Chapter 16

Sense of Pain
Pain

• Discomfort caused by tissue injury or noxious stimulation, and typically leading to evasive action
  
  – important /// helps to protect us
  – lost of pain in diabetes mellitus = diabetic neuropathy
  – If you loose sense of pain then you can not detect tissue damage (e.g. Leprosy )

• Nociceptors = pain receptors

  – two types providing different pain sensations

  – fast pain (alpha) travels in myelinated fibers at 12 - 30 m/sec /// sharp, localized, stabbing pain perceived with injury

  – slow pain (delta) travels unmyelinated fibers at 0.5 - 2 m/sec /// longer-lasting, dull, diffuse feeling

  – Both type in skin /// damage skin first detect the alpha fibers followed by delta fibers
Pain

• **somatic pain** - from skin, muscles and joints

• **visceral pain** - from the viscera - stretch, chemical irritants or ischemia of viscera (poorly localized)

• injured tissues release chemicals that stimulate pain fibers
  
  – **bradykinin** - most potent pain stimulus known

  – makes us aware of injury and activates cascade or reactions that promote healing

  – **histamine, prostaglandin & serotonin** also stimulate nociceptors
Projection Pathway for Pain

- Ascending and descending tracts (plus multiple sub-routes)
  - Neurons in pain ascending route to somatic sensory gyrus:
    - **first-order neuron** cell bodies in dorsal root ganglion of spinal nerves or cranial nerves V, VII, IX, and X
    - **second-order neurons** decussate and send fibers up spinothalamic tract (somatic pain) or through medulla to thalamus /// 2nd order gracile fasciculus carries visceral pain signals
    - **third-order neurons** from thalamus reach postcentral gyrus of cerebrum (somatic sensory gyrus)
Projection Pathway for Pain

- Pain signals travel by way of four ascending tracts:
  - **spinothalamic tract** – most significant pain pathway /// carries most somatic pain signals
  - **spinoreticular tract** – carries pain signals to reticular formation /// activate visceral, emotional and behavioral reactions to pain
  - **gracile fasciculus** – carries signals to the thalamus for visceral pain -- lower extremities
  - **cuneate fasciculus** – carries signals to the thalamus for visceral pain -- upper extremities
Pain Signal Destinations

- Primary somesthetic cortex
- Somesthetic association area
- Thalamus
- Third-order nerve fibers
- Hypothalamus and limbic system
- Reticular formation
- Second-order nerve fibers
- Spinothalamic tract
- Spinoreticular tract
- Anterolateral system
- Spinal cord
- First-order nerve fiber
- Nociceptor
Referred Pain

- Pain in viscera often mistakenly thought to come from the skin or other superficial site

  - results from convergence of neural pathways in CNS

  - brain “assumes” visceral pain is coming from skin

  /// brain can not distinguish source

  - heart pain felt in shoulder or arm because both send pain input to spinal cord segments T1 to T5
Referred Pain

- Lung and diaphragm
- Heart
- Stomach
- Pancreas
- Colon
- Kidney
- Appendix
- Ureter
- Liver and gallbladder
- Small intestine
- Urinary bladder
- Kidney
CNS Modulation of Pain

- analgesic (pain-relieving) mechanisms of CNS /// just beginning to be understood
  - tied to receptor sites for opium, morphine & heroin located in the brain
  - enkephalins - two analgesic oligopeptides with 200 times the potency of morphine
    - endorphins
    - Dynorphins
    - (larger analgesic neuropeptides discovered later)
CNS Modulation of Pain

- **endogenous opioids** /// internally produced opium-like substances
  - enkephalins, endorphins, and dynorphins
  - secreted by the CNS, pituitary gland, digestive tract, and other organs

- **neuromodulators**
  - Enkephalins can block the transmission of pain signals
  - produce feelings of pleasure and euphoria
Spinal Gating

• **Stops pain signals at the posterior horn of the spinal cord**
  – descending analgesic fibers arise in brain stem
  – travel down the spinal cord in the reticulospinal tract
  – block pain signals from traveling up the cord to the brain
Spinal Gating

• Normal pain pathway (ascending)
  
  – nociceptor stimulates second-order nerve fiber
  
  – substance P is neurotransmitter at this synapse
  
  – second-order fiber transmits signal up the spinothalamic tract to the thalamus
  
  – thalamus relays the signals through third order neurons to the cerebral cortex where one becomes conscious of the pain
Spinal Gating: Pathway for Pain Blocking

- signals from the hypothalamus and cerebral cortex feed into the central gray matter of the midbrain / allows both autonomic and conscious influences on pain perception

- midbrain relays signals to certain nuclei in the reticular formation of the medulla oblongata

- medulla issues descending, serotonin-secreting analgesic fibers to the spinal cord / terminate in the posterior horn at all levels of the spinal cord

- in posterior horn, descending analgesic fibers synapse on short spinal interneurons (i.e. local circuit neurons)

- the interneurons synapse on the second-order pain fiber / secrete enkephalins to inhibit the second-order neuron

- some fibers from the medulla also exert presynaptic inhibition by synapsing on the axons of nociceptors and blocking the release of substance P
Spinal Gating of Pain Signals

1. Nociceptor releases substance P onto spinal interneuron.
2. Second-order neuron transmits signal up spinothalamic tract to thalamus.
3. Third-order neuron relays signal to somesthetic cortex.
4. Input from hypothalamus and cerebral cortex converges on central gray matter of midbrain.
5. Midbrain relays signal to reticular formation of medulla oblongata.
6. Some descending analgesic fibers from medulla secrete serotonin onto inhibitory spinal interneurons.
7. Spinal interneurons secrete enkephalins, blocking pain transmission by means of postsynaptic inhibition of second-order pain neuron.
8. Other descending analgesic fibers synapse on first-order pain fiber, blocking pain transmission by means of presynaptic inhibition.
Spinal Gating

- Rubbing or massaging injury
  - another pathway of spinal gating
  - pain-inhibiting neurons of the posterior horn receive input from mechanoreceptors in the skin and deeper tissues
  - rubbing stimulates mechanoreceptors which stimulates spinal interneurons to secrete enkephalins that inhibit second-order pain neurons