What are receptor neurons?
Specialized neurons that respond to physical or chemical stimuli
Respond by changing ion channels, altering graded potentials

High graded potential at receptor ending causes rapid firing of its afferent neuron.

Fig. 6.1, p. 142
Where sensations get received

- Vestibular cortex
- Somatosensory cortex
- Gustatory cortex (taste)
- Visual cortex
- Olfactory cortex
- Auditory cortex

Nociceptors

- Mechanical receptors respond to mechanical damage \(\rightarrow\) fast pain pathway
- Thermal receptors respond to temperature extremes \(\rightarrow\) fast pain pathway
- Polymodal nociceptors respond to damaging stimuli \(\rightarrow\) slow pain pathway

Pain pathways

Pain perception and analgesia pathways

- Substance P is neurotransmitter here
- Perception of pain due to the breakdown of endogenous opioids
- Descending pain pathways via non-opioid receptors
- Local tissue is inhibited by endogenous opioids
- Pain inhibition occurs via descending opioid system
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- Substance P is neurotransmitter here
- Perception of pain due to the breakdown of endogenous opioids
- Descending pain pathways via non-opioid receptors
- Local tissue is inhibited by endogenous opioids
- Pain inhibition occurs via descending opioid system
How does the body react to pain to reduce sensation?

Your brain can influence its own perception of pain

**Endogenous opiates:**
- Enkephalin
- Endorphin

**Ouch!**

- Afferent pain axon
- Substance P blocked
- Transmission of pain reduced
- Enkephalin, Endorphin released
- Nociceptor

Morphine, oxycodone, codeine and heroin can bind to opiate receptors

**Analgesic pathway**

**How might acupuncture work?**

Several hypotheses, including:
1. AP helps release of endorphins, inhibiting pain (previous slide)
2. AP increases local blood flow, promotes healing
3. AP stimulates non-pain pathways that inhibit pain pathways
Phantom limb pain
Brain plasticity in response to loss of limb
– Touch face of hand amputee, report hand touched
– Brain wrongly ‘remaps’ the area

Interesting therapy!

External eye anatomy

Iris contains smooth muscle
Sclera supports eye
Cornea cells specialized to admit light
Pupil

Focusing on the retina:

Lens refracts light to focus images to the back of the retina.
Light rays reflecting from distant vs. near objects

(a) Viewing a distant object
- Nearly parallel light rays
- Flattened lens for weak refraction
- Diverging light rays

(b) Viewing a near object
- Rounded lens for strong refraction

Focusing distant and near objects

- Distant light source
- Parallel rays
- Focal point

- Near light source
- Stronger lens
- Focal point
Accommodation - change in the strength of the lens

Presbyopia

Myopia (near-sightedness)
**Rods** - sense grayscale images, function in low light better than cones

**Cones** - red, blue, green wavelengths, better acuity than rods

**Resolving the problem of the backwards retina**
Along the retina is a ‘dimple’ (macula) with a fovea at its base where neurons that lie above photoreceptors are off to the side.

- Fovea has primarily cones
**Phototransduction**: light stimuli into neural signals.

- Photopigment “rhodopsin” (in rods).
- When a photon of light hits rhodopsin, it changes shape and sodium channels close.

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**Colorblindness**

If one of the three types of cone pigments is abnormal or missing, colorblindness results.

Genes for green and red pigments are on the X chromosome.

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Diagram of the ear showing the parts of the outer, middle, and inner ear.
What is sound?

alternating regions of high and low pressure

“Ear drum” and ear bones convert air vibrations into movement of liquid in cochlea

Movement of last earbone is transferred to cochlea at “oval window”
Amplification of sound waves

Vibrations travel up one cochlea channel and back another

Organ of Corti

Tectorial membrane

Auditory nerve

Basilar membrane
Sensations of different sound frequencies are detected at different areas of the cochlea.

Width & stiffness of basilar membrane changes.
Conductive deafness - sound not conducted through middle ear. Helped w/hearing aids

Sensorineural deafness - Defect in neural signal.
Information from hair cells includes the direction of deflection

- Kinocilium
- Stereocilia
- Hair cell

**increases potential**  **hyperpolarizes**

Detecting rotation (angular motion)

- Utriculus hair cell
- Otoliths in membrane

(a) linear or constant rate of motion
(b) Acceleration
(c) Acceleration
Within the vestibular apparatus are hair cells which sense movement of otoliths—mineral particles detecting linear motion. Why alcohol can make the room spin:

- Alcohol diffuses from blood into endolymph, and endolymph swirls.
- Inner ear passes info. to eye muscles, causing eyes to twitch to right (reverses once liver removes alcohol from blood).
Gustation and Olfaction

Both utilize chemoreceptors that bind with dissolved molecules.

Tasting

Taste buds - contain about 50 - 100 receptors in small groups at a taste pore.
Receptors have cilia that extend into pore.

Variety of taste receptors
Pain receptors at taste buds

- There are nociceptors along tongue, sensitive to acid, ethanol, capsaicin (in spicy foods)
How smell works

• Any ‘smell’ is a combination of numerous odorant molecules of specific types

• Each of these odorant molecules can possibly bind with one of a few different receptors, most receptors cannot bind

• The pattern of binding of odorants to those few receptors types = perception of a smell

• Vomernasal organ - separate area of olfaction low in nasal cavity. Senses pheromones

Autonomic Nervous System

The motor system for homeostasis, involuntary responses of visceral organs

Impulses to the viscera, glands, blood vessels, smooth and cardiac muscles
ANS pathways
ANS impulses travel from the CNS and pass through 2 neurons to reach an effector.

**Sympathetic vs. Parasympathetic systems**

**Sympathetic** - “Fight or Flight” (↑ heart rate, ↓ digestion, ↑ breathing rate, glycogen → glucose, dilate pupil...)

**Parasympathetic** - “Rest and Digest” (↓ heart rate, ↑ digestion, ...etc.)

**SNS fibers** originate from the thoracic and lumbar regions of the spinal cord.
- Preganglionic fibers are short
- Postganglionic fibers are long
With **sympathetic** system activation, the adrenal medulla releases epinephrine and norepinephrine into blood.

**Sympathetic vs. Parasympathetic systems**

PNS fibers originate from the cranial and sacral regions of the CNS.

- Preganglionic fibers are long
- Postganglionic fibers are short

**Two neurotransmitters are utilized in ANS:**
- **Acetylcholine** and **norepinephrine**
  - **ACh** - at autonomic ganglion for both systems
  - At effectors:
    - **ACh** - parasympathetic
    - **Nor** - sympathetic
Cholinergic vs. Adrenergic fibers

**Cholinergic fibers** release Ach

**Adrenergic fibers** release norepinephrine