Sensory physiology

- Inputs to the nerve system (NS) are mediated by **sensory receptors** which detects sensory stimuli like touch, cold, warmth, hearing, light, pain – modalities

- 5 basic types of sensory receptors, which are selective to particular stimuli based on their peripheral sensitivity:
  a. **mechanoreceptors** – pressure, stretch
  b. **thermoreceptors** – warmth, cold
  c. **nociceptors** – pain – physical, chemical factors
  d. **electromagnetic receptors** – light striking the retina
  e. **chemoreceptors** – taste, smell, levels of O_2 in arterial blood, concentration of CO_2, osmolality of body fluids, etc.

- Differential (central) sensitivity *is ensured by specific nerve tract ending in distinct area of CNS*, therefore, the type of sensation after neuron stimulation is determined by the area where particular neuron terminates (nociceptor induce always painful sensation regardless the stimulus which activated the neuron – electrical, mechanical or chemical)

- Receptor excitation will cause the change in electrical potential of receptor – *receptor potential*

- We recognize distinct mechanisms of sensory receptor potential changes (change in transmembrane potential):
  a. mechanical stretch – opening of ion channels
  b. chemical compound (ligand), which cause opening of channel
  c. temperature change of cytoplasmic membrane – changes in membrane permeability
  d. effects of electromagnetic radiation (light) – retinal receptors

- If receptor potential exceeds the threshold action potential (AP) is generated. The higher receptor potential exceeds its threshold, the higher is frequency of APs (firing)

- Another characteristic feature of sensory receptors is ability of adaptation, even with constant stimulation the frequency of AP decreases in time (however, some receptors like nociceptors or chemical receptors are not able to fully adaptate)

- *Signal intensity is regulated* by so called *spatial summation* (integration of more nerve fibers) or by *temporal summation* (increased frequency of firing in one nerve fiber)

- *Signal is interconnected in neuronal „pools“* – brain cortex, basal ganglions, nuclei in distinct brain areas, grey matter of spinal cord

- Area where is initial neuron (input) interconnected with neuron mediating output is called stimulatory field – *suprathreshold stimulus* (is able to stimulate second neuron alone)
  a *subthreshold stimulus* (requires stimulation by more neurons or faster firing)

- It might lead to:
  a. *signal divergence* – weaker signal entering the neuronal pool is able to excite a lot of fibers, e.g. one big pyramidal cell in motor cortex is able to excite up to 10.000 skeletal muscle fibers by facilitation
  b. *signal convergence* – convergence from multiple sources during the regulation of skeletal muscles by motor neurons – interneurons of spinal cord transmit signal from peripheral motor fibers, propriospinal fibers, corticospinal fibers, etc. to the motor neuron (signal summation)

- *Neuronal circuits interconnects excitatory and inhibitory stimuli*, e.g. during walk excitatory signal transmitted by one set of fibers in CNS will cause the forward movement of leg whereas inhibitory signal transmitted by another set of fibers will cause inhibition of skeletal muscles on the back side of leg to not opposite the leg movement

Somatic senses

1. Mechanoreceptive – tactile and position senses
a. tactile – touch, pressure, vibration, itch/tickle
b. position – static position and rate of movement
2. Thermoreceptive – warmth, cold
3. Nociceptive – pain

- **Classification of senses** (sense is understood as a complex of non-dividable feeling/sensations (color, smell) into which the emotionality or experience is projected):
  1. Exteroreceptive – body surface
  2. Proprioceptive – position, tendons and muscles, pressure from feet, etc.
  3. Visceral – from internal organs
  4. Deep – bones, fasciae, muscles – strong pressure, pain, vibration

- ***Tactile senses*** are transmitted by *free nerve terminals*, which mediates *sensations of touch and pressure*. Can be found in whole skin or for example in conjunctiva. *Meissner's bodies* are sensitive to touch, can be found in hairless parts of skin –lips, and finger pads. In areas with Meissner's bodies are often found nerve endings with extended tip such as *Merkel's disks*. In deeper layers of skin such as dermis the *Ruffini bodies* can be found. *Pacini's bodies are able to register very fast vibrations* from 30 to 800 cycles/min. Other listed mechanoreceptors register vibrations with lower frequencies

- Almost all information from somatic segments enters the spinal cord via dorsal horns and are conducted by two pathways – dorsal column-medial lemniscus pathway and spinothalamic tract and are terminated in brain stem and thalamus

- *Dorsal column-medial lemniscus pathway* – tactile senses, touch, vibrations, proprioception, light pressure. Lot of neurons are short and terminated in gray matter of spinal cord – local spinal reflexes

- *Spinothalamic tract* – pain, thermoreception, strong pressure, itching and tickling, sexual sensations. First neuron interconnects in the nuclei of dorsal horns and connects to the second neuron which terminates in thalamus – ventrobasal complex. From there the third neuron originates and ascend to the gyrus postcentralis of somatosensory cortex – somatosensory areas I and II (see image below)

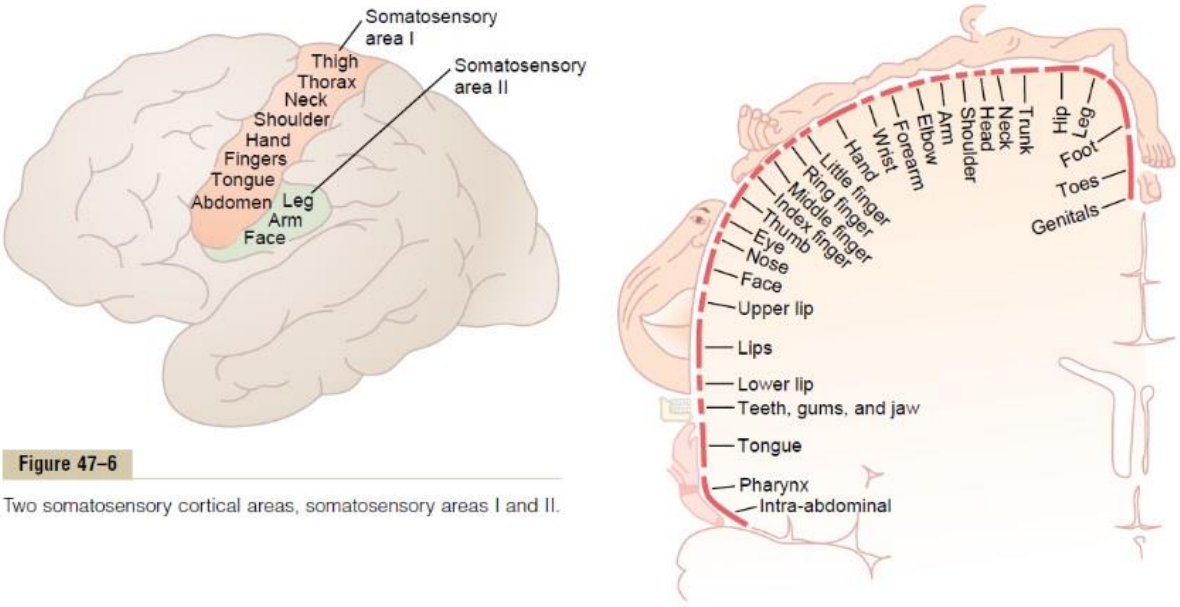

Figure 47–6

Two somatosensory cortical areas, somatosensory areas I and II.

- Functions of somatosensory pathways represents e.g. the ability to precisely localize stimuli in different areas of body, critically evaluate the degree of pressure affecting the body, evaluate the weight of objects, shape of objects, texture and surface of objects

- ***Position senses* or *proprioceptive senses*** recognize static orientation of different body parts in regards to another one and evaluate the rate and velocity of movement – kinesthesia, dynamic proprioception

- Different types of skin, tactile and deep receptors are involved, e.g. muscle spindles, Pacini's bodies, Rufini's bodies and Golgi's tendon receptors

Special senses - vision, taste, hearing, smell, touch please see random physiology book