and olf. epithelium

B Olfactory receptor cell
1 can be replaced when damaged
2 each receptor responds to only one (or a few) odorant
3 receptor cells are ciliated to increase surface area (these are real cilia with real microtubules)
4 receptor cells have cell-surface receptor proteins specific for certain odorants

C Integration
1 a “smell” is a composite of multiple odorant molecules
2 olfactory receptor axons synapse with mitral cell dendrites in structure called glomerulus (within olfactory bulb) — sorts out different odors
3 fibers leave olfactory bulb via two routes
a thalamus to cerebrum route (for conscious perception)
b subcortical route directly to limbic system (for rapid integration with systems involving emotion, mating, feeding)

III Taste (gustation)
A Papillae
1 Moundlike structures on tongue surface
2 Taste buds usually found around the base of papillae
B Taste buds
1 Consist of an array of taste receptors and the cells that generate them
2 taste receptors are not actually neurons
3 substance must be dissolved in saliva to be tasted
C 5 primary tastes
1 salt taste
a stimulated by chemical salts
b influx of Na+ ions stimulates a receptor potential

2 sour taste
a stimulated by acids
b H+ blocks K+ channels and stimulates a receptor potential

3 sweet taste
- a stimulated by glucose (a particular molecular structure)
- b artificial sweeteners have regions with similar molecular structure
- c activates a 2nd messenger pathway to elicit a receptor potential

4 bitter taste
- a stimulated by a diverse group of compounds
  - i alkaloids (caffeine, nicotine, morphine)
  - ii poisons
- b use a variety of mechanisms — involve 2nd messenger systems

5 “flavor” taste
- a also called umami taste
- b stimulated by amino acids and short peptides
- c monosodium glutamate (MSG) stimulates
- d involves 2nd messenger system

Topic 14: PERIPHERAL NERVOUS SYSTEM: EFFERENT DIVISION

I Introduction

A Efferent division is communication link by which the CNS controls activities of muscles and glands.

B Efferent output typically influences either movement or secretion

C Organization

1 Autonomic
- a involuntary branch
- b two parts:
  - i sympathetic
  - ii parasympathetic

2 Somatic
- a voluntary branch

D Neurotransmitters: only two used
1. acetylcholine
2. norepinephrine
3. but epinephrine also used by adrenal glands as a HORMONE

II Autonomic Nervous System

A Organization
1 Sympathetic
- a associated with flight or fight responses

2 Parasympathetic
- b associated with normal non-threatening circumstances

3 Most effector organs innervated by both symp and parasymp.

B Review of Sympathetic/Parasympathetic Structure

1 Each autonomic pathway consists of a two neuron chain
- a Cell body of first neuron in the CNS (brain, spinal cord)
- b Its axon, the preganglionic fiber, synapses with cell body of 2nd.
- c Cell body of 2nd neuron lies in a ganglion.
- d note: a ganglion is a cluster of neuronal cell bodies outside the CNS.
- e Axon of 2nd innervates the effector organ.

2 Structure: Sympathetic Only
- a Originate in the middle portion of spinal cord
- b Cell bodies of many postganglionic neurons lie in sympathetic ganglion chain located along spinal cord.
- c Adrenal medulla (inner part of adrenal gland) is a modified sympathetic ganglion.
  - i secretes hormones into blood when stimulated; 80% epinephrine and 20% norepinephrine

3 Structure: Parasympathetic
- a Originate in the "head and butt" areas of the CNS.
- b Long preganglionic fibers that synapse in terminal ganglia that lie near effector organs.

C Neurotransmitters of the autonomic nervous system

1 Sympathetic
- a preganglionic: acetylcholine; called cholinergic fibers
- b postganglionic: norepinephrine; called adrenergic fibers

2 Parasympathetic
- a preganglionic: acetylcholine; (cholinergic fibers)
- b postganglionic: acetylcholine; (cholinergic fibers)

3 Response depends on effector organ & its receptor proteins, not on neurotransmitter

- a Cholinergic receptors
  - i nicotinic (ionotropic)
    located on postganglionic cell bodies in all autonomic ganglia
    called nicotinic because it also binds nicotine
  - ii muscarinic (metabotropic)
    on membrane of effector organs

- b Adrenergic receptors distributed on effector organs (all are metabotropic)
  - i alpha: binds best to norepinephrine

ii beta-1: binds norepinephrine and epinephrine equally, found primarily in the heart
iii beta-2: binds best to epinephrine

D Function
1 Sympathetic used in fight or flight responses; parasympathetic used under normal, relaxed conditions.
2 Most organs innervated by both sympathetic and parasympathetic systems.
a exceptions
i some blood vessels
ii sweat glands
iii salivary glands
3 Usually both systems partially active: sympathetic tonic activity and parasympathetic tonic activity.
4 Shifts in balance between parasympathetic and sympathetic can be accomplished discretely for individual organs to meet specific demands
5 Or one system can dominate body wide for a massive response (usually sympathetic in fight or flight situation).

III Somatic Nervous System

A Motor Neurons innervate skeletal muscle; they constitute the somatic nervous system.

B Structure of motor neurons
1 Cell bodies are in ventral horn of the spinal cord
2 Axon of motor neuron is continuous from spinal cord to termination in skeletal muscle.
3 Axon terminals release acetylcholine (Ach)

C Function of Motor Neurons: Control
1 Ach release causes excitation and contraction of the muscle
2 Can only stimulate skeletal muscle
3 Control and level of activity exerted by relative balance of EPSP and IPSP from excitatory and inhibitory inputs at the level of the spinal cord; the somatic nervous system is more of an “on-off” system compared to the ANS, which is a dual control system.

D Neuromuscular Junctions

1 Motor neuron action potential (AP) reaches terminal

2 Triggers opening of Ca^{++} channels; Ca^{++} enters terminal

3 Ca^{++} triggers release of acetylcholine from terminal

4 Acetylcholine diffuses across gap and binds with receptors on membrane of motor end plate

5 Binding of Ach results in opening of cation channels; result: lots of Na^{+} enters muscle cell, a little K^{+} leaves cell, membrane depolarizes

6 Entry of Na^{+} results in a depolarization called an end plate potential (EPP). Local current flow leads to AP in membrane of muscle fiber next to motor end plate (AP goes in both directions along muscle cell).

7 Ach is destroyed by acetylcholinesterase, terminating the muscle cell response.

8 NOTE: Unlike synaptic transmission, in which single EPSP is **not** enough to cause AP, magnitude of EPP is nearly always sufficient to cause an AP.