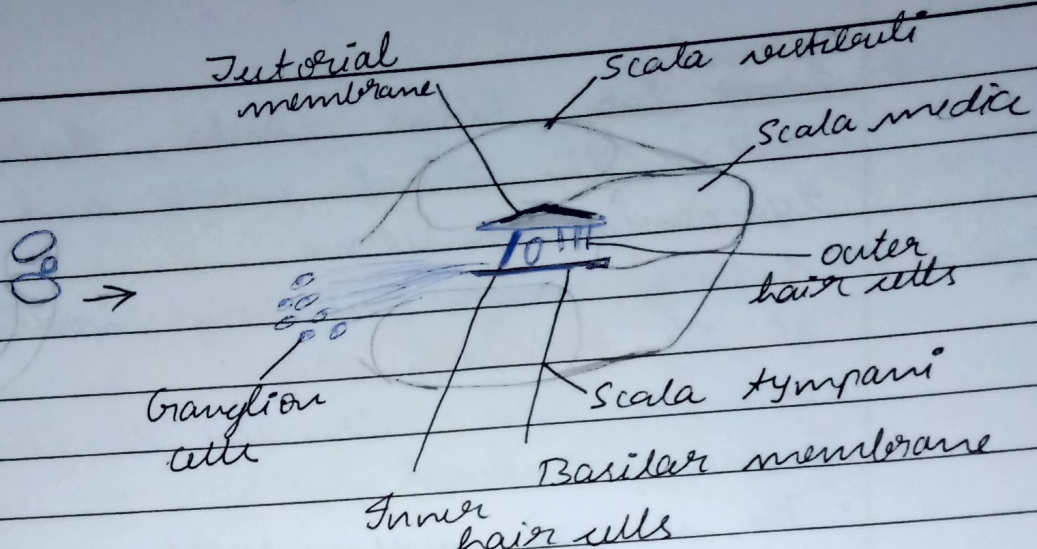
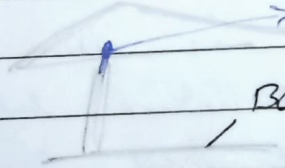
* External Ear: Pinna, Concha, Auditory meatus
- Gathers the sound energy and focuses it on the tympanic membrane.
- Auditory meatus selectively boosts the sound pressure 30 to 100 fold
- Humans are extremely sensitive to 2-5 kHz frequency sound.
- The vertical asymmetrical convolutions of pinna are shaped so that external ear transmits high frequency components from an elevated source than from the source at ear level.

* Middle ear: (Tympanic membrane (drum), ossicles - Malleus, Incus, Stapes)
- Amplification of pressure 200 fold.
- This amplification is needed because outer ear medium is air but inner ear medium is liquid.
- Amplification is done using $P_1 A_1 = P_2 A_2$
Tympanic membrane has more area whereas oval window has small area.
- Ossicles is the group smallest bones in the human beings

* Inner Ear: Cochlea, Auditory nerve
- In cochlea pressure waves is transformed into neural impulses
- Cochlea when unwiled - 35 mm long.
- 2 portion of cochlea - Scala vestibuli, scala tympani.
- Organ of corti: Basilar and tectorial membrane



- Cochlear partition doesn't extend all the ways to the apical end.
- Oval window displaces fluid of the inner ear. This causes round window to bulge out and deforming cochlear partition
- Basilar membrane vibrates
- movements of basilar membrane deforms the end of the inner hair cells leading to the transduction of the mechanical energy into neural impulses



- Stereocilia of hair cells protrude into scala media which contains endolymph - contains high K^+ conc^n.
- Deformation of stereocilia towards longest stereocilia leads to inward flow of current through K^+ channels - depolarization
- Depolarization leads to release of more neuro transmitter on afferent endings which leads more action potential in the auditory nerve.

- Deformation of stereocilia away from longest stereocilia leads to closure K^+ - hyperpolarization
- Hyperpolarization leads to less neurotransmitter which leads to decrease in action potential firing in the auditory nerve

Central Auditory Processing

- Auditory system parallel pathways
- Information from each ear reaches both side of the brain (even brainstem).

* First order neurons: Spiral ganglion cells
- Central processes enter the pontantine medullary junction and bifurcates to innervate the cochlear nucleus.

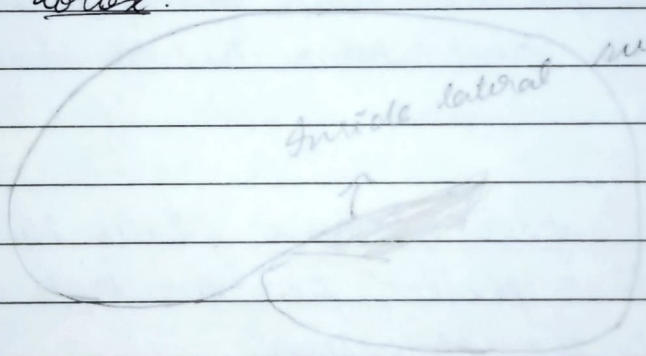
* Second order neurons: Cells in the cochlear nuclei that project to multiple targets on both sides of the brainstem.
- Superior olivary complex in the mid pons: Localizing the sources of sounds in the auditory space.
- Nucleus of lateral lemniscus in the upper pons: Detecting presence and temporal properties of sound from one ear.

- Medial superior olive (MSO): localizes low freq. sounds based on interneural timing differences
- Lateral superior olive (LSO): localizes sound based on interneural ~~timing~~ intensity differences

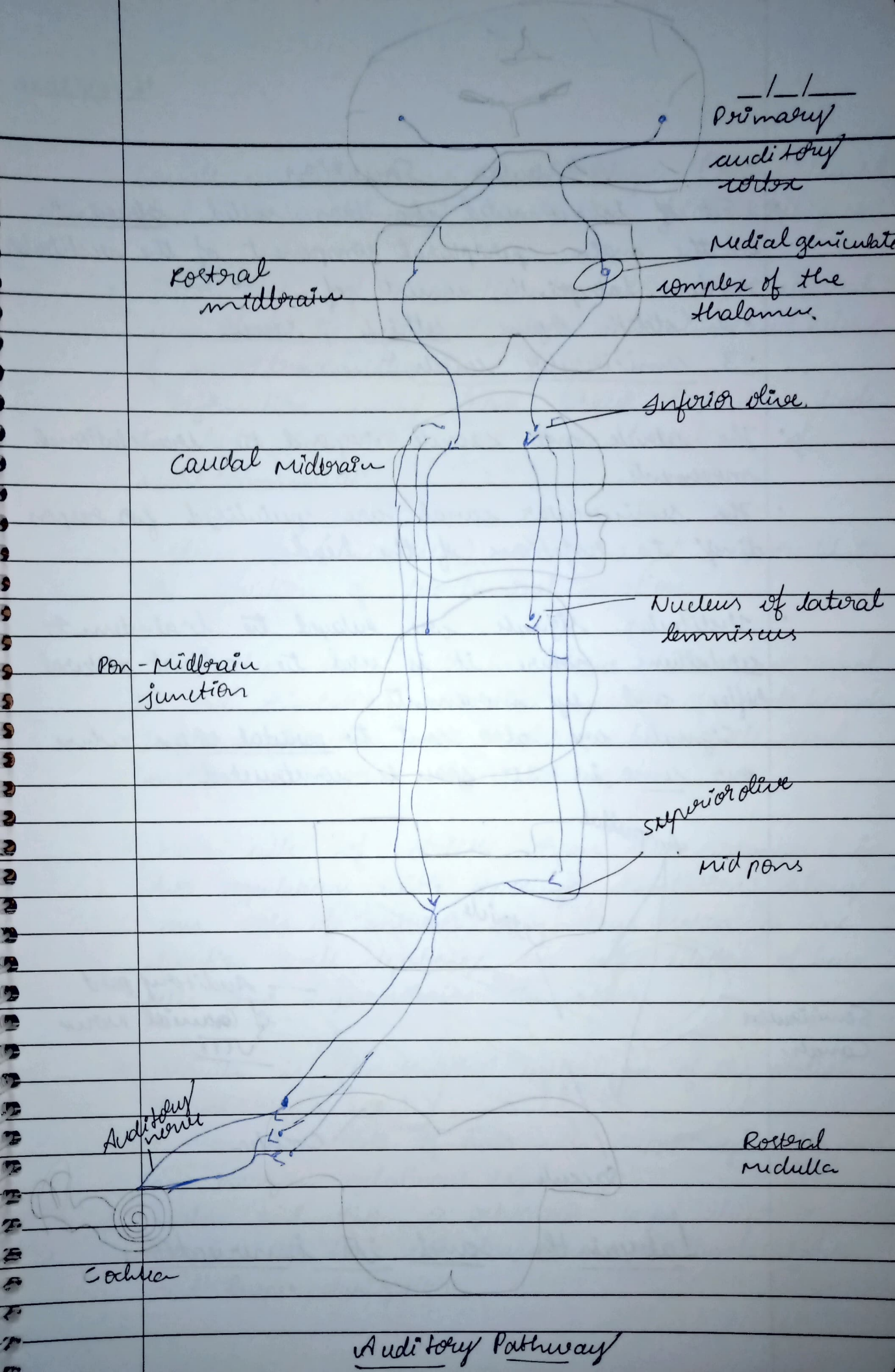
* Inferior colliculus: All lower auditory projections converge on the inferior colliculus.
  - For the first time in the auditory system a complete map of auditory space is computed in the inferior colliculus.

* Auditory thalamus:
  - Inferior colliculus projects to the medial geniculate complex
  - Sensitive to particular combinations of sound with distinct spectral and temporal characteristics.

* Auditory cortex:



  - Wernike's area - speech comprehension
  - For most of the people it is in left hemisphere
  - For music right hemisphere activation is high.



Auditory Pathway

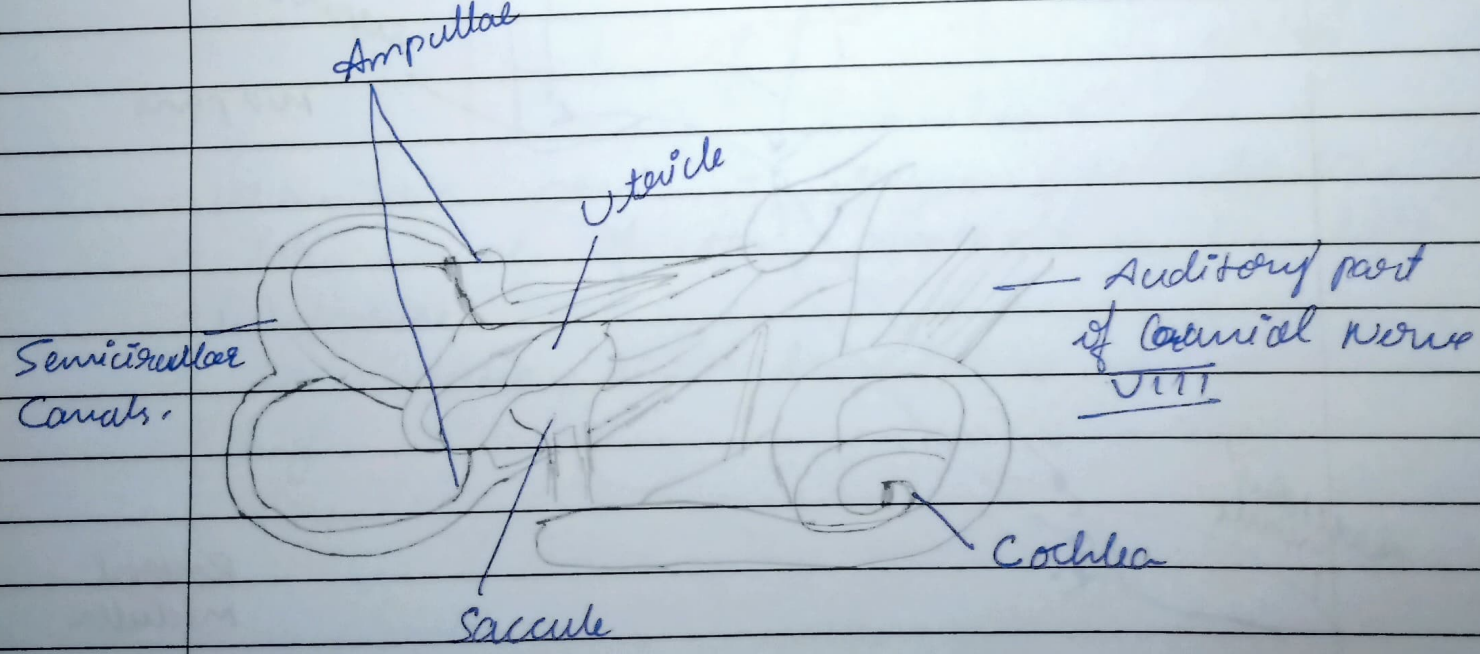
16/04/2020

Vestibular Sensation

* Set of interconnected chambers called labyrinth is the main peripheral component of the vestibular system. Labyrinth consists of
  - 2 otolith organs - utricle, saccule
  - 3 semicircular canals.

- The utricle and saccule respond to translational movements.
- The semicircular canal are specialized for respon - ding to rotations of the head.

- Vestibular signals are relayed to brainstem & cerebellum where it is used to adjust postural reflex and eye movements.
  Signals are also sent to parietal cortex where our sense in 3D space is constructed.



Labyrinth and its innervations

- Canals are filled with endolymph ($high\ K^+ / low\ Na^+$) and surrounded by perilymph ($low\ K^+ / high\ Na^+$)

- Deformation of stereocilia towards largest stereocil-ium leads to depolarization and increased release of neurotransmitter.
  Deformation away from largest stereocilium leads to hyperpolarization and decreased release of neurotransmitter.

- stereocilia (hair cells) are arranged in parallel to the direction of biochemical motion.

- Ampullar hair cells in stereocilia are arranged in one orientation so that motion of endolymph in one direction will depolarize hair cells, and motion in other hyperpolarize.

- Hair cells of otolith organ are arranged into two populations with opposing orientation along an axis of mirror symmetry. Motion in one direction will depolarize one subpopulation of hair cells and hyperpolarize the other.

* Macula is the sensory epithelium of the otolith organs.
  - Macula consists of hair cells, supporting cells and an overlying gelatinous layer.
  - when head tilts → gelatinous layer shift → displaces the hair cell stereocilium → depolarization and hyperpolarization.

__/__/____

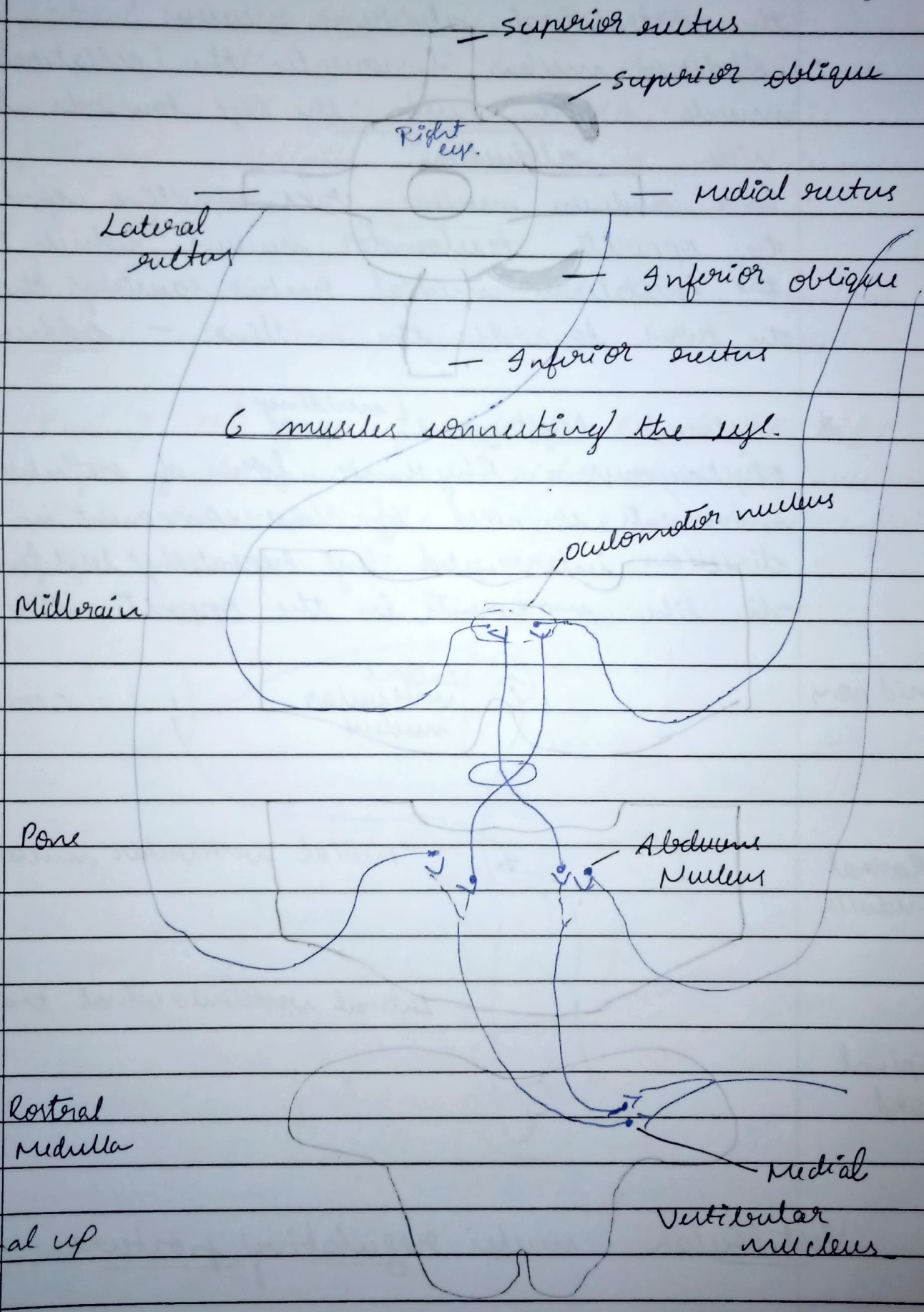
- Utricular maculae are oriented horizontally, since movements of head in the horizontal plane
- Saccular maculae are oriented roughly vertically, sense up and down movements of head

* Ampula holds the sensory epithelium of semi-circular canal. overlying gelatinous mass into which hair cell penetrate is called cupula

- when the head is rotated in the plane of the semicircular canal, the inertia of the endolymph produces a transient force that distends the cupula away from the direction of rotation. which leads to depolarization or hyperpolarization.

Central Vestibular Processing

- Vestibular system keeps the eye fixation when body and eye move. - Vestibulo Ocular Reflex

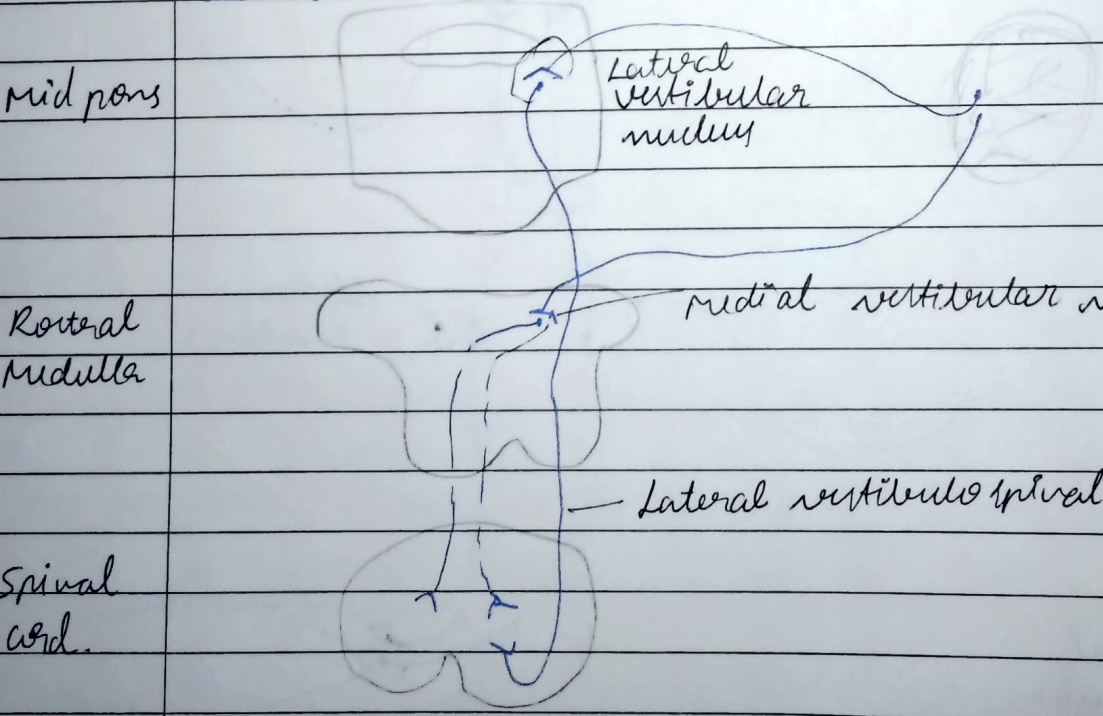


below

- Horizontal canals reaches the vestibular nuclei on the two sides of the medulla
- Vestibular nucleus sends excitatory projections to the contralateral abducens nucleus
- Abducens nucleus innervates the ipsilateral rectus muscle, which pulls the eye towards lateral side - abduction.
- Some abducens nucleus cross midline and project to opposite oculomotor nucleus, which innervates the ipsilateral medial rectus causing the eye to turn towards the midline - adduction.

* Vestibular Nystagmus (nodding)

Nystagmus = Rhythmic form of reflexive eye movements composed of slow component in one direction interrupted by repeatedly by fast saccadic like movements in the opposite direction



Vestibular nuclei regulating posture

Medial vestibulospinal projection to the upper cervical cord that regulate head and neck position

Lateral vestibulospinal projection to motor neurons in the medial ventral horn that excites extensor muscles in the trunk and limbs - This pathway mediates balance and maintainance of an upright posture

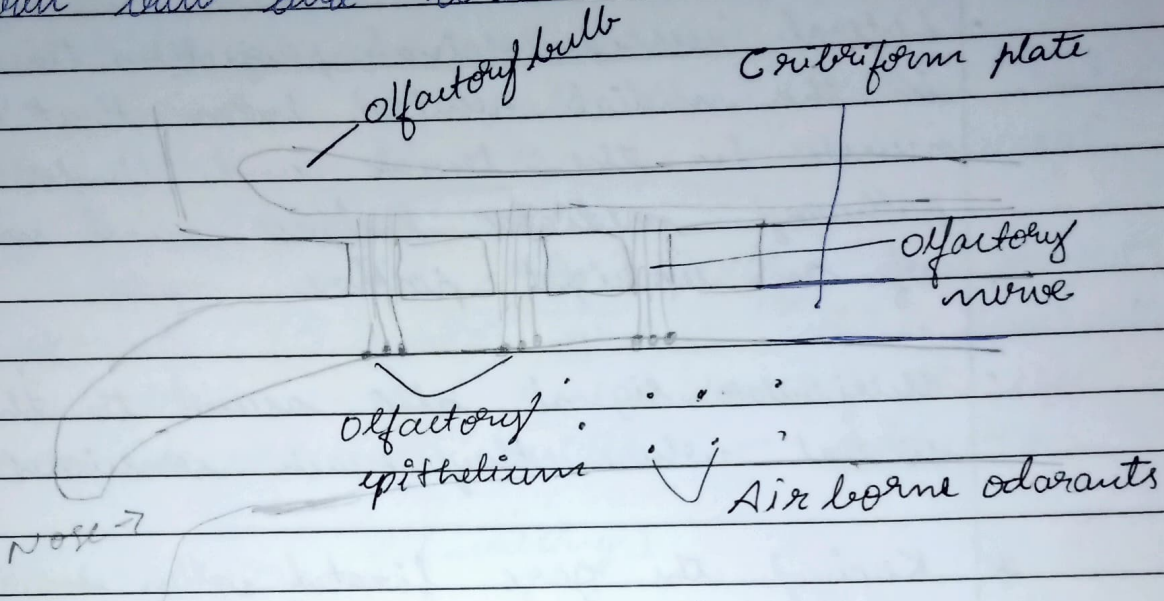
Vestibular signal also ascend to the cerebral cortex where they evoke conscious perception.

Keeping the gaze fixated when moving to right

The motor neurons in right oculomotor nucleus which innervate right medial rectus increase firing rate.

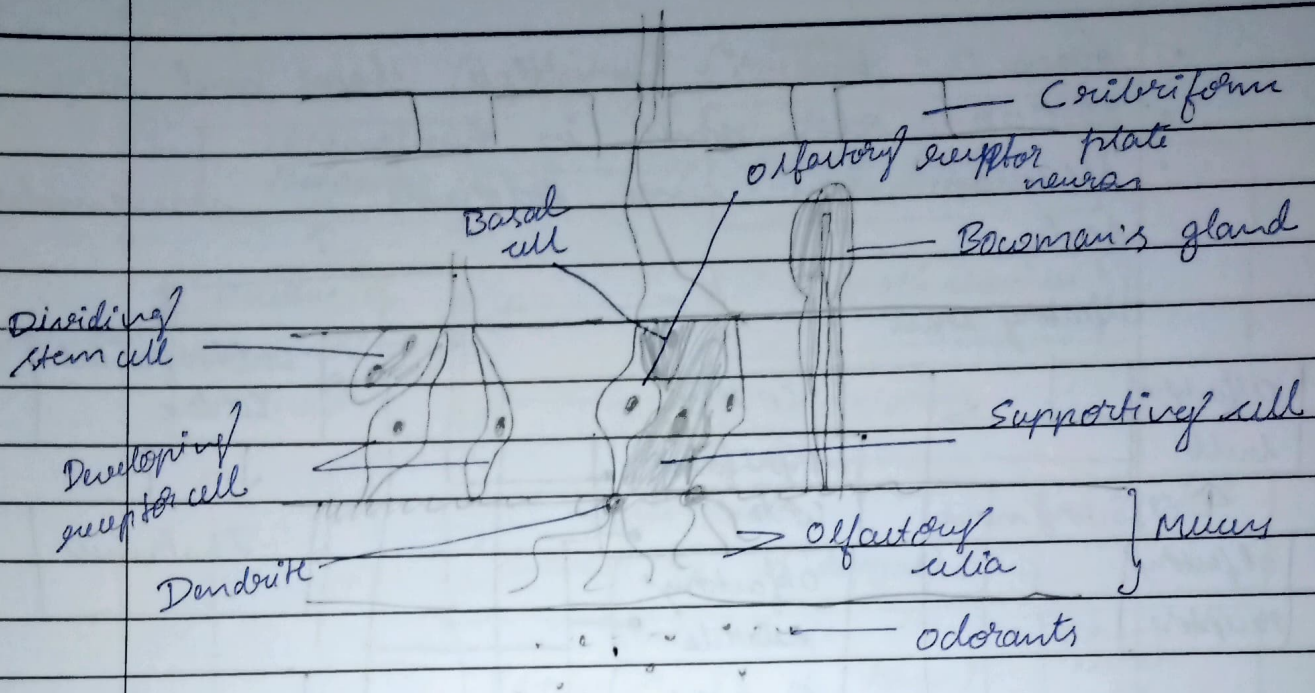
Chemical Senses - Olfaction

- Olfactory bulb is part of the brain.
- In olfactory system there is NO thalamic relay between bulb and cortex



Primary olfactory pathway

- Air borne molecules = odorants diffuse through mucus layer and interact with olfactory receptor neurons in the olfactory epithelium.
- Receptor cell axons to olfactory bulb.
- Mitral cells (projection neurons of olfactory bulb) to olfactory cortex
  - → Piriform cortex in junction of temporal and posterior frontal lobe.
  - → Olfactory tubercle - part of ventral striatum
  - → Cortical divisions of amygdala
  - → Entorhinal cortex - part of the hippocampal formation in para hippocampal gyrus.



Olfactory Epithelium

- odorants bind the specific molecular receptors located in the plasma membrane of the cilia
- Bowman's gland secretes mucus
- Dividing stem cells produce olfactory receptor neurons.

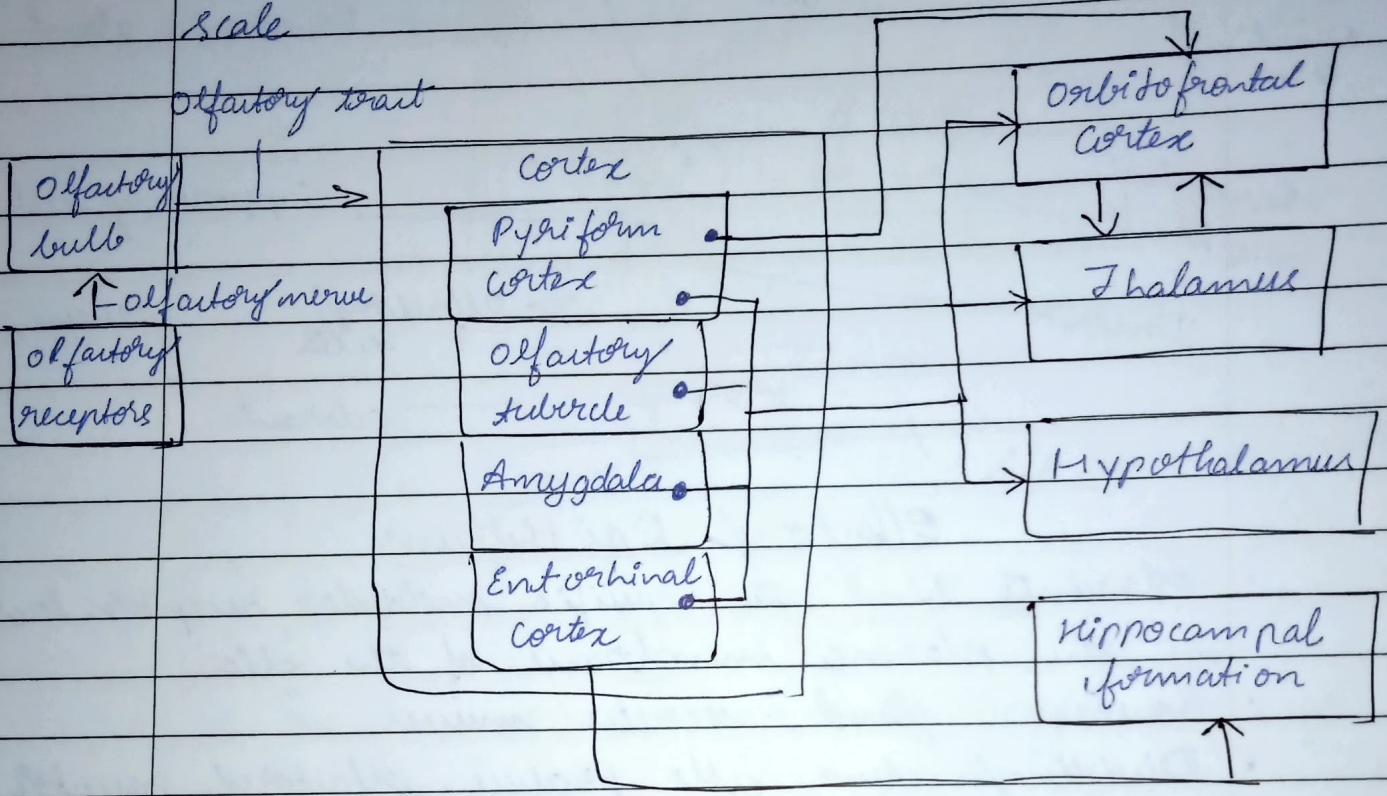
* Molecular reactions

- Odorant binding activates an olfactory G-protein
- This G-protein, in turn, activate an olfactory specific adenylate cyclase, which increase the production of cAMP.
- CAMP opens cation selective ion channels that allow influx of Na^+ and Ca^{+2} (depolarization)
- when threshold is reached action potentials are generated.

* Anosmia: loss of sense of smell

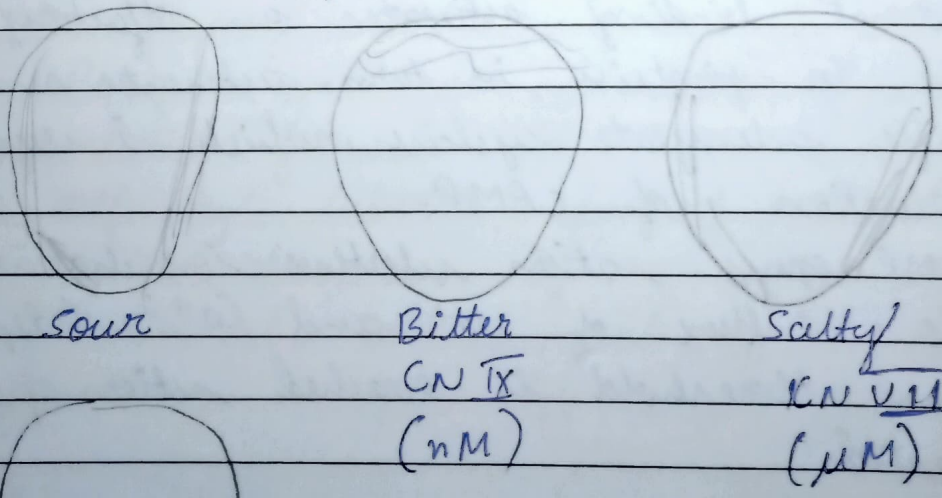
21/4/2020

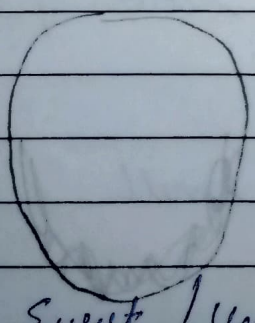
- odorants ~~does~~ come in multiple shapes and sizes
- 12,000 odor genes in humans
- Humans can sense odorants in nanomolar scale



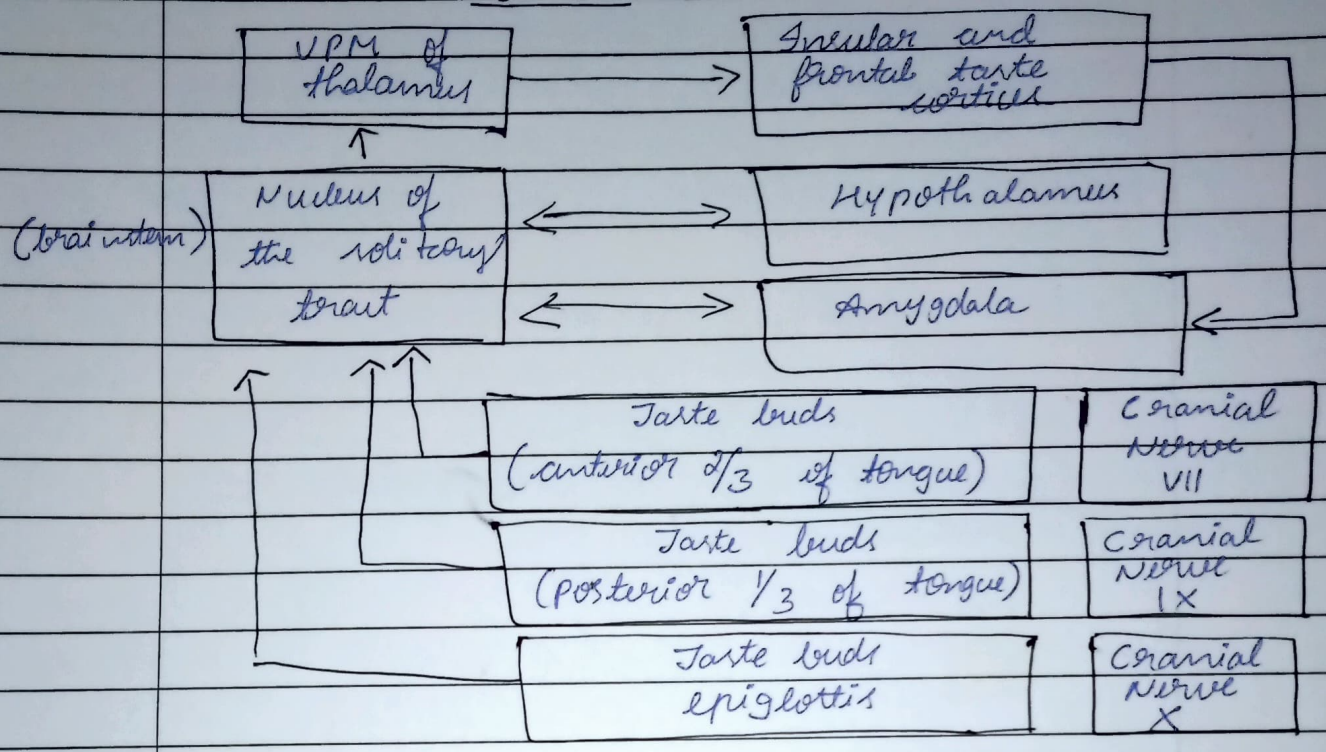
- Olfactory function declines with age.

* Topography of taste receptors.





Gustation (taste)



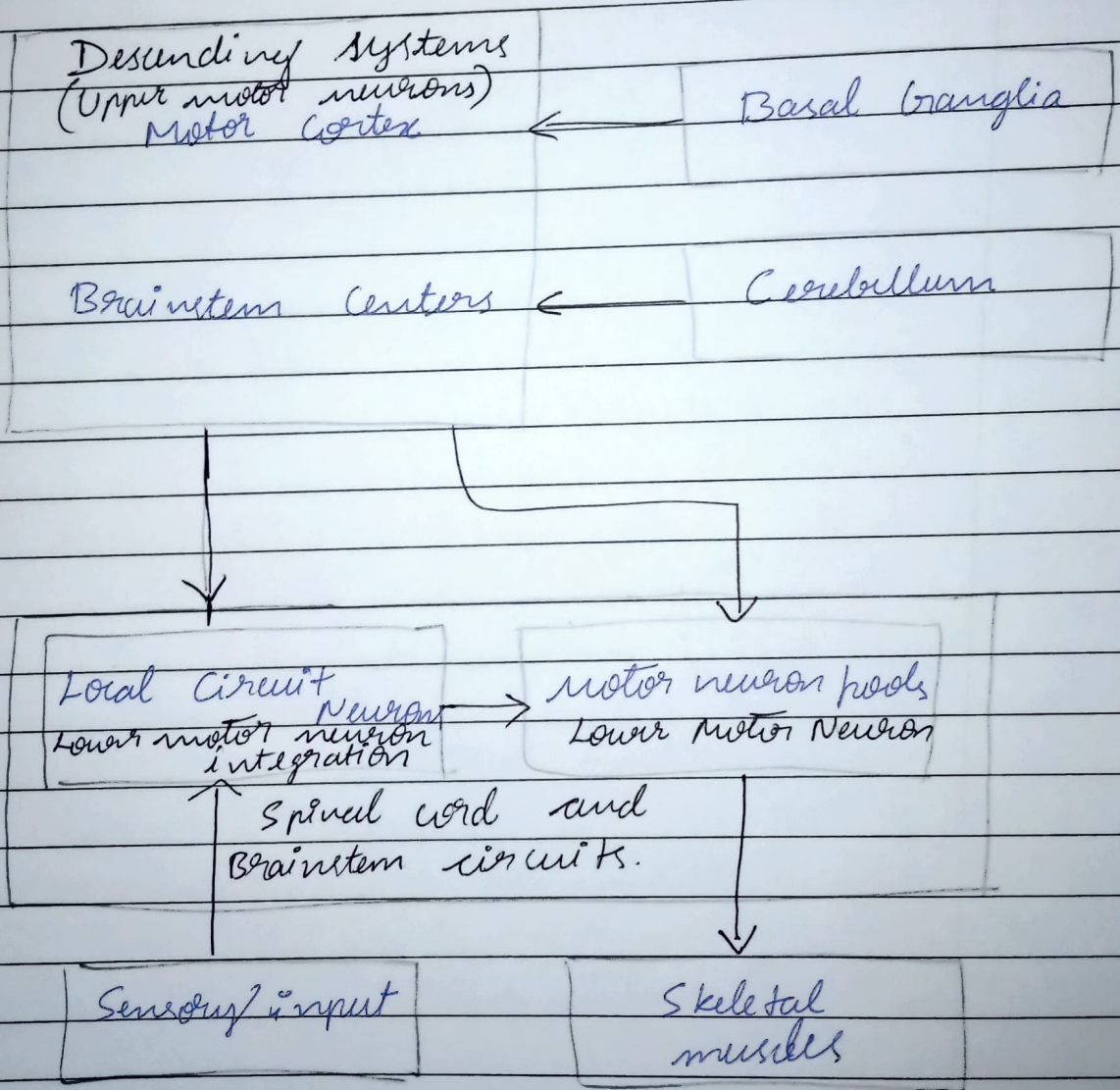
* Sensory transduction in taste cells
- Has apical and basal junction separated by domain junction.
- Salt and Sour tastants interact with receptor or ion channels. Here opening of Na^+ and closing of K^+ channel.
- Sweet and bitter tastants interact with G-protein coupled receptors that use second messengers to elevate intracellular Ca^{+2} concentration.
- Depolarization and elevated intracellular Ca^{+2} leads to the exocytosis of a chemical neuro-transmitter
- Neurotransmitter interacts with serotonin receptor and leads to action potential.

24/04/2021

Lower Motor Neuronal Control of Movement

* Visural motor system = Autonomic motor system
→ Sympathetic, parasympathetic, enteric division).
→ Autonomic ganglia nerves
→ Smooth muscles, cardiac muscles and glands.

* Somatic motor system -
→ motor nerves
→ skeletal muscles = striated muscles.



* Motor cortex: Planning, initiating and directing voluntary movements. - Pyramidal tract.
Involuntary movement - NO Pyramidal tract.

* Brainstem centers: Basic movements and postural control.

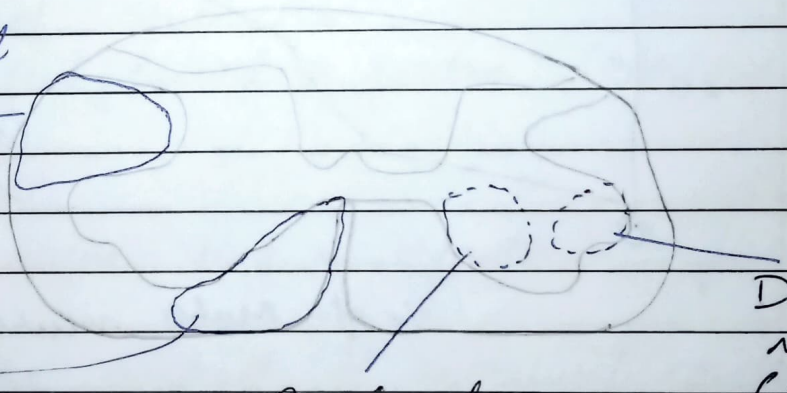
* Basal Ganglia: Grating proper initiation of movement.

* Cerebellum: Sensory motor co-ordination of ongoing movement.

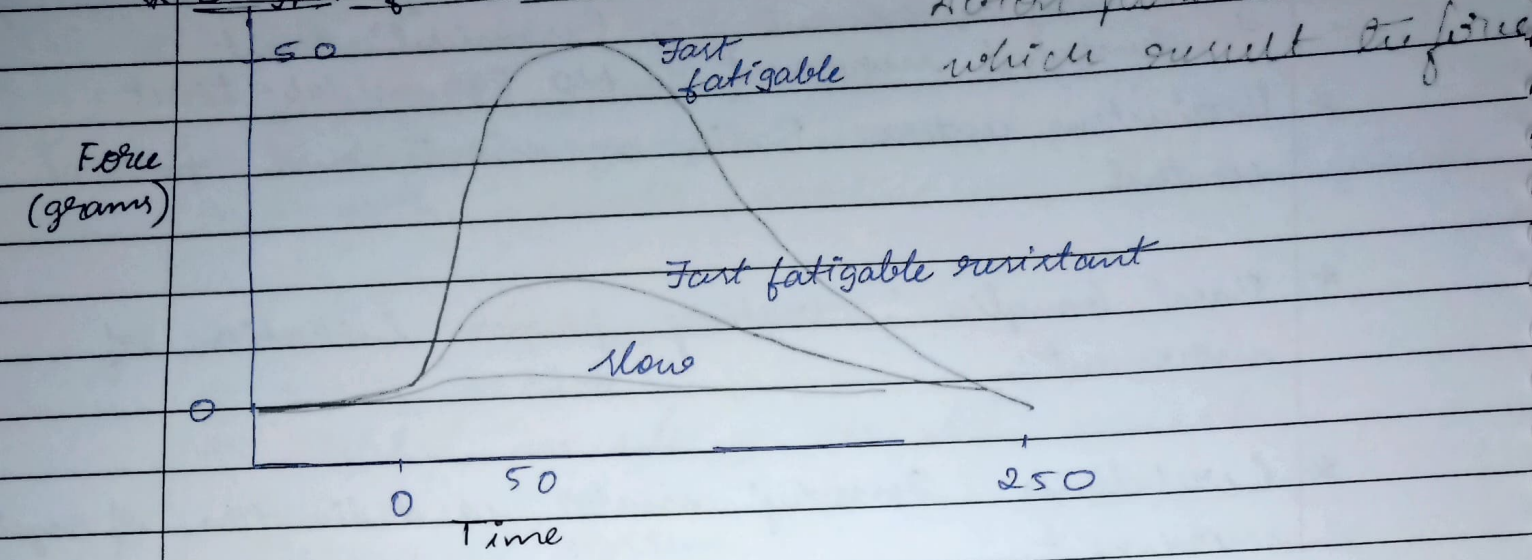
25/04/2020

Motor Unit

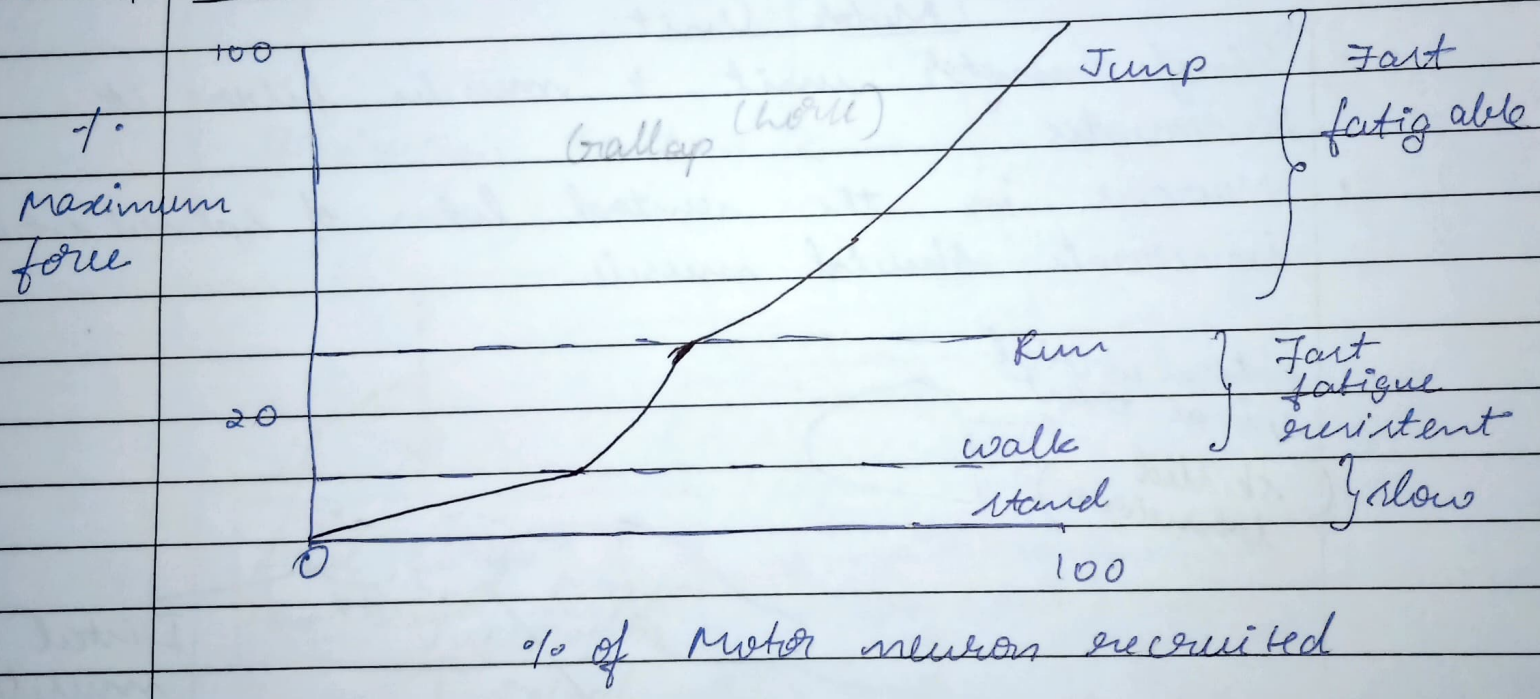
- "Single α motor unit + muscle fibers it innervates."
- Neurons in the ventral horn of spinal cord innervate skeletal muscle.



* 3 types of motor unit



* The size principle



Principle: Slow motor units are recruited first, then fast fatigue resistant motor units and finally fast fatigable motor units.

Segmental reflex

- Myotatic reflex = stretch reflex = deep tendon reflex
  - System that monitors and maintains the muscle length.
- Muscle spindles are in the skeletal muscle. In which intrafusal fibers are in parallel with extrafusal fibers
- Groups Ia afferant fibers innervate intrafusal fibers.
- Groups II afferant fibers innervate intrafusal fibers.
- Groups I afferant axon have large diameter ∴ fast action potential transduction.
- Groups Ia - Respond phasically
  Groups II - " Tonically
- γ motor neuron regulate the excitability

- Spindle provide feedback → Cerebellum. Regulate strength of contraction.
- Spindle feedforward → Cortex (conscious proprio-ception).

- Loss of muscle tone = "Hypotonia" → flaccid muscle

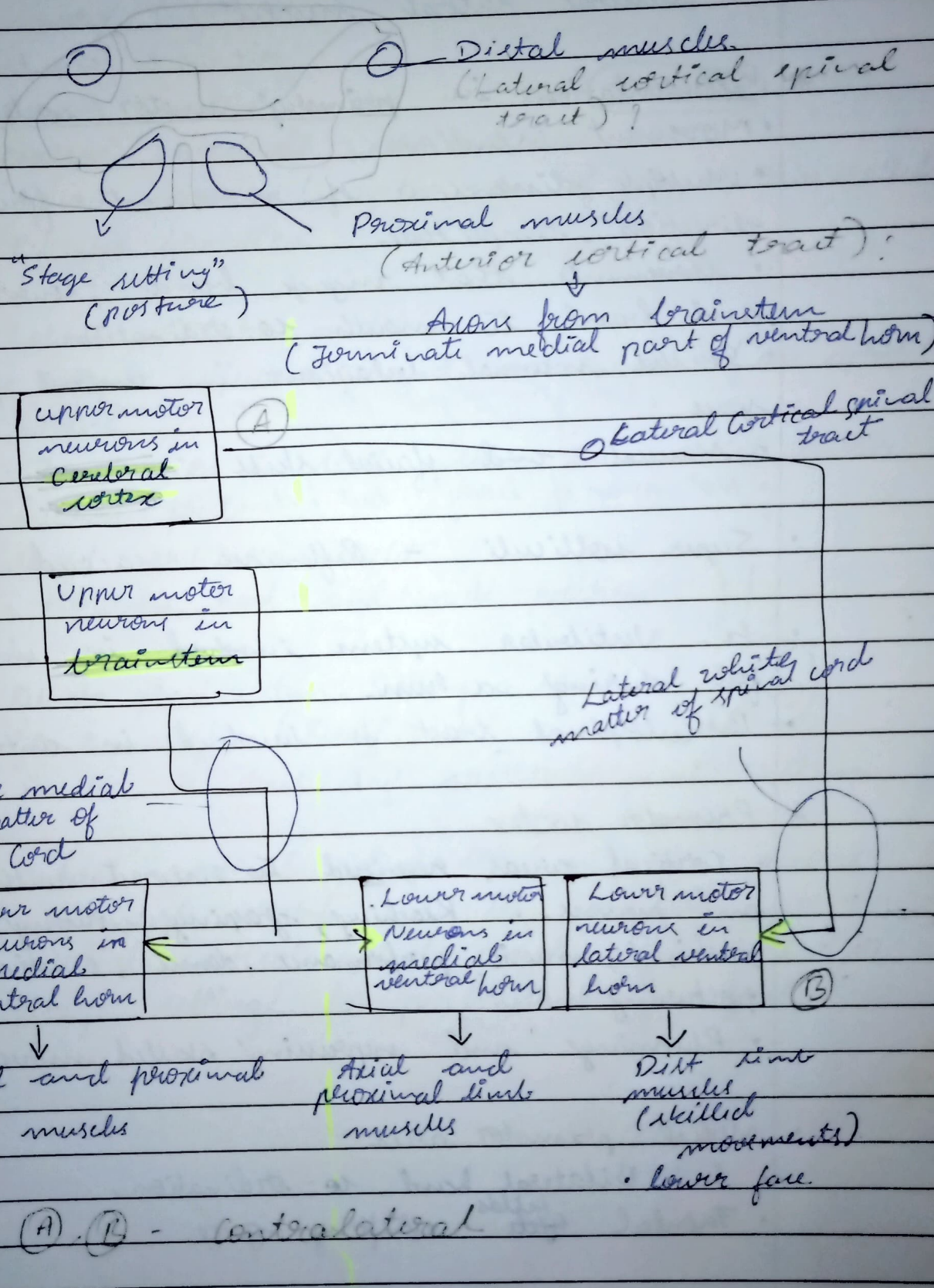
* Gain: The amount of extrafusal contraction elicited by a given stretch applied to the muscle.
- Gain adjustments may be made by alterations in the firing of gamma motor neurons
- Increase in muscle tone termed as hypertonia

- Motor cortex = Intention of movement.
- Brainstem = Stage setting.

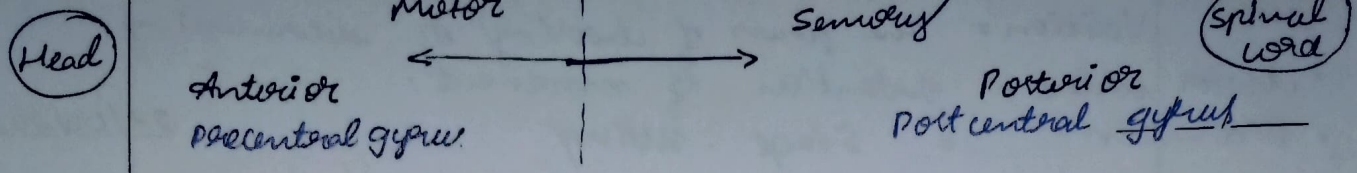
27/04/2021

Upper Motor Neuronal Control of movement

- Lower motor neuron = Final common pathway



(A) (B) - contralateral



- 2 nucleus of the thalamus which are primarily responsible for projections to the cortex
  - → Ventral anterior (VA) nucleus
  - → Ventral lateral (VL) nuclei.

anterior to precentral gyrus

* Representation in primary motor cortex -

- Movement intention - Precentral Gyrus.
- Multiple dimensions of movement - force, direction, amplitude.
- movements that engage hand, lower face and hand to-mouth co-ordination.
- Skilled manual behaviour in ventral personal space - Bringing object to our visual field
- Manual and facial skill
- Not map of body but intention.

- Superior colliculi - Reflexive saccad
- Ex: Vestibular system involved in the unexpected fall during a run.
- Reticulospinal tract is involved in anticipation

* Premotor cortex

- Cortical areas required to interact with objects and persons: Reaching, grasping, writing, gesturing, talking, music performance, dance, emotional posturing.
- Planning and expressing skilled movements

- Medial premotor area
- Ex: Bilateral hand co-ordination.
- Frontal eye fields shifting gaze.

Digit in anatomy means fingers or toes.

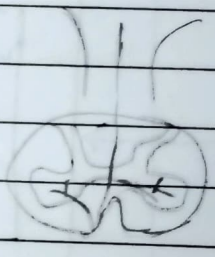
__/__/____

- Lateral premotor area
- Imitation learning.
- Organizing movements that are guided by sensory information.

* Motor control centers in the brainstem
① → Neurons associated with vestibular nuclei.
② → Neurons associated with core of tegmentum called Reticular formation

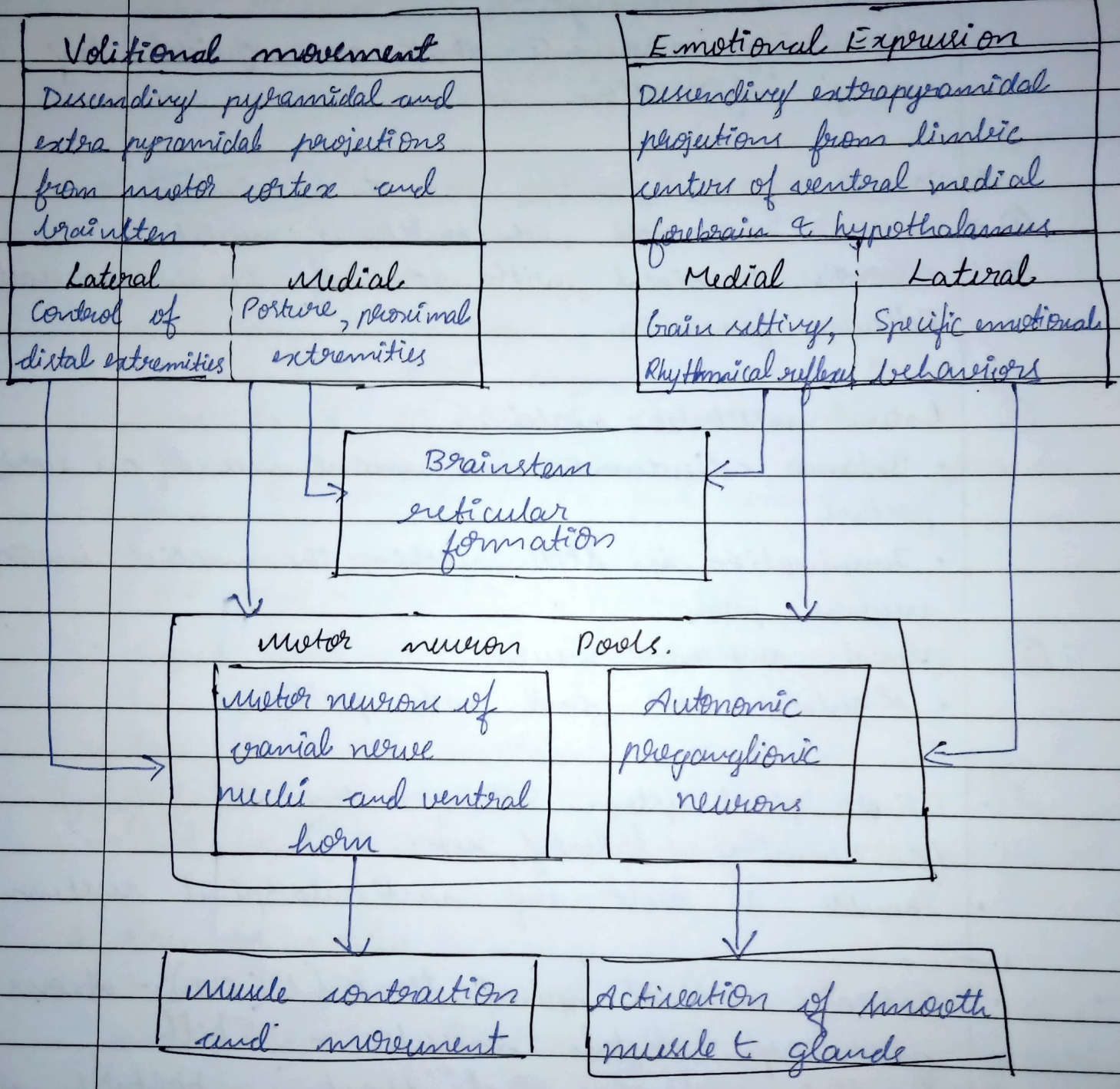
① Lateral vestibular nuclei:
- Balance adjustments and maintenance of an upright posture
- Termination is still within the medial motor neuron pool.

② Medial vestibular nuclei
- Regulates head and neck position



Example:
- Reticulo spinal system: Setting a tone for running (Ready, set ...).
- Stumble is dealt by vestibulospinal system.
- Lateral vertical spinal tract (LCST) - Axons governing distal muscles. - Skill
- Medial vertical spinal tract: posture or stage setting for performance of skill

Motor control - Parallel pathway



17/10/2021

Medical Neuroscience Course - Revision

* Reticular theory: Camillo Golgi was the main proponent. "Neurons formed a continuum, by physically conjoined into a single network or reticulum. - Theory was wrong.

* Neuron doctrine: Santiago Ramón y Cajal and Charles Sherrington were the main proponents. "Nerve cells are discrete entities, and they communicate with one another by means of specialized contacts are not continuum".

* organelle -> Subcellular structure. One/many/some of all organelle,
  -> Nucleus: which store genetic information
  -> Mitochondria: which produces chemical energy
  -> Ribosomes: which assembles proteins.