TOPIC 7: PERIPHERAL NERVOUS SYSTEM: AFFERENT DIVISION

I. Introduction

- A. Review the organization of whole nervous system
  - 1. Figure 7.1
  - 2. Afferent division sends information from body to CNS
- B. Definitions
  - 1. A *visceral afferent* is subconscious information sent from the internal viscera to the CNS
    - a) e.g., concentration of CO_2 in the blood (chemoreceptors)
    - b) e.g., blood pressure (baroreceptors)
  - 2. Afferent input that does reach level of conscious awareness is called sensory information, and the pathway is called a *sensory afferent*. Can be categorized into two groups:
    - *a) Somatosensory system*
      - (1) body surface sensations
        - (a) e.g., skin, muscles, joints, inner ear, limb position
    - *b) special senses*
      - (1) vision
      - (2) touch
      - (3) hearing
      - (4) taste
      - (5) smell
- C. Perceiving reality:
  - 1. We can perceive
    - a) sound
    - b) color
    - c) shape
    - d) texture
    - e) smells
    - f) tastes
    - g) temperature
  - 2. We can not perceive
    - a) magnetic fields (birds can)
    - b) light polarization (birds can)
    - c) radio waves
    - d) x rays
  - 3. Humans are limited in even perceptions we do have
    - a) we cant hear high frequencies that dogs can
    - b) some features of stimuli are accented or ignored during precortical processing
    - c) cerebral cortex further manipulates data to "complete the picture" (Fig 10.1)
    - d) thus our perceptions do NOT replicate reality

II. Receptor Physiology

- A. Sensitivity of receptors to stimuli
  - 1. Transduction
    - a) a receptor functions by converting stimulus energy to an action potential (AP)
  - 2. A receptor is specialized for specific stimuli
    - a) eyes see but do not hear
    - b) but if you are hit in the eye (hitting is a mechanical stimulus) you "see stars"

3. 6 kinds of receptors
    a) photoreceptors
    b) thermoreceptors
    c) mechanoreceptors
    d) osmoreceptors
    e) chemoreceptors
    f) nociceptors (pain)
4. Compound sensations also occur
    a) e.g., wet = mechano + thermo

B. Responses of receptors to stimuli
1. Two types of receptor structure (Fig 10.2)
    a) separate cell, produces a receptor potential, which is a *graded potential*
        (1) most special senses are like this
    b) modified ending of afferent neuron, produces a generator potential, which is also a *graded potential*
        (1) olfactory is only special sense like this
2. When receptor stimulated (either type), results in
    a) the non-selective opening of all small ion channels
    b) usually results in the net influx of Na^+ ions
    c) which causes a membrane depolarization
    d) this is a graded potential, not an action potential, so the bigger the stimulus, the bigger the change in potential
3. Conversion of receptor and generator potentials into APs
    a) modified ending of afferent neuron (Fig 10.2a)
        (1) local current flow occurs from end of afferent neuron to axon of same afferent neuron
        (2) causes opening of Na^+ channels
        (3) if threshold is reached *in the axon*, an AP occurs
    b) separate cell (Fig 10.2b)
        (1) separate receptor cell stimulated which opens Ca^{++} channels
        (2) influx of Ca^{++} causes release of chemical messenger
        (3) messenger binds to protein receptor on membrane of afferent axon
        (4) causes Na^+ channels to open on afferent axon
        (5) if enough Na^+ channels open, threshold is reached, and an AP occurs
4. *The stronger the stimulus, the higher the frequency of AP* that occur in afferent neuron (Fig 10.8a)
5. *As more receptors are activated, more APs are produced* (Fig 10.8b)

C. Adaptation of receptors to stimuli (Fig 10.3)
1. Slow adapting (tonic) receptors
    a) do *not* adapt to stimuli
    b) continue to produce APs as stimuli continue
    c) e.g., muscle stretch receptors
2. Fast adapting (phasic) receptors
    a) rapidly adapt to stimuli
    b) stop producing APs even though stimuli continue

c) e.g., body surface tactile receptors (once you put on shirt, you are no longer aware of it being on)

D. Fate of information transmitted by receptors (Fig 10.6)
1. Receptor causes AP in afferent neuron
2. Afferent AP reaching spinal cord either
a) becomes part of a reflex arc (see Topic 6)
b) or is relayed toward brain
3. Somatosensory pathways relay information to brain
a) composed of discrete chains of neurons
b) activation of a sensory pathway at *any point in the pathway* results in *same* sensation as true stimulation

III. Taste and Smell
A. Description
1. Receptors are chemoreceptors
a) Receptor binds specific chemical and generates neural signal
2. Stimulation of taste and smell receptors can cause "pleasurable" or "objectionable" sensations
3. Important in finding good food, avoiding toxins, finding mates

B. Taste
1. Taste buds (Fig 10.47) are modified epithelial cells
a) 10,000 taste buds in mouth, mostly on tongue
b) each taste bud has a single opening
c) consists of about 50 receptor cells
(1) each receptor has binding sites that selectively bind chemicals
(2) binding a chemical causes depolarization of receptor membrane
(3) can initiate APs in afferent neurons with which they synapse
(4) taste receptors has lifespan of 10 days
2. Taste sensations (Figs 10.47 and 10.48)
a) Sour (Fig 10.48a)
(1) Caused by acids (H^+)
(2) H^+ blocks K^+ channels, which reduces K^+ leaking out of cell, which depolarizes membrane
(3) When membrane depolarizes, Ca^{++} channels open and Ca^{++} enters cell
(4) Entry of Ca^{++} causes release of neurotransmitter
b) Salt (primarily NaCl) (Fig 10.48a)
(1) Na^+ moves through specialized Na^+ channels to depolarize membrane
(2) When membrane depolarizes, Ca^{++} channels open and Ca^{++} enters cell
(3) Entry of Ca^{++} causes release of neurotransmitter
c) Sweet (Fig 10.48a)
(1) Glucose or related sugar bind receptor
(2) Activiates a “G protein” system that involves several enzymes
(3) Ultimately results in blocking K^+ channels, which reduces K^+ leaking out of cell, which depolarizes membrane
(4) When membrane depolarizes, Ca^{++} channels open and Ca^{++} enters cell
(5) Entry of Ca^{++} causes release of neurotransmitter
d) Bitter (Fig 10.48a)

(1) Many chemicals can bind to bitter receptors (caffeine, nicotine, morphine, strychnine)
(2) Bitter molecule blocks K^+ channels, which reduces K^+ leaking out of cell, which depolarizes membrane
(3) When membrane depolarizes, Ca^{++} channels open and Ca^{++} enters cell
(4) Entry of Ca^{++} causes release of neurotransmitter
(5) Note: Some bitter taste buds apparently use a G protein sytem (as described for sweet) which ultimately causes relsease of neurotransmitter

e) Umami
(1) Amino acids, especially glutamate, bind receptors
(2) Causes net influx of Na^+ which depolarizes membrane and ultimately causes release of neurotransmitter

3. Taste also influenced heavily by smell

C. Smell
1. Olfactory receptors (Fig 10.50)
a) Only special sense receptor that is modified endings of afferent neurons (instead of separate cell)
b) Axons of olfactory receptors collectively form olfactory nerve
c) Receptor cells constantly replaced; only neurons known that do this
d) 5 million receptors of 1000 different kinds (compared to only 3 receptor types for color vision and 4 for taste)
e) each receptor responds to specific components of odors

2. Smell sensations
a) Receptor binds specific odor chemical
b) Cascade of intercellular reactions that open Na^+ and Ca^{++} channels
c) Can thus generate APs in the afferent axon
d) High frequency of binding = high frequency of APs

D. Vomeronasal organ
1. Specialized organ in nose for detecting pheromones
2. Been know in other vertebrates a long time, recently discovered in humans = love at first sight (smell)????