

## Topic 10: PERIPHERAL NERVOUS SYSTEM: AFFERENT DIVISION – GENERAL SENSES

- I Organization of nervous system
  - A Arbitrary subdivisions of single integrated system; based on differences in structure, function and location
  - B Three classes of neurons
    - 1 afferent neurons -- bring in information (sensory)
    - 2 efferent neurons -- cause action to be taken
      - a autonomic
      - b somatic (motor)
    - 3 interneurons
      - a lie within CNS
      - b 99% of all neurons are interneurons
  
- II Afferent NS
  - A Definitions
    - 1 visceral afferent: subconscious info from the internal viscera
    - 2 sensory afferent
      - a somatic (general) -- body surface sensations
      - b special senses, e.g. vision, hearing, smell
  - B Perceiving Reality
  
- III Receptor Cell Physiology
  - A Sensitivity to stimuli
    - 1 Receptors specialized for certain stimuli
    - 2 6 kinds of receptors
      - a photoreceptors
      - b mechanoreceptors
      - c osmoreceptors
      - d chemoreceptors
      - e nociceptors
      - f thermoreceptors
  - B Response to stimuli
    - 1 two types of receptor structure
      - a separate cell
      - b modified ending of afferent neuron
    - 2 Receptor stimulation
      - a usually results in influx of Na<sup>+</sup>
      - b results in membrane depolarization
      - c is a **graded potential**
      - d so bigger the stimulus, the bigger the potential

- 3 How AP begins
  - a if sensory receptor is a separate cell
    - neurotransmitter released from sensory receptor
    - binds to protein receptor on afferent membrane
    - opens Na<sup>+</sup> channels
    - if threshold reached, AP results
  - b if sensory receptor is a modified ending
    - if threshold reached, there is an AP

C Acuity = “how well the sense works”

- 1 Affected by:
  - a density of receptors
  - b degree of convergence
  - c lateral inhibition; allows more precise localization of stimulus

#### IV The General Senses

##### A Touch

- 1 deformation of skin surface
- 2 mediated by mechanoreceptors
  - a Pacinian corpuscles
  - b Meissner’s corpuscles
  - c Merkel discs
- 3 distortion of cell strains the cytoskeleton and pops open an ion channel

##### B Pain

- 1 Protective mechanism
- 2 3 types of pain receptors
  - a mechanical: damage leads to AP (these are myelinated and respond rapidly)
  - b thermal: heat leads to AP (also myelinated)
  - c polymodal: certain chemicals can cause AP (K<sup>+</sup>, histamine, prostaglandins); polymodal receptors are nonmyelinated and slower to respond
- 3 More on thermal nociceptors
  - A “hot” taste
    - 1 many hot foods contain capsaicin
    - 2 cell type that senses hot foods is a “painful temperature” sensory neuron
    - 3 capsaicin opens a Ca<sup>++</sup> channel on these neurons
    - 4 causes an action potential
    - 5 this Ca<sup>++</sup> channel normally opens at painfully high temperatures

6 repeated stimulation ultimately kills the sensory neuron  
B these noxious heat-sensing neurons are found outside the mouth, also

- 4 More on polymodal nociceptors: Prostaglandins  
a fatty acid that has a signaling function  
b enhance receptor response (increase pain)  
c analgesics (aspirin) inhibit their synthesis

V Endogenous analgesia

- A pain-sensing neuron synapses in spinal cord on ascending (to brain) neuron  
1 pain-sensing neuron uses glutamate and Substance P (peptide) as neurotransmitters  
2 Both cause an EPSP in post-synaptic neuron  
3 this part is a simple axo-dendritic synapse  
B Synapse is modified by additional neuron from the brain  
1 this neuron uses enkephalin (an opiate neurotransmitter)  
2 enkephalin binds to a receptor on the presynaptic neuron  
3 axo-axonal synapse  
C Action of enkephalin  
1 enkephalin binding its receptor activates a second-messenger system  
2 second messenger system results in making voltage-regulated  $Ca^{++}$  channels harder to open  
3 action potential in pre-synaptic neuron doesn't activate  $Ca^{++}$  channels  
4 release of Substance P is inhibited  
5 no EPSPs in ascending neuron, therefore no action potential  
6 No Pain!  
D Endogenous analgesia also involves other enkephalin-releasing neurons in the CNS

## Topic 11: PERIPHERAL NERVOUS SYSTEM: AFFERENT DIVISION – SPECIAL SENSES I

### I Vision

#### A Eyes

- 1 specialized structures that collect and focus light on the neural retina
2. Most focusing accomplished by the cornea, fine-tuned by the lens
  - a opaque lens = cataract
  - b stiff lens = presbyopia
3. Errors of refraction
  - a myopia
  - b hyperopia
  
- 4 neural retina — the tissue that lines the back of the eye; is the photosensitive part of the eye
  - a photoreceptors – the cells that actually sense light
  - b bipolar cells – next neuron in the pathway
  - c ganglion cells – next neuron in the pathway
- 5 retinal pigmented epithelium (RPE)
  - a located adjacent to photoreceptors
  - b contains melanin which absorbs light; prevents light scatter
  - c protective and supportive of photoreceptors

#### B Photoreceptors

- 1 two general types
  - a rod
    - i highly sensitive
    - ii rod-shaped
    - iii does not discriminate color
  - b cone
    - i less sensitive to light than rod
    - ii cone-shaped
    - iii multiple types with different spectral sensitivities allow discrimination of color

- 2 compartmentalized structure
  - a outer segment
  - b inner segment
  - c cell body
  - d axon/synaptic knob
  
- 3 functional light-sensitive substance is protein called opsin
  - a located on disk membranes in outer segment
  - b requires attachment of 11-cis retinal chromophore (vitamin A derivative)
  - c light changes 11-cis retinal to all-trans retinal
  - d all-trans retinal detaches from opsin; causes shape change in opsin
  - e triggers 2<sup>nd</sup> messenger cascade that closes Na<sup>+</sup> channels in plasma membrane
  - f different opsins in different photoreceptors cause different spectral sensitivities; chromophore (11-cis retinal) is always the same
  
- 4 photoreceptors are depolarized in dark
  - a light (and closure of Na<sup>+</sup> channels) causes hyperpolarization
  - b hyperpolarization causes decrease in neurotransmitter release
  - c neurotransmitter of photoreceptors is glutamate

C Integration

- 1 signal is sent via bipolar cells to ganglion cells
- 2 ganglion cells exit the eye via optic nerve
- 3 ganglion cells synapse in thalamus, then signal travels to visual cortex

D Retinal disease: one example

- 1 hereditary retinal degenerations frequently caused by a defective rod

- photoreceptor protein
- 2 rods ultimately die – causes night blindness
- 3 ultimately cones die, too – later total blindness
- 4 no cure but many possibilities

## II Hearing

### A Ears

- 1 Outer ear allows collection of sound waves
  - a tympanic membrane
    - i stretched across entrance to inner ear
    - ii vibrates when hit by sound waves
- 2 Middle ear
  - a transmits sound waves to inner ear
  - b three bones (ossicles) — malleus, incus, stapes
  - c stapes is attached to the oval window, the entrance to the inner ear
- 3 Inner ear
  - a actual sensation of sound waves
  - b cochlea — hollow coiled tube
  - c fluid within cochlea moves in response to stapes vibration
  - d basilar membrane oscillates
  - e basilar membrane is narrow at base (near oval window) and wide at tip
  - f position of oscillation depends on frequency of sound
    - i high frequency sound — narrow base oscillates
    - ii low frequency sound — wide tip oscillates

### B Organ of Corti

- 1 located “beneath” tectorial membrane
- 2 consists of hair cells and supporting cells
- 3 hair cells
  - a are the receptor cells
  - b constantly release neurotransmitter
  - c have stereocilia at surface that faces tectorial membrane – these are not conventional cilia, but contain actin filaments
  - d hair cells move when basilar membrane vibrates; since cilia are embedded in tectorial membrane, this makes the cilia bend
- 4 the next neuron
  - a constantly transmits an AP
  - b is part of the auditory nerve

c frequency of this AP depends on stimulation by neurotransmitter from hair cell