Sensory and Motor Pathways

- Levels and components of sensation
- Pathways for sensations from body to brain
- Pathways for motor signals from brain to body
**Sensation vs. Perception**

- **Sensation** is any stimuli the body is aware of
  - Conscious or unconscious awareness
  - What are we not aware of?
    - X-rays, ultra high frequency sound waves, UV light
    - We have no sensory receptors for those stimuli

- **Perception** is the conscious awareness & interpretation of a sensation.
  - Function of cerebral cortex
  - Memories of our perceptions are stored in cortex
  - No perception of some sensory info because it does not reach cortex
Sensory Modalities

• Different types of sensations
  – touch, pain, temperature, vibration, hearing, vision

• Each type of sensory neuron can respond to only one type of stimuli

• Two classes of sensory modalities
  – general senses
    • somatic are sensations from body walls
    • visceral are sensations from internal organs
  – special senses
    • smell, taste, hearing, vision, and balance
Process of Sensation

• Sensory receptors demonstrate selectivity
  – respond to only one type of stimuli

• Events occurring within a sensation
  – stimulation of the receptor
  – transduction (conversion) of stimulus into a graded potential
    • vary in amplitude and are not propagated
  – generation of impulses when graded potential reaches threshold
  – integration of sensory input by the CNS
Sensory Receptors

• Selectively respond to only one kind of stimuli
• Have simple or complex structures
  – General Sensory Receptors (Somatic Receptors)
    • no structural specializations in free nerve endings that provide us with pain, tickle, itch, temperatures
    • some structural specializations in receptors for touch, pressure & vibration
  – Special Sensory Receptors (Special Sense Receptors)
    • very complex structures---vision, hearing, taste, & smell
Classification of Sensory Receptors

- Structural classification
- Type of response to a stimulus
- Location of receptors & origin of stimuli
- Type of stimuli they detect
• Compare free nerve ending, encapsulated nerve ending and sensory receptor cell
Classification by Location

• **Exteroceptors**
  – near surface of body
  – receive external stimuli
  – hearing, vision, smell, taste, touch, pressure, pain, vibration & temperature

• **Interoceptors**
  – monitors internal environment (BV or viscera)
  – not conscious except for pain or pressure

• **Proprioceptors**
  – muscle, tendon, joint & internal ear
  – senses body position & movement
Classification by Stimuli Detected

• Mechanoreceptors
  – detect pressure or stretch
  – touch, pressure, vibration, hearing, proprioception, equilibrium & blood pressure

• Thermoreceptors detect temperature

• Nociceptors detect damage to tissues

• Photoreceptors detect light

• Chemoreceptors detect molecules
  – taste, smell & changes in body fluid chemistry
Adaptation of Sensory Receptors

• Change in sensitivity to long-lasting stimuli
  – decrease in responsiveness of a receptor
    • bad smells disappear
    • very hot water starts to feel only warm
  – potential amplitudes decrease during a maintained, constant stimulus

• Receptors vary in their ability to adapt
  – Rapidly adapting receptors (smell, pressure, touch)
    • adapt quickly; specialized for signaling stimulus changes
  – Slowly adapting receptors (pain, body position)
    • continuation of nerve impulses as long as stimulus persists
Somatic Tactile Sensations

• Touch
  – crude touch is ability to perceive something has touched the skin
  – discriminative touch provides location and texture of source

• Pressure is sustained sensation over a large area

• Vibration is rapidly repetitive sensory signals

• Itching is chemical stimulation of free nerve endings

• Tickle is stimulation of free nerve endings only by someone else
Thermal Sensations

- Free nerve endings with 1mm diameter receptive fields on the skin surface
- Cold receptors in the stratum basale respond to temperatures between 50-105 degrees F
- Warm receptors in the dermis respond to temperatures between 90-118 degrees F
- Both adapt rapidly at first, but continue to generate impulses at a low frequency
- Pain is produced below 50 and over 118 degrees F.
Pain Sensations

- Nociceptors = pain receptors
- Free nerve endings found in every tissue of body except the brain
- Stimulated by excessive distension, muscle spasm, & inadequate blood flow
- Tissue injury releases chemicals such as K+, kinins or prostaglandins that stimulate nociceptors
- Little adaptation occurs
Referred Pain

- Visceral pain that is felt just deep to the skin overlying the stimulated organ or in a surface area far from the organ.
- Skin area & organ are served by the same segment of the spinal cord.
  - Heart attack is felt in skin along left arm since both are supplied by spinal cord segment T1-T5
Pain Relief

• Aspirin and ibuprofen block formation of prostaglandins that stimulate nociceptors
• Novocaine blocks conduction of nerve impulses along pain fibers
• Morphine lessen the perception of pain in the brain.
Proprioceptive or Kinesthetic Sense

• Awareness of body position & movement
  – walk or type without looking
  – estimate weight of objects

• Sensory information is sent to cerebellum & cerebral cortex
  – from muscle, tendon, joint capsules & hair cells
    in the vestibular apparatus
Somatic Sensory Pathways

• **First-order neuron** conduct impulses to brainstem or spinal cord
  – either spinal or cranial nerves

• **Second-order neurons** conducts impulses from spinal cord or brainstem to thalamus--cross over to opposite side before reaching thalamus

• **Third-order neuron** conducts impulses from thalamus to primary somatosensory cortex
Somatic Sensory Pathway

Posterior Column-Medial Lemniscus Pathway of CNS
Somatic Motor Pathways

• Control of body movement
  – motor portions of cerebral cortex
    • initiate & control precise movements
  – cerebellum helps make movements smooth & helps maintain posture & balance

• Somatic motor pathways
  – direct pathway from cerebral cortex to spinal cord & out to muscles
  – indirect pathway includes synapses in thalamus, reticular formation & cerebellum
Motor neuron pathway

- 1 million upper motor neurons in cerebral cortex
- 90% of fibers decussate (cross over) in the medulla
  - right side of brain controls left side muscles
- Terminate on interneurons which synapse on lower motor neurons in either:
  - nuclei of cranial nerves or anterior horns of spinal cord
Details of Motor Pathways

- Primary motor area of cerebral cortex
- Internal capsule
- Cerebral peduncle
- Decussation (crossing) in medulla
- Left lateral corticospinal tract
- Right anterior corticospinal tract
- Spinal nerve
- Lower motor neurons
- Spinal cord
- To skeletal muscles