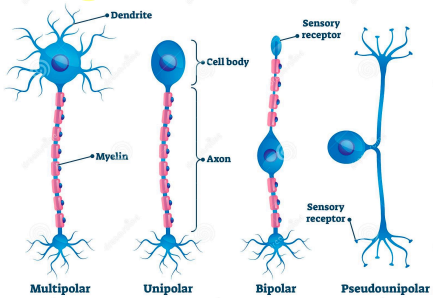
NB → only contains work that hasn't been done in previous Blocks (prevent Repitition).
→ sometimes only a term written down for a mental reminder!

L01: Physiology of the neuron - Prof H. Strijdom.

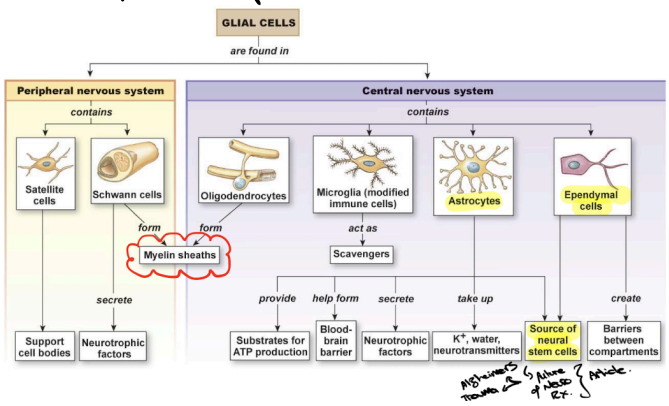
[cation : (+) Q
Anion : (-) Q]

NS = control system : Homeostasis.
Stimulus = Δ in environment.
Sensor/R. → Afferent Path → Integration → Efferent Path → Effector.
PNS CNS PNS
↳ Excitable cells!

Cells of NS { Neurons → functional unit of NS → TYPES OF NEURONS → Electrically Active.

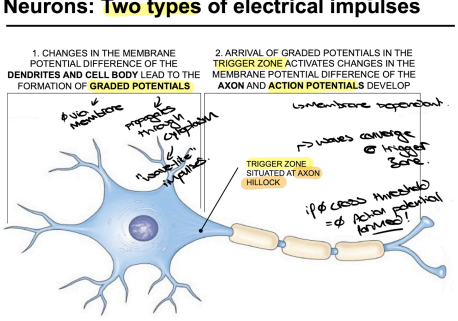


Glial cells { Peripheral nervous system / Central nervous system



Graded Potentials : Dendrites & cell Bodies
Action Potentials: Axons

Nerves = Bundles of Neurons ∴ nerves carry/relay signals with completely different msgs within them. (Multiple Neurons).

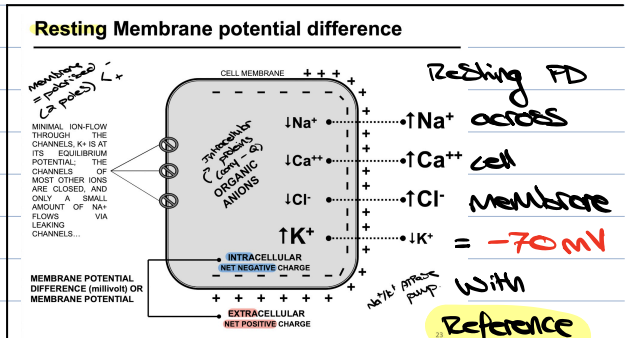


Axo-Dendritic Synapse
Neuron-Target Synapse
] Synaptic cleft.

Myelin Sheath { CNS : oligodendrocytes. } 20% protein
PNS : Schwann cells } 80% Lipid.

Demyelinating conditions → "Multiple Sclerosis"

Dysmyelinating conditions → Genetic — X-Linked
"Leukodystrophy." — Recessive.



Signal transmission:

1) Electrical (AP).
2) Chemical (Neurotransmitters).
3) Electrical Synapses. → 4pp junctions.

Ion channels → voltage Gated
→ Ligand Gated
→ chemically Gated. } facilitate Diffusion [] gradients $Na^+/k^+/ca^{2+}$ etc.

Depolarisation. (open Na^+ channels)
Repolarisation. (open k^+ channels)
Hyperpolarization. (Sluggish k^+ channels)

Nernst Potential → k^+ (-80mV)
↳ k^+ contributes most to resting polarized state.

Membrane R. { Ligand Gated ion channels
— GPCR
R. — Enzyme R.
Integrin R.

Graded vs. Action Potentials

TABLE 8-3 Comparison of Graded Potential and Action Potential in Neurons

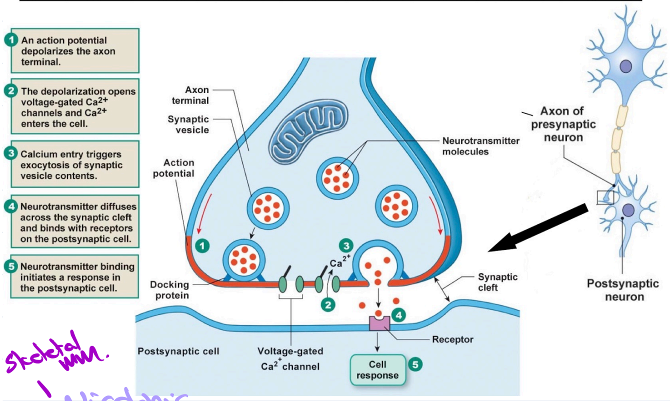
	GRADED POTENTIAL	ACTION POTENTIAL
Type of signal	Input signal	Regenerating conduction signal
Occurs where?	Usually dendrites and cell body	Trigger zone through axon
Types of gated ion channels involved	Mechanically, chemically, or voltage-gated channels	Voltage-gated channels
Ions involved	Usually Na^+, Cl^-, Ca^{2+}	Na^+ and K^+
Type of signal	Depolarizing (e.g., Na^+) or hyperpolarizing (e.g., Cl^-)	Depolarizing
Strength of signal	Depends on initial stimulus; can be summed	All-or-none phenomenon; cannot be summed
What initiates the signal?	Entry of ions through channels	Above-threshold graded potential at the trigger zone
Unique characteristics	No minimum level required to initiate	Threshold stimulus required to initiate
	Two signals coming close together in time will sum	Refractory period: two signals too close together in time cannot sum
	Proportional to the amplitude of the potential	Proportional to the number of AP's fired per second (amplitudes remain constant)

NB: **SENSORY RECEPTORS**, WHEN STIMULATED, ALSO INITIATE THE CONDUCTION OF THE SIGNAL VIA GRADED POTENTIALS, CALLED **"RECEPTOR POTENTIALS"** OR **"GENERATOR POTENTIALS"**. → Graded Potential in Sensory Neurons where R. is.

Cell-to-cell signalling ⇒ Electrical signal to Chemical signal
↳ Neurotransmitters.

⇒ post synaptic cell can be 1) Neuronal
2) Non-Neuronal → usually the final effector cell.

Cell-to-cell signalling: The chemical synapse



1 An action potential depolarizes the axon terminal.
2 The depolarization opens voltage-gated Ca^{2+} channels and Ca^{2+} enters the cell.
3 Calcium entry triggers exocytosis of synaptic vesicle contents.
4 Neurotransmitter diffuses across the synaptic cleft and binds with receptors on the postsynaptic cell.
5 Neurotransmitter binding initiates a response in the postsynaptic cell.
Axon terminal
Synaptic vesicle
Action potential
Neurotransmitter molecules
Axon of presynaptic neuron
Docking protein
Ca^{2+}
Synaptic cleft
Postsynaptic neuron
Receptor
Postsynaptic cell
Voltage-gated Ca^{2+} channel
Cell response

Termination of Neurotransmitter FX
Excess Neurotransmitter removed rapidly.
1) Returned to Axon (reuse)
2) Enzyme inactivates Neurotransmitter.
3) Diffuse out of synaptic cleft.

Where Does Neurotransmitter come from?
Rough ER → Golgi (packaged) → microtubules
↳ vesicles.
↱ Ach = Eg.
[Made in cell body or in Axon Terminal]
NB: Lysosomes digest old Membrane components.

Post Synaptic Receptors:
Neurotransmitters = can bind to 2 Diff R. classes.
1) GPCR
2) Gated ion channels.
} cellular Mech. Determine Biological FX.
└ Generate Graded potential (ion channel)
└ Activate/inhibit protein – function
(GPCR) – synthesis

Skeletal MM. – Nicotinic
ANS/CNS – Muscarinic > Ach ←

Amines:
- NE < α / β } ANS
- Dopamine – Dopa R (CNS)
- Serotonin (5-HT) – 5-HT R (CNS)
- Histamine – Histamine R. (CNS)

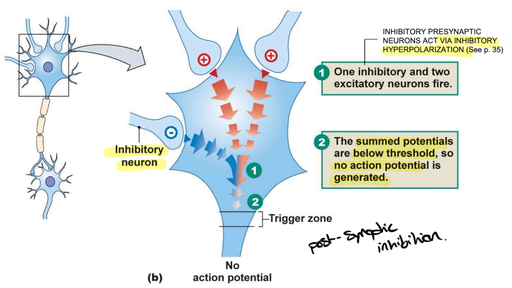
Amino A.:
- Glutamate – iGluR/mGluR. AMPA/NMDA (CNS)
- GABA – GABA R (CNS)
- Glycine – Glycine R. (CNS)

Purines (Adenosine – Purine R. (CNS)
Gasses (Nitric Oxide (NO) (N/A).

Variations in synaptic connections
Divergent pathways: 
Convergent pathways: 

} EPSP'S – Excitatory Post synaptic potential.
→ NB Graded potential must sum to over threshold @ hillock to initiate AP
IPSP'S – inhibitory post synaptic potential.
⇒ post-synaptic inhibition.

Variations in synaptic connections

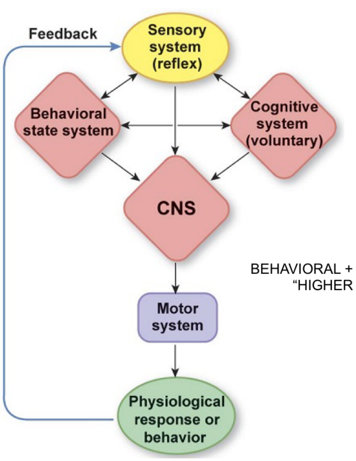


INHIBITORY PRESYNAPTIC NEURONS ACT VIA INHIBITORY HYPERPOLARIZATION (See p. 35)
1 One inhibitory and two excitatory neurons fire.
2 The summed potentials are below threshold, so no action potential is generated.
Inhibitory neuron
Trigger zone
post-synaptic inhibition.
No action potential
(b)

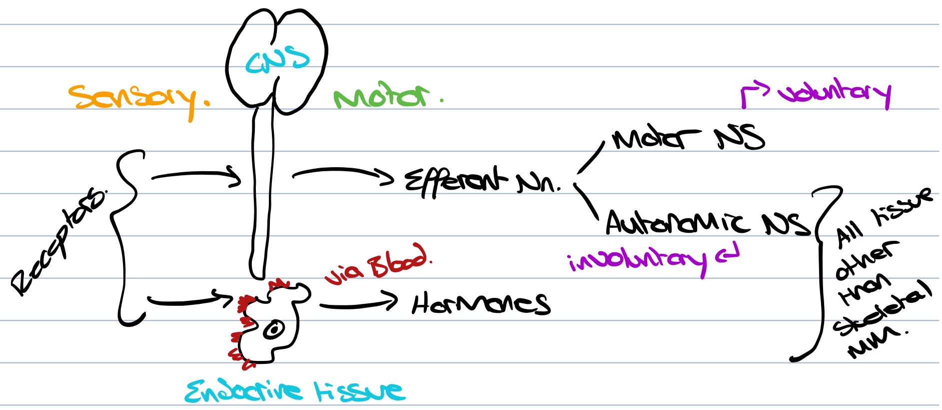
GRADED POTENTIAL DIFFERENCE GENERATED BY TWO EXCITATORY PRESYNAPTIC NEURONS IS COUNTERED BY INHIBITORY HYPERPOLARIZATION GENERATED BY THE INHIBITORY PRESYNAPTIC NEURON. THE RESULT IS THAT THE THRESHOLD IS NOT REACHED AT THE TRIGGER ZONE WITH NO ACTION POTENIAL = POSTSYNAPTIC INHIBITION 50

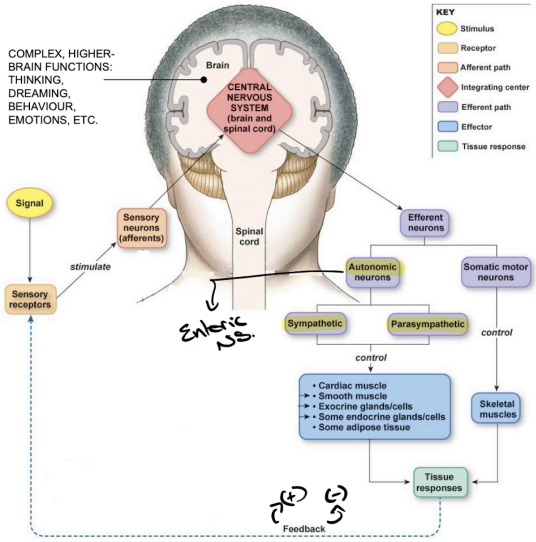
LO2: functional organisation of the CNS.

Behavioural & cognitive functions = higher Brain functions.



BEHAVIORAL + COGNITIVE FUNCTIONS = "HIGHER BRAIN FUNCTIONS"



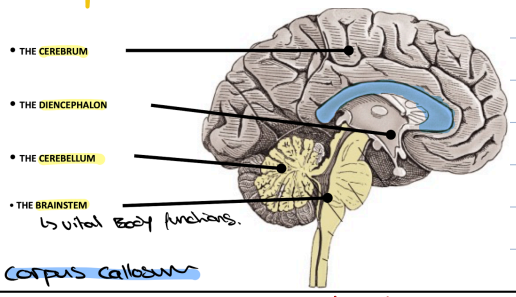


NB → there are dependant & independant Activities which occur in the NS.

Dependant / independant from input / output from PNS

Functional Regions of The Brain

1) Cerebrum
2) Diencephalon
3) Cerebellum
4) Brainstem



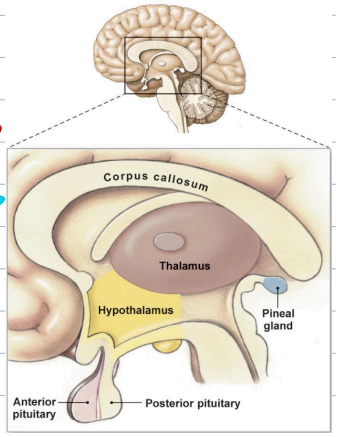
Corpus callosum

---

1) Cerebrum
- Cerebral cortex (3-4 mm thick)
  - Sensory (perception)
  - Motor (skeletal mm. movement.)
  - Associative (Integration of voluntary movement)
- Basal Ganglia (Movement)
- Limbic System
  - Amygdala (Emotion / memory)
  - Hippocampus (Learning & memory)
  - Cingulate Gyrus

Links Emotions & physiology

2) Diencephalon
- Thalamus integration - relay path for sensory & motor info
- Hypothalamus Homeostasis
- Pituitary secretes Hormones
- Pineal Gland Melatonin secretion



3) Cerebellum : Movement coordination

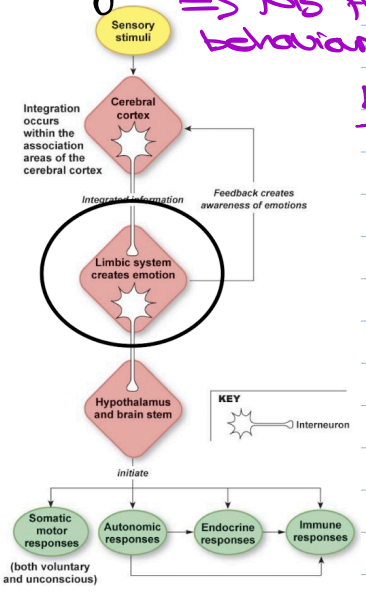
4) Brain Stem
- Midbrain eye Movement
- Pons Relay Station (Breathing centre)
- Medulla oblongata involuntary functions. (♡.)
- Reticular formation Arousal, Sleep, muscle tone & pain Modulation

White Matter : Axons
Grey Matter : Neuronal cell bodies

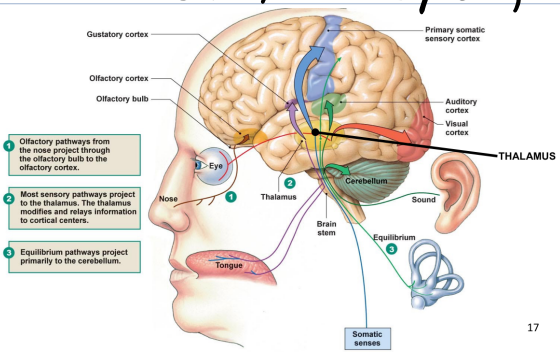
NB: cerebral hemispheres connected via corpus callosum.

Basal Ganglia = Grey Matter

Limbic Emotions & physiological functions
=> NB there is always a behavioural component to Disease!

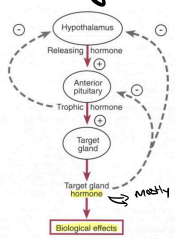


Thalamus:
- Has Ability to Modify info it Receives.
- Relay Station for sensory (input) tracts going to cortex
- (+) Receives input from Eyes. Ears.
- Also Relays signals from Motor cortex to Body (output)



Hypothalamus: [Homeostasis]

- Temp
- Thirst
- Endocrine → Ant. pituitary / Post. pituitary
- Hunger



HPA - Axis

↻ - feedback

[HPA Axis]

[- feedback]

CNX = only CN to leave Brain

Cranial Nerves → originate from Brainstem → PNS — Sensory — Motor — Mixed.

TABLE 9.1 The Cranial Nerves

Number	Name	Type	Primary Function
I	Olfactory	Sensory	Olfactory (smell) information from nose
II	Optic	Sensory	Visual information from eyes
III	Oculomotor	Motor	Eye movement, pupil constriction, lens shape
IV	Trochlear	Motor	Eye movement
V	Trigeminal	Mixed	Sensory information from face, mouth; motor signals for chewing
VI	Abducens	Motor	Eye movement
VII	Facial	Mixed	Sensory for taste; efferent signals for tear and salivary glands, facial expression
VIII	Vestibulocochlear	Sensory	Hearing and equilibrium
IX	Glossopharyngeal	Mixed	Sensory from oral cavity, baro- and chemoreceptors in blood vessels; efferent for swallowing, parotid salivary gland secretion
X	Vagus	Mixed	Sensory and efferents to many internal organs, muscles, and glands
XI	Spinal accessory	Motor	Some muscles in neck and shoulder
XII	Hypoglossal	Motor	Tongue muscles

Note: Mnemonic for remembering the cranial nerves in order: **O**h **O**nce **O**ne **T**akes **T**he **A**natomy **F**inal, **V**ery **G**ood **V**acations **S**ound **H**eavenly.

Brainstem & cerebellum

Vital centres → cardiac & vasc → BaroR. (carotid bodies & Aortic Bodies) → PE → SA Node, Ventricles, Arterioles, Veins.

→ Breathing

CNS = Medulla

Resp = Medulla & Pons

↳ Emotions / Voluntary → Higher centres (+ Limbic Sys.)

↳ CO_2 → Medullary chemoR

O_2 & pH → carotid & Aortic chemoR

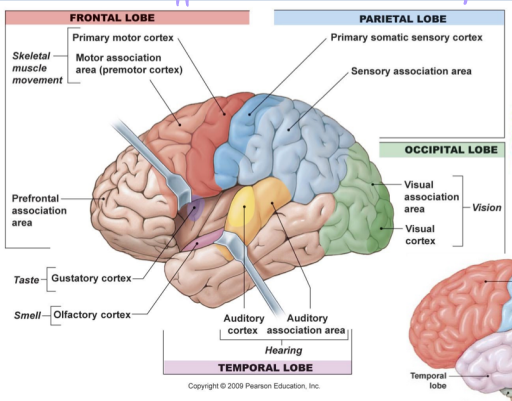
Medulla oblongata & Pons → Motor Neurons

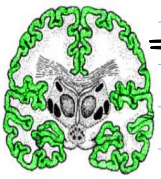
- inspiration
  - ↳ Scalene
  - ↳ Sternocleidomastoids
  - ↳ EIC MM.
  - ↳ Diaphragm.
- Expiration
  - ↳ Abdominals
  - ↳ IIC MM.

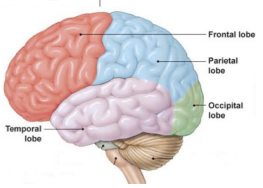
Corpus callosum → functional connection (R/L Hemispheres)

Cerebral cortex → Integrating sensory & Motor input & output.

↳ primary motor cortex executes all movements based off what it recieves from primary sensory cortex.







=> central sulcus divides sensory (post.) & motor (ant.) cortex.

Gyrus → Ridge

Sulcus → Canal

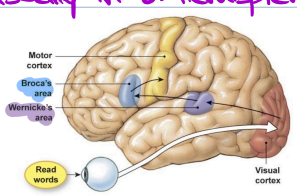
Cerebral processing of speech

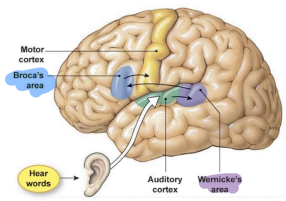
2 areas in cerebral cortex

Wernicke's area: Recieves & integrates spoken/visual (reading) language.

Broca's area: Recieves info from Wernicke & integrates it for speech (Motor response)

usually in L. Hemisphere

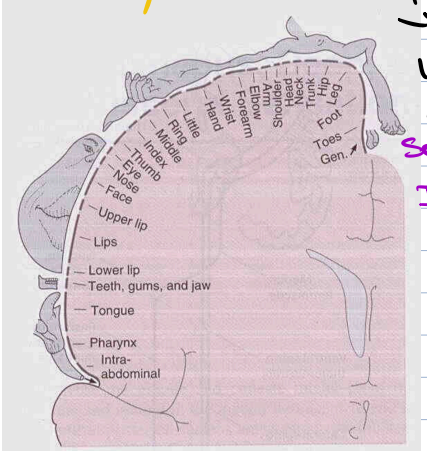




Sensory Homunculus: (parietal Lobe)

→ parts of sensory cortex which recieve stimuli from certain areas!

Sensory fallout = help ID where injury IS!

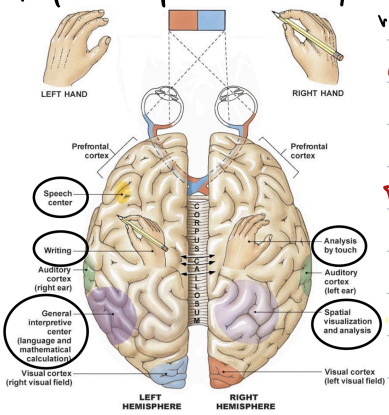


NB: Brain = Asymmetrical functional Regions:

if fallout of a certain fxn = help you ID where fallout is!

PET Scan = Measure functional Act. of Brain.

injected with tracer Mol.
Similar to Glu.
= taken up by neurons with high Metabolic Act.



Left: Language / speech / writing.
Maths processing & control.
Categorical Hemisphere.

Right: Visualization.
Analysis.
ID.
Representational Hemisphere

LO3: Physiology of the Sensory NS [Sensory = Afferent Division]

You have CNS & PNS.

Sensory Deprivation (↓ External Stimuli = become more aware of Int.)

Afferent Division = provides info About environment to CNS.

Homeostasis.

Sensory System.
- central R. in / close to Brain
- peripheral R outside Brain. → Skin

special senses
- Eyes vision
- Ears Hearing / Equn
- Nose Smell
- tongue taste

somatic senses
- ChemoR pH / Gases / chemicals
- OsmoR osmolarity
- ThermoR temp
- BaroR pressure
- ProprioR position
- other (MechanoR.) pain / vibration / touch.

NB processing by Sensory Division is Subconscious!

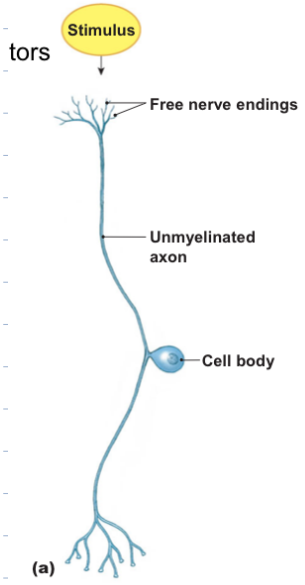
Sensory pathways

Stimulus (physical E⁻) → Sensory R. → Intracellular signal ∩ AP → Integration (CNS) → Response (via efferent Division)

Sensory R:

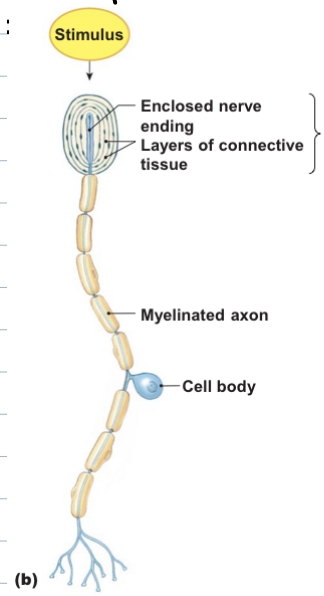
Simple R:

usually pseudounipolar neurons.

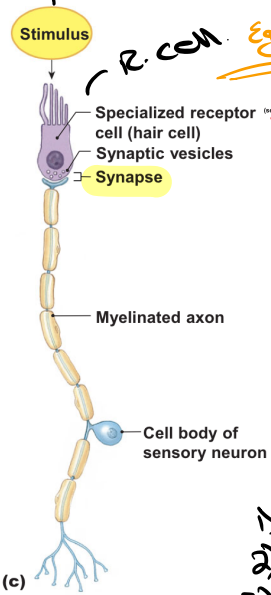


complex R.

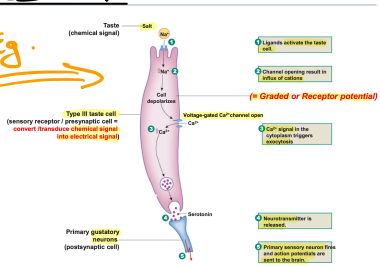
vibration stimuli



Special senses R:



eg.



eg.

stim E⁻ converted into info processed by CNS.

Sensory transduction
1) Adequate stim
2) Threshold
3) R. potential
4) Graded potential

NB

4 Major Groups of R:

ChemoR O2 / pH / Mol. etc.
MechanoR Pressure / Stretch (OsmoR.) / vibration / acc / sound
PhotoR Photons
ThermoR. Degrees of Heat.

↳ 2 point discrimination test. ↗ Demonstrates sensitivity to touch.

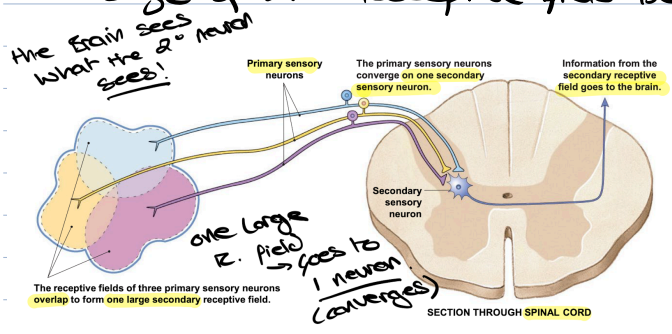
Receptive fields of Sensory Neurons:

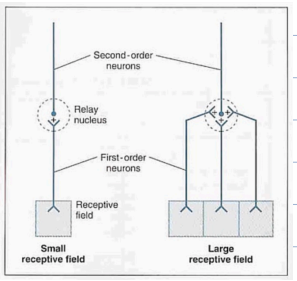
NB Brain sees what 2° Neuron sees.

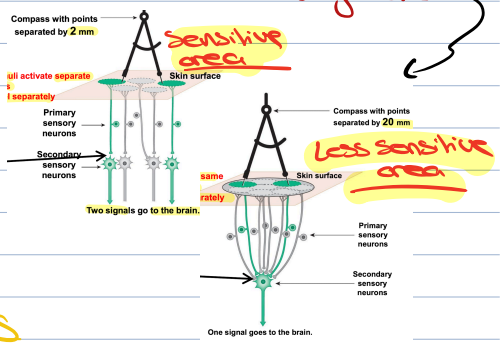
NB Size of 2nd Receptive field determines area sensitivity.

↳ Small R field = More sensitive than a large one.

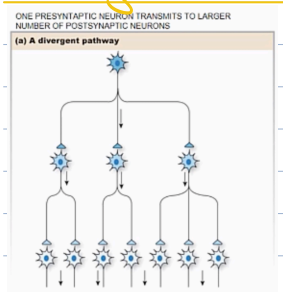
↳ Sensitive area = 1:1 ratio non sensitive



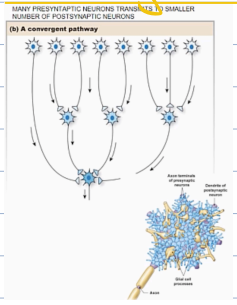




Divergent Pathway



Convergent Pathway



Dermatomes

R. fields of a specific section of SC

Area of skin that makes up R. field of a Spinal Nn, Dorsal root & Spinal segment.

Sensory cortex

Amount of space devoted to each Body part = proportional to sensitivity of that part.

[Homunculus]

Somatic Senses Pathways

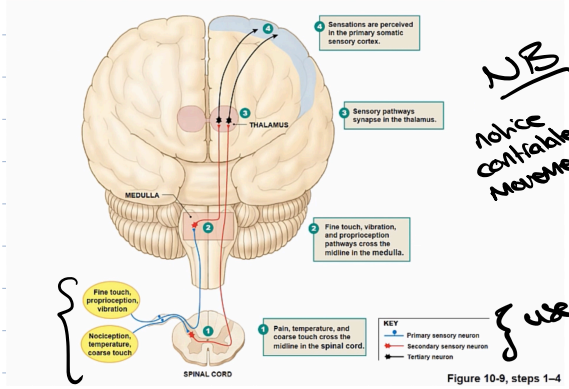


Figure 10-9, steps 1–4

understand how things cross

NB notice contralateral movement.

use key.

NB: Integration by CNS

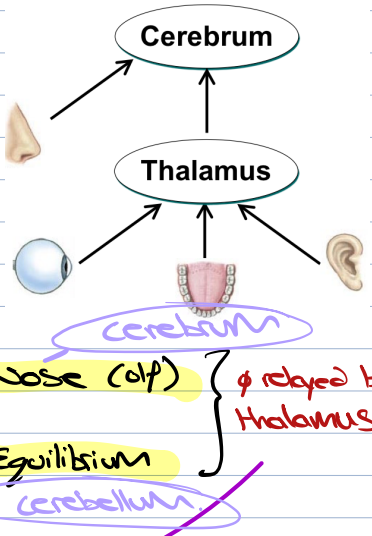
Sensory Info → spinal cord to Brain via Asc. pathways

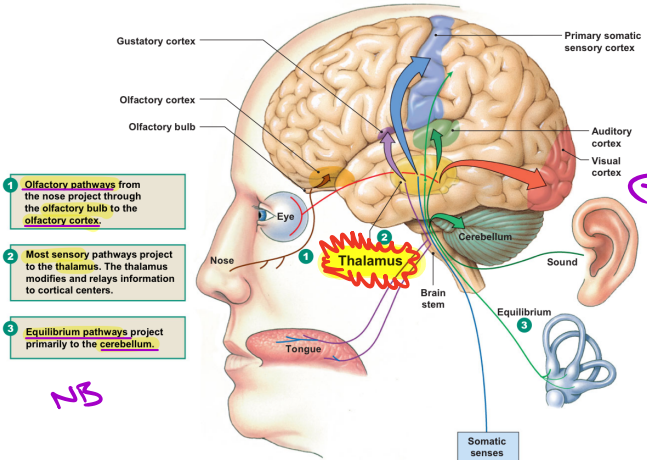
↳ Directly to Brainstem via CN.

Visceral Reflexes: Integrated in Brainstem / Spinal cord (subconscious)

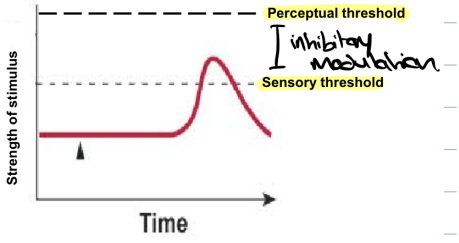
NB Most sensory info gets relayed by thalamus

↳ Exceptions: Nose (olf), Equilibrium → ϕ relayed by Thalamus





NB



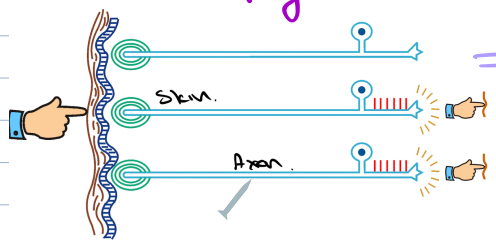
Perceptional threshold: Nl of stimulus necessary to be aware of particular sensation

NB – CNS distinguishes 4 properties of stimulus { Modality, Location, Intensity, Duration

↳ **Modality** indicated by which & where : Sensory Neurons are activated
: Neurons terminate in Brain
[∴ R. is specific for a certain stimulus]

↳ **Location** which R. fields are activated { Stim Above threshold
projects AP to organized sensory Regions of cerebrum

↳ NB CNS ∅ distinguish AP Generated @ sensor & those Along Afferent-Asc. route [Axon conveying Sensation]

∴ 

=> Phantom Limbs phenomenon. Axons severed!

=> **Auditory Info** = Exception { ∅ R. field
Sensitive to diff freq.
↳ Brain use timing Diff to localize sound.

=> **Lateral inhibition** : ↑ contrast between Activated R. fields & inactive neighbours.

=> **Population coding** : Multiple R. functioning together.

- **Lateral inhibition** enhances contrast and makes a stimulus easier to perceive

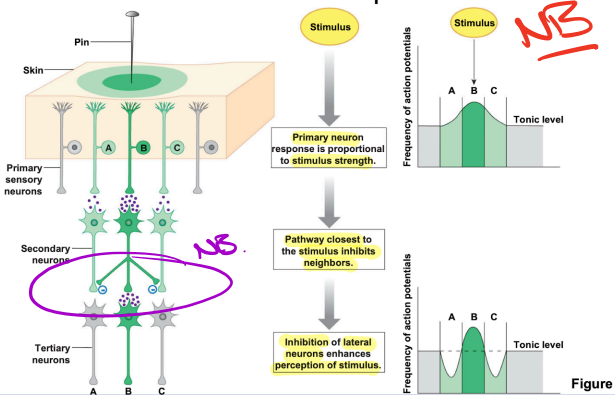
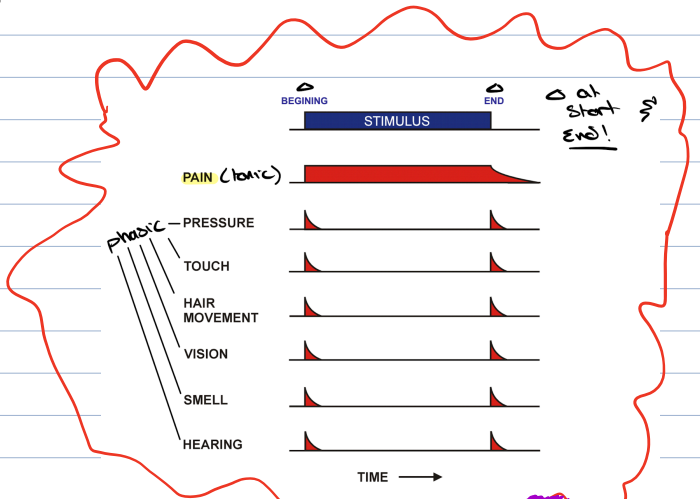


Figure 10-6



∅ at start & end!

↳ **Intensity & Duration** → AP = All-or-nothing
↳ Duration of AP
↓
# of R. activated & frequency of AP.

→ Some R. can Adapt Lease
↳ tonic R. vs phasic R.

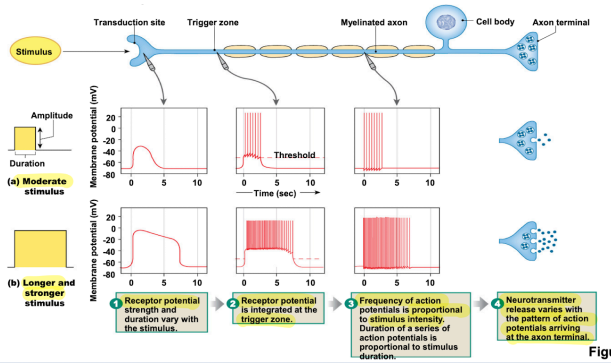
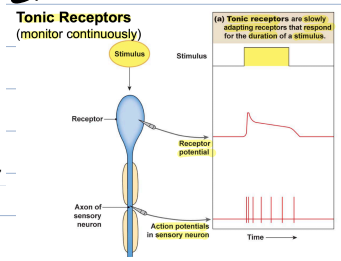


Figure 10-7

[Monitor continuously]
Respond for duration of stimulus.



Rapidly Adapts to constants Stimulus & then turns off.
[Monitors Δ's]