

Neuronal pool

Def Collection of neurones having the same function eg Brain Thalamus LG13

Organization.

1 Divergence

Single input diverges to

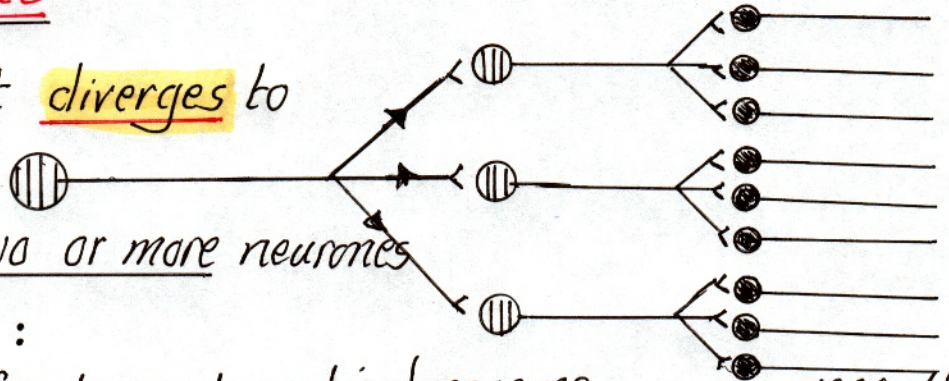
activate two or more neurones

Importance:

a Amplification 1 cortical neurone → 1000 AHCs

b Distribution.

Painful signal → AHCs → Flexor withdrawal reflex
Cortical cells → Pain



2 Convergence

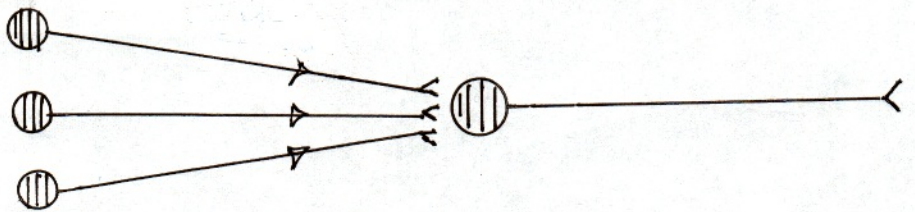
Multiple signals converge to activate one neurone

Importance:

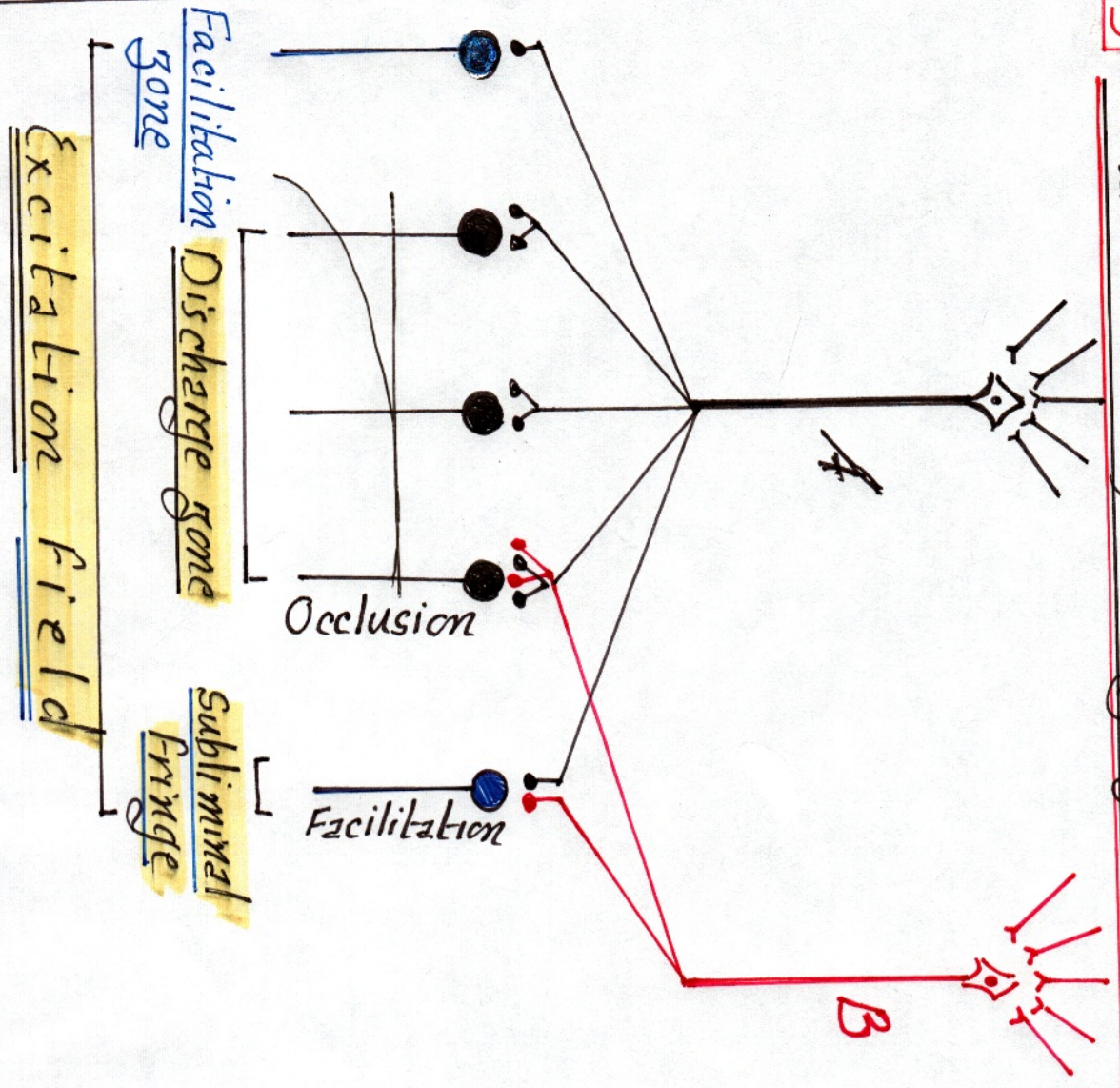
a Spatial summation Stimulus intensification

b Summation of important information

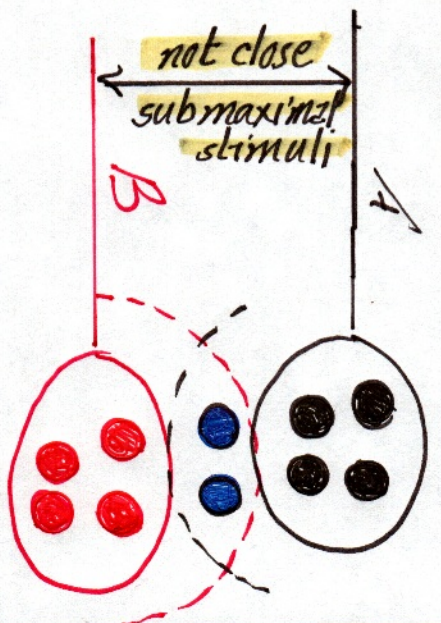
Selection of important information



3 Excitation Field, discharge zones & subliminal fringe

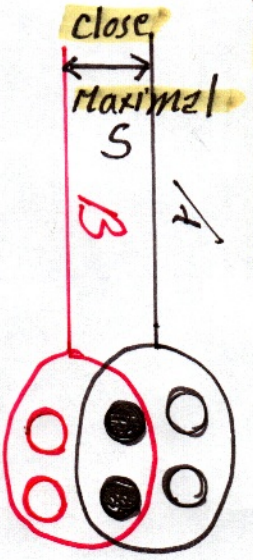


Facilitation



Facilitation zone

Occlusion



Discharge zone

4 Inhibitory circuits

Single input can give rise to BOTH

excitation by itself

inhibition via Inhibitory interneurone

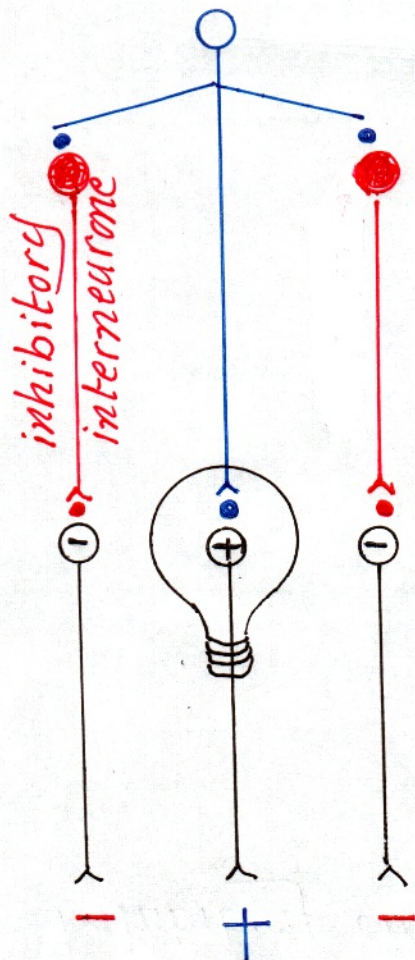
Two ch. tr. one is excitatory
second is inhibitory

Lateral inhibition

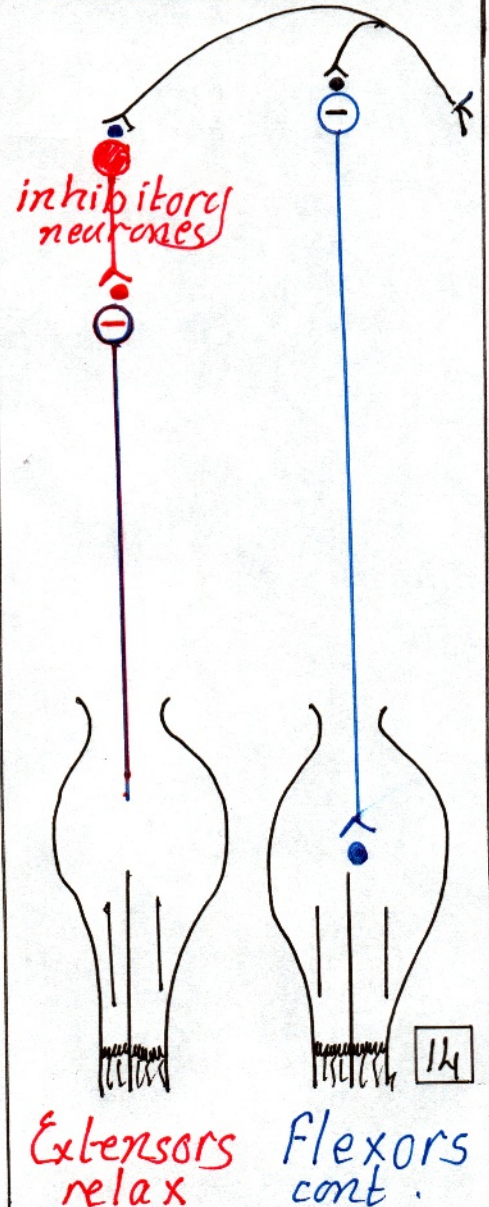
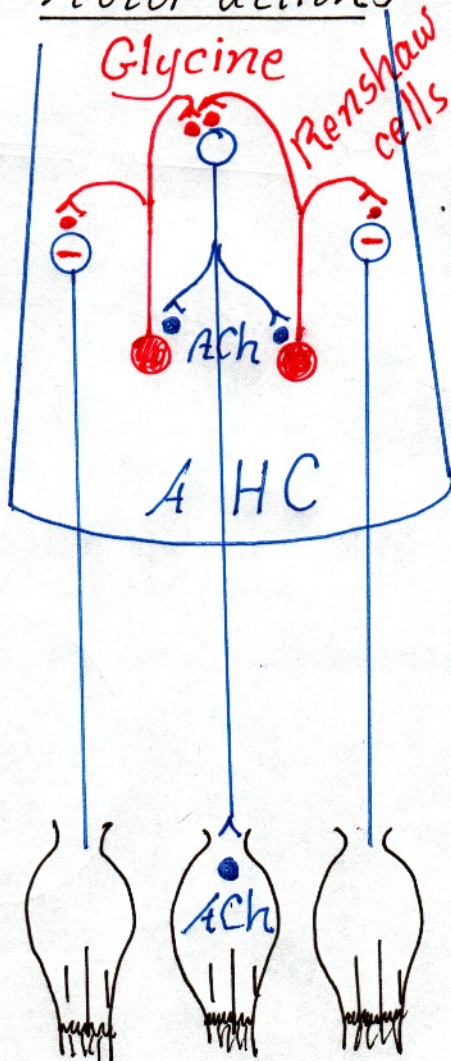
Renshaw cell inhibition

Reciprocal innervation

Sharpness of Sensations



Sharpness of Motor actions

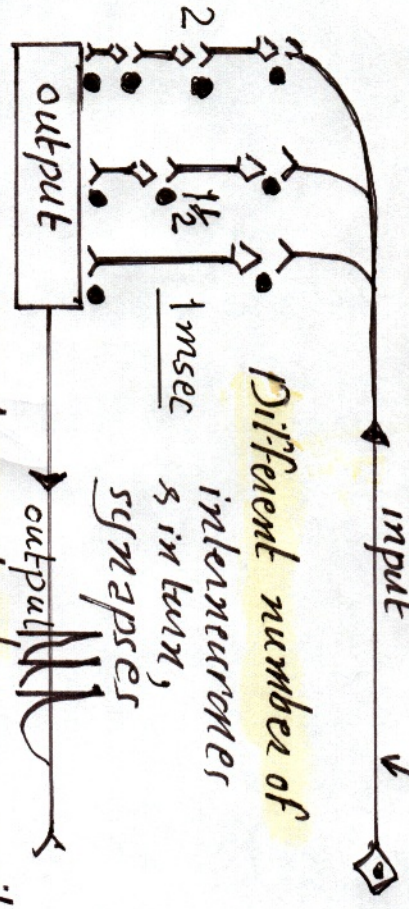


5 Activating circuits (After discharge)

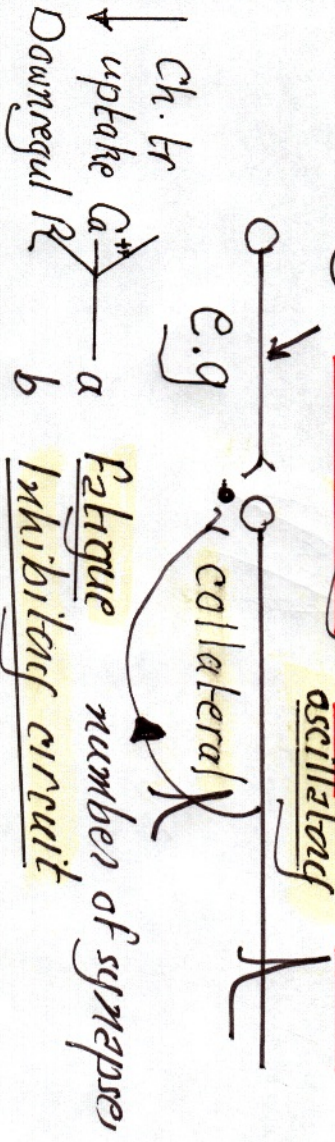
Def. Output neurone continues to stoppage of stim. of input Discharge After

Mech. ① Synaptic after discharge
Post tetanic potentiation.

② Parallel circuits



③ Reverberating = closed = oscillating circuit



Motion pictures

Receptors

15



Def. mf

Functions: Detector
Transducers
Generator

• Compressor

Classification:

1 Mechano: Proprioceptors

touch, P vibration
• vestibular R.

2 Thermo: cold warm

3 Chemo: olfactory & taste
osmo & gluco in hypoth

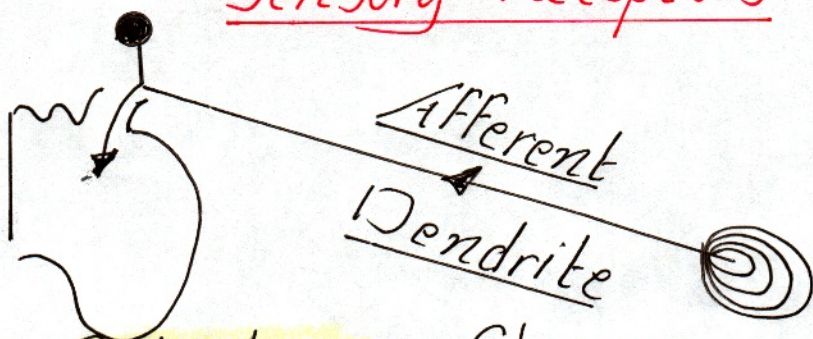
4 Photo: rods & cones

5 Noci: pain

Receptors

Sensory Receptors

● Definition



● Functions

- 1 Detectors Changes
- 2 Transducers S → RP
- 3 Generator A potentials
- 4 Compressor ↑ S 1000 → ↑ A pot 3

● Classifications

- ① Mechanoreceptors Touch, Pressure & Vibration
subtype Proprioceptors Position, Movement
 Rate of movement
 e.g. Merkel cells & Ruffini corpuscles: Sustained P
Meissner corpuscle slow vibration, change in texture
Pacinian corpuscle fast vibration & deep pressure
Proprioceptors Muscle, joints & vestibular receptors

② Thermoreceptors

③ Chemoreceptors including osmo, olfaction & taste receptors

④ Photoreceptors rods & cones detect light

⑤ Nociceptors Free n endings detect pain

Types Mechanical nociceptors Strong p

Thermal nociceptors > 45°C & Severe cold

Chemically sensitive nociceptors e.g. bradykinin
 histamine, high acidity & irritants

Polymodal combination

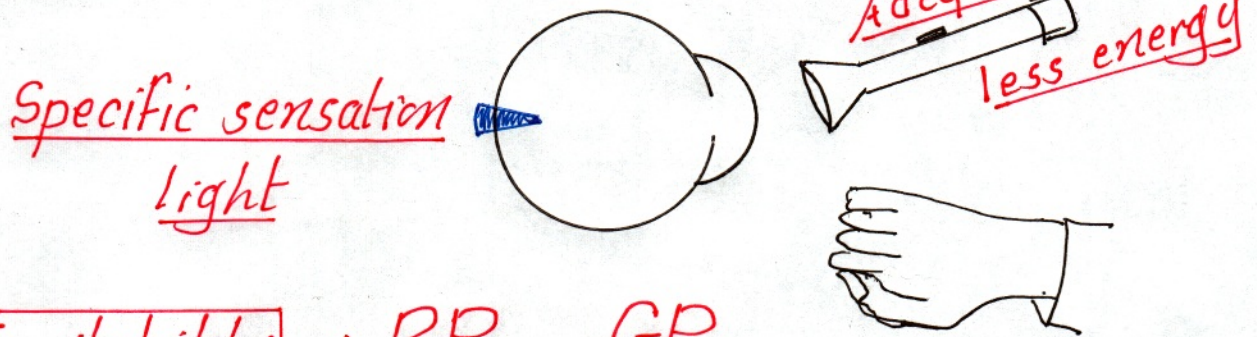
Subtypes Teching & tickling receptors

● Properties

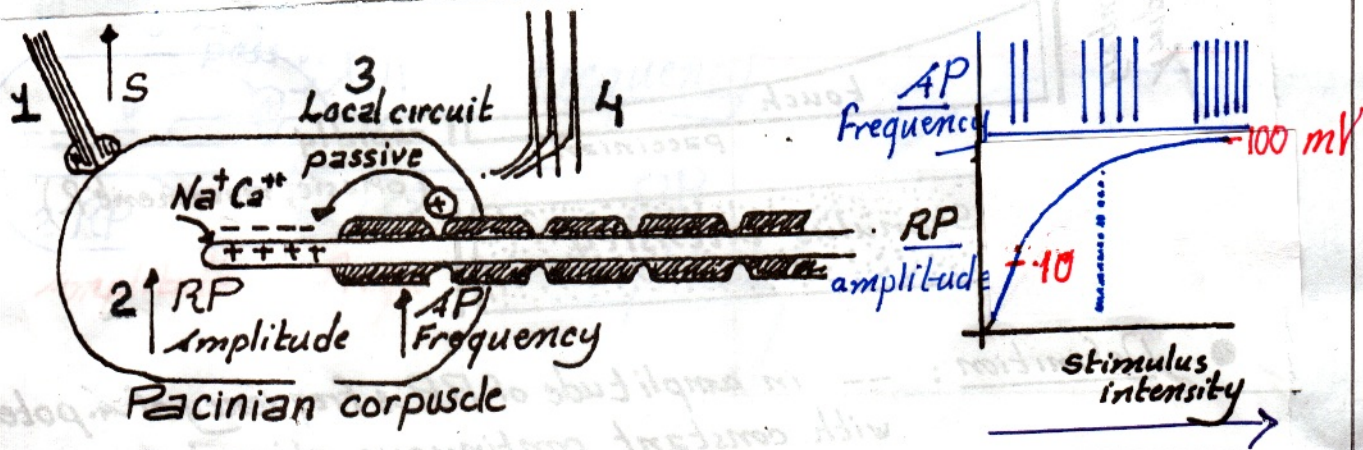
Properties of sensory receptors

1 Specificity

- a Specific sensation : Müller 1835
Law of specific nerve energies
- b Specific stimulus : Adequate stimulus



2 Excitability · RP GP



Properties of RP (GP)

- 1 Localised (nonpropagated) partial depolarization
- 2 Doesn't obey All or none law = Graded
- 3 No A'RP = Summated
- 4 Longer in duration than AP i.e 5-10 msec
- 5 Initiates many APs start at 10 mV (threshold)
- 6 Maximal amplitude 100 mV

Note Amplitude of RPs & Frequency of APs \propto S intensity

3

Adaptation of receptors

Definition

Amplitude
Frequency

Slowly **Static** Tonic response

Moderately

RP
AP

Rapidly **phasic**

Stimulus
intensity

Types

Cause "Mechanisms"

a

Rods & cones

changing conc of photosensitive pigments

b

Mechanoreceptors 2 mechanisms

1 Remodeling (readjustment) of R. structure

2 Inactivation of Na channels
terminal n. fibres

It is not related to fatigue
1st node of Ranvier

Pain, Pacini endings; Position

Merkel cells; M. spindle

chemo bare

Temp, smell & taste.

Touch

"Pacini" Meissners

Rate of movements
Receptors of SGCs

Importance of information

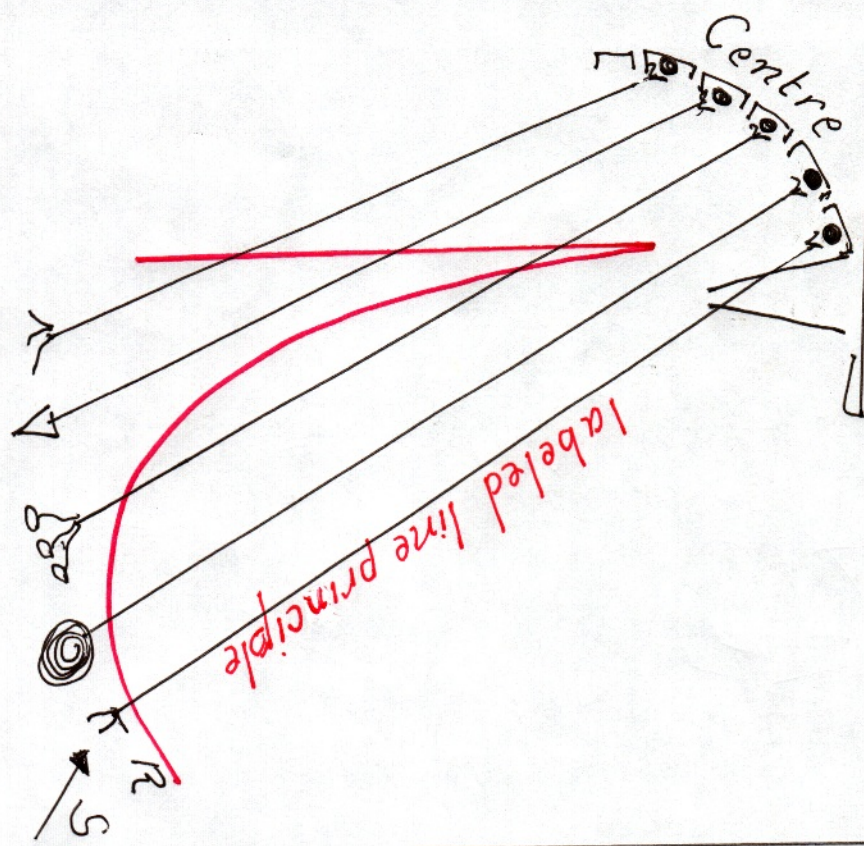
4 Sensory code

• Define Ability of CNS to recognise

Modality (types).

Intensity.

Locality.



Modality: **SPECIFICITY**

- 1 Adequate stimulus
- 2 Muller's law Specific sensation.
- 3 Labeled line principle
- 4 Specific centre

Intensity Stronger stimulus
 a- Receptors activated.

b- 4 potential Frequency.

Weber - Feshner High intensity
 Frequency \propto log intensity of S
 3 1000

Compression Function

Stevens power principle
 R (sensation felt) = $K S^A$

Locality **PROJECTION**

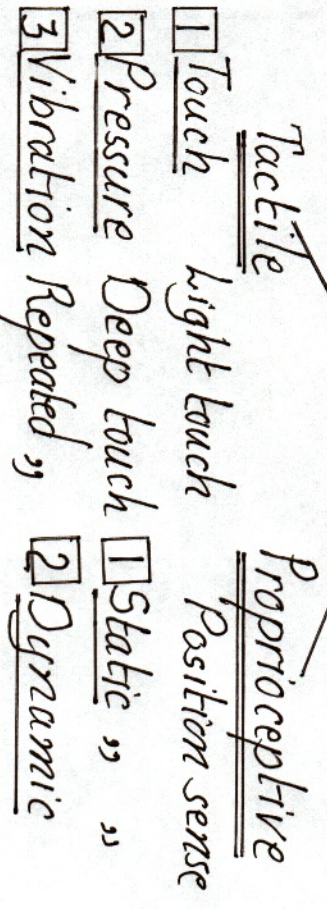
Each body part has representative area
 Impulses reach area Sensation is projected.
 receptive field eg phantom limb.
 of sensory unit (sites branches)

Sensations

3

- ① Organic senses
- ② Special senses
- ③ Somatic senses

- 1 Pain sense
- 2 Thermoreceptive sense
- 3 Mechanorereceptive



Rate of mov
Kinesthesia

Other Classifications

- ① Exteroreceptive
- ② Visceral
- ③ Deep Deep P, vibrations

Cutaneous Mechanoreceptive senses

4 Major encapsulated receptors

- Tactile At least 6 receptors
- Touch light touch

<u>Crude touch</u>	<u>Locality</u>	<u>Fine touch</u>
<u>Poor</u> localis.	<u>Low</u> intensity	<u>Well</u> localised
<u>Few</u> grades 10	<u>Free n. endings</u>	<u>Many</u> grades 100
<u>Free n. endings</u>	<u>Receptors</u>	<u>Merkel's discs</u>
<u>Hair end organs</u>		<u>All areas</u>
		<u>Meissner's corpus.</u>
		• non hairy areas
		• very sensitive

Pressure Deep touch

Receptors Ruffini corpus slowly adapting.
Pacinian corpuscles most rapidly adapt.

● Vibration All touch R Over bony promin

Meissner's 80/s Pacinian 800/second

● Pallesthesia: Uncontrolled diabetes, ↓ vit. B12, Pernicious anemia, Early tabes dorsalis [20]

Fine touch

Dorsal column system

Tests (Types)

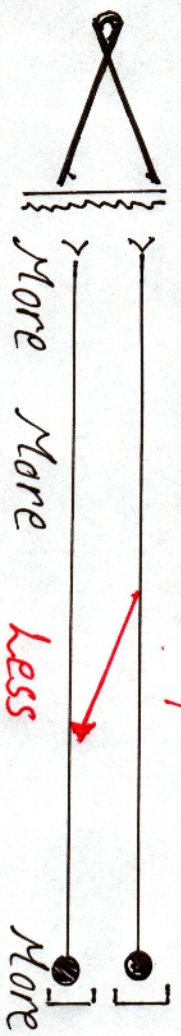
With both eyes closed, (without looking)

1 Tactile localization

2 Tactile Discrimination Measures tactile acuity

Finger tips 2 mm Back 65 mm

Braille dots 2.5 mm separation

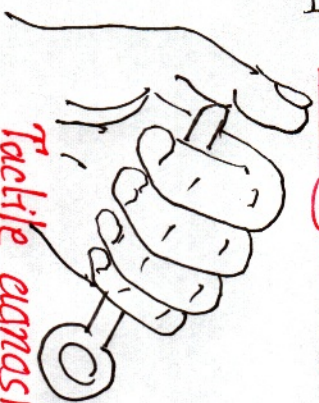


3 Texture of materials

4 Stereognosis a All sensations especially Fine touch

b Past cortical experience

c Normal hand muscles



Dorsal column damage (current try)
Tactile agnosia
Early sign of damage of sensory cortex

Proprioceptive senses

2 types:

1 Static : Position sense.

2 Dynamic : Rate of movements. **Kinaesthesia**

Depending on knowing the:

Degree of angulation of all joints in all planes & their rate of change

Receptors Tactile skin & deep receptors in ms, tendons and joints

Skin receptors $\frac{1}{2}$ infer in case of fingers

Midrange joint angulation : M. spindles

Extremes of " " : Stretch of tissues

Pacinian cor., Ruffini corpus. & Golgi tendon

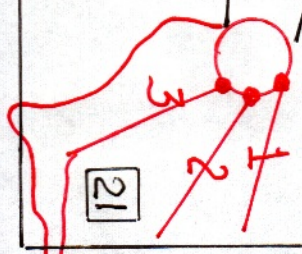
Note: Pacinian cor. & M. spindle for dynamic

Conscious inform along Dorsal column

Unconscious inform along Sp. cerebellar tr.

Vibration & proprioceptive senses

are closely related



Thermal sensations

Receptors :

- ① Cold receptors Dendritic endings of A δ & C fibres
20 m/s 2 m/s
- ② Warmth receptors " " " " C fibres
- ③ Thermal nociceptors above 45°C (42°C) severe cold 5°C

Characters located in Subcut. t immediately under the skin at discrete separated Spots

Lips 15-25 > Fingers 8-5 > Trunk 1 spot/cm²

Cold receptors

More numerous 3-10 times

More superficial

Adapt more slowly Moderately Adapt

A delta & C

Threshold 10°C

Peak 24°C then ↓ to 40°C

Warmth receptors

Less

Less

Less

Only C

30°C

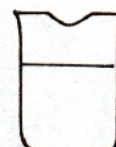
45-46°C

Mechanism of stimulation

Change in metabolite concentrations ↑10°C → ↑2 folds

Sensation depends on :

- 1 Original skin temperature
- 2 Rate of temp changes
- 3 Area exposed.



Tract : Lateral sp. th tr with pain

- Determination of gradations by relative degree of stim. of different types of receptors

- Paroxysmal cold sensation > 45°C may be due to damage of receptors

- Freezing cold & burning hot felt almost alike.

Pain senses

Pain signals t. damage \rightarrow protective reflexes
Pain receptors \rightarrow seek medical advise

- Free nerve endings

<ul style="list-style-type: none"> ● <u>A delta</u> 2-5 μ 20 (6-30) m/second Release Glutamate. <u>First Fast Epicritic pain</u> 	<ul style="list-style-type: none"> ● <u>C fibres</u> 0.4 - 1.2 μ 2 (0.5 - 2) m/second Glutamate & Substance P <u>Second Slow Protopathic</u>
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- Types
 - ① Mechanical nociceptors : strong pressure.
 - ② Thermal nociceptors : $> 45^\circ\text{C}$ & Severe cold.
 - ③ Chemically sensitive ,, : Bradykinin, Serotonin, K^+
 histamine, acids, ACh, proteolytic enzymes
 prostaglandins & substance P.
 - ④ Polymodal nociceptors.
 - ⑤ Sleeping (silent) pain receptors only with inflamm.

- Distribution
 - More Skin, Periosteum, Arterial walls, joint surfaces
 falx and tentorium cerebri
 - Less Viscera & deep tissues (needs widespread t. damage)
 - No Liver & Lung — Brain & Bones

- Adaptation Slowly (static - tonic). Nonadapting receptors
- R are Nonselective Cation Channels called TRP
 include TRP V₁ Transient Receptor Potential related to
 Vanilloid activated by intense heat, acids & chemical
 e.g capsaicin (hot pepper).

Note Itching Pruritus in health & severe diseases (chronic kidney diseases, liver diseases, HIV) caused by histamine & bradykinin 23

Types of pain senses

① Cutaneous pain C & A delta

② Deep pain

C "mostly"

Diffuse.

Dull aching.

Depressor effects i.e. -- HR -- ABP

Causes

Muscle spasm
Inflammation
Ischemic pain
ischemia
stim. mechano
sp

Cause -- blood flow

Mechanisms ++ lactic acid

release of proteolytic enzymes

Characters ++ by activity of ms

-- by rest

e.g

Angina pectoris

Intermittent claudication

③ Visceral pain

C "covers A delta"

Causes

4

Ischemia. e.g. spasm
Inflammation.
overdistension

Irritation.

Infiltration.

Characters

Diffuse.

5

Dull aching.

Depressor effects.

Rigidity of overlying muscles

Referred

note Sharp cut → no pain
No proprioceptors Few temp. & touch. R

④ Neuropathic pain

e.g 1 Trigeminal neuralgia

2 Sciatica

3 Diabetes neuropathy

4 Herpes zoster

5 Phantom limb

Characters

Electric shooting

bouts or paroxysms

hyperalgesia & paresthesia

Partial respond to morphine

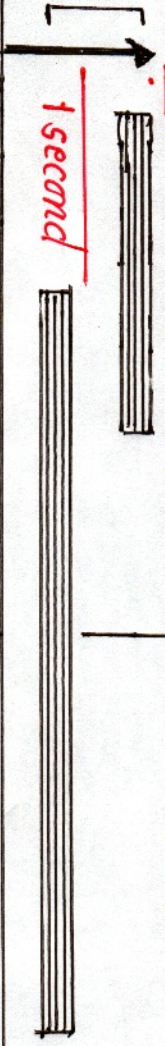
Cutaneous pain

Fast

immediate, acute, pricking, electric, sharp

0.1s

1 second



A delta

Neo sp. th. tr Lat. sp. th. tr

C

Paleo sp. th. tr

Sensory cortex
Well localised

RFs nonspecific th.
Poorly localised.

Slow

chronic, burning, throbbing, aching, nauseous

Threshold of pain

45°C

Reactions to pain:

① Motor reflexes: sp. reflex

Fast: F. Withdrawal R
Slow: Rigidity of ms

② Autonomic reflexes:

Acute: symp.
Chronic: parasymp.
nausea, vomiting

③ Emotional:

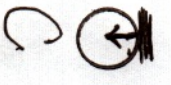
Acute: Grogg anxiety
Chronic: Depression

Mech. & Therm. Receptors
Skin Tissues
Sympathetic mem & Covers
All types
All tissues
skin deep & viscera

Pressure
O₂ lack



A delta

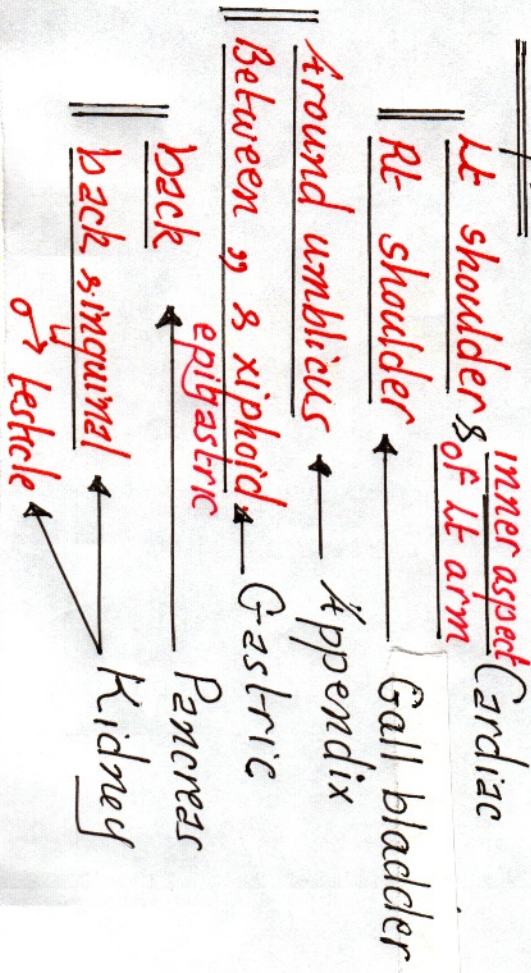


h. anaesthesia
e.g. cocaine

Referred pain

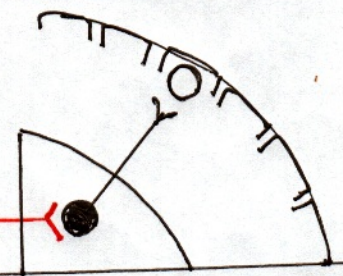
- Definition: **Same dermatome** (same post. root)

- Examples:

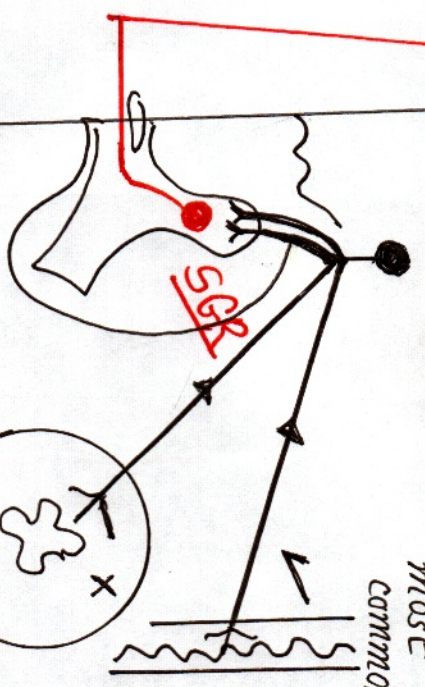


not stereotypical. i.e. unusual references occur.
Cardiac pain referred Rt arm,
 abdom. region even back, neck or jaw.

- Mechanisms:
Convergence Projection theory
Facilitation theory



Thalamic project

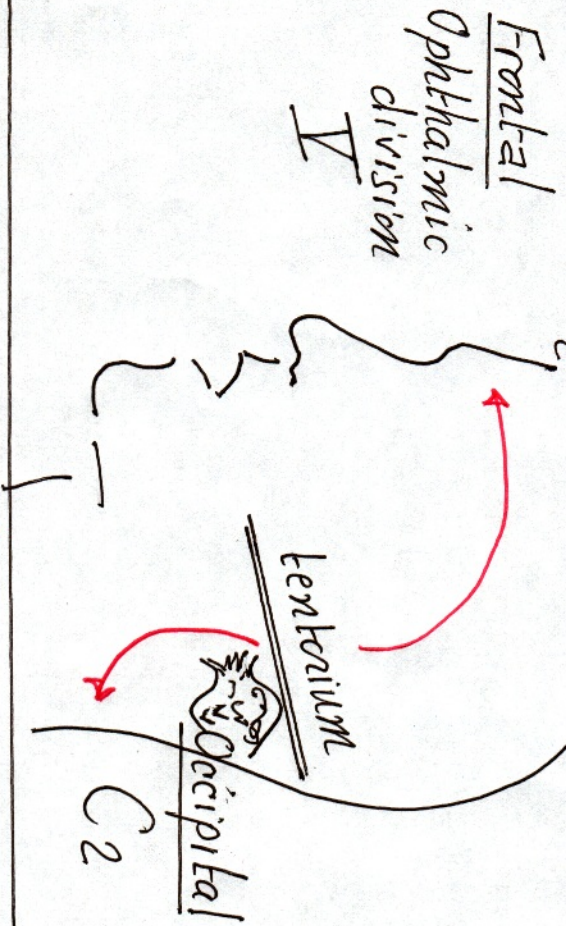


convergence

most common

Headache

referred pain



Brain is insensitive to pain

Intracranial pain sensitive structures

Artery Dural especially Middle Meningeal

Vein Sinuses

Nerve V, IX & X

Dura & cerebellum

Causes of Headache:

Extracranial 95%

Intracranial 5%

- 1 Eye
- 2 Ear
- 3 Nose & sinuses
- 4 Mouth

- 1 Meningitis
- 2 Meningeal trauma e.g. operation
- 3 Meningeal irritation & traction e.g. tumour

5 Scalp & neck ms Tension headache.

4 Migraine

6 Trigeminal neuralgia.

VC → VD
problems → headache

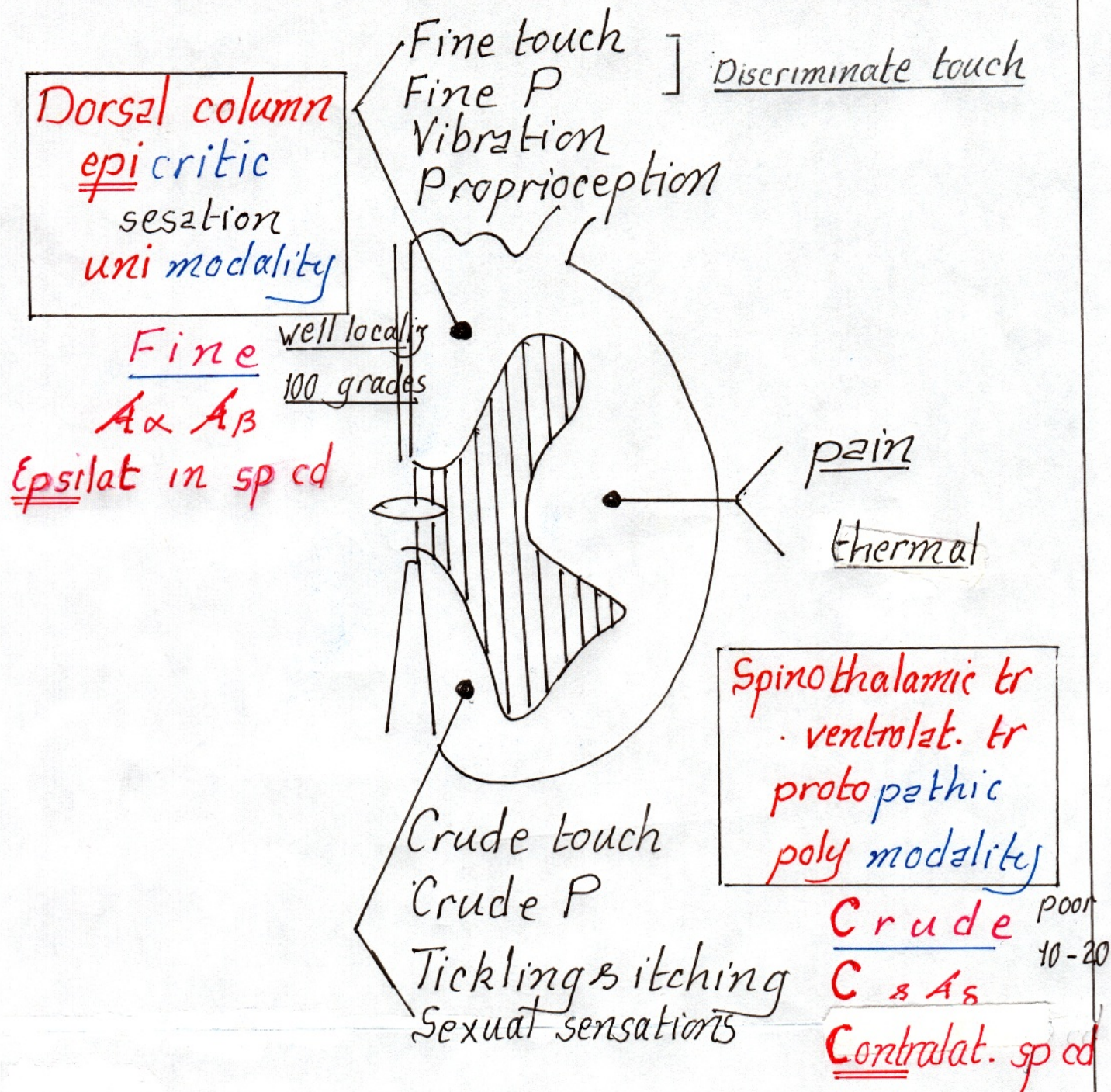
7 Systemic disorder e.g. anemia.

5 ↑ ABP → headache PP

6 ↓ CSF P

7 Toxic headache:

Alcoholic
Constipation



Rules :

1. 3 groups in sp. cd
corresponding to
3 columns

But,

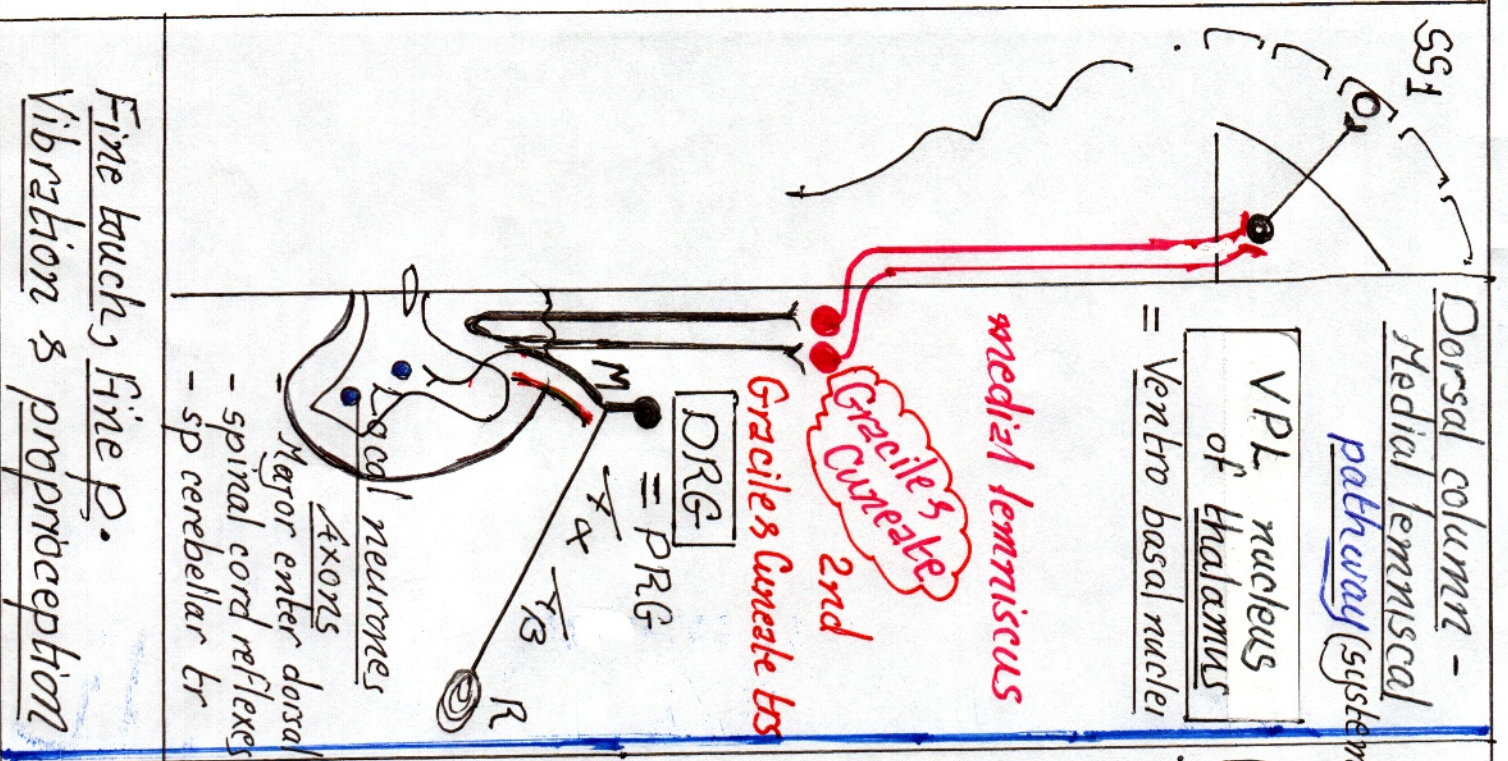
2 pathways

2. 3 order neurones

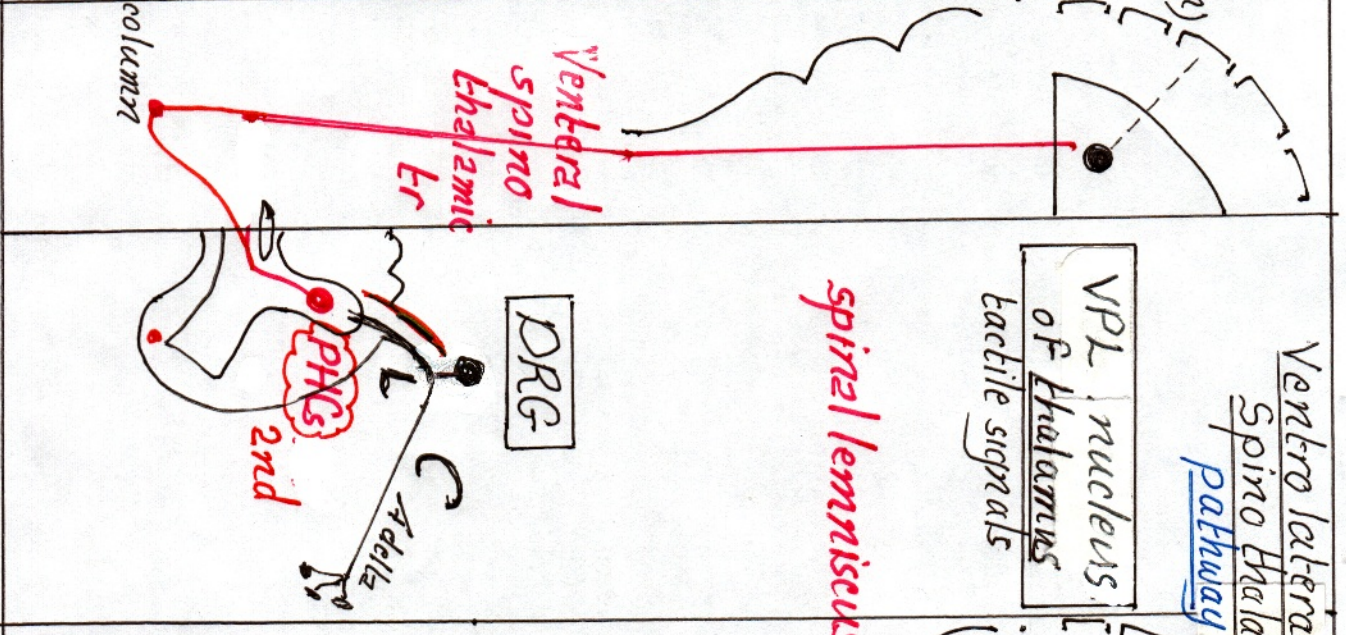
1st DRG

3rd Thalamus

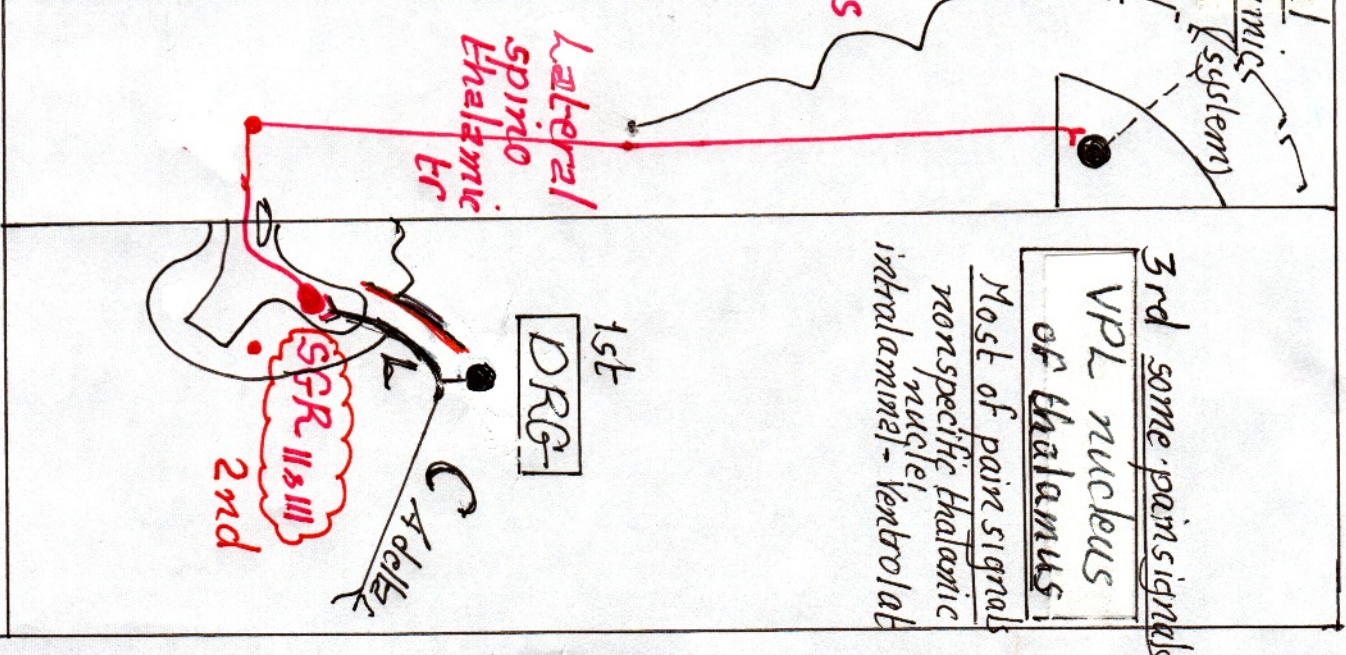
2nd different sites
Axons cross



Fine touch, fine p.
Vibration & proprioception



crude touch, crude p.
Tickling, itching, sexual



Pain & temp

Paleospinothalamic tr pathway

Slow chromic pair

Partly localised.
to one arm or leg.

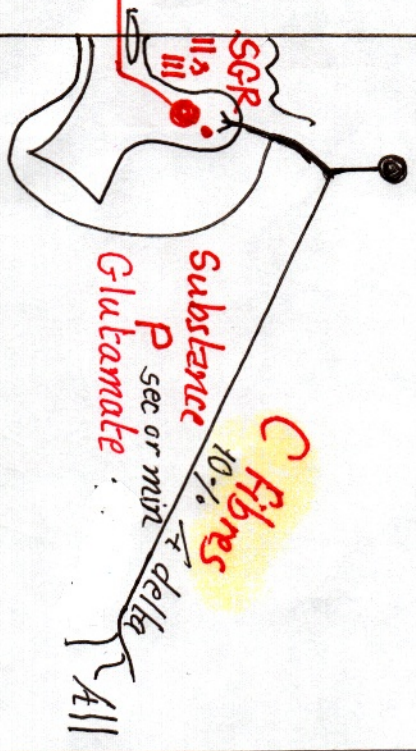
10% Ventral Postrolateral nuclei of thalamus

90% 3 areas (suffering type of pain)

- 1 Reticular nuclei of brain stem
- 2 Tectal area of midbrain
- 3 Periaqueductal gray region

Then to non specific nuclei of thalamus (intralaminar & ventrolat) & Hypoth & other brain centres

DRG (PRG)



Neospinothalamic tr pathway

Fast pair

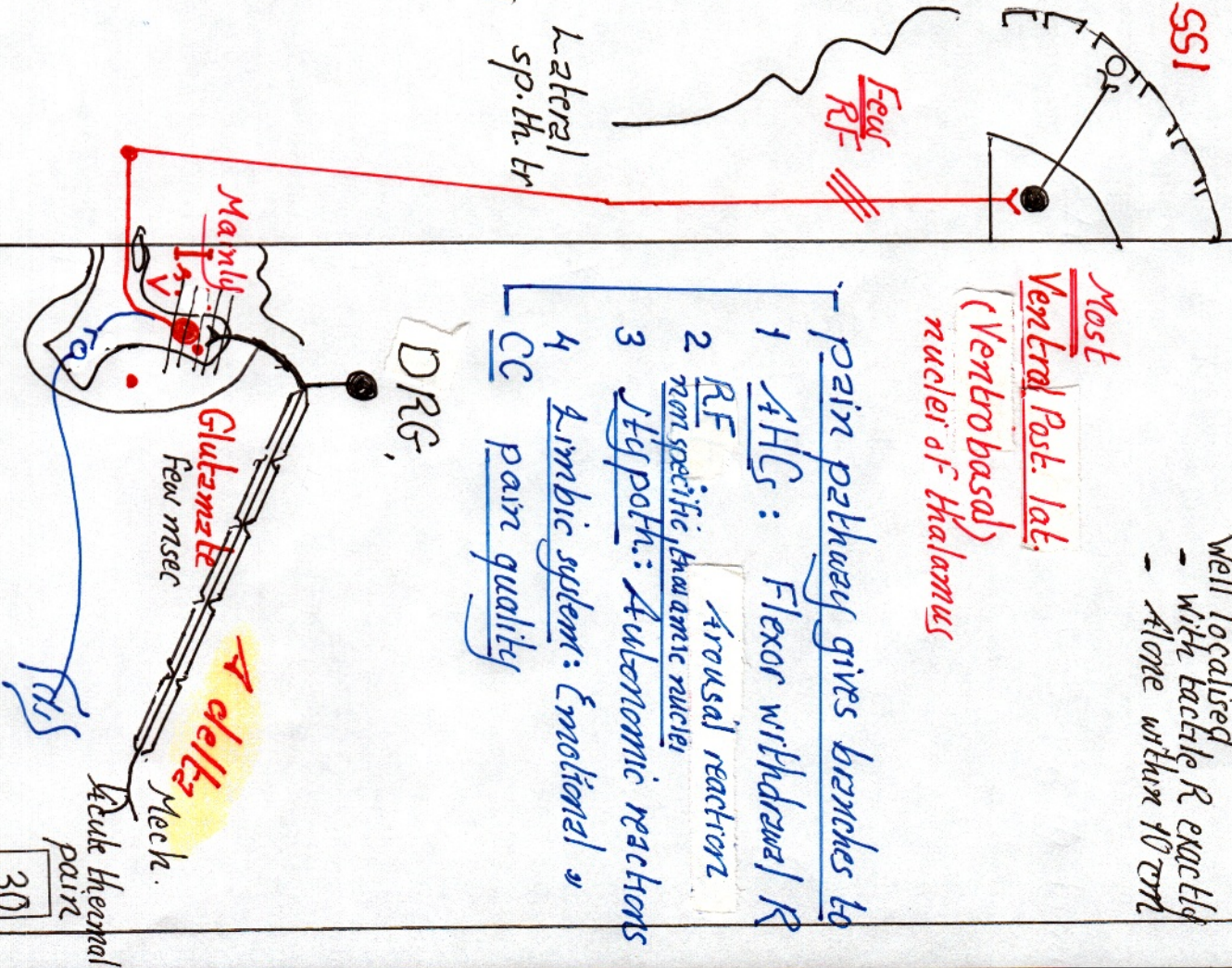
Well localised
- with tactile R exactly
- Alone within 10cm

Most Ventral Post. lat. (Ventral basals) nuclei of thalamus

Pair pathway gives branches to

- 1 AHG: Flexor withdrawal R
 - 2 RF non specific thalamic nuclei Arousal reaction
 - 3 Hypoth.: Autonomic reactions
 - 4 Limbic system: Emotional
- CC pair quality

DRG,



Dorsal column Medial lemniscal pathway

- Joined in brain stem by fibres mediating sensations from the **head** (main sensory & mesencephalic nuclei of trigeminal nerve).
 - **Somatotopic organisation**
 - Fibres from **Sacral** cord are positioned most **medially**
 - Fibres from **Cervical** cord are positioned most **laterally**
- It continues through the thalamus & cortex.

Ventrolateral spinothalamic pathway

- Fibres from second order neurone synapse in RF of brainstem (spinothalamic pathway) then project to central lateral nucleus of thalamus. Pain activates prim. & secondary somatosensory cortex, cingulate gyrus, amygdala & frontal lobe & insular cortex.
- **Two components** of pain pathway
 - 1 Noxious stimuli that don't induce change in affect to prim. somatosensory cortex only discriminative aspect of pain
 - 2 Noxious stimuli that elicit motivational affective responses to RF, central lat. thalamic nucleus projects to frontal lobe, limbic system & insular cortex

Cortical plasticity

Neuronal connections **not innate** but can be changed by experience to reflect the use of represented area

② Somato sensory area II SS₁

Site 40 Below & Behind lower end of SS₁

Spatial orientation Poor face ant, arm centrally & legs post.

Connections signals from both sides of body, SS₁, other sensory areas of brain, visual & auditory areas

Functions Not clear, However removal has no apparent effect on SS₁. May help in primates to remember differences tactile, shapes & texture.

③ Somatosensory association areas

Secondary somatosensory cortex

Site 5, 7 behind SS₁ Post. half of parietal lobe in wall of lateral fissure (sylvian fissure) which separates

Combine information from multiple points SS₁, thalamus, visual and auditory

Functions Deeper meaning of sensory information.

Integration of sensory information related to **object** or conscious picture of position of **body** in space.

Stimulation complex body sensation even feeling of an object

Removal (lesion) on one side **Amorphosynthesis** on opposite side

- Objects loss of ability to recognise complex objects & complex forms felt in opposite side of body **e.g. asternognosis**
- Loss most of the sense of form of opposite 1/2 of body
 - forgets the use of this 1/2 for motor function
 - forgets & ignore the opposite 1/2 of his body & when feeling an objects recognises only one side of object

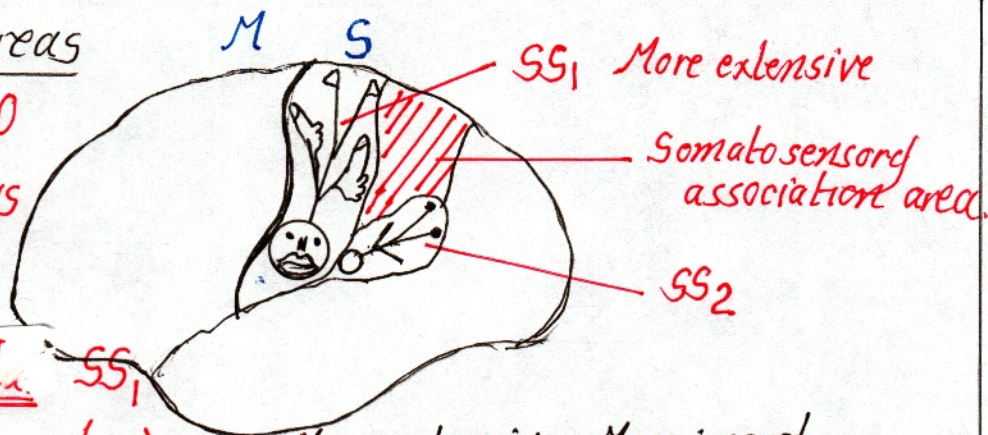
Note Motor cortex is informed about position & motion senses of the different parts of body [32]

Somatic sensory areas

1, 2, 3, 5, 7, 40

Brodmann's areas

52 Histolog. 1909



① Somatosensory Area I SS₁ (Prim. somatosensory cortex)

More extensive More import

Site 3 a, b, 2, 1 e.g 3a proprioception 3b touch
Post central gyrus Ant half of parietal lobe

Spatial orientation Crossed
Upside down except face (legs top & medial)
Area \propto number of R (use of part)

Lips greatest then face then thumb then hand : LH & trunk small

6 layers of neurones 1 to (VI deepest) incoming signals to layer IV

layer I & II receive nonspecific signals from lower brain centres

II & III sends axons to opposite side of brain

V & VI " " to deeper layer of brain e.g BG, BS, spinal

Vertical columns of neurones each serves a single specific sensory spot with specific modality

Functions Fine sensations (Dorsal column)

Fast pain.

Temp discrimination

Lesion Bilateral excision of SS₁

Person is unable to

1 localise discretely different sensations in different parts of body

However, localize crudely e.g particular hand, body trunk via thalamus, brain stem, parts of CC.

2 judge critical degree of pressure against the body

3 judge weights of object

4 judge shapes or forms of objects **astereognosis**

5 judge texture of materials.

Note Pain & temp sense are preserved in quality (modality) & intensity but **poorly localised**.