Sensory Systems Anatomy

- Vision
- Hearing
- Balance
- Taste
- Smell
- Touch
- Pain
- Proprioception
- Interoception

MUDr. Azzat Al-Redouan
Sensory receptors

- Vision
- Taste
- Smell
- Hearing
- Touch

- Internal
  - Baroreceptors - blood pressure
  - Osmoreceptors - osmolarity
  - Chemoreceptors – chemical concentration
Conjunctiva
Conjunctivitis

uninflamed conjunctiva

inflamed conjunctiva
Exophthalmos

Periorbital Edema

Palbepral Inflammation
Lacrimal Apparatus

- Superior rectus muscle
- Lacrimal gland
- Lacrimal gland ducts
- Lateral canthus
- Lower eyelid
- Inferior rectus muscle
- Inferior oblique muscle
- Tendon of superior oblique muscle
- Lacrimal punctum
- Superior lacrimal canaliculus
- Medial canthus
- Inferior lacrimal canaliculus
- Lacrimal sac
- Nasolacrimal duct
- Opening of nasolacrimal duct
- Middle meatus
- Inferior nasal concha
Lacrimial Canaliculi Obstruction
Strabismus (Misalignment of eyeballs)

A. Esotropia

B. Exotropia

C. Hypertropia

D. Hypotropia
Development of Glaucoma

Healthy Eye

Flow of aqueous humour through the drainage canal.

Glaucoma

1. Drainage canal blocked; build up of fluid.
2. Increased pressure damages blood vessels and optic nerve.
Cataract
Refraction Errors

Myopia (Nearsighted)
- Retina
- Cornea
- Lens

Hyperopia (Farsighted)
- Focal point

Correction with a plus lens allows light to once again focus on the retina.
Fundoscopy
macular degeneration
Glaucoma

Normal Retina
Circular muscles contract to constrict pupil

Radial muscles contract to dilate pupil

Iris
Papillary Reflex Pathway
Nerve Pathway & Muscles

Constriction (Parasympathetic)

Dilation (Sympathetic)

A. Miosis (constriction)

B. Mydriasis (dilatation)
Trauma

Preauricular Fistula

Grade I Microtia
Grade II Microtia
Grade III Microtia
Grade IV Microtia

Cauliflower Ear
Otoscopy
Middle Ear Walls

- Tegmental Wall
  - Epitympanic recess
  - Malleus
  - Incus
  - Stapes
  - Chorda tympani
  - Stapes (VIII.n.)
  - Oval window
  - Promontary
  - Jugular fossa
Auditory Pathway

- Auditory cortex (temporal lobe)
- Low-frequency sounds
- High-frequency sounds
- Medial geniculate nucleus
- Inferior colliculus (mesencephalon)
- Motor output to cranial nerve nuclei through the tectobulbar tracts
- Motor output to spinal cord through the tectospinal tracts
- Cochlea
- Thalamus
- Vestibular branch
- Cochlear branch
- Vestibulocochlear nerve (N VIII)
- Cochlear nucleus
- Low-frequency sounds
- High-frequency sounds
Vestibular Pathway

- Semicircular canals
- Vestibular ganglion
- Vestibular branch
- Vestibule
- Cochlear branch
- Vestibulocochlear nerve (VIII)
- Red nucleus
- N III
- N IV
- N VI
- N XI
- Vestibular nucleus
- Vestibulospinal tracts
- To superior colliculus and relay to cerebral cortex
- To cerebellum
Taste Buds Types & localization

- Filiform papilla
- Fungiform papilla
- Vallate papilla
- Foliate papilla

Key:
- Epithelium
- Taste bud
- Root of tongue
- Body of tongue
- Dorsal surface of tongue
- Apex of tongue
Taste Buds

- Epiglottis
- Palatine tonsil
- Lingual tonsil
- Connective tissue
- Taste fibers of cranial nerve
- Gustatory hairs
- Basal epithelial cells
- Gustatory epithelial cells
- Taste pore
- Stratified squamous epithelium of tongue

Vallate papillae

Fungiform Papillae

Taste bud
Gustatory Pathway
Taste Sensation:

- Sweet
- Bitter
- Sour
- Salty
- Umami
- Water (Even though some still don’t agree)
- Toxic? (It could be grouped under extreme bitterness)
Olfaction

- Nerve fibers to brain
- Receptor cells
- Olfactory tract
- Olfactory bulb
- Cilia
- Airborne odors
- Food chemicals
- Taste bud pores
- Synapse
- Taste (gustatory) nerve to brain
- Tongue
Olfactory Pathway
Example of Anatomical related disorder interfering with olfaction quality: 

**Nasal Polyp**
Pain: Evolutionary mechanism initiating neurophysiologic process toward stimuli disturbing haemostasis (damage) → Protection
a) Repulsion away from harmful triggers
b) Awareness of harmful sources

*When a stimuli is NOT sensed → SIELNT HARM
e.g. Diabetic foot (Delayed awareness of bleeding and infection during stepping injuries)

<table>
<thead>
<tr>
<th>Pain types</th>
<th>Nociceptive</th>
<th>Neuropathic</th>
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<tbody>
<tr>
<td>Definition</td>
<td>Pain caused by physiological activation of pain receptors</td>
<td>Pain caused by lesion or dysfunction of the somatosensory system, especially the nociceptive pathway</td>
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<tr>
<td>Mechanism</td>
<td>Natural physiological transduction</td>
<td>Ectopic impulse generation, among others</td>
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<tr>
<td>Localization</td>
<td>Local + referred pain</td>
<td>Confined to innervation territory of the lesioned nervous structure</td>
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<td>Quality of symptoms</td>
<td>Ordinary painful sensation (good verbal descriptors)</td>
<td>New strange sensations (poor verbal descriptors)</td>
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<td>Treatment</td>
<td>Good response</td>
<td>Poor-moderate response</td>
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Classification of pain based on etiology:

- **Nociceptive pain**
  - Somatic pain
  - Visceral pain

- **Neuropathic pain**
  - Peripheral neuropathic pain
  - Central neuropathic pain

Graph showing severity of pain experienced vs. strength of the painful stimulus:

- **Harmless**
- **Potentially harmful zone**
- **Allodynia**
- **Hyperalgesia**
- **Neuropathy**
Pain

Nociceptors

- Nociceptors are special receptors that respond only to **noxious** stimuli and generate nerve impulses which the brain interprets as “pain”
- Free nerve endings
- Tissue damage
Nociceptors

- Free nerve endings that respond to intense stimuli

Types:
  - **Mechanical**
    - Strong pressure, sharp objects
  - **Thermal**
    - Burning heat (>45°C)
    - Noxious cold (variable)
  - **Chemical**
    - pH extremes
    - Environmental irritants
    - Internal neuroactive substances
  - **Polymodal**

Sensations mediated by Aδ fibers (sharp, intense pain) and C fibers (persistent, dull pain).
Pain Pathways:

A) From Body (Left)
B) From Face (Right)
1st Respond – Spinal Arch Reflex

*Immediate & fast before signal had reached the brain → repulse from pain stimuli without thinking!
2\textsuperscript{nd} Respond – Cortical modulation

*Delayed & speed varies $\rightarrow$ Thinking of how to deal with the situation
*Repetitive or Long term stimulation lead to adaptability
*Establish memory $\rightarrow$ a. Influence future responses b. Mechanism in psychological Trauma
Headache???

*Source: Vessels, Meanings, Surrounding tissues
*NOT the Brain itself
Common Headache Causes

A headache is defined as a pain in the head that is located above or around the eyes or ears, at the back of the head or in the upper area of the neck. Headaches have many causes, including:

- Blood vessels that become constricted or are dilated.
- Muscles in the neck and head that are tight or tense due to stress.
- Muscles around the eyes that become strained due to poor vision or overwork.
- Sinuses that are swollen or congested due to allergies, colds or infection.
Visceral pain perceived on a distal dermatome

* Brain misinterpret signal due to common segmental innervations.
* Useful in understanding patients subjective pain complain.

* Multiple hypothesized mechanisms – subject of research
Refereed Pain

- Ascending aorta (T2–T3)
- Gall bladder (T7–T8)
- Appendix (T11–T12)
- Prostate (S2–S4)
- Heart (T1–T3)
- Pancreas (T7–T8)
- Testis (T10–T11)
- Ureter (T10–L1)
- Kidney (T10–L1)
- Colon (T11–L1)
- Ovary (♀) (T10–T11)
- Cervix/vagina (♀) (S2–S4)
Sites Where Pharmaceutical Pain Blockers Exert their Mechanism Of Action
Interoception – Baroreceptors

Coordinating center

Afferent pathways

Medulla

Efficient pathways

Detector

Baroreceptors

Mean arterial pressure: ↑

Heart, Vessels

Bradycardia and vasodilation counteract increased mean arterial pressure.
Interoception – Baroreceptors

~2 mg!
Interoception – Chemoreceptors

- Higher brain centers (cerebral cortex—voluntary control over breathing)
- Other receptors (e.g., pain) and emotional stimuli acting through the hypothalamus
- Respiratory centers (medulla and pons)
- Peripheral chemoreceptors: $O_2$, $CO_2$, $H^+$
- Central chemoreceptors: $CO_2$, $H^+$
- Stretch receptors in lungs
- Irritant receptors
- Receptors in muscles and joints
Interoception – Chemoreceptors
Interoception – Chemoreceptors

CENTRAL CHEMORECEPTORS

[Diagram showing the process involving capillary, CO₂, H₂CO₃, H⁺, HCO₃⁻, and brain tissue.]
Interoception – Osmoreceptors

Osmoreceptors detect increased osmotic pressure

Baroreceptors (aortic arch, carotid sinus) detect decreased blood pressure

Hypothalamic neuron
Posterior pituitary
ADH

Blood vessel
Vasoconstriction

Increased blood volume
Increased blood pressure

Kidney

Increased reabsorption of water
Interoception – Osmoreceptors

Hypothalmic nuclei
Interoception – Osmoreceptors

juxtaglomerular apparatus
Type Of Cutaneous Receptors

**Free Nerve Endings**
- Are the branching tips of sensory neurons; are unprotected and nonspecific; can respond to tactile, pain, and temperature stimuli.

**Root Hair Plexus**
- Monitor distortions and movements across the body surface; adapt rapidly.

**Tactile Discs and Merkel Cells**
- Tactile discs: fine touch and pressure receptors; are extremely sensitive tonic receptors with very small receptive fields. Merkel cells: unusually large epithelial cells in the stratum basale of the skin.

**Tactile Corpuscles**
- Provide sensations of fine touch and pressure at low-frequency vibratory stimuli; also called Meissner corpuscles.

**Lamellated Corpuscles**
- Layers of collagen fibers separated by fluid; are sensitive to deep pressure, especially pulsing or high-frequency vibrating stimuli; are fast-adapting receptors.

**Ruffini Corpuscles**
- Are sensitive to pressure and distortion of the deep dermis.
KEEP UP THE HARD WORK...!