"Mitosis" = Method of cell division.

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body of the lateral ventricle

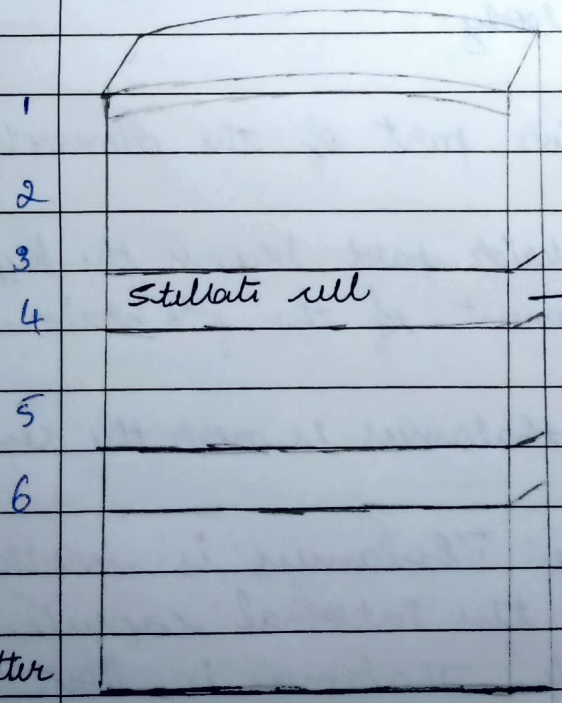
- Anterior group nucleus projects to cingulate gyrus.
- Medial group projects to anterior frontal lobe in the front of the motor cortex (prefrontal cortex), the insula and the medial temporal lobe.
- Lateral group projects to different regions of the remaining sensory and motor regions of the cerebral cortex in each lobe

-> Thalamus relay information from/to somatic sensation, audition, vision, modulation of movement.

* Overview and origins of Cortical circuits

=> We had twice as many neurons when were in early embryonical life when compared to adult brain

-> Neuronal precursors = neuroblast.



Brainstem modulatory systems : Layer 1, 2, 3, 4, 5, 6.

Other cortical areas : Layer 1, 2, 4

→ Thalamus : Layer 4 (Granular)

Layer 4 to upper : Supragranular.

Layer 5 to lower : Infragranular.

Layer 5 projects to basal ganglia

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* Cortical columns function: (Cortical microcircuit)

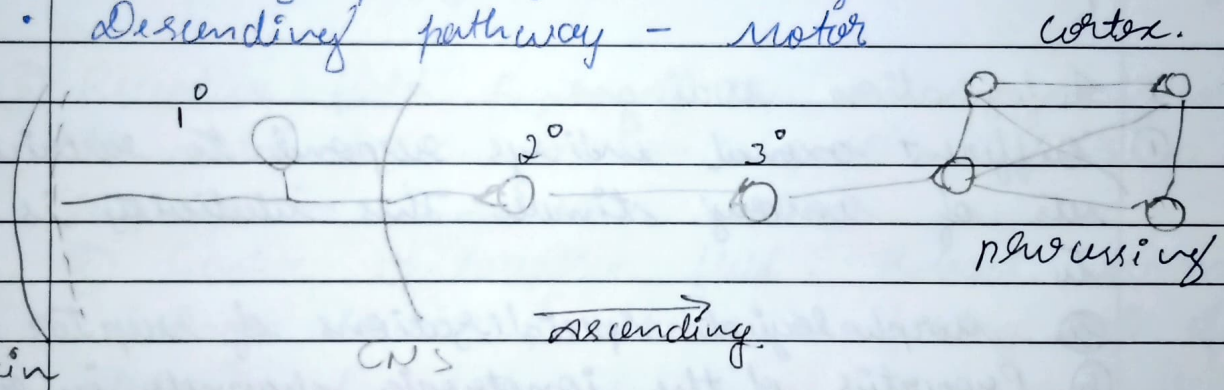
A - Amplification.
C - Computation.
C - Communication

→ Paleocortex: Piriform cortex
Archicortex: Hippocampus

→ "Cytoarchitecture" refers to the cellular composition of neural tissue.

* Neuronal pathways:

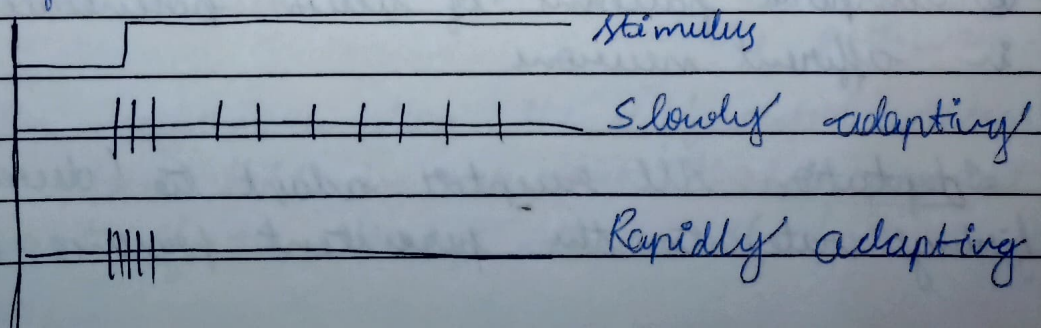
- Ascending pathway - sensory
- Descending pathway - motor



→ Post central gyrus - ascending.
Pre-central gyrus - descending.

→ Receptor ending: Pacinian corpuscle has a nerve ending with cation selective ion channel which open when there is mechanical force.

* Information adaptation



Antagonist (Physiology): A muscle that acts in opposition to another.

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→ larger receptive field ⇒ high convergence

⇒ High sensory acuity: Densely innervated sensory surfaces and small receptive fields.

* Somatic sensory system:

① Application of external stimulus deforms the skin and sensory receptors embedded within it.

② Physical deformation of receptors opens ion channels and sodium flows into the receptor ending.

③ This sodium current flow depolarizes receptor membrane producing a receptor (or generator) potential.

* Information coding.

① Different axonal endings respond to restricted sets of sensory stimuli. This selectivity is due to.

ⓐ Morphological specializations of receptor endings.

ⓑ Properties of the ionotropic channels in receptor membranes.

This selectivity is conveyed and preserved in parallel pathway in the CNS.

② Strength of the stimulus is encoded by.

ⓐ Rate of action potentials in the afferent neurons.

ⓑ Temporal patterns of action potentials fired in afferent neurons

③ Adaptation: All receptor adapt to (decrease in firing rate) to the persistent presence of a stimulus.

In neural tissue, Nissl substance is rough endoplasmic reticulum, Nissl substance is found in cell bodies and in the proximal dendrites of the largest / / neurons in neural tissue.

a. Some adapt slowly and display tonic firing/ firing patterns (more static qualities).
b. others adapt rapidly and display phasic firing patterns (more dynamic qualities).

④ Sensory threshold: All receptor have sensory threshold for firing action potentials. "Threshold" is the strength of mechanical deformation necessary for producing a generator potential of sufficient amplitude to elicit an action potential.
ⓐ Some have low threshold (ex: Encapsulated endings)
ⓑ others have high threshold (ex: Free nerve endings).

⑤ Receptive field: Region of the sensory body when stimulated by a mechanical stress elicits a response in a sensory neuron.
ⓐ Center of receptive field: Robust response (sharp increase / decrease in firing rate of the neuron). of center
ⓑ Surround of receptive field: Annular/surround antagonize the center zone.

→ Primary neurons:
receptive field size $\propto \frac{1}{\text{density of peripheral processes (receptors)}}$

→ Neurons in cortex:
receptive field size $\propto$ degree of convergence in sensory pathways.

→ In mechanosensation, the differential sizes of the receptive fields in neurons that represent different part of the body accounts for the differences

Thalamus - Grey matter

__/__/__

in 2 point discrimination along the body surface

* "In cerebral cortex, cognitive factors like attention and stress may modify the size and sensitivity of receptive fields."

* Thalamus
a. Dorsal aspect of Diencephalon
b. Superior to hypothalamus
c. Medial to fibers from genu and posterior limb of the internal capsule.

* 3 conventional parts of thalamus:
① Epithalamus: Dorsal medial aspect of thalamus
→ Pineal gland is attached.

② Subthalamus: Porterior to hypothalamus. ~~where~~
→ Modulates output of basal ganglia.

③ Dorsal thalamus: Simply called thalamus.
→ Procreation of sensory signal.

→ Thalamus acts as relay station for sensory and motor signals to specific area of cerebral cortex with an exception of olfactory cortex which receives inputs directly from olfactory bulb.

→ "Thalamic projection" target middle layers of the cerebral cortex where they serve to drive or sharply modulate activity in local columnar circuits of cortical neurons".

"viscera": Internal organs in the main cavities of the body, especially those in the abdomen.

18/11/2020

Somatic Sensation

3 principal categories of sensation

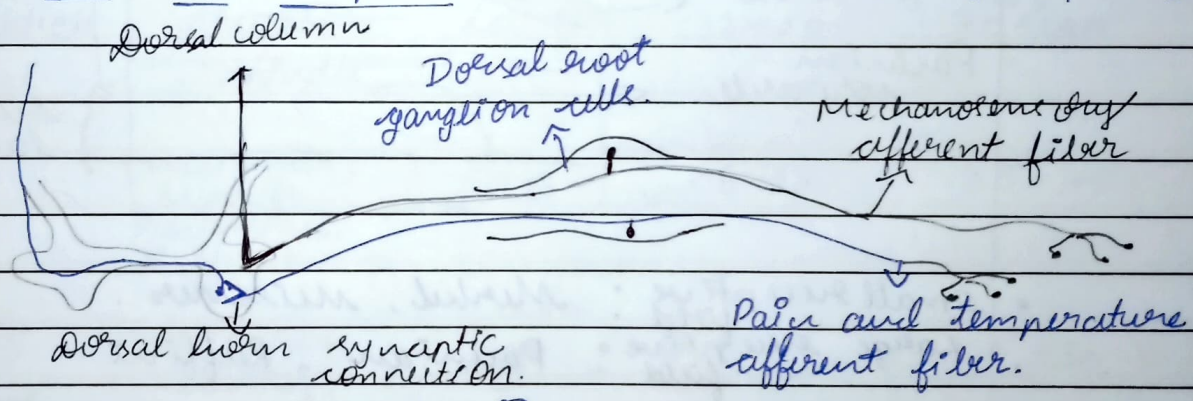
① Interoception: Perception of internal state of visceral organs of the body

② Exteroception: Perception of the external world mediated by our special sensory systems.

③ Proprioception: Perception of movement derived from specialized sensory elements in muscles, tendons and joints. (Sense of self)

① * Mechano sensation: Shape, texture with our skin. Forces acting on / within the body.

② Pain and temperature: (Nociception = pain perception)



Dorsal root Nucleus ← ⊙ → Body

Spinal cord

-> Neurons in the dorsal root ganglia - body

-> Neurons in the cranial nerve ganglia - head

-> In somatosensory system stimulus alters the permeability of cation channel in the afferent nerve. (receptor potential).

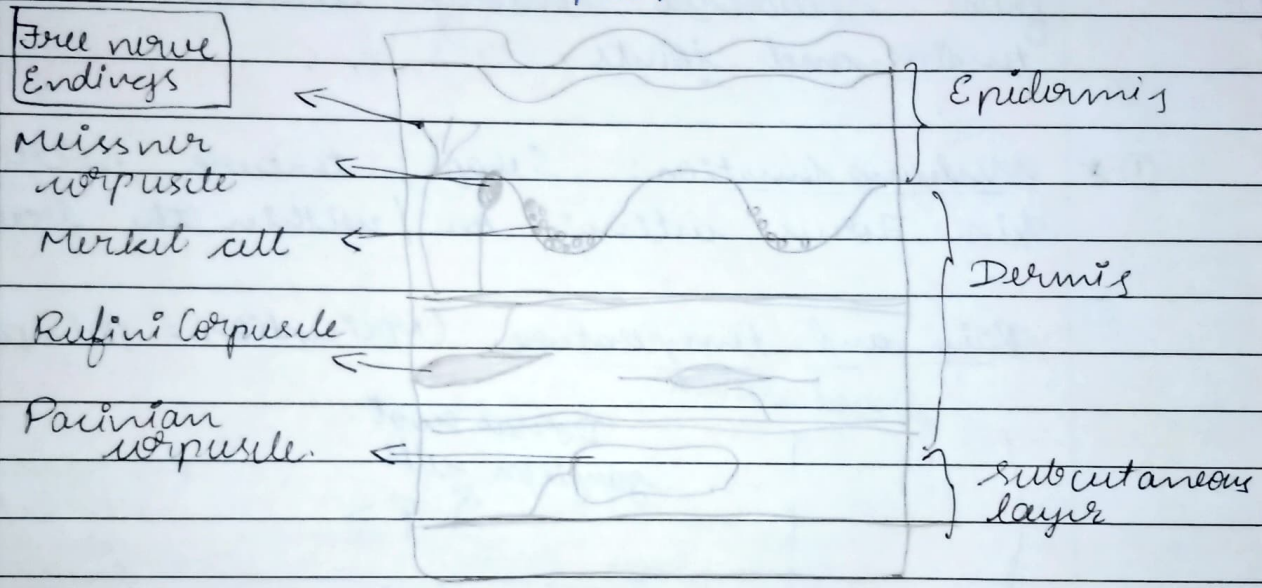
__/__/____

-> Free nerve ending: Afferent fibers lacking receptor cells.

-> Dense innervation $\propto \frac{1}{\text{receptive field size}}$

* Sensory nerve ending

Light touch signals: Meissner corpuscle, Merkel cell neurite complex.



- Small receptive field: Merkel, Meissner.
- Large receptive field: Pacinian, Ruffini.

- Merkel: Edges, points, corners, curvature
- Meissner: Skin motion
- Pacinian: vibration
- Ruffini: Skin stretch.

-> Primary sensory cortex is the first part of cortex to receive info about mechanosensation

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* Sensory pathways

(A) Face (anterior portion of the head)

- Mechanosensation: Pathway through chief/principal sensory nucleus of trigeminal complex
- Pain and temperature: Pathway through spinal nucleus of trigeminal complex.

(B) Post cranial body (below face/head & posterior head)

- Mechano sensation: Dorsal column medial lemniscal system
- Pain and temperature: anterolateral system (a visceral pathway).

* Somatosensory Afferents that link receptors to the CNS

Sensory function	Receptor type	Axon type	Axon dia um	Conduction velocity m/s
Proprioception	Muscle spindle	Ia, II	13-20	80-120
Touch	Meissner, Merkel, Pacinian, Ruffini	Aβ	6-12	35-75.
Pain, Temperature	Free nerve ending.	Aδ (delta)	1-5	5-30
Pain, temperature, itch, non-discriminatory touch	Free nerve endings	C	0.2-1.5	0.5-2

→ Cutaneous mechanoreceptors provide information derived from external stimuli.

* "Proprioceptors" provide information about mechanical forces arising within the body, particularly from the musculoskeletal system.

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→ Proprioceptors continuously provide info about position of limb and other body parts in space.
Ex: Muscle spindles, Golgi tendon organs and joint receptors.

① Muscle spindle: (Found in striated muscles).
- Small number of intrafusal muscle fibres are surrounded by extrafusal striated muscle.
- Primary sensory endings from group Ia and group II afferent fibers encircle intrafusal fibers.
- Both are stimulated by stretch applied to the muscle spindle

② Golgi tendon organs: (low threshold).
- Free nerve endings of group Ib afferent fibers that are woven into the matrix of collagen fibrils in tendons.
- Sense of force / tension generated by muscle contraction.

③ Joint receptors:
- Mechanosensory afferents distributed around joints.
- Sense of fingers, joints.

* Somatic sensory thalamus
ventral posterior complex is the thalamic division that processes mechanosensory system.
a. Ventral posterior lateral nucleus: Posterior head and receives info about/from body.
b. Ventral posterior medial nucleus: Anterior head and receives info from the face.

Ventral posterior complex → Primary somatic sensory cortex.

* Somatic sensory cortex (located in posterior bank of central sulcus).
- Brodmann's areas included.

a. Area 3a: Responds to proper proprioceptors.
b. Area 3b: " " Cutaneous stimuli.
c. Area 1: " " complex cutaneous stimuli.
d. Area 2: " " both complex tactile and proprioceptive stimuli.

20/11/2020 Mechanosensory Pathways

* 3 neurons are involved in mechanosensation [skin → cortex]

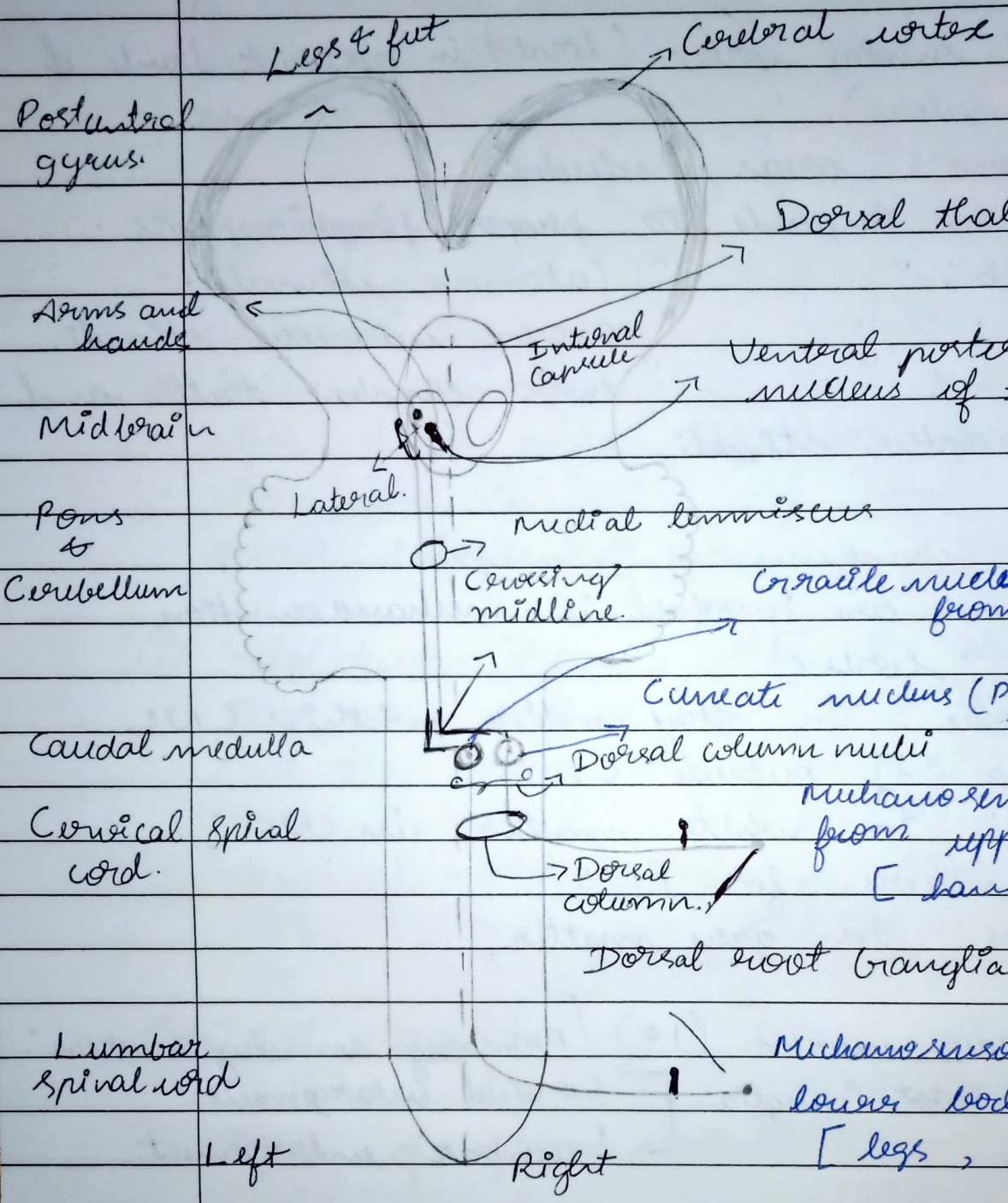
⇒ Cell bodies: In grey matter within CNS. Ganglia if outside CNS.
⇒ Axons: In white matter in CNS; In nerves for PNS
⇒ Synapses: In grey matter.

Cervical & Lumbar: First order neuron (1°) / Primary sensory neuron: Dorsal root Ganglia → Cervical enlargement / → Lumbar enlargement

Caudal Medulla: Second order neuron (2°). [Contralateral sup^n]. decussation ← Crossing midline

Thalamus: Third order neuron (3°): In ventral posterior lateral nucleus of thalamus (VPL).

Cortex: Next to post central gyrus.



Dorsal column - medial lemniscal pathway - Carrying mechanosensory info from posterior head and lower body and upper body.

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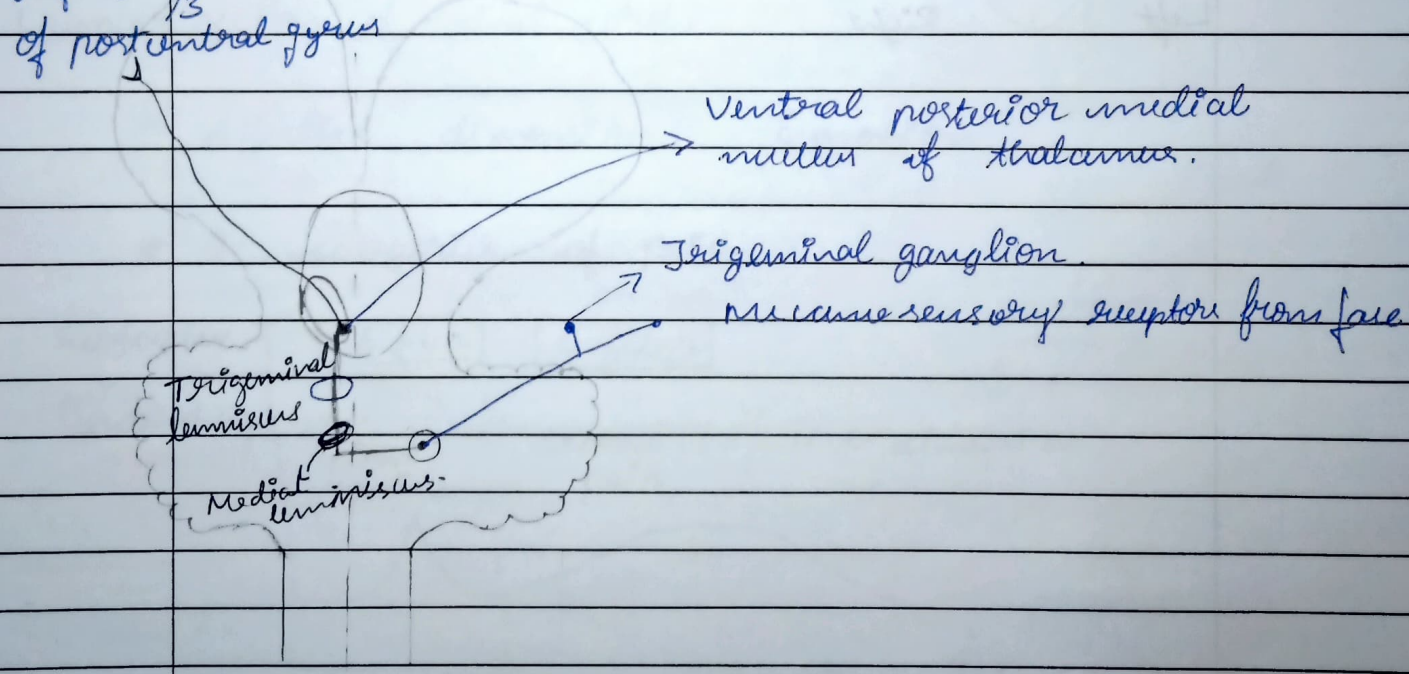
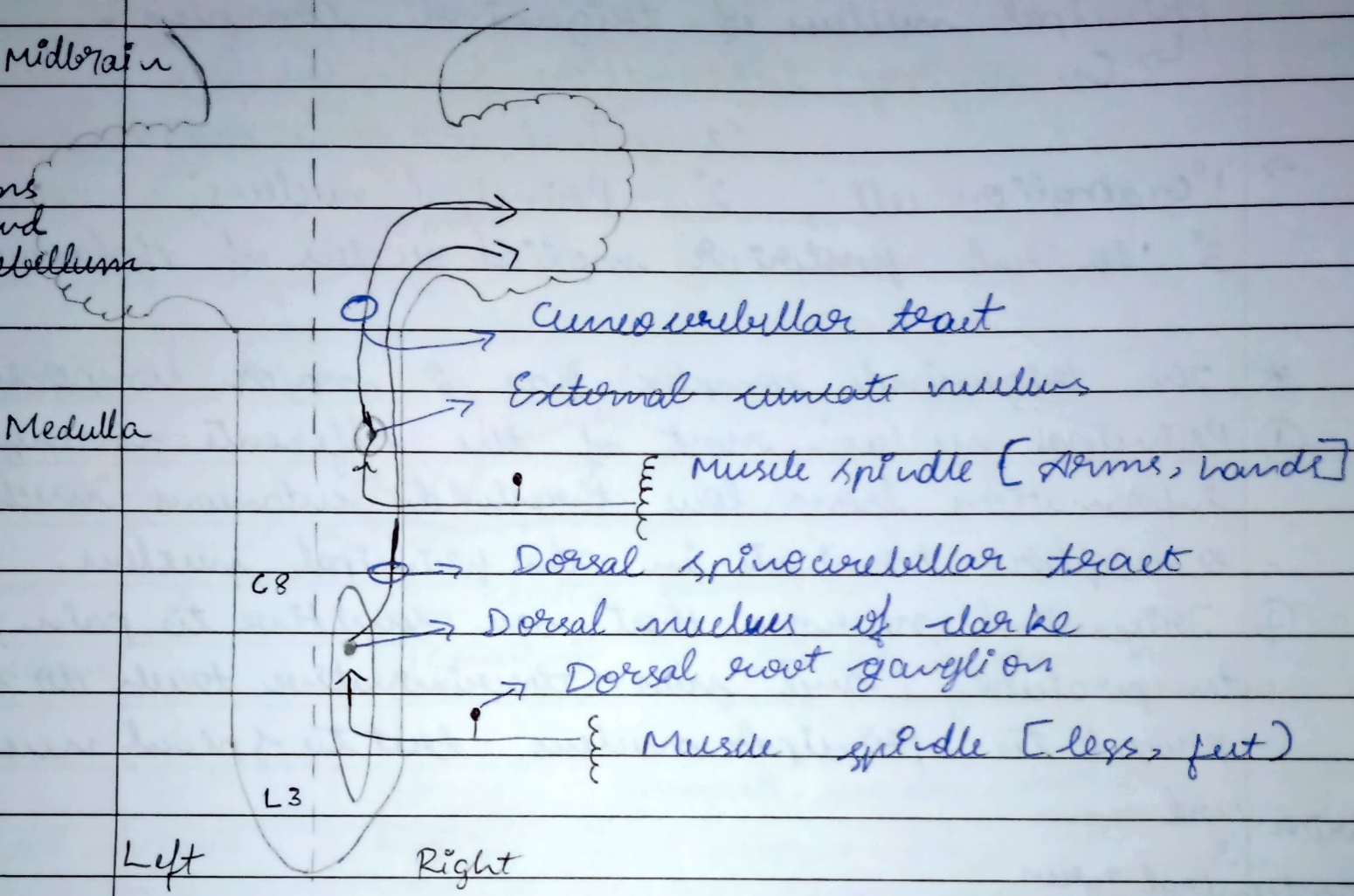
* Trigeminal lemniscus pathway / Pathway of chief / principal nucleus of trigeminal complex:
↳ Conveying information from the face.
(trigeminal brainstem complex).

→ 1° Gasserian ganglion cell; 2° - Principal nucleus; 3° Ventral posterior medial nucleus of thalamus.

* The trigeminal complex has 2 major components
① Principal nucleus: Most of the afferents conveying information from low threshold cutaneous mechano-receptors terminate in the principal nucleus.
② Trigeminal neurons that are sensitive to pain, temperature, and non-discriminative touch do not project to principal nucleus but to spinal nucleus.



The trigeminal portion of the mechanosensory system


Midbrain
Medulla
C8
L3
Left
Right
Cuneocerebellar tract
External cuneate nucleus
Muscle spindle [Arms, hands]
Dorsal spinocerebellar tract
Dorsal nucleus of clarke
Dorsal root ganglion
Muscle spindle [legs, feet]

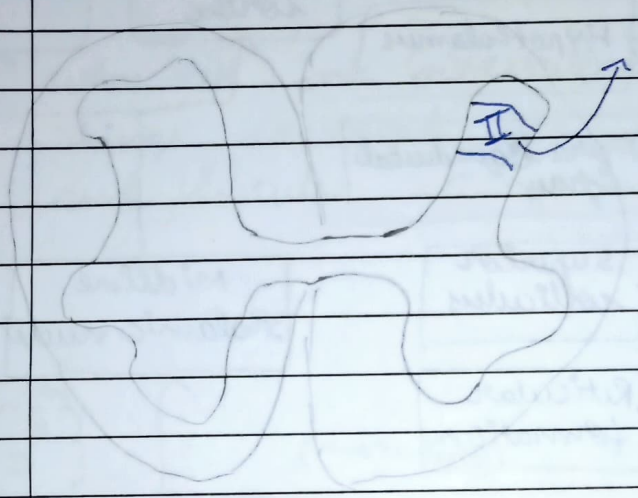
20/11/2020

Pain systems

→ Pain and temperature axon: Aδ, C

→ C fibres are polymodal (thermal, mechanical and chemical stimuli).

Ends of axon found here is Transient receptor potential family [TRP channels]



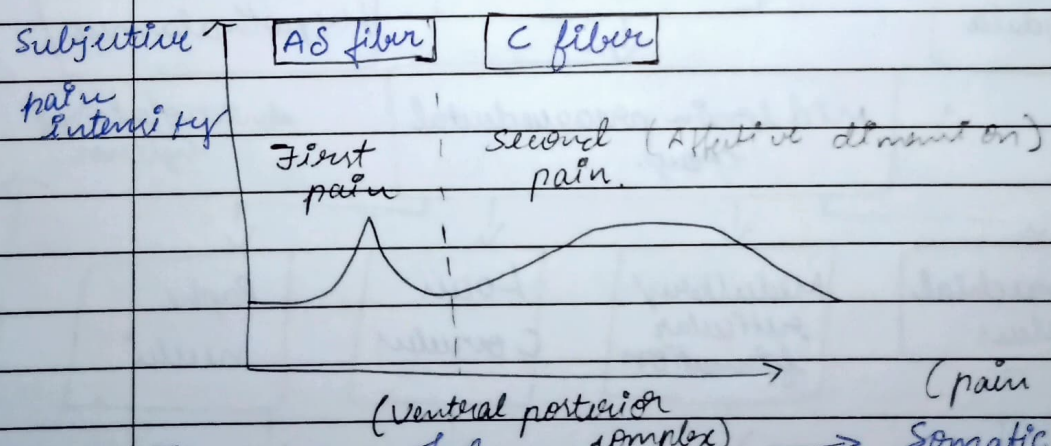
Pain: Substantia gelatinosa.

- C fibers
- Aδ more deeply at the base of the dorsal horn

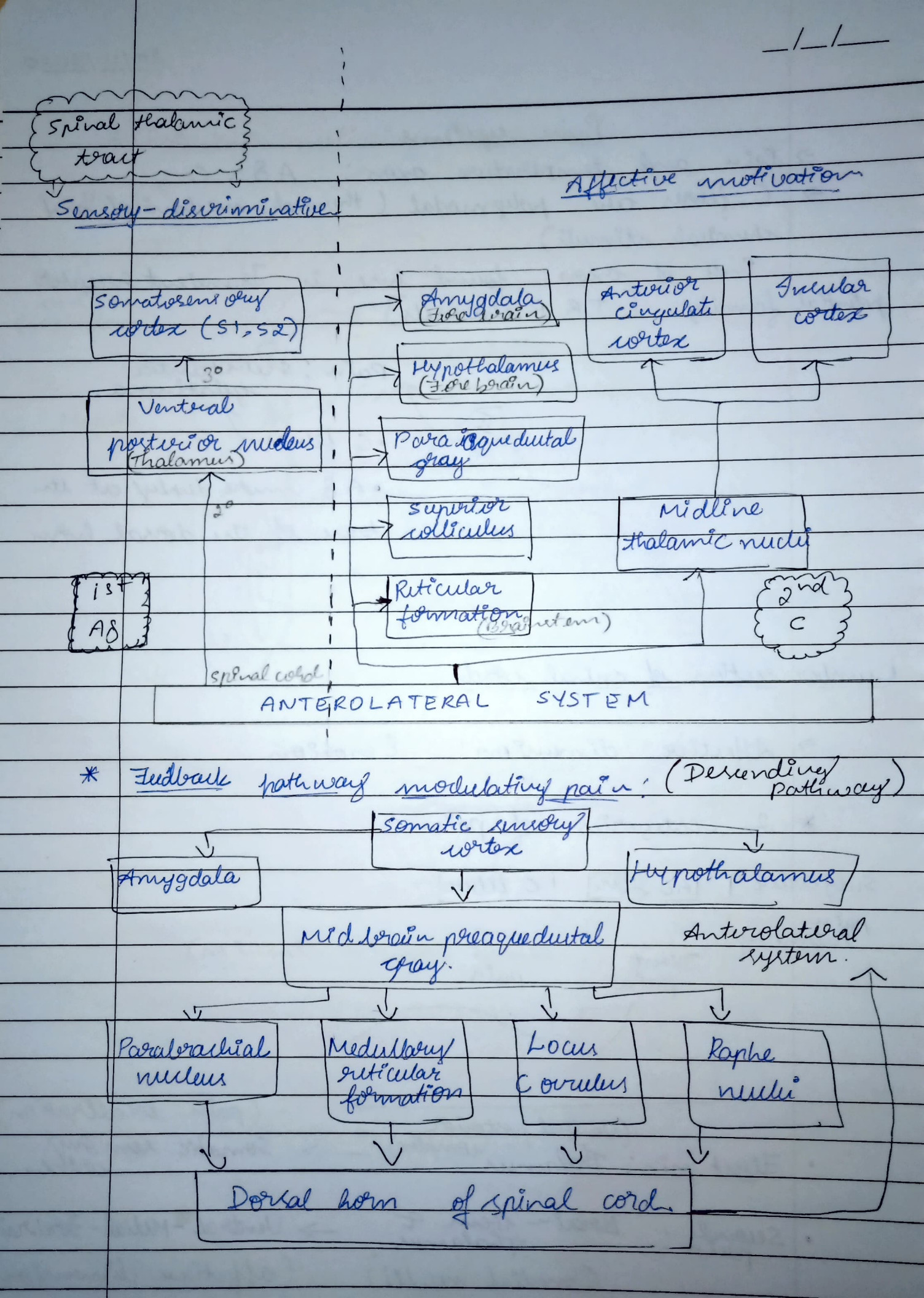
Lumbar section of spinal cord

→ Affective dimension: Emotion

* 2 categories of pain



- First pain: Thalamus (ventral posterior complex) → Somatic sensory cortex.
- Second pain: Brain stem & Thalamus (medial nuclei) → Ventral-Medial-Forebrain (affective dimensions)


Spinal thalamic tract
Sensory-discriminative
Affective motivation
Somatosensory cortex (S1, S2)
3°
Ventral posterior nucleus (Thalamus)
2°
1st Aδ
spinal cord
Amygdala (Forebrain)
Hypothalamus (Forebrain)
Paraaqueductal gray
superior colliculus
Reticular formation (Brainstem)
Anterior cingulate cortex
Insular cortex
Midline thalamic nuclei
2nd C
ANTEROLATERAL SYSTEM
* Feedback pathway modulating pain: (Descending pathway)
Somatic sensory cortex
Amygdala
Hypothalamus
Midbrain preaqueductal gray.
Anterolateral system.
Parabrachial nucleus
Medullary reticular formation
Locus Coeruleus
Raphe nuclei
Dorsal horn of spinal cord.

__/__/___

* Axons responding to pain

① Aδ mechanosensitive nociceptors. (lightly myelinated)

② Aδ mechano thermal nociceptors. " "

③ C polymodal nociceptor. (unmyelinated).

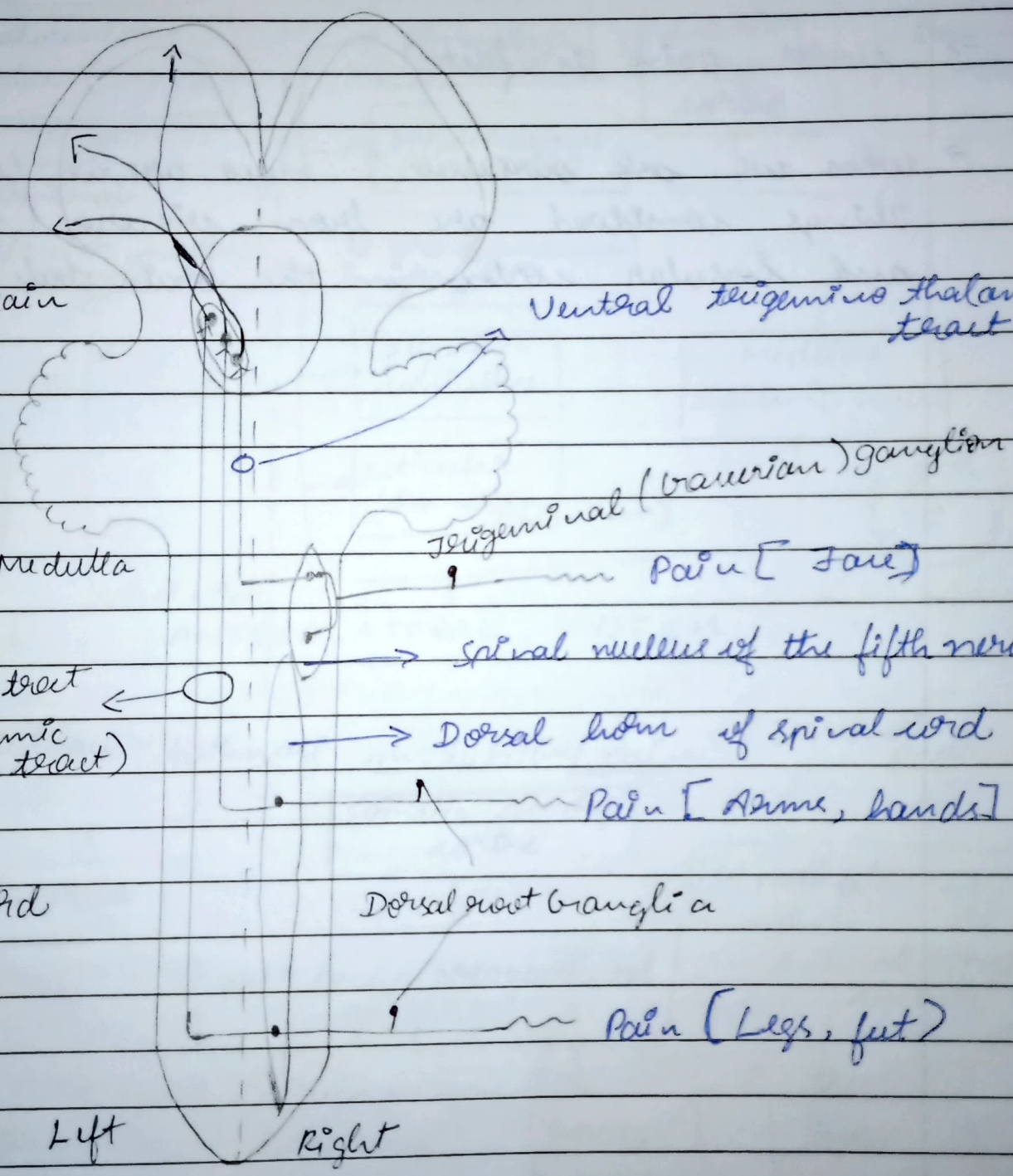
→ First pain is fast.

→ when we ask ourselves: where are we feeling? Things considered are from viscera (gut) and insular cortex in the brain deals with this

Pain and temperature pathway

Antero lateral system - a pain and temp. pathway. (post cranial)

Spinal nucleus of the trigeminal complex - a pain / temp pathway of face.



Antero lateral system: (dorsal horn)

Dorsal root ganglion cells → 2° → VPL

↓

Cortex ← Internal capsule ← 3°

"C fibers" that mediate non-discriminative touch, itch, hot/cold.

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* Spinal nucleus of the trigeminal complex (face).

1° → Trigeminal ganglion → 2° → VPM → Internal capsule → Cortex.

* Visceral pain pathway:
Small visceral component runs in dorsal column.

→ Somatosensory receptors are associated with myelinated axon and have high conduction velocity

On the other hand nociceptors are associated with lightly myelinated axon and have low conduction velocity.

- Aδ - Heat, mechanical nociceptive stimuli.
(unmyelinated) C-fiber - Thermal, mechanical, chemical.

→ 43°C - min thermal stimuli to consider it as noxious.

Revision

8/12/2020

Lateral Surface of the Brain - Week-2

→ (face) Precentral gyrus ← Central Sulcus → Postcentral (back) gyrus

Precentral gyrus ↓ Motor Cortex

Postcentral gyrus ↓ Somatosensory cortex

Planning response *
- Superior, middle & inferior frontal gyrus.
- Posterior of inferior frontal gyrus = Broca's area
  ↓ Expression of language

Recognizing stimuli *
- Superior temporal gyri : Audition, language reception.
- Middle " " :
- Inferior " " : Highly processed visual information

* Insular cortex ; b/w frontal & temporal lobe.
- ↳ posterior : Visural, autonomic (taste).
- ↳ Rostral : Implicit feeling (social cognition).

Attending to stimuli *
- Super parietal lobe
- Intraparietal sulcus
- Inferior parietal lobule

} Somatosensory, visual, auditory, vestibular signals. body image

* Occipital lobe : visual perception, multimodal sensory processing

* Wernicke's area : Posterior part of superior temporal gyrus.

16/12/2020

Neural Signalling: Electrical Excitability & Signal propagation

- **Equillibrium**: There is no net movement of ions across the membrane. At equillibrium potential potential across the membrane (membrane potential) exactly offsets concentration gradient.

- **Nernst equation**: To find equillibrium potention in presence of only single ion.

$$E_x = \frac{RT}{zF} \ln\left(\frac{[X]_{OUT}}{[X]_{IN}}\right) = \frac{58}{z} \log \frac{[X]_{OUT}}{[X]_{IN}}$$

- **Goldman equation**: To find equillibrium potential in the presence of multiple ions

$$V_m = 58 \log \frac{P_K[K]_{OUT} + P_{Na}[Na]_{OUT} + P_{Cl}[Cl]_{IN}}{P_K[K]_{IN} + P_{Na}[Na]_{IN} + P_{Cl}[Cl]_{OUT}}$$

where P_x is permeability of the membrane to each ion of interest.

During resting state permeability P_K is high P_{Na} is low due to action of ion transporters.

→ **Tetrodotoxin**: Is an alkaloid neurotoxin found in certain puffer fish, tropical frogs and salamanders, blocks Na^+ current without effecting the K^+

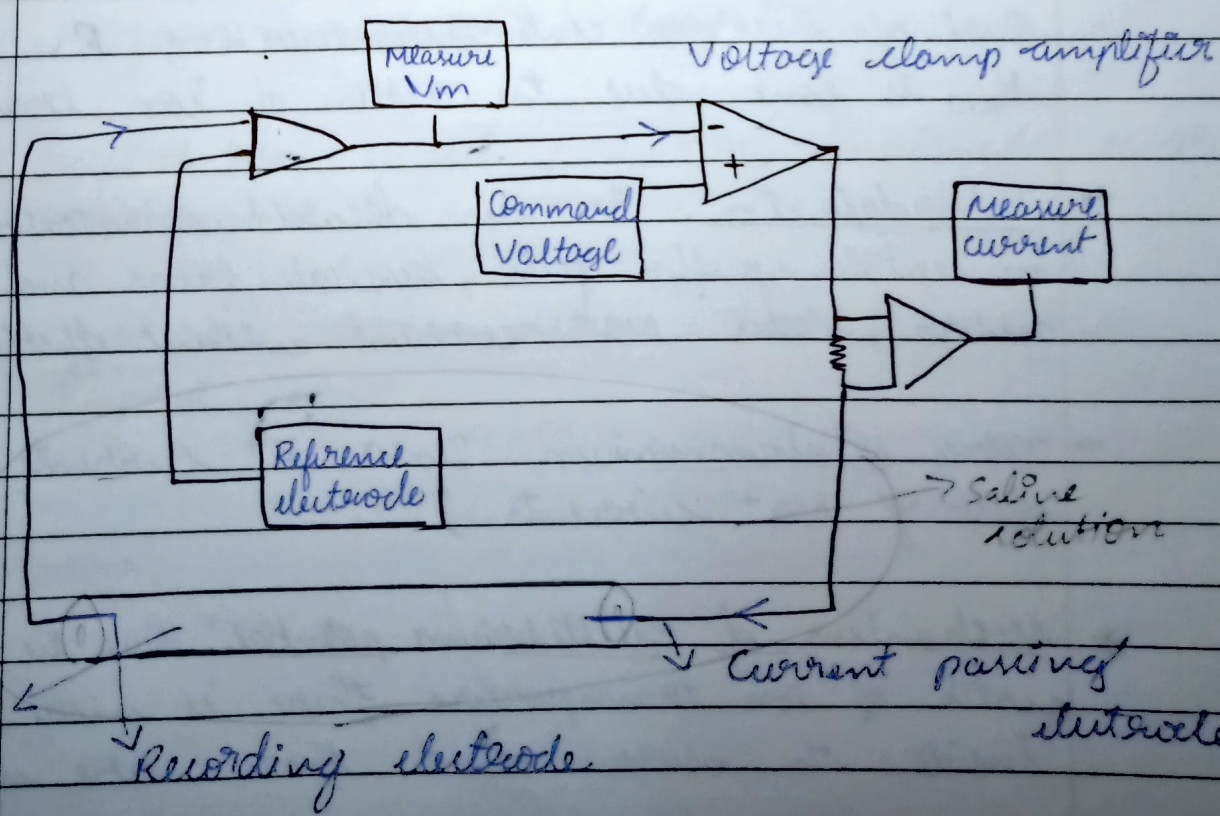
→ **Tetra ethylammonium**: Blocks K^+ currents without affecting Na^+ currents.

* **Mechanism of equillibrium potential**: Due to the work of ion transporters there is more K^+ inside the neuron and there are more

Na^+ and Cl^- outside. Now there is diffusive force due to unequal distribution [concentration gradient]. This con^n gradient makes K^+ move out of the cell, when K^+ move out of the neuron they take their +ve charge along with them making inside of the neuron more -ve and outside of the neuron +ve. Due to the accumulation of +ve charges outside there is potential gradient in the opposite direction thus it opposes further arrival of K^+ outside. At particular membrane potential (Equillibrium potential) there is exact balance b/n con^n gradient and potential gradient and there is no net flow of ions.

* **Voltage Clamp method**: This experiment allows to control membrane potential and simultaneously measure the underlying permeability changes.

Command potential = Desired potential.



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- $E_{ion} = g_{ion} (V_m - E_{ion})$

V_m = membrane potential
E_{ion} = ion equilibrium potential
g_{ion} = ion conductivity.

* Conclusion 1: Na^+, K^+ conductances change over time
* Conclusion 2: Na^+, K^+ conductances are voltage dependent

* Action potential conduction: (node both positive and active current flow)
- Depolarization open Na^+ channel an action potential is generated
- Resulting inward current passively flows down the axon. This depolarizes adjacent membrane
- opens Na^+ channel, action potential is generated and this continues
- +ve feedback once initiated it is sustained by the intrinsic properties of the neuron. The action potential is self supporting or regenerative

-> If a laboratory axon is stimulated in the middle, then 2 action potentials will be generated one travelling towards the axon hillock and other travelling towards synaptic knobs

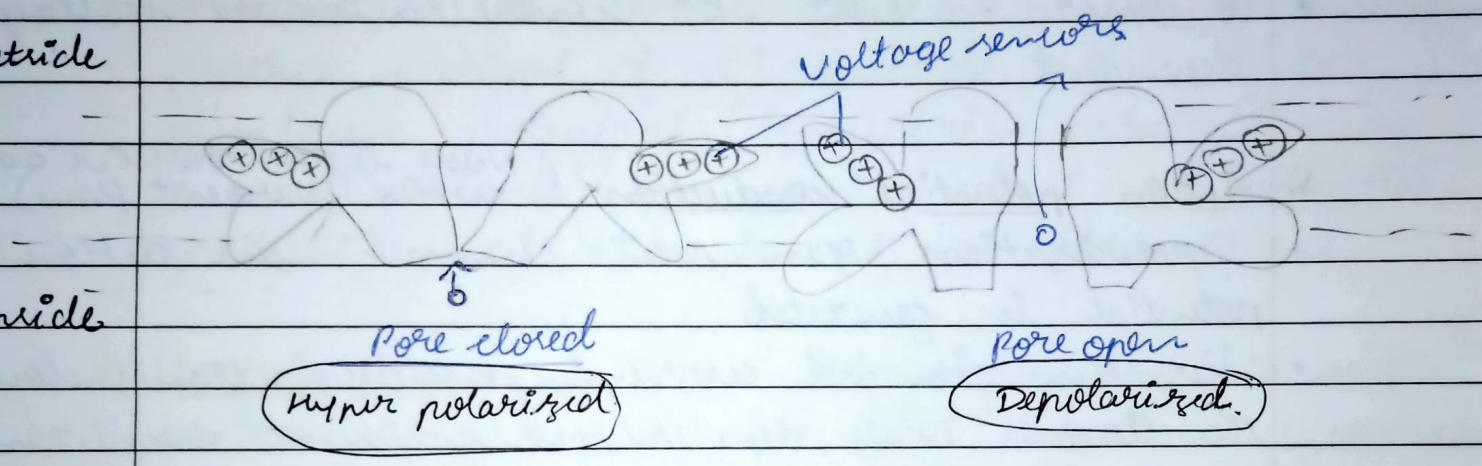
-> If a axon is depolarized in the beginning then the action potential travels only in 1 direction. Action potential (in this case positive current) trying to move backward. It is present for refractory period

Molecular mechanism of action potential generation

* Voltage clamp apparatus: Measure current resulting from flow of ions in thousands of channels.
Patch clamp method: A technique capable of measuring the currents flowing through single channels.

voltage gated K+ channel structure & mech.

Voltage gated K^+ channel.



- The voltage sensor contains +ve charges that enable movement within the membrane in response to changes in membrane potential.

- Channel includes 4 subunits each with a transmembrane domain + T1 domain.
T1 domain is attached with α β subunit.

- Case 1: Depolarization → Voltage sensor pushed towards extracellular space → linker pulled → open channel pore

- Case 2: Hyperpolarization → Voltage sensor down → linker pushed down → Shutting the channel pore.

Cytoplasm - fluid fluid

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→ 10 Na^+ channel gene = SCN genes
⇒ Ca^{+2} channel genes = CACNA genes.
⇒ K^+ channel genes = KCN genes
→ Cl^- channel genes = CLCN genes
↳ Structurally different from all other voltage gated channels
Selectivity filter has +ve charge that co-ordinate the movement of Cl^-. Cl^- channel does not have voltage sensor that is found in Na^+, K^+, Ca^{+2} but voltage dependence seems to arise from voltage dependent movement of -ve charged amino acid near selectivity filter.

Ligand - Gated Ion Channels

- Ion channels that respond to chemical signal.
- Less selective and allow multiple types of ions to flow.

* Thermosensitive and mechano sensitive channels:
- Sensation of pain and body temperature.
- Stretch receptors and neuromuscular stretch reflexes

* Active transporters: (create and maintain ion gradients)
Types ① ATPase pumps ② Ion exchangers.

① * ATPase: Na^+ pump for brain function is crucial. This transporter accounts for 2/3 of the brain's total energy consumption.
- The rate of K^+ influx is only 2/3 that of Na^+ efflux, indicating that the pump transports $2K^+$ into the cell for every $3Na^+$ that are removed.

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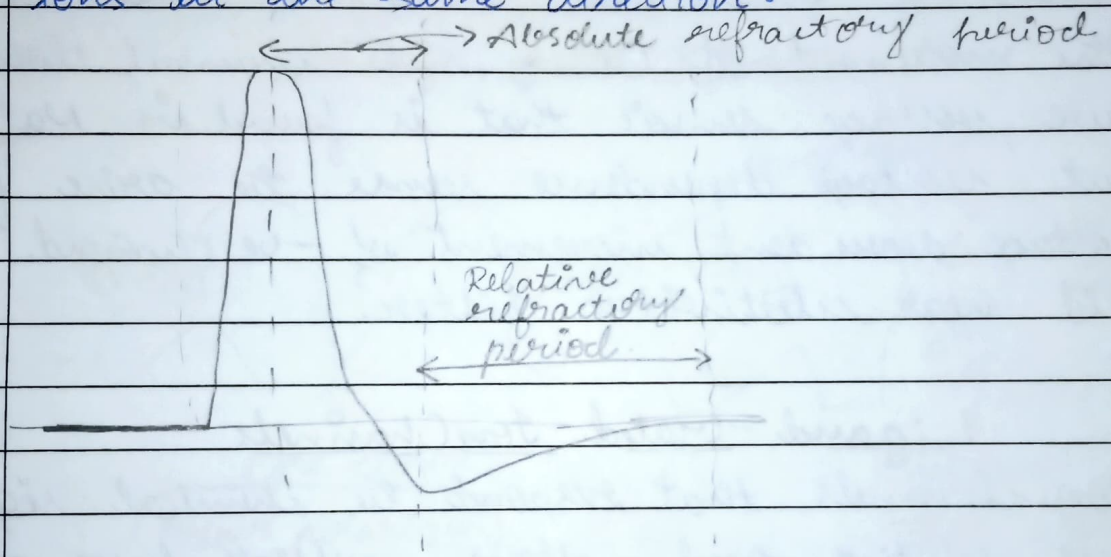
(2) Ion exchangers : Does not use ATP but instead uses electrochemical gradients of other ions as an energy source.

(a) Antiporters : Exchange intracellular and extra-cellular ions.

(b) Co-transporters : work by carrying multiple ions in the same direction.



17/12/2020

Synaptic Transmission (Revision)

* Electrical synapse: Connexons form the connections, connexons are composed of 'connexin' ion channel protein.
- The pore diameter is more than 1nm in diameter.
- Ex: Brainstem neuron dealing with breathing, interneurons in cerebral cortex, thalamus, cerebellum
- 6 connexins make a connexon.

→ Synthesis of small molecule neurotransmitter occurs at presynaptic terminal.
whereas synthesis of neuropeptides occur at cell body

→ End plate = synapse b/n synaptic axon & muscle fiber
End plate potential (EPP): Membrane potential change that occurs when presynaptic action potential invades post synaptic membrane. EPP is large enough to produce postsynaptic action potential.

→ MEPP (Miniature end plate potentials): Change in membrane potential that occurs when synaptic vesicle fuse (in small number). This change in post synaptic membrane potential is not large enough to elicit postsynaptic action potential.
If many vesicle fuse then EPP is produced.

→ The precursor to synaptic vesicles originally produced in endoplasmic reticulum and Golgi apparatus. Due to long distance vesicles are recycled locally

→ Reducing Ca^{+2} outside presynaptic terminal reduces the size of the EPP.

__/__/__

→ ACh opens ion channel of ion 'x' if the reversal potential of EPC is at equilibrium potential of 'x'.

- ACh - Non selectively permeable to cation
- Glutamate - Na^+, K^+ are permeable
- GABA - Cl^- is permeable

Continued:

Receptors

→ Excitatory postsynaptic currents (EPSPs) produced by NMDA is smaller, slower and lasts longer.

→ AMPA is larger (EPSPs)

→ Glycine and GABA are 2 important inhibitory neurotransmitter receptor

In spinal cord: ½ of each acts as inhibitory

→ Glycine receptors are ligand-gated Cl^- channel. Cl^- influx inhibits the postsynaptic neuron.

* 3 classes of cell signalling molecules:

① Cell impermeant: Cannot pass through plasma membrane directly. They bind to extracellular portion of transmembrane receptor protein.

② Cell-permeant: Can pass through plasma membrane and bind to receptors

③ Cell associated signalling molecules: These are present on extracellular surface and receptor cells are activated only if they are in contact.

Phosphorylation: Addition of phosphate groups.
Protein phosphatase: Enzyme that removes phosphate groups.
22/12/2020

* Receptors for impermeant signalling molecules:

① Channel linked receptors:
Signal binds → Channel opens → Ions flow across membrane

② Enzyme linked receptors: Signal binds → Enzyme activates → Enzymes generate activated effector

③ G-protein-coupled receptors: (Metabotropic receptors)
Signal binds → G-protein binds → G protein activated

Cell permeant ↓

④ Intracellular receptors:
signalling molecule passes plasma membrane binds to receptor and then this activates receptor regulates transcription.

* Neuronal second messengers: Ca^{+2}, Cyclic AMP, Cyclic GMP, IP3, Diacylglycerol.

24/12/2020

Plasticity

* **LTP**: ① Induction of LTP is due to accumulation of Ca^{+2} in postsynaptic cell as a result of Ca^{+2} influx through NMDA receptors. Increase in postsynaptic Ca^{+2} concentration serves as a second messenger signal that induce LTP.

The NMDA channel can open only during depolarisation of the postsynaptic neuron from its normal resting potential.

② Expression of LTP relies on dynamic changes in AMPA receptors. NMDA receptors does not play a major role LTP expression.

Ca^{+2} entering through postsynaptic NMDA receptors lead to activation of synaptotagmins and protein kinases that regulate trafficking of AMPA receptors, thereby enhancing the postsynaptic response to glutamate released from the presynaptic terminal.

Increase in AMPA receptors increase postsynaptic response yielding a strengthening of synaptic transmission that can last for as long as LTP is maintained.

* **LTD in hippocampus**: LTD at Schaffer collaterali CA1 require activation of NMDA type glutamate receptors and the resulting entry of Ca^{+2} into postsynaptic cell. Small and slow rises in Ca^{+2} leads to depression

LTD results from activation of phosphatases, specifically PP1 and PP2B (Ca^{+2} dependent phosphatase)
It is possible that LTD and LTP phosphorylate and dephosphorylate same set of regulatory proteins to control the efficacy of transmission.

LTD occurs due to loss of synaptic AMPA receptors. This is due to internalization of AMPA receptors into sorting endosomes in the postsynaptic cell by clathrin dependent endocytosis mechanism (which is also imp for synaptic vesicle recycling)

* Cerebellar LTD: 2 types of neurons innervate purkinje neurons of cerebellum [climbing fiber + parallel fiber]

(I) LTD is associative: It requires both parallel and climbing fibers activated at the same time.

(1) Parallel fiber: Glutamate released from parallel pathway activates 2 receptors: AMPA and glutamate receptors. (AMPA -> mild depolarization) (GluR => IP3) and DAG second messengers are released.)

(2) (climbing) fiber: -> AMPA receptor which strongly depolarizes purkinje cell membrane potential and secondary messenger (Ca^{+2}) influx takes place

IP3 and Ca^{+2} causes amplified rise in intracellular Ca^{+2}. This activates PKC. PKC phosphorylates downstream substrate protein including AMPA. This causes internalization of AMPA receptors via clathrin dependent endocytosis.

? An dendrite (not) can be innervated by many axons. For now A, B presynaptic, C being postsyn-
A -> C (action potential) then B -> C [there is already action potential at C.] ∴ LTD ?

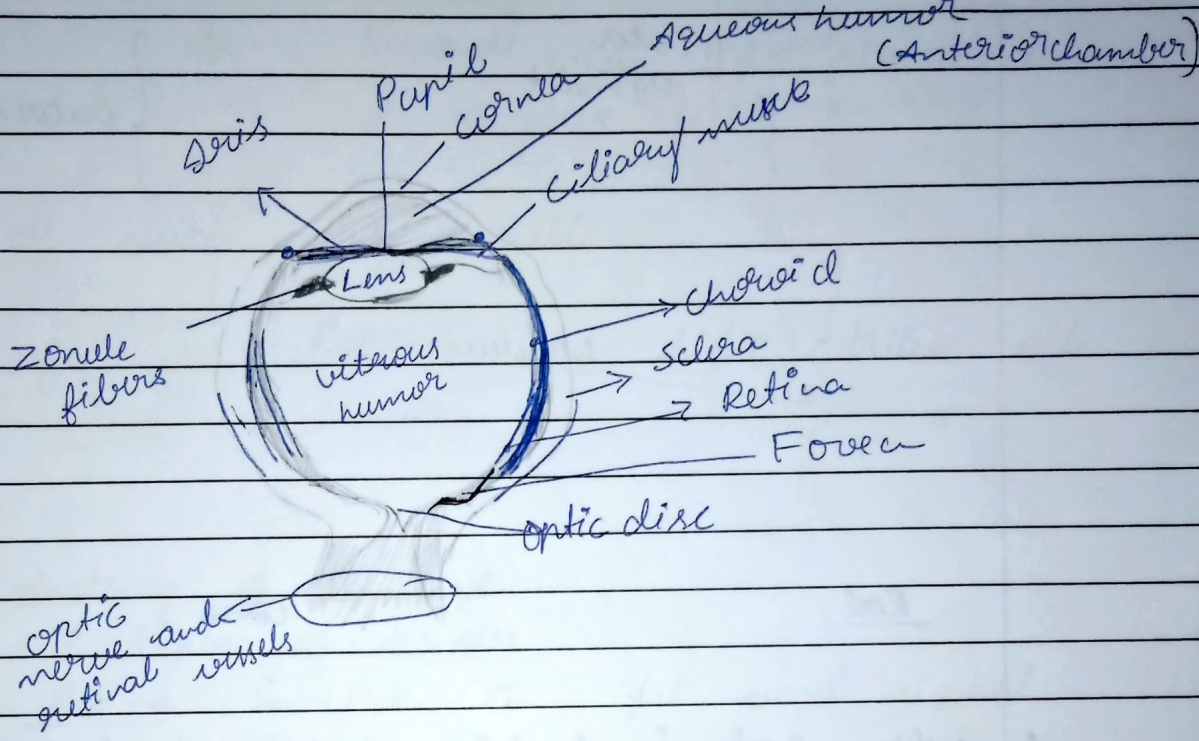
Spike Timing - Dependent Plasticity:

- LTD will occur if presynaptic activity happens after postsynaptic activity (potential)
- LTP will occur if the postsynaptic action potential follows presynaptic activity.

28/2/2021

Basic Structure of the Eye and Retina

(L1)

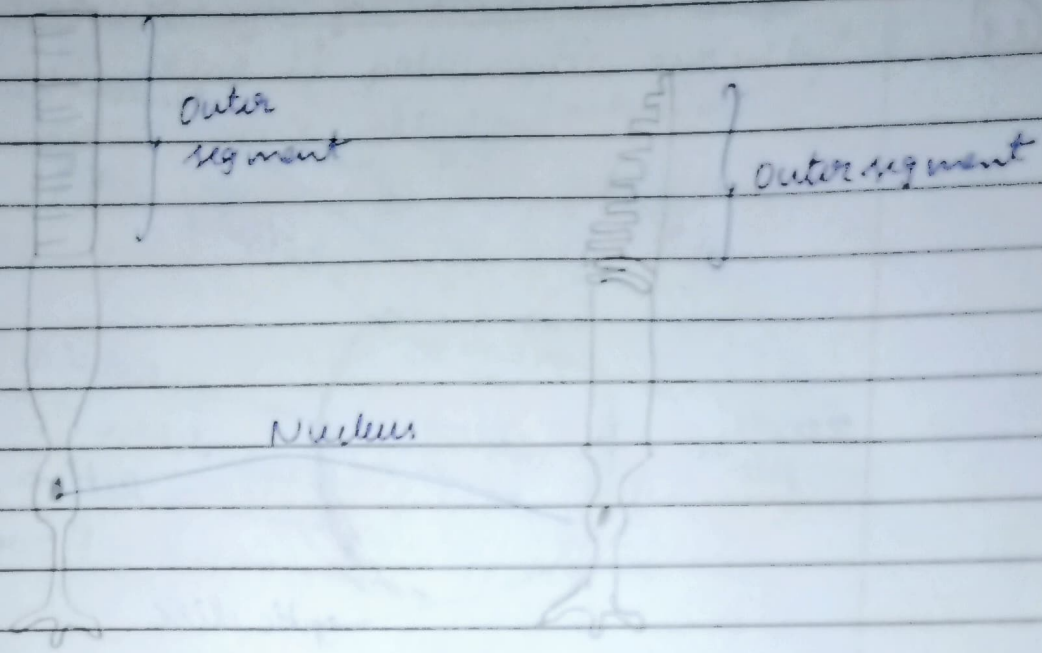


- Cornea: 80% refraction
- Accomodation: Adjustment of lens
- Retina is diencephalic

* Retina is made up of 5 types of cells
- Photoreceptors: Rods and cones graded potential
- Horizontal cell sensitivity to contrast
- Bipolar cell Graded potential
- Amacrine cell Direction selective response
- Ganglion cell Action potential

⇒ Retina thickness ~ 1mm ∴ No action potential is not needed here.

quire 1 photon for activation.
require about 100 photons for activation.
o of Rods to ganglion cells is high
he cones.



Rod Cone

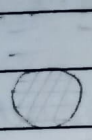
when rod is kept in dark → depolarized
opsin protein contains 11-cis retinal. when light falls on it converts into all trans retinal.

Rods	Cones
• Sensitive to light	• Relatively insensitive to light
• Low spatial resolution	• High spatial resolution
• Scotopic (low light)	• Photopic
• vision at low light level	• Colour vision
	• vision at high light level

Many rods connect to single bipolar cell unlike cones.

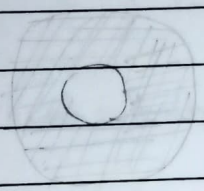
In fovea there is no rods but filled with cones. In fovea visual acuity is the greatest.

- on center ganglion cell



Responds when light strike center of receptive field

- off center ganglion cell



Responds when light strikes off center

* Anatomy of the eye

3 layers of tissues

① Retina: Sensitive to light and signal transduction

② Uveal tract: a) Choroid: Nourishing retinal photo receptors.
b) Ciliary body: 2 components, muscular component that adjusts the refractive power of the lens. vascular component ~~adjusts refractive~~ produces fluid that fills front of the eye.
c) Iris: Adjusting size of the pupil.

③ Sclera: Tough, white, fibrous tissue - Cornea → where light enters.

* Fluid in anterior chamber is replaced, failure of this drainage causes glaucoma. Glaucoma is a disorder in which high levels of intraocular pressure reduce the blood supply to the eye and eventually damage retinal neurons.

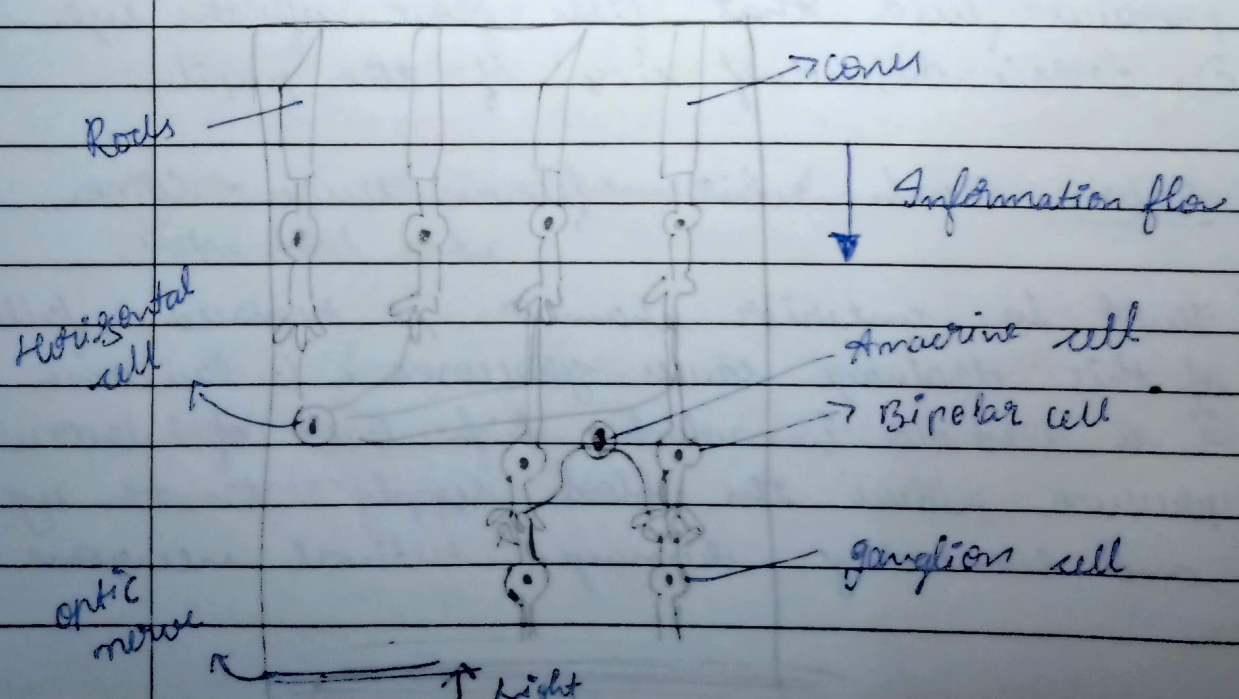
* Vitreous humor: 80% volume of eye, maintaining shape of the eye, phagocytic activity.

* optic disc / optic papilla : Blood vessels enter or leave.
- Region of retina containing no photoreceptors is called scotoma.
- Distant vision: lens is thin, flat and low refractive power.
- Near vision: Thick lens, rounder, high refractive power
  Dynamic changes is called accomodation

* Fundus: Interior surface of the eye - opposite the lens. Includes retina, optic disc, fovea, macula.
- Macula contains Xanthophyll filters ultra violet wavelength

fovea ?

- Larger axons of ganglion cells form the optic nerve. optic nerve carries info to rest of CNS



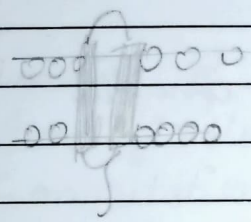
_/_/__

* Photo transduction:

* Dark - depolarization : Supported by dark current.

- Plasma membrane of photoreceptor has ion channel permeable to Ca^{+2}, Na^{+}. Channel is gated by cyclic GMP.
- Also ion channel which involve in efflux of K^{+}, thus depolarized state.

→ Photo pigment. opsin which interacts with 11 cis retinal which interacts with photons



- 7 transmembrane structure
- 3 types of opsins for short, long, medium wavelengths of light. For cones.

* Light - Hyperpolarization

- Reduction in concentration of cyclic GMP.
- Ca^{+2}, Na^{+} cannot enter
- K^{+} efflux takes place (hyperpolarization)

→ Hyperpolarization:

11 Cis retinal → 11 trans retinal.

- Second messenger photo transduction:

- Light striking photo pigment
- Configuration change
- Activation of G protein (transducin)
- Phosphodiesterase (PDE) enzyme is turned ON
- PDE cleaves cyclic GMP ~~cleaves~~
- Channel closes.

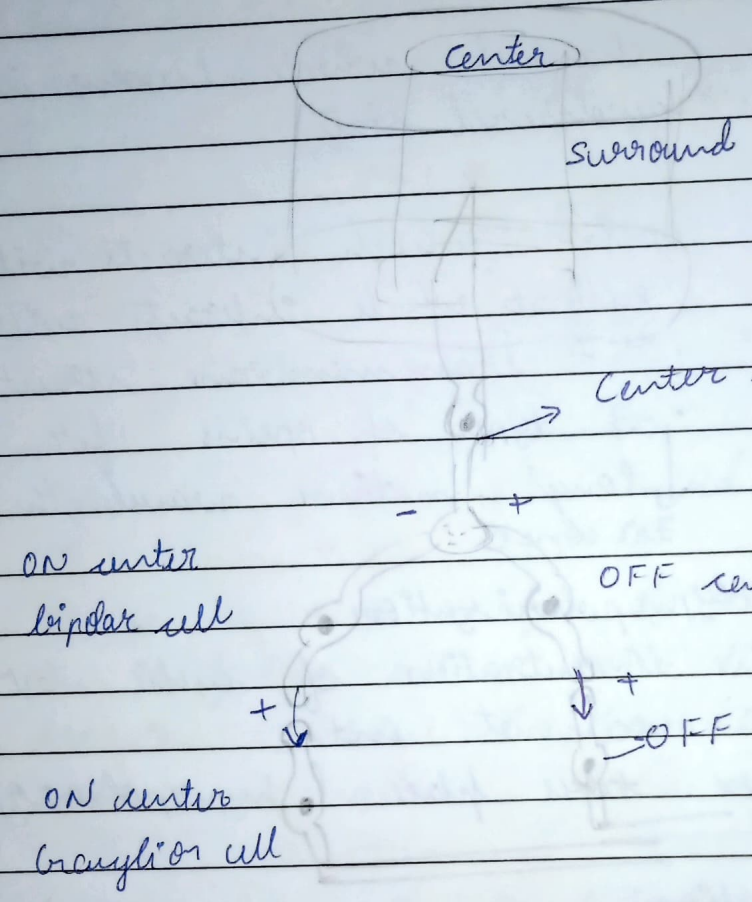
24/03/2021

Ganglion cell has center surround response.

Ganglion cell receptive fields

ON center bipolar cell - Metabotropic receptor.

OFF center bipolar cell - AMPA receptor.



Lens flat - least refractive power - for vision

Lens round - Most refractive power. - Near vision

Pupil restricts the passage of light to the center of lens

5 neuronal cell types in retinal processing

Photoreceptors: Main sensory transducer

Bipolar cells: Interneuron b/n photoreceptors and ganglion cells.

Ganglion cells: Integrates electrical activity from bipolar cells and give rise to axons that form optic nerve.

(4) Horizontal cells: Mediate lateral interactions b/n photoreceptors and bipolar cells.

(5) Amacrine cells: Later interactions b/n bipolar cells, other amacrine cells and ganglion cells.

- Scotopic vision: very low levels of illumination
- Mesopic vision: Low levels of illumination
- Photopic vision: Moderate and high levels of illumination.

* Function of vertical circuit

Amplification. of thalamic input.

Computation.

Communication.

29/03/2022

Central Visual Processing

V1

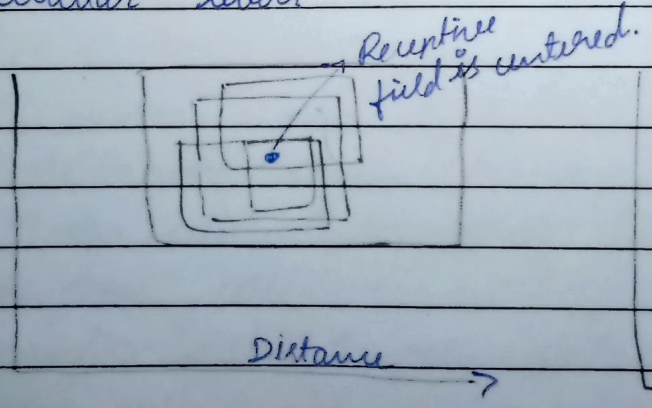
Primary visual cortex = V1
= visual area 1 =
Brodmann area 17 =
striate cortex

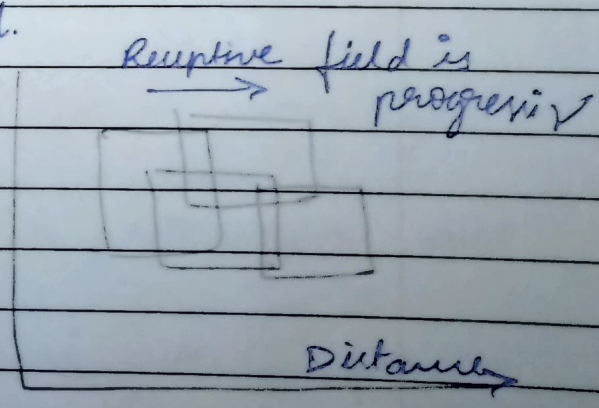
Striate Cortex
V1

V1 receives i/p from lateral geniculate nucleus

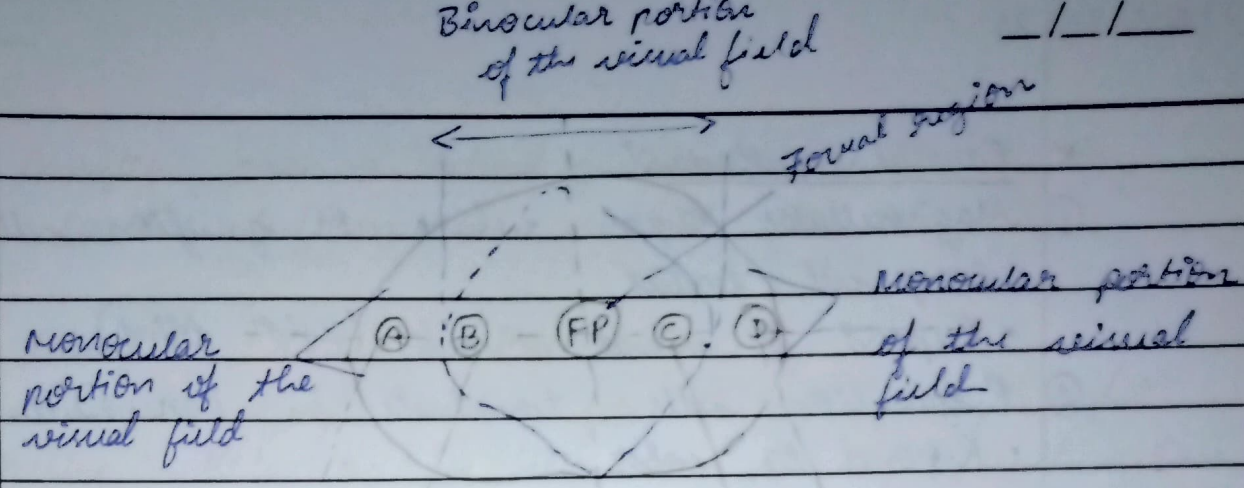
V1 respond best to a moving edge that is within a narrow range of orientation in space: orientation specificity.
Many neurons respond best to particular orientation moving in one direction. Direction selectivity

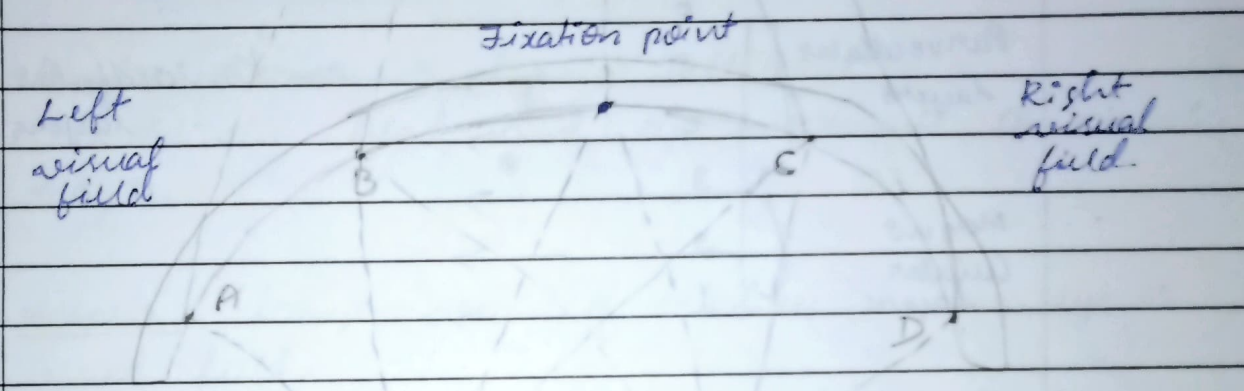
Neo cortex: • Outer layer of the cerebrum
• Accounts for 76% of brain volume
• Newest part in terms of evolution.
2 classes of neurons in Neocortex
1) Spiny neurons - Pyramidal and stellate
2) Smooth neurons -
Neocortex is conventionally divided into 6 cellular levels

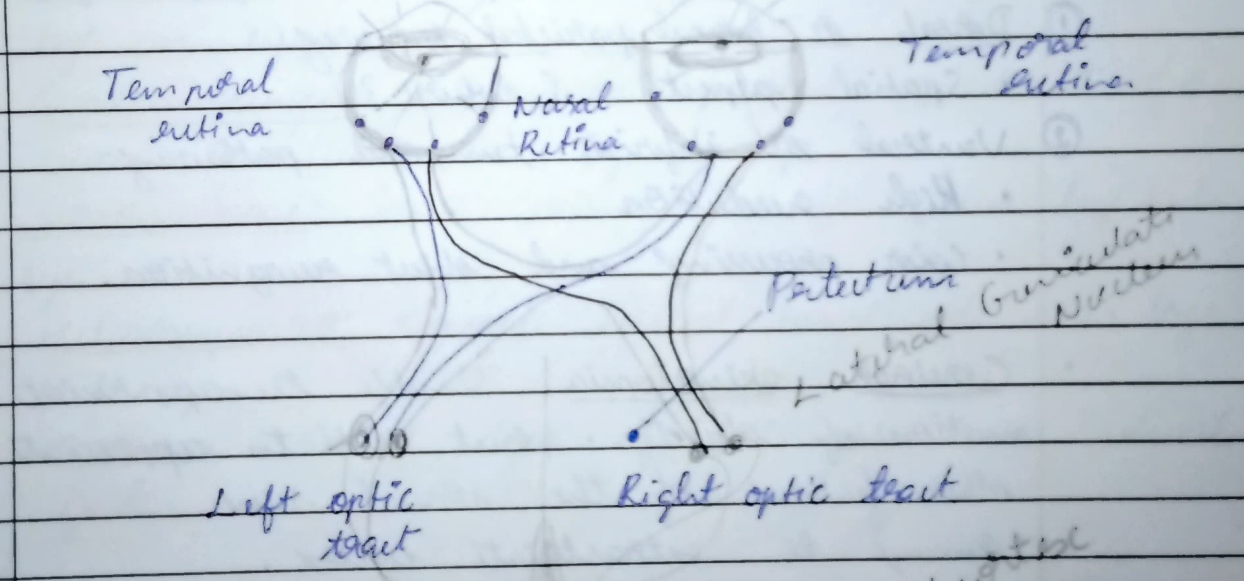




vertical electrode penetration horizontal electrode







Binocular Vision

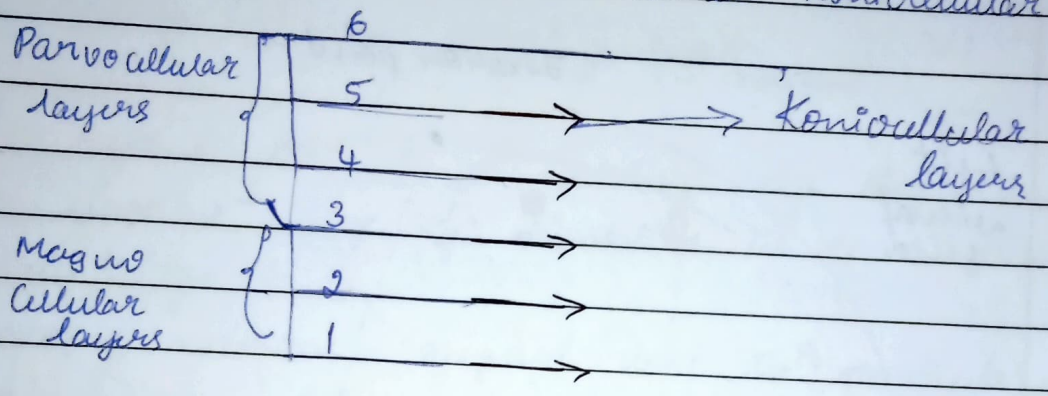
- Ganglion cell axon → lateral geniculate nucleus → optic radiation (part of internal capsule) → primary visual cortex (V1, striate cortex, 17 & 17).

* Parallel pathways

① Magnocellular layers where M ganglion cells terminate
- Large cell bodies
- Respond to visual stimuli. (color blind)

② P ganglion cells terminate in Parvocellular layers
- Respond to color.

③ K ganglion cells terminate in Koniocellular pathways



* Extrastriate cortex: (2 functional pathways)

① Dorsal or lateral paristal pathway:
- Spatial aspect (where?)

② Ventral or inferior temporal pathway:
- High resolution
- Color processing and object recognition.

- Cerebral akinetopsia: Unable to appreciate the motion of objects. But able to appreciate the other features of the visual scene.
- Damage to extrastriate cortex.

- Cerebral achromatopsia: Loosing ability to see the world in color all other aspects of vision remain in good working order.

12/04/2021

* Ganglion axon → lateral geniculate nucleus
  - Conveys information essential for seeing

* Ganglion axon → Pretectum.
  - Co-ordinating center for the pupilary light reflex - Reduction in diameter of the pupil when sufficient light falls on the retina

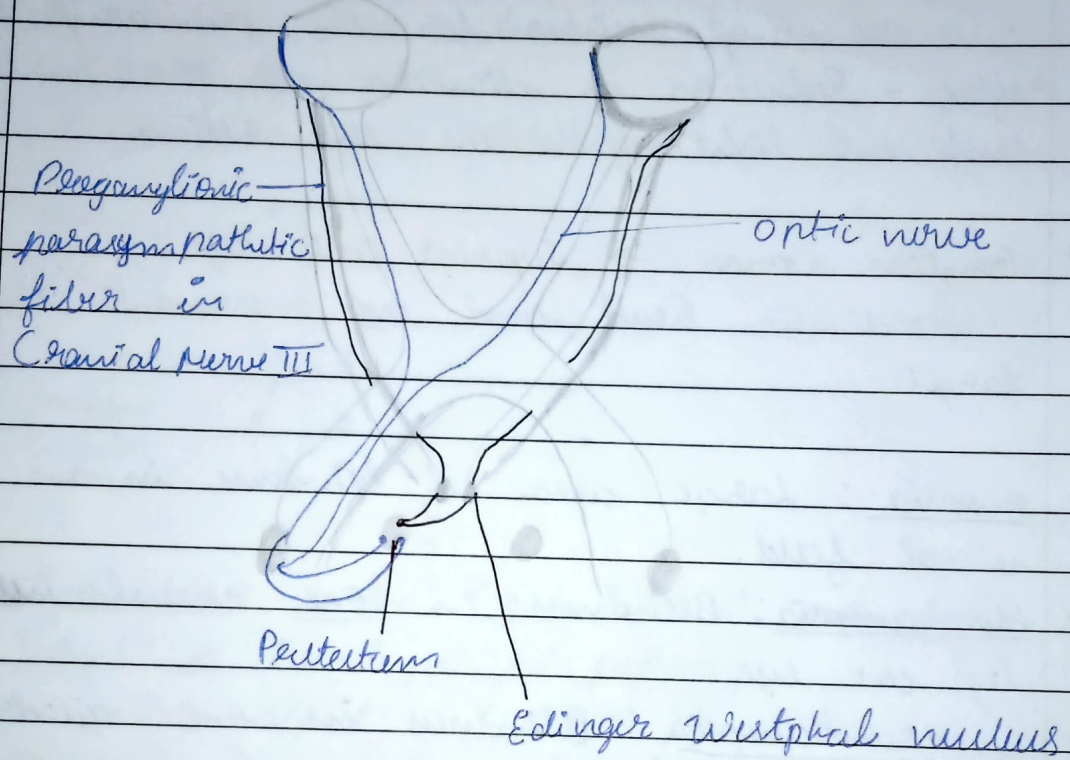
* Ganglion axon → Superior Colliculus.
  - Co ordinates head and eye movements to visual targets.

- Anopsia : Large area of blindness in an eye or visual field.
- Hemianopsia: Blindness in one visual field seen by an eye
- Quadrantanopsia : Blindness in one quadrant of a visual hemifield seen by an eye
- Homonymous: Same visual hemifield seen by each eye
- Heteronymous: Opposite visual hemifields seen by each eye
- Scotoma: Small area of blindness in a visual field

→ Pituitary gland attaches just below optic chiasm

- Superior and Inferior Colliculli collectively called as tectum.

→ Pupilary constriction – Parasympathetic III nerve
Pupilary dilation – Sympathetic nerve



Pupilary light reflex

12/04/2020

Audition

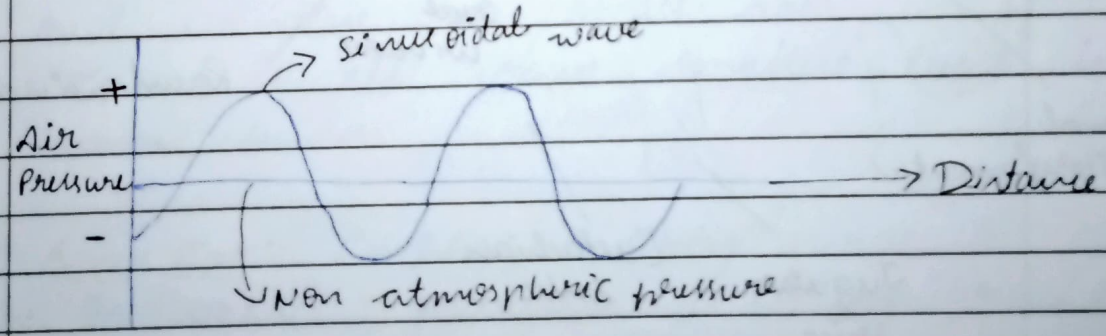
- Sound waves are collected and amplified by physical structures in the external and middle ear for transfer to neural elements in the inner ear

- In the inner ear and throughout central processing stations, tonotopy is preserved. [systematic representations of sound frequency

- In the brainstem auditory information is first processed and divided into neural parallel pathways, some of which compare the signals derived from the two ears, a process that allows for the localization of sounds in space.

- Brainstem relays information to the midbrain which in turn projects to auditory thalamus

- Auditory cortex then receive input from the thalamus and process more complex aspects



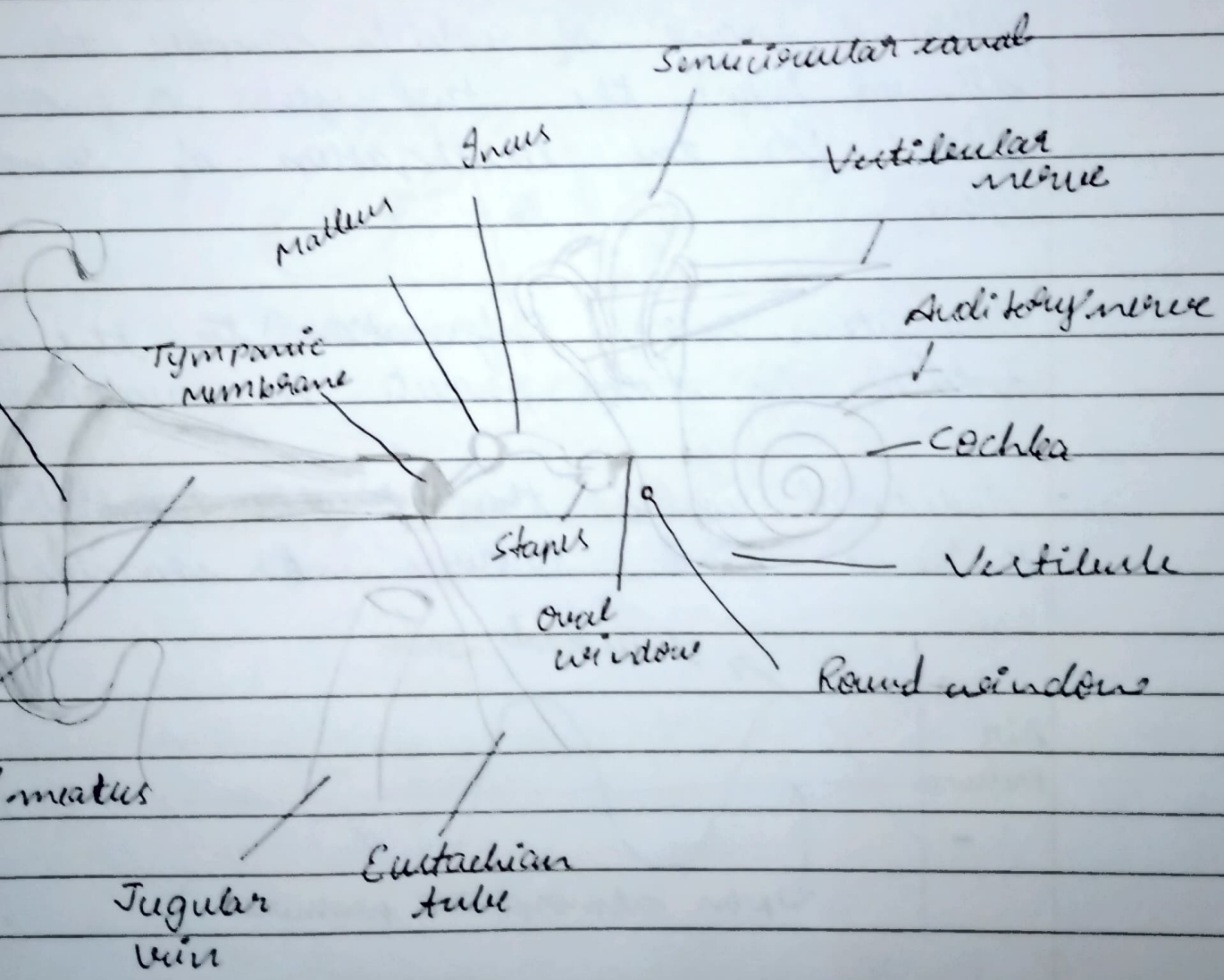
- "Sound refers to pressure waves generated by vibrating air molecule"

- Signal transduction (amplitude, phase, frequency) is done by hair cells and encoded by

the electrical activity of the auditory nerve fibers.

Systemic representation of sound frequency along the length of cochlea tonotopy.

Brainstem → Midbrain → Auditory thalamus → Auditory cortex



Human Ear