Lectures

- Histo (CNS)
- anatomy (organization of CNS)
- Anatomy (spinal cord)
- Anatomy (sensory tracts)
- Anatomy & physiology (brain stem)
- Physiology (motor tracts)
- Physiology (synapses & receptors)
- Physiology (spinal cord functions & reflexes)
- Physiology (stretch reflexes)
- Histo (eye)
- Anatomy (2,3,4,6 CN)
- Physiology (refraction, accommodation & pupillary reflex)
- Physiology (accommodation & Pupillary reflexes)
- Anatomy (ear)
- Physiology (hearing)
- Anatomy (nose) & physiology (smell)
- Comparison between (Auditory, Vision, Olfactory, Taste)
### Histo (CNS)

- **Astrocytes** *(Most common)*
  - Repair Injury of CNS tissue *(gliosis)*
  - Support & Nutrition
  - Form BBB
- **Oligodendrocytes**
  - Formation of myelin sheath in CNS
  - Insulation
- **Microglia** *(bone marrow derived)*
  - Phagocytosis
- **Ependymal Cells**
  - Simple columnar Epithelial Cells
  - Lining brain ventricles & Central canal of spinal cord

### anatomy (organization of CNS)

- **nervous system**
  - Collection of sensory input
  - Integration
  - Motor output
- **Autonomic + endocrine**
  - Homeostasis
- **Basal nuclei**
  - voluntary motor activities.
- **Cerebellum**
  - precise coordination for body movement
  - helps maintain equilibrium.
- **glia cells**
  - supporting and nutrition for neurons.

### Anatomy (spinal cord)

- **filum terminale**
  - anchors spinal cord to coccyx
- **denticulate ligaments**
  - attach the spinal cord to the dura mater
- **Substantia Gelatinosa (II)**
  - pain, temperature, crude touch
- **Nucleus Proprius (IV)**
  - fine touch, proprioception, 2 point discrimination, vibration
- **Nucleus Dorsalis (VII)**
  - Proprioception *(from muscle spindles & tendon organs)*
- **Renshaw cells**
  - Feedback **inhibition** on motor neurons
- **Dorsal Rami**
  - movements of the vertebral column

### Anatomy (sensory tracts)

- **Dorsal Column**
  - Proprioception, discrimination, 1/2 crude touch, stereognosis, fine touch
- **Spinothalamic** *(Lateral)*
  - pain, temperature
- *(Ventral)* 1/2 crude touch*(non discriminative), pressure
- **Spinocerebellar**
  - **Posterior** – inferior peduncle / **Anterior**- superior peduncle.
  - control of posture & coordination of movements *(from muscle spindles, Golgi tendon & tactile receptors)*
  - *(unconscious proprioception)*
- **Spinotectal**
  - Movement of head & eyes toward **cutaneous** stimulation
- **Spinoreticular**
  - Perception of dull aching *(slow pain)* [RAS]
- **Spinolivary**
  - movement coordination associated with balance *(Inferior olivary nucleus)*
### Anatomy & physio (brain stem)

**Brain stem**

- **Conduct functions:**
  - Ascending & Descending tracts between cerebral cortex & spinal cord.
- **Site of origin of nuclei & emergence of cranial nerves (from 3rd to 12th).**
- **Conjugate eye movement**
- **Integrative functions:**
  - Controls consciousness & sleep cycle through reticular formation
  - (ventral surface = motor / middle surface = sensory)

#### Medulla

<table>
<thead>
<tr>
<th>(Medulla) caudal closed (pyramidal)</th>
<th>Motor Decussation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Centers</strong></td>
<td>Cardiac, Respiratory, Vasomotor cough, gag, swallow, &amp; vomit.</td>
</tr>
<tr>
<td><strong>Spinal Nucleus of 5th sensory</strong></td>
<td>pain &amp; temperature, from (face, forehead).</td>
</tr>
<tr>
<td><strong>Mid (Medulla) Medial Lemniscus</strong></td>
<td>Sensory Decussation</td>
</tr>
<tr>
<td><strong>Rostral open (Medulla)</strong></td>
<td>Proprioception &amp; deep sensation</td>
</tr>
<tr>
<td><strong>Inferior Olivary Nucleus</strong></td>
<td>Control of movement</td>
</tr>
<tr>
<td><strong>(MLF) vestibulo-ocular tract (ascending)</strong></td>
<td>Eye movements with head movements.</td>
</tr>
<tr>
<td><strong>(MLF) vestibulospinal tract (descending)</strong></td>
<td>Neck &amp; trunk movement with head movements.</td>
</tr>
<tr>
<td><strong>Vestibular nuclei</strong></td>
<td>Equilibrium</td>
</tr>
<tr>
<td><strong>Nucleus Ambiguus (motor)</strong></td>
<td>Along 9th &amp; 10th CN. To (pharynx, larynx, palate msg &amp; stylopharygus ms.)</td>
</tr>
<tr>
<td><strong>Solitary nucleus (sensory)</strong></td>
<td>Taste sensation (from the tongue) along 7th, 9th &amp; 10th</td>
</tr>
<tr>
<td><strong>Tectospinal tract</strong></td>
<td>Head movements during visual &amp; auditory tracking</td>
</tr>
</tbody>
</table>
### Pons (caudal)

<table>
<thead>
<tr>
<th>Center</th>
<th>Respiratory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trapezoid Body(lateral lemniscus)</td>
<td>Hearing</td>
</tr>
</tbody>
</table>

### Midbrain

<table>
<thead>
<tr>
<th>Periaqueductal Gray</th>
<th>analgesia &amp; pain desensitization (endogenous opioids)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Cerebral peduncul)Crus Cerebri (UMN)</td>
<td>coordination of movement</td>
</tr>
<tr>
<td>Inferior colliculus</td>
<td>Hearing</td>
</tr>
<tr>
<td>Superior colliculus</td>
<td>reflex movements of the eyes, head &amp; neck in response to visual stimuli</td>
</tr>
<tr>
<td>Red nucleus</td>
<td>motor control (Rubrospinal tract)</td>
</tr>
<tr>
<td>Substantia Nigra</td>
<td>• motor function.</td>
</tr>
<tr>
<td></td>
<td>• part of the basal ganglia.</td>
</tr>
<tr>
<td></td>
<td>• secrete dopamine.</td>
</tr>
<tr>
<td>Central Tegmental Tract</td>
<td>many tracts project up to the cortex and down to the spinal cord.</td>
</tr>
<tr>
<td>Reticular formation (tegmentum) (LMN)</td>
<td>Respiratory &amp; Cardiovascular centers</td>
</tr>
<tr>
<td>Reticulo spinal tracts</td>
<td>Influence a muscle tone &amp; posture</td>
</tr>
<tr>
<td>Reticular Activating system</td>
<td>activate the cerebral cortex through the thalamus.</td>
</tr>
<tr>
<td>Raphe Nuclei (serotonergic)</td>
<td>ascending fibers – sleep</td>
</tr>
<tr>
<td></td>
<td>descending fibers – Pain desensitization</td>
</tr>
<tr>
<td>Locus Ceruleus (noradrenergic)</td>
<td>Helps in arousal &amp; sleep- wake cycles.</td>
</tr>
<tr>
<td>Physiology (motor tracts)</td>
<td></td>
</tr>
<tr>
<td>--------------------------</td>
<td></td>
</tr>
<tr>
<td><strong>Premotor area</strong></td>
<td>complex coordinated movements, certain posture to perform a specific task</td>
</tr>
</tbody>
</table>
| **Supplemetary cortex**  | ● planning & programming motor sequences  
                           | ● bilateral movement |
| **Betz cells (layer 5)** | most rapid rate of transmission, inhibit adjacent regions of the cortex, sharpening” the excitatory signal |
| **Corticobulbor tract**  | control face & neck muscles, facilitate tone (mastication, swallowing) |
| **corticospinal tracts** | ● stretch reflex by Facilitating muscle tone via gamma MN.  
                           | ● sensory-motor coordination by alpha MN.  
                           | (Lateral) fine, discrete skilled movement of Distal limb ms.  
                           | (Monosynaptic)  
                           | (Ventral) control axial, proximal ms. & posture (balance)  
                           | (Interneuron) |
| **Column of Neurons**    | integrative processing – unit & amplifying system |
| **Dynamic neurons**      | initial rapid development of force (short period) |
| **Static neurons**       | maintain the force of contraction (long period)  
                           | (greater percentage in the primary cortex area) |
| **Primary Motor Cortex (Area Pyramidalis) is essential For** | Voluntary initiation of finely controlled movements, especially of hands & fingers. |
| **Extrapyramidal tracts** | ● Sets the postural background  
                              | ● subconscious gross movements |
| **Rubrospinal (red nucleus)** | ● inhibitory to Distal limb motor neurons (extensor ms.), & control skilled movements (sitting) (opposite of lateral corticospinal)  
                              | ● facillatory (flexor ms.) |
| **Tectospinal**          | turning of the head in response to visual/ Auditory stimuli |
| Vestibulospinal   | • Controls eye move. Postural & righting reflexes  
|                  | • **Excitatory** to ipsilateral spinal MN that supply axial & posotural ms.  
|                  | • selectively control the **excitatory** signals to the **antigravity ms.** *(equilibrium)* with pontine reticular  
|                  | (Lateral)-**excitatory** extensor motor neurons to maintain posture *(ipsilateral)* from *(Deiter’s nucleus)*  
|                  | (Medial)(MLF)-  
|                  | • coordination of head & eye movements *(ascending)*  
|                  | • control the posture *(descending)* *(both Bilaterally)*  

| Reticulospinal   | • Influence motor functions *(voluntary & reflex Movement)*.  
|                  | • Excitatory/inhibitory to muscle tone.  
|                  | **Pontine (Medial) [bulboreticular]**  
|                  | • **Increases** Gamma efferent activity *(excitatory=↑muscle tone)*.  
|                  | • **Exciting** anti-gravity, extensor ms., inhibit flexor ms. *(As vestibulospinal tract)*  
|                  | **Medullary (Lateral)**  
|                  | • **Inhibits** Gamma efferent activity *(inhibitory=↓muscle tone)*.  
|                  | • **Inhibiting** anti-gravity, extensor ms.  

| Olivospinal Tract (cervical) | control of **movement** |
### Physiology (synapses & receptors)

| AXON HILLOCK | Synaptic input is converted to a nerve impulse |
| Conjoint Synapse lateral vestibular nucleus | balance & equilibrium |
| **Excitatory NT** | ACH, glutamate |
| **Inhibitory NT** | GABA, glycine |
| **Metabotropic receptor (Slow)** | Memory, Intracellular enzymes activation, gene transcription |
| **IONOTROPIC (fast)** | |
| **Spatial summation** | When EPSP occurs in more than one synaptic knob at the same time. (Increase power) |
| **Temporal summation** | EPSPs in a pre-synaptic knob are successively repeated without significant delay, so the effect of previous stimulus is summated to the next. |
| **EPSPs** | Depolarization |
| **IPSPs** | Hyperpolarization |

### Physiology (ANS)

<p>| ANS | |
| - Control involuntary (subconsciously) visceral functions |
| - Visceral motor innervates non-skeletal (non-somatic) (NOT under conscious control) |
| - capable of rapidly and intensely changing visceral functions |</p>
<table>
<thead>
<tr>
<th><strong>Physio (spinal cord functions &amp; reflexes)</strong></th>
</tr>
</thead>
</table>
| **Spinal Cord** | ● two-way traffic (sensory, motor)  
● Generating Spinal Reflexes |
| **Convergence** | Signals from multiple inputs (neurons) unite to excite a single neuron’s multiple action potentials.  
*(spatial summation)*  
(neurons almost never excited by an AP from a single input) |
| **Divergence** | ● **Helps** to spread a single stimulus to a wide area of the spinal cord.  
● important for weak signals (amplification) |
| **Reciprocal inhibition** | by GABA or Glycine prevent over activity in many parts of the brain. |
| **Reverberatory (Oscillatory) Circuit** | signal prolongation (collateral nerve fiber)  
parallel fibers |
| **Afterdischarge** | **prolongs** protective response of reflex.  
**depends** on intensity of the stimulus |
| **Synaptic delay** | minimal period of time required for transmission of a neuronal signal from a presynaptic neuron to a postsynaptic neuron |
| **Reaction time (Reflex time)** | time between application of the stimulus & the response |
| **Irradiation** | spread of excitatory impulses up and down the spinal cord  
**depends** on the intensity of the stimulus |
| **Neuronal Recruitment** | Gradual activation (increase) of motor neurons (AHCS) on stim of afferent nerve in a reflex arc by maintained repetitive stimulus. |
| **Motor unit recruitment** | If a repetitive & stronger stimulus is maintained, gradual increase in the force of the muscle contraction |
| **Pattern of withdrawal** | results when the flexor reflex is elicited depends on which sensory nerve is stimulated.  
*(local sign)* |
| **withdrawal reflex** | ● Contracts flexor muscle (protective)  
● Relax inhibit extensor muscle of same limb  
● reverse effect on opposite limb ( cross extensor reflex)  
*(maintaining posture)* |
| **Crossed extensor reflex** | ● supports the body weight against gravity |
- (longer period of afterdischarge, result from reverberating circuits)
- Reciprocal innervations (flexor)

### Physio (stretch reflexes)

| stretch reflex | • maintain a normal posture  
|                | • oppose sudden changes in muscle length.  
|                | • Regulation of muscle length  
|                | • Genesis of muscle tone  

| Nuclear bag fibers | • Can sense the onset of stretch.  
|                    | • Can respond to rapid stretch  

| intrafusal fibers | • prevent muscle injury by activating extrafusal fibres in response to force acting on the muscle.  
|                  | • produces an antagonism of that force  

| Gamma- d (plate endings) | enhances the dynamic response.  
| flower spray | Measures Mainly muscle length  

| muscle spindle | • PROPRIOCEPTION  
|                | • Maintain muscle length against rupture.  

| Muscle contraction | • Stimulation of alpha motor neurons by muscle stretch.  
|                   | • Stimulation of gamma motor neurons.  
|                   | • Coactivation stim of both alpha & gamma.  

| purpose of Coactivation | • maintains the proper damping function of the muscle spindle.  
|                         | • Oppose sudden changes in muscle length.  

| Damping | stretch reflex ability to prevent oscillation or jerkiness of body movements. (Muscle spindle)  

| Muscle Tone | resistance of muscle to stretch (antigravity muscle)  

| Reciprocal inhibition | prevents conflict between opposing muscles and is vital in coordinating body movements. By inhibitory interneuron (Agonist Stimulation by glutamate) / (Antagonist inhibition by GABA/ glycine)  


<table>
<thead>
<tr>
<th><strong>Supraspinal regulation</strong></th>
<th>Control Gamma by (e.g., reticulospinal and vestibulospinal).</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Golgi Tendon Reflex (Disynaptic)</strong></td>
<td><strong>Transmit info. about</strong>: tendon tension or rate of change of tension. <strong>reciprocal innervation</strong>: Protect muscle from rupture, and tendon from avulsion &amp; tear. <strong>By (excitatory interneuron)</strong></td>
</tr>
<tr>
<td><strong>Histo (eye)</strong></td>
<td></td>
</tr>
<tr>
<td>----------------</td>
<td></td>
</tr>
<tr>
<td><strong>Corneal epithelium</strong></td>
<td>Non-keratinized stratified squamous Epithelium.</td>
</tr>
</tbody>
</table>
| **Corneal endothelium** | Simple squamous Epithelium  
• Formation of Descemet’s membrane.  
• Keeping stroma relatively dehydrated |
| **Sclera** | Formation & secretion of melanin |
| **Canal of Schlemm** | drains aqueous humor into venous system |
| **Ciliary Processes** | Give attachment to lens suspensory ligaments (zonule fibers). |
| **Pigmented epithelium of retina** | Cuboidal to Columnar cells (single layer)  
• Absorb light Prevent its reflectionback.  
• Phagocytosis of membranous discs from tips of rods.  
• Estrification of Vit. A in Smooth endoplasmic reticulum. |
| **Muller cells** | extend Between vitreous body and the inner segments of rods and cones. |
| **Conjunctiva** | Stratified columnar epithelium with goblet cells |

**Anatomy (2,3,4,6 CN)**

<p>| partial crossing at optic chiasma | requirement for binocular vision. |
| visual association cortex | involved in interpretation and recognition of objects and perception of color, depth, motion, and other aspects of vision. |</p>
<table>
<thead>
<tr>
<th>Physiology (refraction, accommodation &amp; pupillary reflex)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>vision</strong></td>
</tr>
<tr>
<td>• Discriminates between light &amp; dark.</td>
</tr>
<tr>
<td>• Detects movement.</td>
</tr>
<tr>
<td>• Detects color (Adaptive value of color vision)</td>
</tr>
<tr>
<td><strong>Sclera</strong></td>
</tr>
<tr>
<td>protection-spherical appearance.</td>
</tr>
<tr>
<td><strong>Choroides</strong></td>
</tr>
<tr>
<td>primary source of nourishment for retinal photoreceptors &amp; O2 to rods and cons.</td>
</tr>
<tr>
<td><strong>Cornea (40-45 D)</strong></td>
</tr>
<tr>
<td>RESIDENT IMMUNE CELLS</td>
</tr>
<tr>
<td><strong>Iris</strong></td>
</tr>
<tr>
<td>• Give eyes its color</td>
</tr>
<tr>
<td>• Pupillary reflex ms.</td>
</tr>
<tr>
<td><strong>Pupil</strong></td>
</tr>
<tr>
<td>Control &amp; allow light to enter the eye</td>
</tr>
<tr>
<td><strong>Lens (15-20 D)</strong></td>
</tr>
<tr>
<td>• helps focus images on the retina to facilitate clear vision</td>
</tr>
<tr>
<td>• response to nervous signals from brain, its curvature can be increased markedly to provide accommodation.</td>
</tr>
<tr>
<td>(Crystallins)- makes up the refractive media of the lens</td>
</tr>
<tr>
<td><strong>Conjunctiva</strong></td>
</tr>
<tr>
<td>Covered with thin film of tears for Cleaning, wetness and protection</td>
</tr>
<tr>
<td><strong>total refractive power</strong></td>
</tr>
<tr>
<td>59 diopters (distant vision)</td>
</tr>
<tr>
<td><strong>Aqueous Humor</strong></td>
</tr>
<tr>
<td>Continually formed and reabsorbed</td>
</tr>
<tr>
<td>• Nourishes the cornea &amp; iris</td>
</tr>
<tr>
<td>• causes intraocular pressure 10-20 mmhg</td>
</tr>
<tr>
<td><strong>Vitreous Humor</strong></td>
</tr>
<tr>
<td>remains from birth</td>
</tr>
<tr>
<td>• nourishing retina &amp; keep spheroid shape of the eye</td>
</tr>
<tr>
<td>• allows light to pass through</td>
</tr>
<tr>
<td><strong>External Protection Of Eye</strong></td>
</tr>
<tr>
<td>• Bony orbit</td>
</tr>
<tr>
<td>• Lids blinking keep cornea moist</td>
</tr>
<tr>
<td>• Conjuctiva</td>
</tr>
</tbody>
</table>
- Tears from lacrimal gland has antibacterial, lubricating effect, keep moist & clear & provide nutrition to the cornea

<table>
<thead>
<tr>
<th>Retina</th>
<th>light-sensitive layer of tissue</th>
</tr>
</thead>
</table>
| **Fovea Centralis** *(yellow)* | - only cones, high visual acuity for colors, vision & details detection  
- allows light to pass unimpeded to cones *(Larger representation in primary visual cortex)* |
| **Photoreceptors** | capturing light and transforming this into generator potential to be used by nervous system |
| **Müller Cells** | - architectural support structure.  
- providing metabolic support to retina.  
- Maintains synaptic levels of NTs.  
- Differentiate into neural progenitor following (injury to the retina).  
- Act as light conductor which funnels light from vitreous to rods & cons cells |
| **Concave Lenses** | neutralize the refractive power of convex lenses. |
| **Binocular vision** | - Have a large visual field.  
- Cancel the effect of blind spots  
- Stereoscopic vision  
One eye lesion does not affect the other |

### Physiology *(accommodation & Pupillary reflexes)*

| prectental region of midbrain | Pupillary reflexes & eye movement. |
| superior colliculus midbrain | - accommodation reflex & its miosis component  
- control rapid directional movements of the two eyes. |
| **Accommodation** | Focusing of light in the retina, by increasing the curvature of lens. *(for near objects)* |
| **Depth Perception** | - Sizes  
- phenomenon of moving parallax  
- phenomenon of stereopsis or Binocular Vision |
<table>
<thead>
<tr>
<th>Purkinje images</th>
<th>reflections of objects from the structure of the eye.</th>
</tr>
</thead>
</table>
| LGB            | • relay station  
|                | • spatial fidelity  
|                | • gate controls signal transmission to visual cortex  
|                | • color vision & detect shapes & texture |
| Magnocellular  | detection of movement, depth, and flicker. |
| (1,2)          |                                                     |
| Parvocellular  | color vision, texture, shape, and fine detail. |
| (3,4,5,6)      |                                                     |
| Primary visual | movement + shapes+ stereoscopic vision + brightness) &  
| cortex         | has blobs for color detection.                      |
| Association visual cortex | Fixation mechanism |
| Color Blobs    | **(Simple cells)** detect color contrast details, bars of light,  
|                | lines, borders and edges.                          |
|                | **(Complex cells)** detect linear movements of a stimulus |
# Anatomy (ear+ VIII)

## EXTERNAL EAR

| Nerve supply               |extrinsic muscles-> facial
|                           |Sensation is carried by:
great auricular & auriculotemporal nerves |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Auricle</td>
<td>collects air vibrations</td>
</tr>
<tr>
<td>external auditory canal</td>
<td>conducts &amp; collects sound waves from the auricle to the tympanic</td>
</tr>
</tbody>
</table>

## MIDDLE EAR (TYMPANIC CAVITY)

<table>
<thead>
<tr>
<th>Ossicles (synovial joints)</th>
<th>transmit the vibrations of tympanic M. (eardrum) to internal ear (Perilymph)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auditory Tube</td>
<td>equalize pressure on both sides of ear drum.</td>
</tr>
<tr>
<td>Posterior wall</td>
<td>aditus to the mastoid antrum: (contains air cells)</td>
</tr>
</tbody>
</table>
| lateral wall (tympanic membrane) | Nerve supply of ear drum:  
|                           | • Outer surface:  
|                           | 1- Auriculotemporal nerve. (5th)                                          
|                           | 2- Auricular branch of vagus.                                              |
|                           | • Inner surface:  
|                           | 1-Tympanic branch of the glossopharyngeal nerve. (extremely sensitive to pain) |
| Tensor tympani            | Nerve supply: Mandibular nerve. Action: Contracts reflexly in response to loud sounds to limit excursion of tympanic M. |
| Stapedius                 | Nerve supply: Facial nerve. Action: Reflexly damps down the vibrations of stapes by pulling on the neck. |
| Nerves within middle ear  | 1- Tympanic nerve (9th CN)  
| Give: Lesser petrosal /Supply: parotid gland  
|                            | 2- Facial nerve (Geniculate ganglion).  
| Give:                      | • Greater Petrosal nerve.  
|                           | • Nerve to Stapedius.  
|                           | • Chorda Tympani |
**Inner ear**

<table>
<thead>
<tr>
<th>Structure</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>utricle, saccule and semicircular ducts</td>
<td>Equilibrium</td>
</tr>
<tr>
<td>Wernick’s area</td>
<td>recognition and processing of language</td>
</tr>
<tr>
<td>Vestibular Cortex</td>
<td>Conscious awareness of vestibular sensation.</td>
</tr>
<tr>
<td>Superior olivary nucleus</td>
<td>Send olivocochlear fibers inhibitory &amp; serve to modulate transmission of sound to cochlear nerve</td>
</tr>
<tr>
<td>Superior olivary nucleus &amp; lateral lemniscus nucleus</td>
<td>reflex connections with motor neurons of trigeminal and facial motor nuclei mediating contraction of tensor tympani and stapedius muscles</td>
</tr>
<tr>
<td>Inferior colliculi</td>
<td>reflex connections with motor neurons in the cervical spinal segments (tectospinal tract) for movement of head and neck in response to auditory stimulation.</td>
</tr>
</tbody>
</table>

Rostral to the cochlear nuclei The representation of cochlea is essentially bilateral at all levels. (Hearing is bilaterally represented).

**Physio (hearing)**

<table>
<thead>
<tr>
<th>Functions of ear:</th>
<th>Hearing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Characteristic of sound</td>
<td>Equilibrium</td>
</tr>
<tr>
<td>Pitch (Tone) depends on number of cycle/sec</td>
<td></td>
</tr>
<tr>
<td>Intensity (Loudness) depends on amplitude</td>
<td></td>
</tr>
<tr>
<td>Quality depends on overtone/interference.</td>
<td></td>
</tr>
<tr>
<td>Functions of External ear</td>
<td>funnel to collect sound</td>
</tr>
<tr>
<td>Sound localisation (pinna)</td>
<td></td>
</tr>
<tr>
<td>Protection</td>
<td></td>
</tr>
<tr>
<td>Functions of the middle ear</td>
<td>Muscles Protection effect against constant loud noise. Not sudden noise, latency of 40-80 ms</td>
</tr>
<tr>
<td></td>
<td>Middle ear magnifying effect</td>
</tr>
<tr>
<td></td>
<td>Transmission of sound through the middle ear</td>
</tr>
<tr>
<td><strong>Ossicles amplification</strong></td>
<td>needed for movement of sound waves in the fluid of the inner ear</td>
</tr>
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<td>---------------------------</td>
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</tr>
</tbody>
</table>
| **Functions of Inner ear** | • **Transduction:** convert sound wave to nerve impulses  
• **Transmission:** send auditory signals to the CNS |
| **Outer hair cells**       | control sensitivity of inner hair cells to particular sound frequency. |
| **Inner hair cells**       | primary receptors for sound “hearing”  
transducing fluid movement in cochlea into action potential in the auditory nerve |
| **Sound localization**     | • Differences in the time arrival of the sound wave at the ears (time-lag).  
• Differences in the loudness |
### Anatomy (nose) & physiology (smell)

| Paranasal (Air) sinuses | • lighten skull  
|                        | • amplify sound as we speak.  
| Respiratory mucosa     | • **Moisten** inspired air by secretion of serous glands  
|                        | • **Warm** inspired air by submucous venous plexus  
|                        | • **Clean** inspired air by ciliary action of ciliated columnar epithelium  
| Nerve supply           |  
| general sensation      | Ophthalmic & Maxillary divisions of trigeminal nerve.  
| anterior part          | Anterior Ethmoidal nerve  
| posterior part         | pterygopalatine ganglion:  
|                        | 1-Nasopalatine,  2- Nasal, and  3- Palatine  
| Arterial supply        | • Sphenopalatine artery (maxillary)  
|                        | • Ethmoidal anterior and posterior (ophthalmic)  
|                        | • Superior labial (facial)  
| Venous drainage        | Cavernous sinus & pterygoid venous plexus  
| Lymphatic drainage     | Submandibular nodes & Upper deep cervical nodes  
| olfactory segment      | **pseudo-stratified columnar epithelium called olfactory epithelium (olfactory mucous membrane ) which contains olfactory receptors(bipolar neuron)**
<table>
<thead>
<tr>
<th>Auditory</th>
<th>Vision</th>
<th>Olfactory</th>
<th>Taste</th>
</tr>
</thead>
<tbody>
<tr>
<td>inferior colliculus</td>
<td>superior colliculus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>inferior brachium to MGB</td>
<td>superior brachium to LGB</td>
<td>Receptor= bipolar</td>
<td>Receptor= Gustatory</td>
</tr>
<tr>
<td>Superior olivary nucleus</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>lateral lemniscus</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>medial geniculate body (thalamus)</td>
<td>lateral geniculate body (thalamus)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>sublenticular part of the internal capsule</td>
<td>retrolenticular part of posterior limb of internal capsule</td>
<td>No thalamus relay</td>
<td></td>
</tr>
<tr>
<td>primary auditory cortex (area 41&amp; 42) [hearing] superior temporal gyrus (Heschl’s gyrus)</td>
<td>primary visual cortex (area 17) Visual area (1)</td>
<td>Uncus</td>
<td>Anterior insular cortex. Operculum(in insula)</td>
</tr>
<tr>
<td>Auditory association areas (wernicke's area),(area 22) [interpretation]</td>
<td>visual association cortex area (18,19)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vestibular Cortex Lower part of postcentral gyrus</td>
<td></td>
<td></td>
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<tr>
<td>bilateral cortical connection</td>
<td>olfactory centre receives smell sensation from both halves of nasal cavity.</td>
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</tbody>
</table>