

RECEPTORS

Dr. Priyanka Rane

DEPT. OF PHYSIOLOGY

MGMMC, NM

Table 13-1 Receptor Classification

Classification by Adequate Stimulus
Class

	<i>Stimulus</i>	<i>Examples</i>
Mechanoreceptors	Mechanical distortion	Cutaneous touch receptors, pacinian corpuscles, hair cells of the ear
Chemoreceptors	Chemical	Taste receptors, olfactory receptors
Thermal receptors	Temperature	Warm cutaneous receptors, cold cutaneous receptors
Photoreceptors	Photons	Rods and cones of the retina

Classification by Function
Class

	<i>Definition</i>	<i>Examples</i>
Exteroceptors	Respond to cutaneous stimuli	Cutaneous afferent endings
Proprioceptors	Signal position of body parts	Muscle spindle endings
Interoceptors	Respond to internal body stimuli	Alimentary tract endings
Teleceptors	Respond to stimuli that originate remotely	Rods and cones of the retina

Clinical Classification
Class

	<i>Location</i>	<i>Examples</i>
Superficial	Skin	Touch and pressure
Special	Head; complex organs served by special cranial nerves	Vision, audition, equilibrium (vestibular), olfaction, taste
Deep	Skeletal muscles, tendons, joints, bone	Proprioception
Visceral	Viscera	Visceral pain

Classification by Embryological Origin
Class

	<i>Derivation</i>	<i>Examples</i>
Somatic	Somatopleura	Cutaneous and muscle receptors
Visceral	Visceropleura	Alimentary tract receptors

Competency

- PY. 10.2
- Functions and properties of receptors

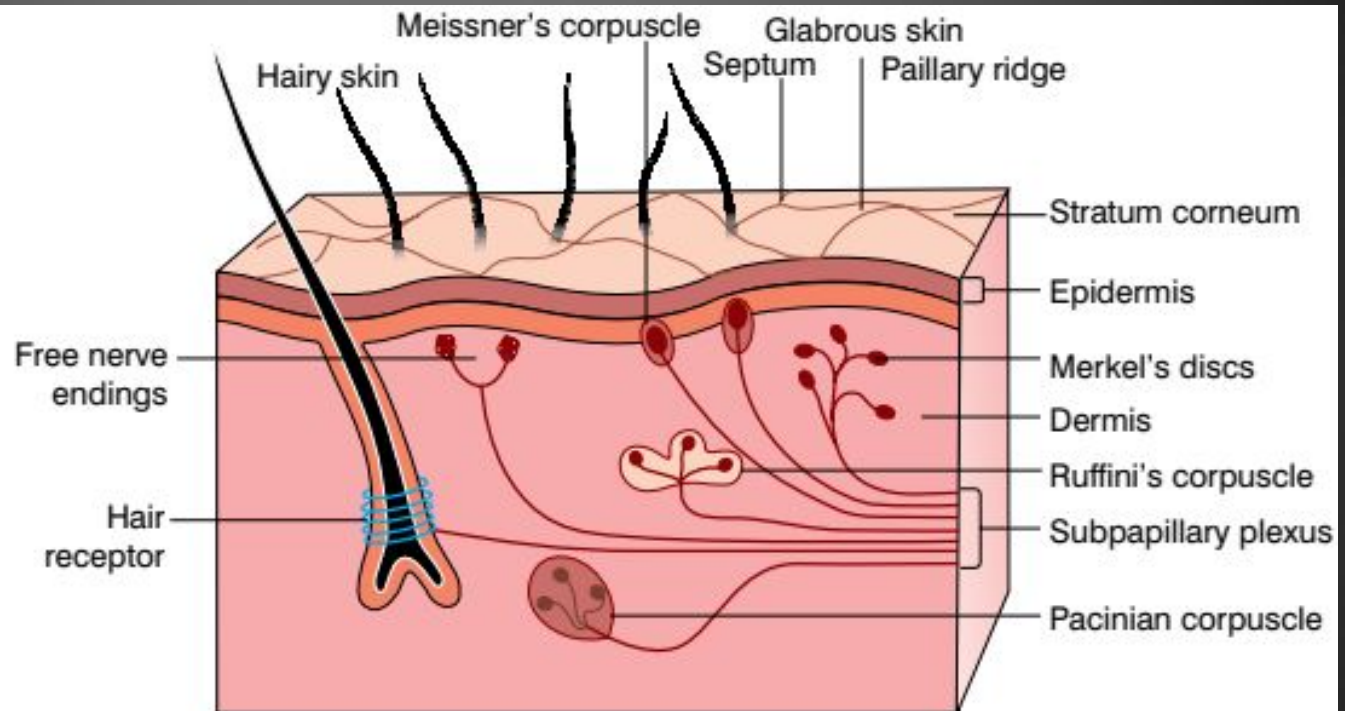
Learning objectives

At the end of this class, the student should be able to:

- Define receptors.
- Classify receptors .
- Enumerate the functions of receptors.
- Describe the properties of receptors.

DEFINITION AND FUNCTION

- **DEFINITION:** It is a specialised sensory nerve ending which undergoes depolarisation in response to a specific stimulus and in turn sends information to CNS.
- **FUNCTION:** It acts as a transducer that converts various forms of energy in environment into electrical energy (i.e. action potential) in the neuron.



Slowly adapting: Merkel's discs and Ruffini's corpuscles
 Rapidly adapting: Meissner's and Pacinian corpuscles

CLASSIFICATION OF RECEPTORS

- I. Depending upon type of stimulus
- II. Depending upon source of stimulus
- III. Clinical or anatomical classification of receptors

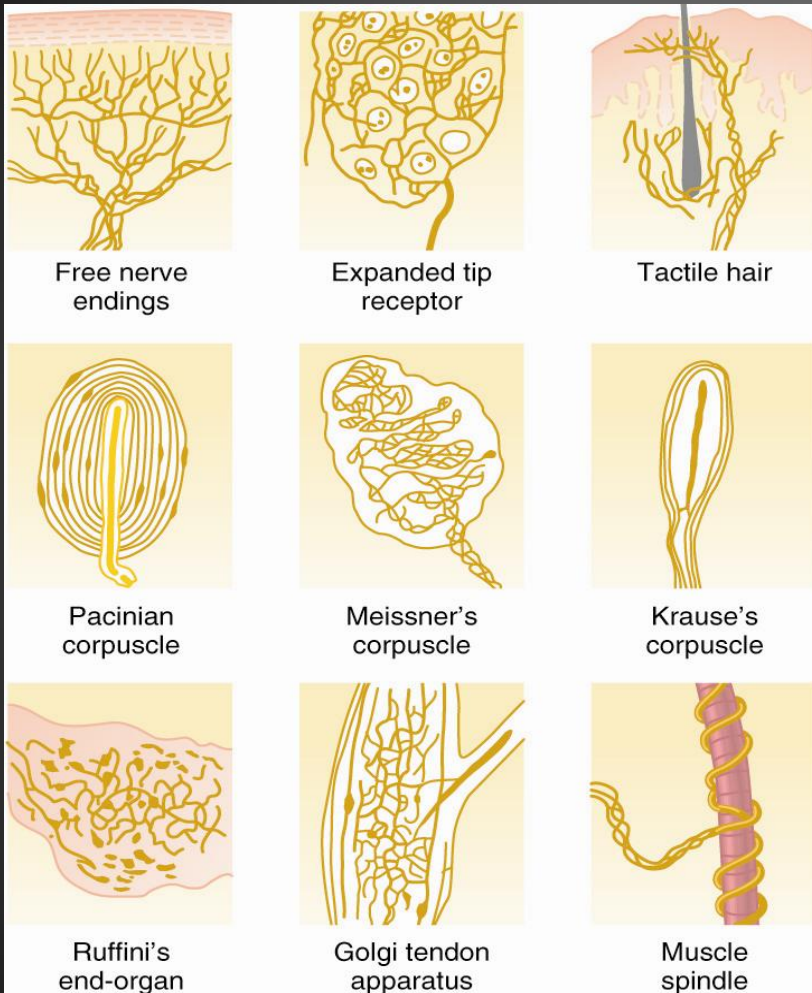
I CLASSIFICATION (Depending upon type of stimulus)

<i>RECEPTOR TYPE</i>	<i>FORM OF ENERGY</i>
1. <u>Mechanoreceptor</u>	- mechanical (touch, vibration, pressure)
2. <u>Chemoreceptor</u>	- chemical (osmoreceptors, glucoreceptors)
3. <u>Thermoreceptors</u>	- thermal (warmth/cold)
4. <u>Nociceptors</u>	- noxious stimulus (pain)
5. <u>Electromagnetic receptors</u>	- light (rods and cones)

TABLE 8–1 Principle sensory modalities.

Sensory System	Modality	Stimulus Energy	Receptor Class	Receptor Cell Types
Somatosensory	Touch	Tap, flutter 5–40 Hz	Cutaneous mechanoreceptor	Meissner corpuscles
Somatosensory	Touch	Motion	Cutaneous mechanoreceptor	Hair follicle receptors
Somatosensory	Touch	Deep pressure, vibration 60–300 Hz	Cutaneous mechanoreceptor	Pacinian corpuscles
Somatosensory	Touch	Touch, pressure	Cutaneous mechanoreceptor	Merkel cells
Somatosensory	Touch	Sustained pressure	Cutaneous mechanoreceptor	Ruffini corpuscles
Somatosensory	Proprioception	Stretch	Mechanoreceptor	Muscle spindles
Somatosensory	Proprioception	Tension	Mechanoreceptor	Golgi tendon organ
Somatosensory	Temperature	Thermal	Thermoreceptor	Cold and warm receptors
Somatosensory	Pain	Chemical, thermal, and mechanical	Chemoreceptor, thermoreceptor, and mechanoreceptor	Polymodal receptors or chemical, thermal, and mechanical nociceptors
Somatosensory	Itch	Chemical	Chemoreceptor	Chemical nociceptor
Visual	Vision	Light	Photoreceptor	Rods, cones
Auditory	Hearing	Sound	Mechanoreceptor	Hair cells (cochlea)
Vestibular	Balance	Angular acceleration	Mechanoreceptor	Hair cells (semicircular canals)
Vestibular	Balance	Linear acceleration, gravity	Mechanoreceptor	Hair cells (otolith organs)
Olfactory	Smell	Chemical	Chemoreceptor	Olfactory sensory neuron
Gustatory	Taste	Chemical	Chemoreceptor	Taste buds

TYPES OF SKIN RECEPTORS



- Merkel's disc- $A\beta$ and $A\delta$
- Meissner's corpuscle - $A\beta$ and $A\delta$, rapidly adapting
- Pacinian corpuscle - large, onion shape, for perception of pressure, rapidly adapting
- Ruffini's end organs - $A\delta$ and C, warmth sense
- Krause's end bulb - $A\delta$, sensation of cold
- Naked nerve endings - $A\delta$ or C, touch & temperature

SENSORY RECEPTORS IN THE HUMAN SKIN



RUFFINI ENDINGS



MERKEL DISKS



PACINIAN CORPUSCLE



MEISSNER
CORPUSCLE



FREE NERVE
ENDINGS



KRAUSE END BULBS



ROOT HAIR PLEX

RECEPTORS FOR CUTANEOUS

Cutaneous sensibilities: Conscious and general sensations

SENSIBILITY

Note: The density of mechanoreceptors is greater on the more distal parts of the fingers

Receptor group	Receptor	Location	Character	Neural type
Mechanoreceptors	Merkel's discs ☐	Deep epidermis (lips, finger-tips, nipple, around hair follicles & orifices). Superficial dermis	Slow adapting intensity receptors, tonic response. For pressure	A-(β & δ) fibers
	Meissner's corpuscle ☐		Rapidly adapting. For touch & texture (& also flutter)	
	Hair follicles	Deep dermis	Slow adapting. For flutter	
	Pacinian corpuscle		Rapidly adapting. For high-frequency stimuli/vibration & pressure sense	A-(β) fibres
	Ruffini's endings	Dermis (skin, nail beds and joints)	Slow adapting. For touch-pressure & warmth	A (δ) or C fibres
	Krause's bulbs/end-organs	Encapsulated nerve endings in mucosa (& skin)	For touch and pressure (@ conjunctiva, tongue, genitalia, skin etc.)	A-(δ) fibres
Nociceptors	Naked nerve endings	Hairy skin	For pain sensation, limited tactile function	A-(δ) fibres
Thermoreceptors		Lips, nose, anterior forearms & arms, chest & abdomen	Cold: Thin myelinated Warmth: Nonmyelinated	A-(δ) & C fibers

II. Depending upon source of stimulus

Sherrington's classification

1. **Telereceptors**:- concerned with sensory perception at a distance e.g. hearing, vision, smell.
2. **Exteroreceptors**:- concerned with perception of external environment e.g. touch, temperature, pain, pressure.
3. **Enteroreceptors**:- respond to changes within body itself.

SUBTYPES OF ENTERORECEPTORS

- **PROPRIORECEPTORS** -sense change in position of body in space mainly joints or ligament, muscle spindle.
- **VISCERORECEPTORS** –on visceral organs- baroreceptors, osmoreceptors, glucoreceptors.
- **CHEMORECEPTORS**:-carotid & aortic bodies

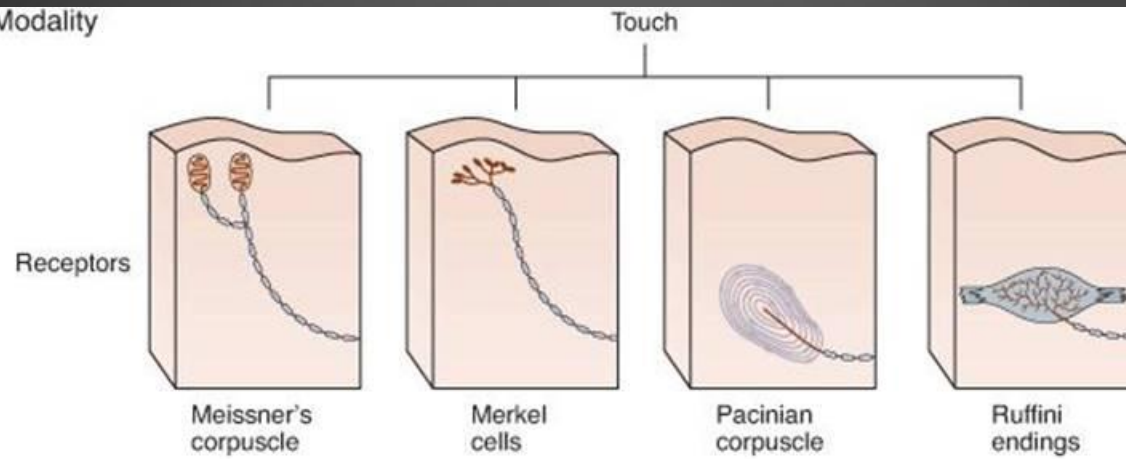
C. CLINICAL OR ANATOMICAL CLASSIFICATION OF RECEPTORS

- 1. Superficial receptors**, i.e. Those present in skin and mucous membrane.
- 2. Deep receptors**, i.e. Those present in muscles, tendons, joints and subcutaneous tissue.
- 3. Visceral receptors**, which are present in the visceral organs.

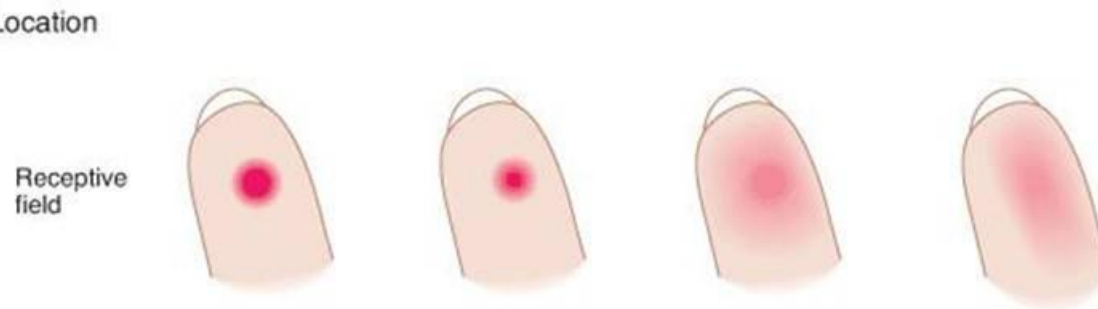
SENSATION

- Each of the principle types sensation; touch, pain, sight, sound, is called a ***modality of sensation***.
- Each receptor is responsive to one type of stimulus energy. Specificity is a key property of a receptor, t underlines the most important coding mechanism, ***the labeled line***.
- How the sensation is perceived is determined by the characteristics of the receptor and the central connections of the axon connected to the receptor.

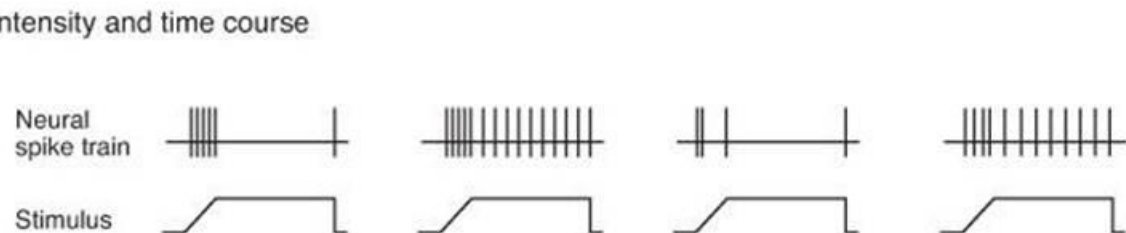
A Modality



B Location



C Intensity and time course



LOCAL ELECTRICAL CURRENTS AT NERVE ENDINGS - RECEPTOR POTENTIALS

- All sensory receptors have one feature in common. Whatever the type of stimulus that excites the receptor, the immediate action is to change the membrane potential of the receptor.
- This change in potential is called RECEPTOR POTENTIAL.

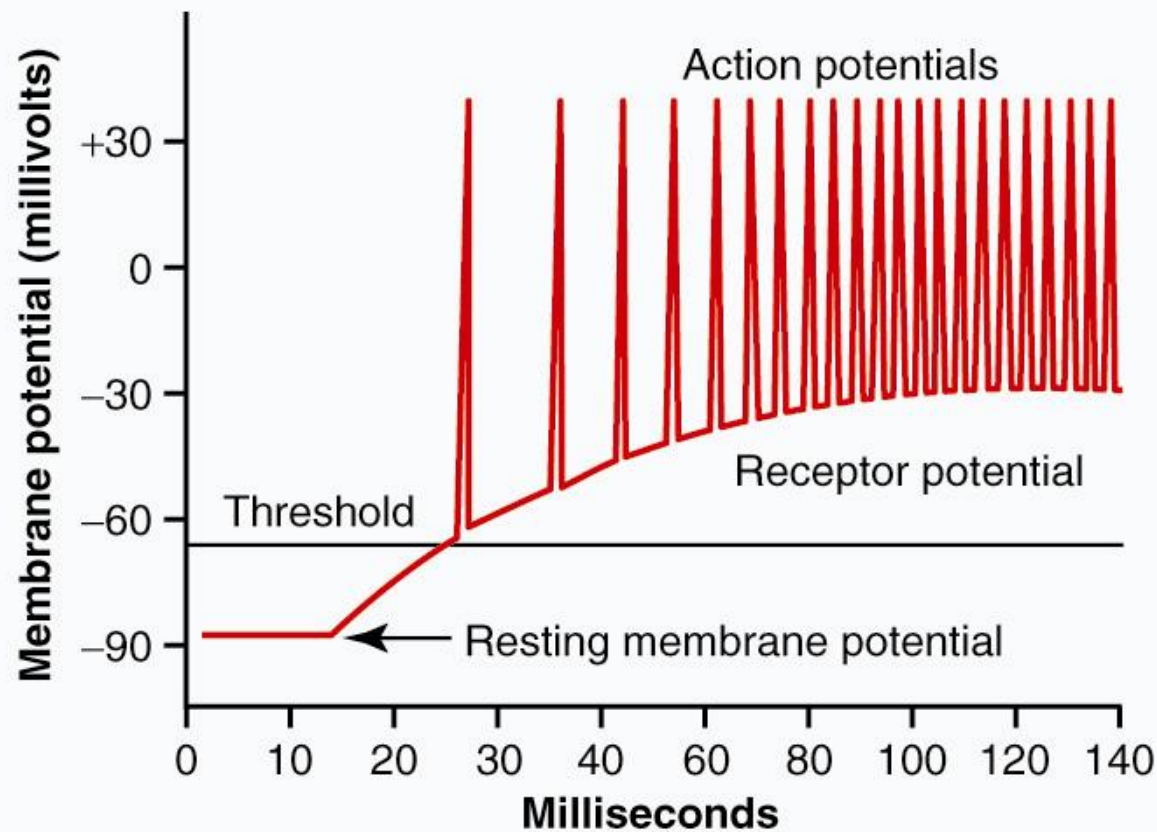
Receptor Excitation

- mechanical deformation which stretches the membrane and opens ion channels
- application of chemicals which also opens ion channels
- change in temperature which alters the permeability of the membrane
- electromagnetic radiation that changes the membrane characteristics

RELATION OF RECEPTOR POTENTIAL TO ACTION POTENTIALS

- When receptor potential rises above threshold for eliciting action potentials in the nerve fiber attached to the receptor, then action potentials occur.
- More the receptor potential rises above the threshold level, greater becomes the action potential frequency as shown in next diagram.

ACTION POTENTIAL Vs RECEPTOR POTENTIAL

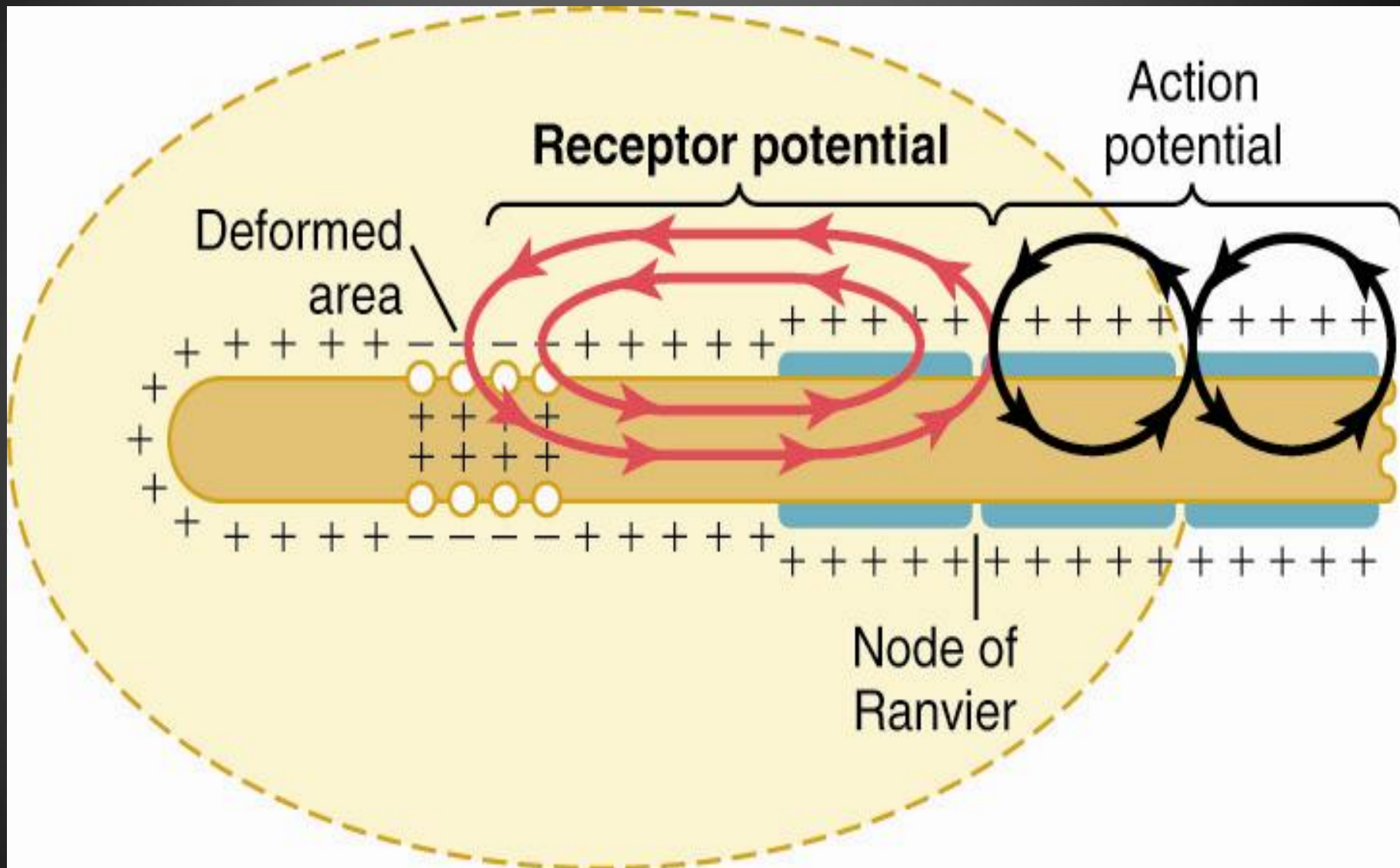


RECEPTOR POTENTIAL OF PACINIAN CORPUSCLE

- This receptor has a central nerve fiber extending through its core surrounded by concentric capsule layers.
- Diagram shows small area of terminal fiber deformed by compression of corpuscle.
- Ion channels open at this area causing positive charges to move in creating positivity inside fiber which is receptor potential.

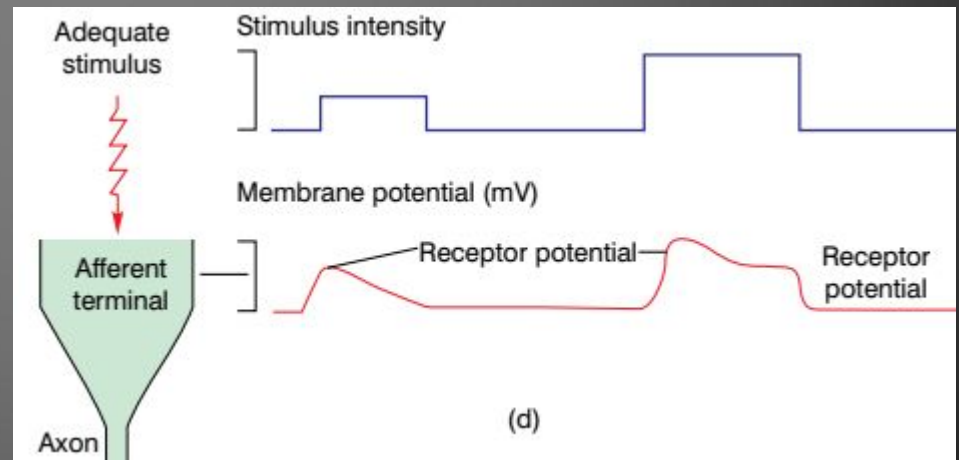
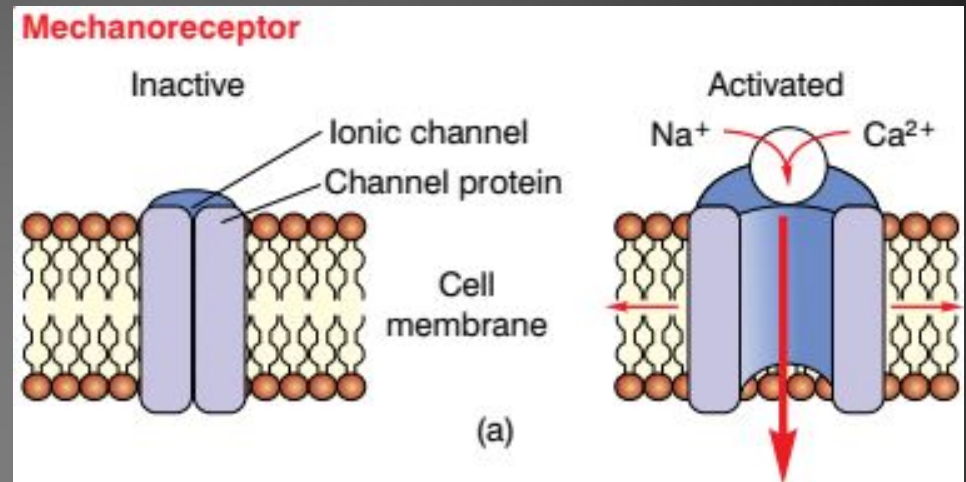
RECEPTOR POTENTIAL IN PACINIAN CORPUSCLE

- Receptor potential induces local circuit of current flow shown in red in diagram which sets typical action potentials that are transmitted along nerve fiber to CNS.



SENSORY RECEPTOR POTENTIAL

- Receptor deformation □ ion channel opening/closing
- Eletrotonic potentials (generator potential)
 - Cumulated potentials = receptor potential, e.g., electroretinogram, cochlear microphonics etc.
- Quantum of potential change is a function of stimulus intensity & duration

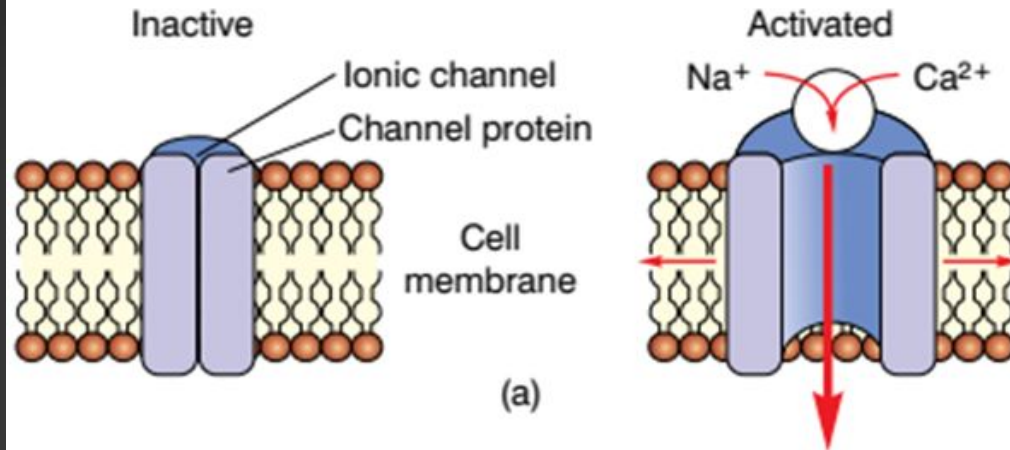


Pattern of response of sensory receptor

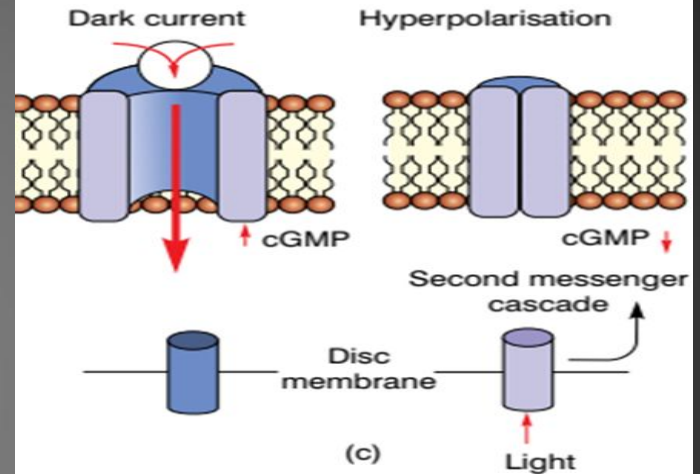
SOME TYPES OF RECEPTORS AND MECHANISM OF ACTIVATION

Transformation of environmental energy into generator/receptor potential

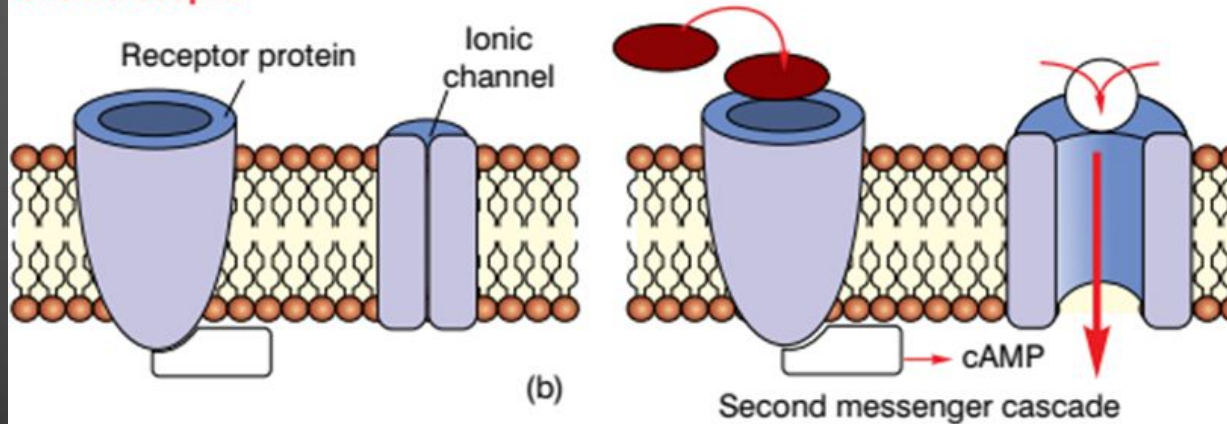
Mechanoreceptor



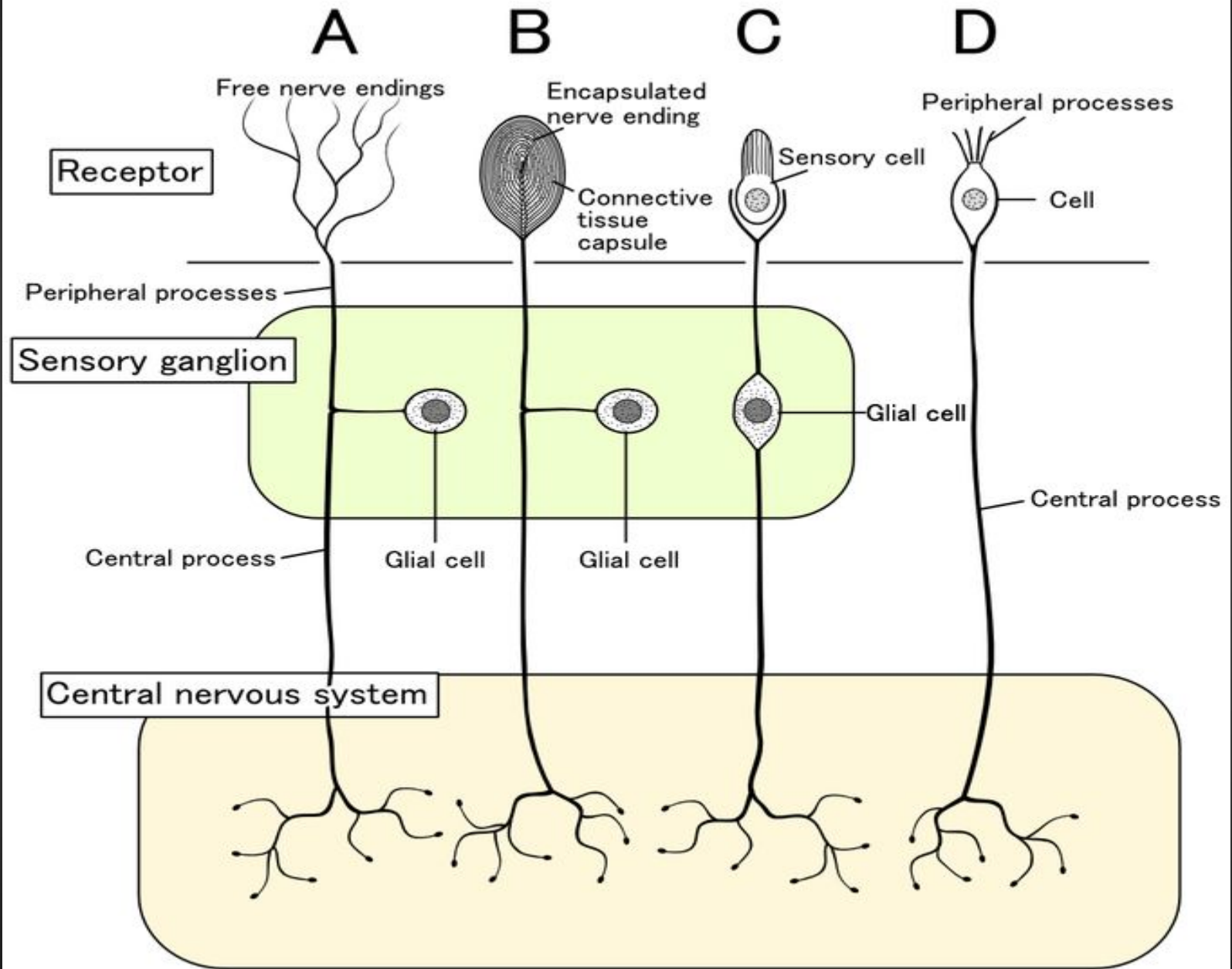
Photoreceptor



Chemoreceptor



TYPE OF SENORY NEURON



PROPERTIES OF RECEPTORS

- 1. Specificity or law of adequate stimulus
- 2. Adaptation- tonic and phasic receptors
- 3. Muller's doctrine of specific energies
- 4. Law of projection- phantom limb
- 5. Law of intensity discrimination

PROPERTIES OF SENSORY RECEPTORS

- 1) SPECIFICITY:

- Adequate stimulus:

- ❖ ↑sensitivity & ↓threshold to a specific stimulus

- ❖ ***Threshold*** altered by:

- Interference of other stimuli (e.g., hearing during noise)
 - Accessory structures
(e.g., lens, structures in middle ear)

2. Adaptation of Receptors

- When a continuous stimulus is applied, receptors respond rapidly at first, but response declines until all receptors stop firing.

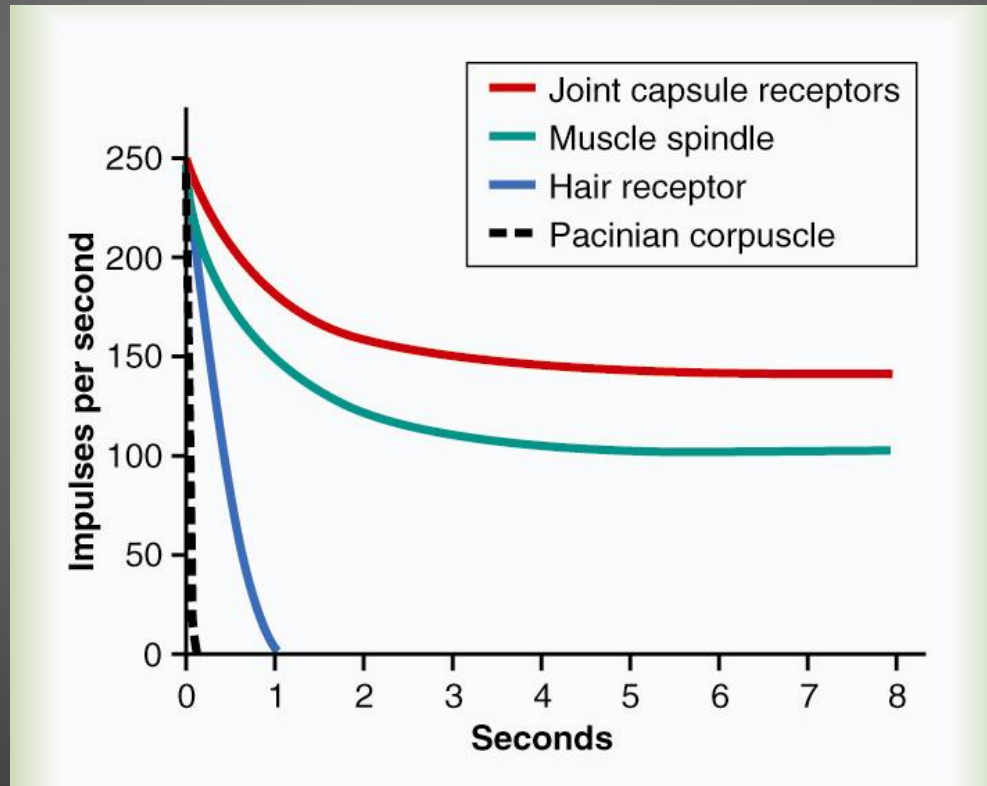
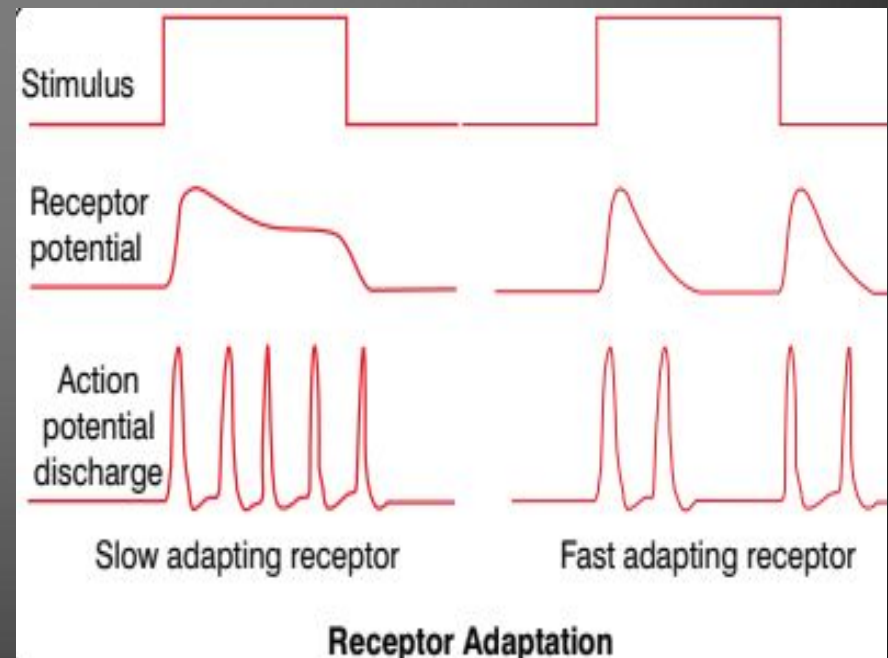


Figure 46-5; Guyton & Hall

Adaptation

- Rate of adaptation varies with type of receptor.
 - Therefore, receptors respond when a change is taking place (i.e., think of the feel of clothing on your skin.)
- Receptors that adapt:
- ❖ Phasic/velocity receptors (fast adapting)
 - ❖ Normally inactive, active for short time only when change occurs
 - ❖ Inform intensity/rate of change in stimulus



Mechanism of Adaptation

- varies with the type of receptor
- *photoreceptors* change the amount of light sensitive chemicals
- *mechanoreceptors* redistribute themselves to accommodate the distorting force (i.e., the pacinian corpuscle)
- some mechanoreceptors adapt slowly, some adapt rapidly

Rapidly Adapting (Phasic) Receptors

- respond only when change is taking place
- rate and strength of the response is related to the rate and intensity of the stimulus
- important for predicting the future position or condition of the body
- very important for balance and movement
- types of rapidly adapting receptors: *pacinian corpuscle, semicircular canals*

Slowly Adapting (Tonic) Receptors

- continue to transmit impulses to the brain for long periods of time while the stimulus is present
- keep brain apprised of the status of the body with respect to its surroundings
- will adapt to extinction as long as the stimulus is present, however, this may take hours or days
- these receptors include: *muscle spindle, golgi tendon apparatus, Ruffini's endings, Merckels discs, Macula, chemo- and baroreceptors*

- Receptors that do not show adaptation:
 - Intensity/Tonic receptors
 - ❖ Prolonged generator potential & slow decay
 - ❖ Slow adapting/ no adaptation □ always active
 - ❖ Examples: Pain sensor, muscle spindle, baroreceptors etc.
 - Purpose: To serve long-sustained & vital functions

3) LAW/DOCTRINE OF SPECIFIC NERVE

Energies [Johannes Muller (1835)]:

- Stimulation of a receptor/sensory pathway produces assigned sensation irrespective of type of stimulus, e.g.;
 - ❖ Pressing the eyeball/stimulation of optic path interpreted as light and not pressure sensation
- Specificity of sensory pathways known as '***labelled lines***

4) LAW OF PROJECTION:

- Positional sense:
 - ❖ Ability to assign a position of origin of stimulus in space/body, on stimulation of sensory pathway anywhere
 - ❖ Example: '**Phantom limb**' phenomenon

5. Law of intensity discrimination

- **Discrimination of Intensity:**
 - Quantal relation between the degree of deformation & ionic-channel response
 - ❖ Threshold generator potential $\square$ AP firing
 - ❖ Frequency of discharge $\propto$ intensity of stimulus

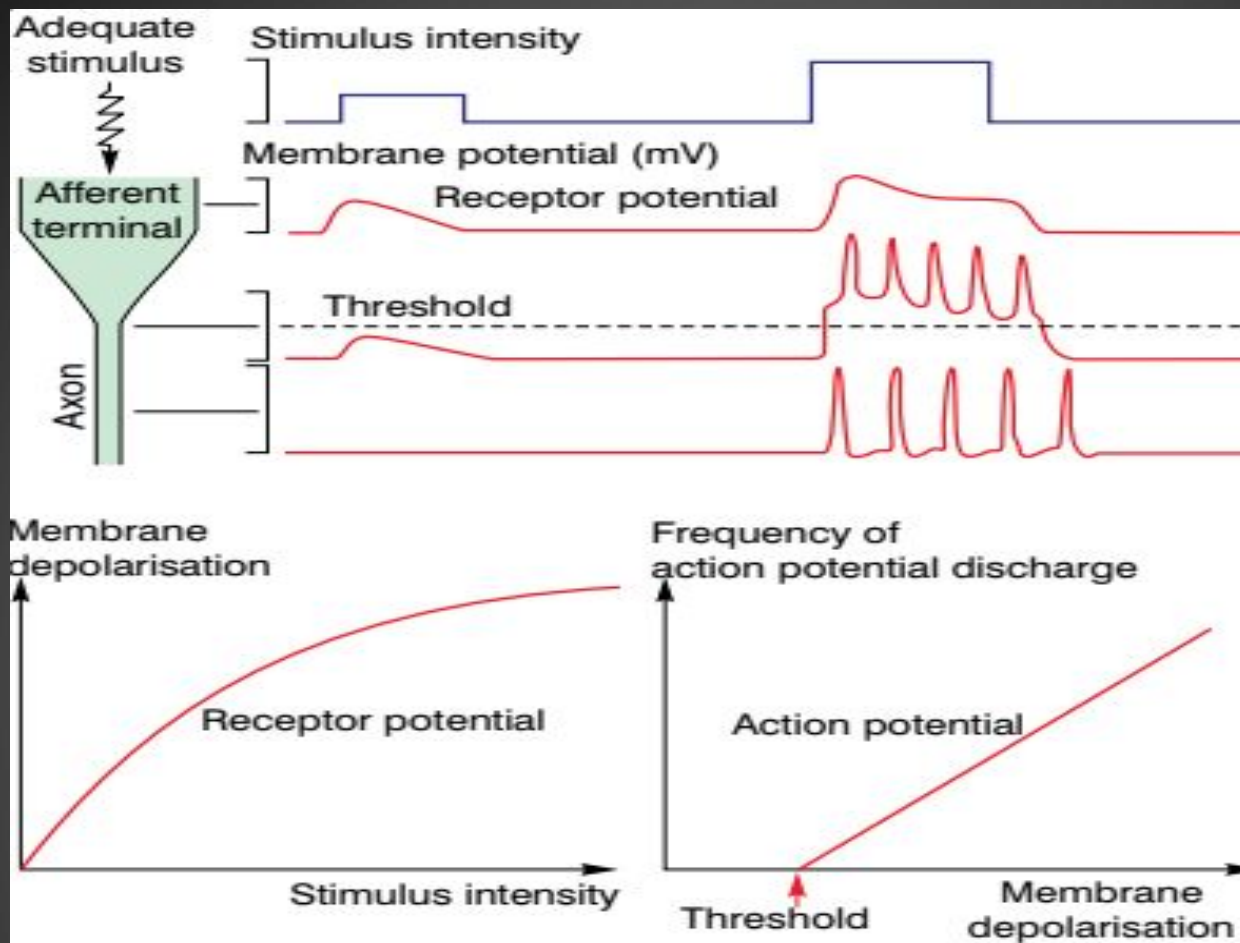
- Determinants of '*Magnitude of Sensation*':

- ❖ Change in the rate of impulses
- ❖ No. of receptors activated
- ❖ Influence of centrifugal neural pathways from brain
- ❖ **Recruitment**: Higher the intensity of stimulus $\square$ spread to neighbouring specific & nonspecific sensory receptors

- ❖ **Weber–Fechner Law/Power Law:**

- Sensation felt $\propto$ to log of stimulus intensity, i.e.; $R \propto \log S$
- **More realistic relation: $R \propto KSA$**

($R = KSA$, R —sensation felt, S —intensity of stimulus, K & A —the constants)

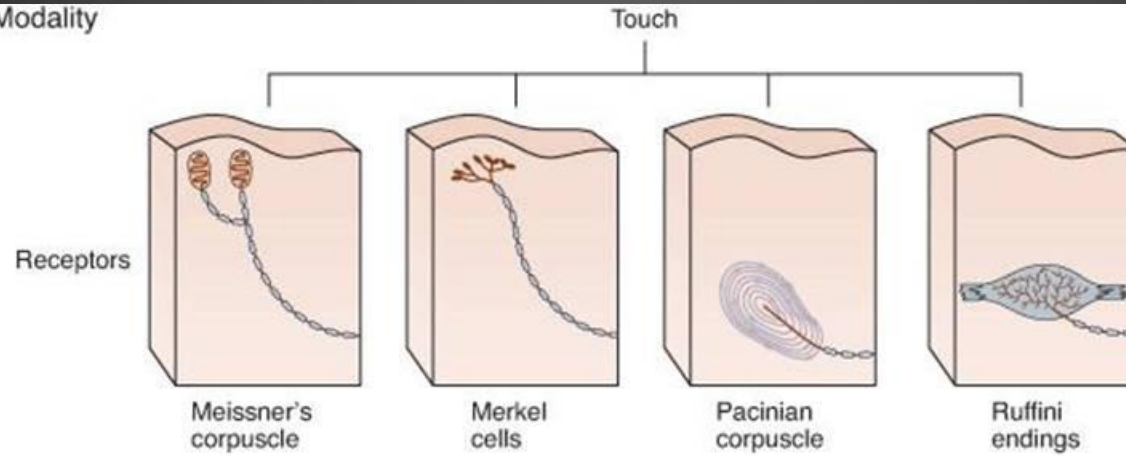


Power Law explains exponential $\uparrow$ in the range of receptor sensitivity, e.g.;

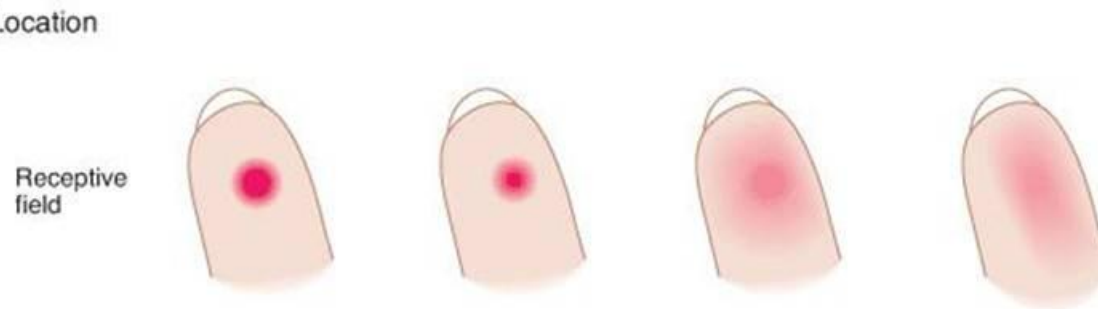
- Ear can respond to very weak sounds only 1/10 billionth as strong as the strongest sound
- Eye can see the weakest light which is 1/1, 00,000 of the brightest light

- Diverse sensory information requires coding for perception
 - **receptors**: Qualities of signal (e.g. specificity, location, intensity & duration) by the properties of receptors
 - @ transmission level:
 - ❖ Compression of information
 - ❖ Labelled line transmission
 - ❖ Delivery to cerebrum or subcortical centres
 - @ CNS: Many factors, e.g.;
 - ❖ Properties of localisation, specific projection etc.
 - ❖ Pin-point representation & integration/interpretation at specific neural centres
- Final decoding at CNS: Reproduction of exact nature of the sensory energy

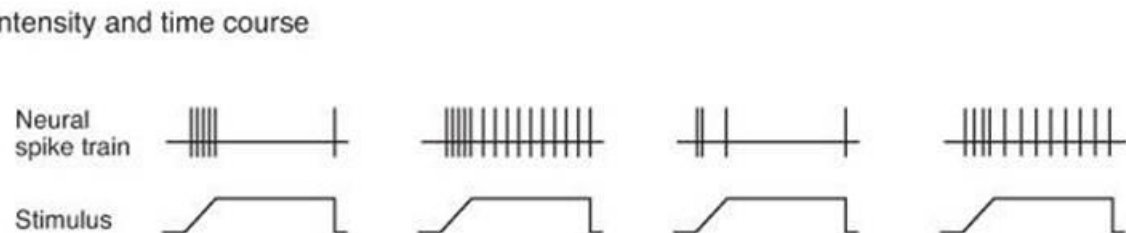
A Modality



B Location

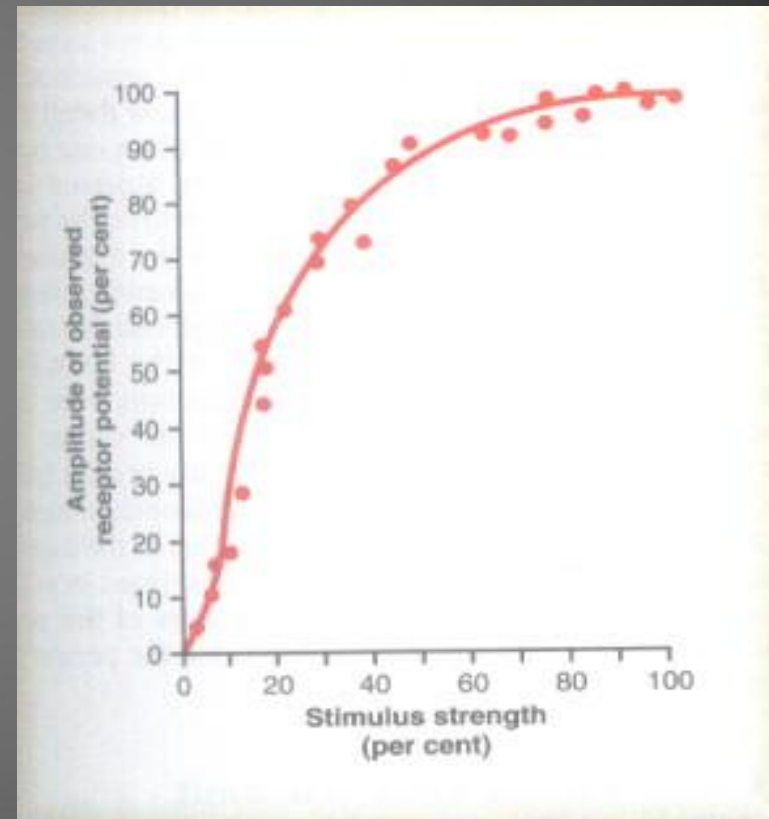


C Intensity and time course



RELATION BETWEEN STIMULUS INTENSITY AND RECEPTOR POTENTIAL

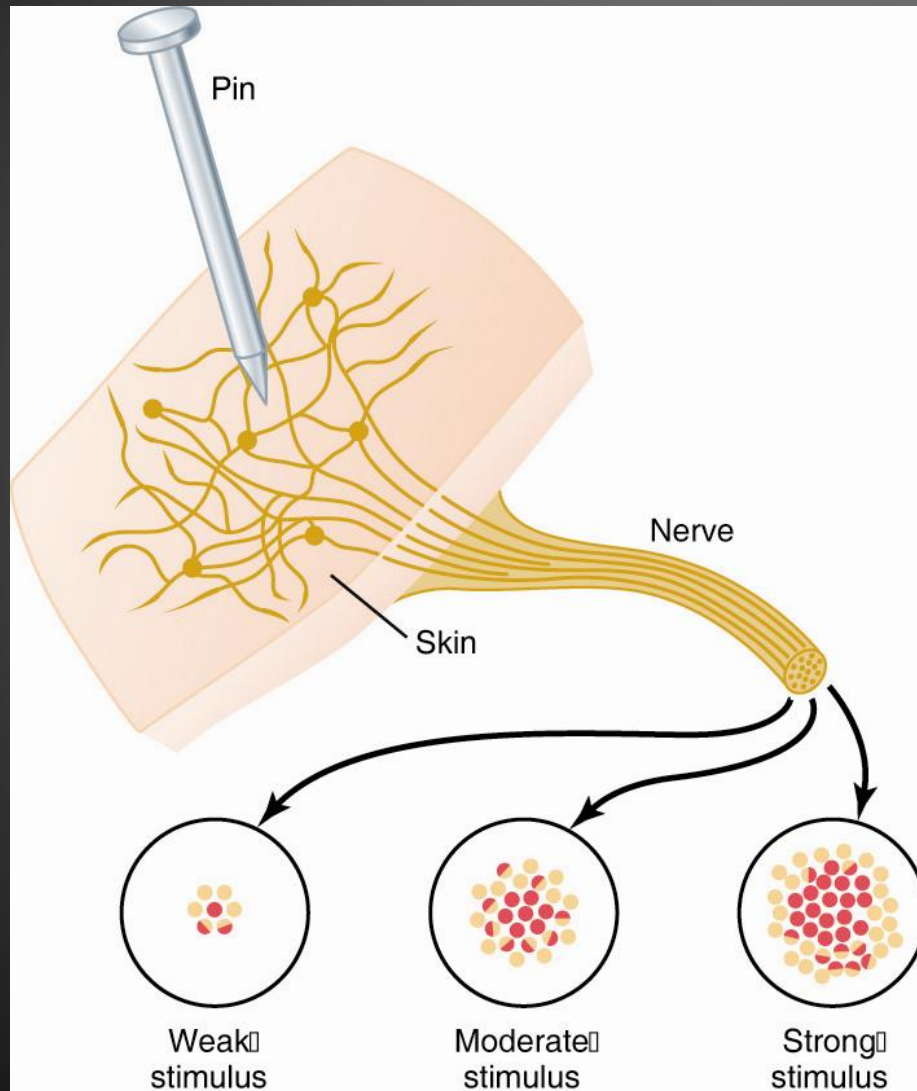
- Amplitude of receptor potential caused by progressively stronger mechanical compression increases rapidly at first but less rapidly at high stimulus intensity which allows receptors to have extreme range of response.



SPATIAL SUMMATION

- A pin prick of skin usually stimulates endings from many different pain fibres simultaneously. When pinprick is in center of receptive field of a particular pain fiber, the degree of stimulation of that fiber is far greater than when it is in periphery of field because number of free endings in middle of the field is much greater than at periphery.

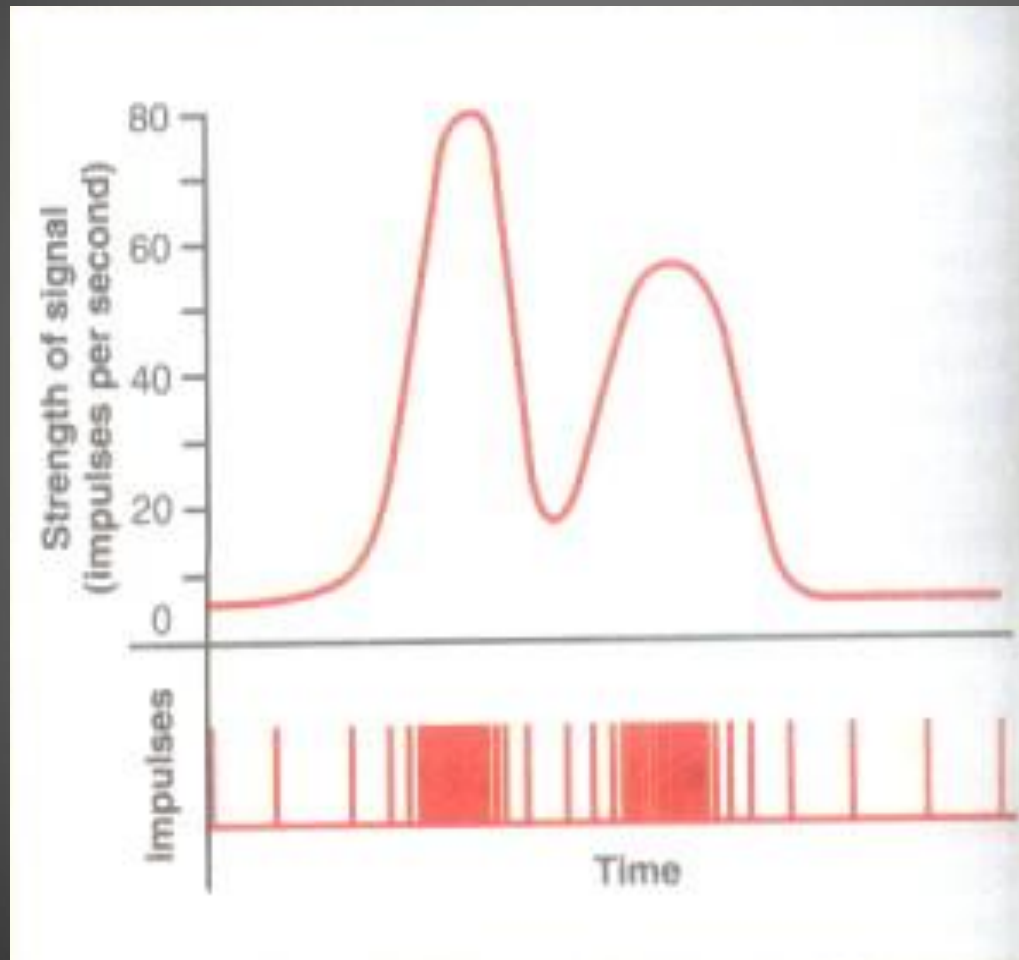
SPATIAL SUMMATION



TEMPORAL SUMMATION

- It is a second means for transmitting signals of increasing strength, by increasing frequency of nerve impulses in each fiber & is called temporal summation.

TEMPORAL SUMMATION



Importance of Signal Intensity

- Signal intensity is critical for interpretation of the signal by the brain (i.e., pain).
- Gradations in signal intensity can be achieved by:
 - 1) increasing the number of fibers stimulated, **spatial summation**
 - 2) increasing the rate of firing in a limited number of fibers, **temporal summation**.

Transmission of Receptor Information to the Brain

- the larger the nerve fiber diameter the faster the rate of transmission of the signal
- velocity of transmission can be as fast as 120 m/sec or as slow as 0.5 m/sec
- nerve fiber classification
 - type A - myelinated fibers of varying sizes, generally fast transmission speed
 - subdivided into α , β , δ , γ
 - type C - unmyelinated fibers, small with slow transmission speed

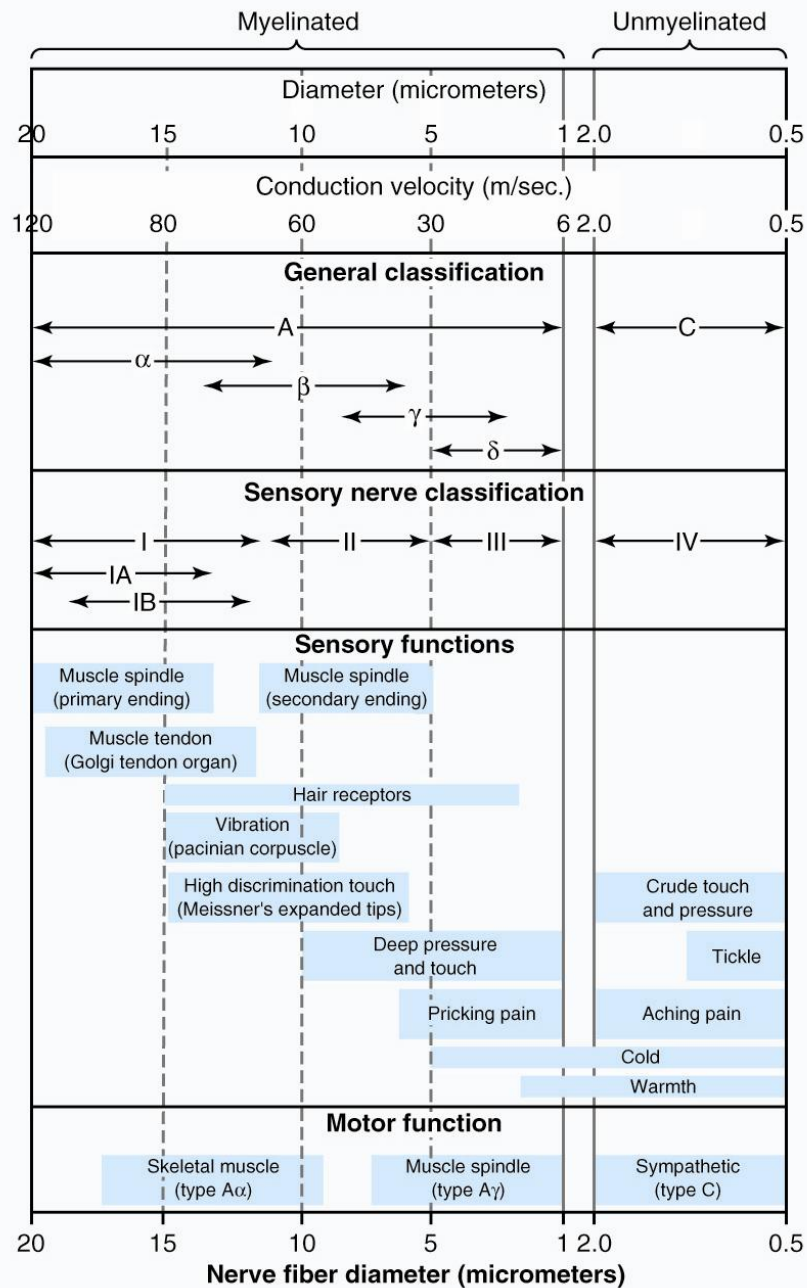


Figure 46-6;
Guyton &
Hall

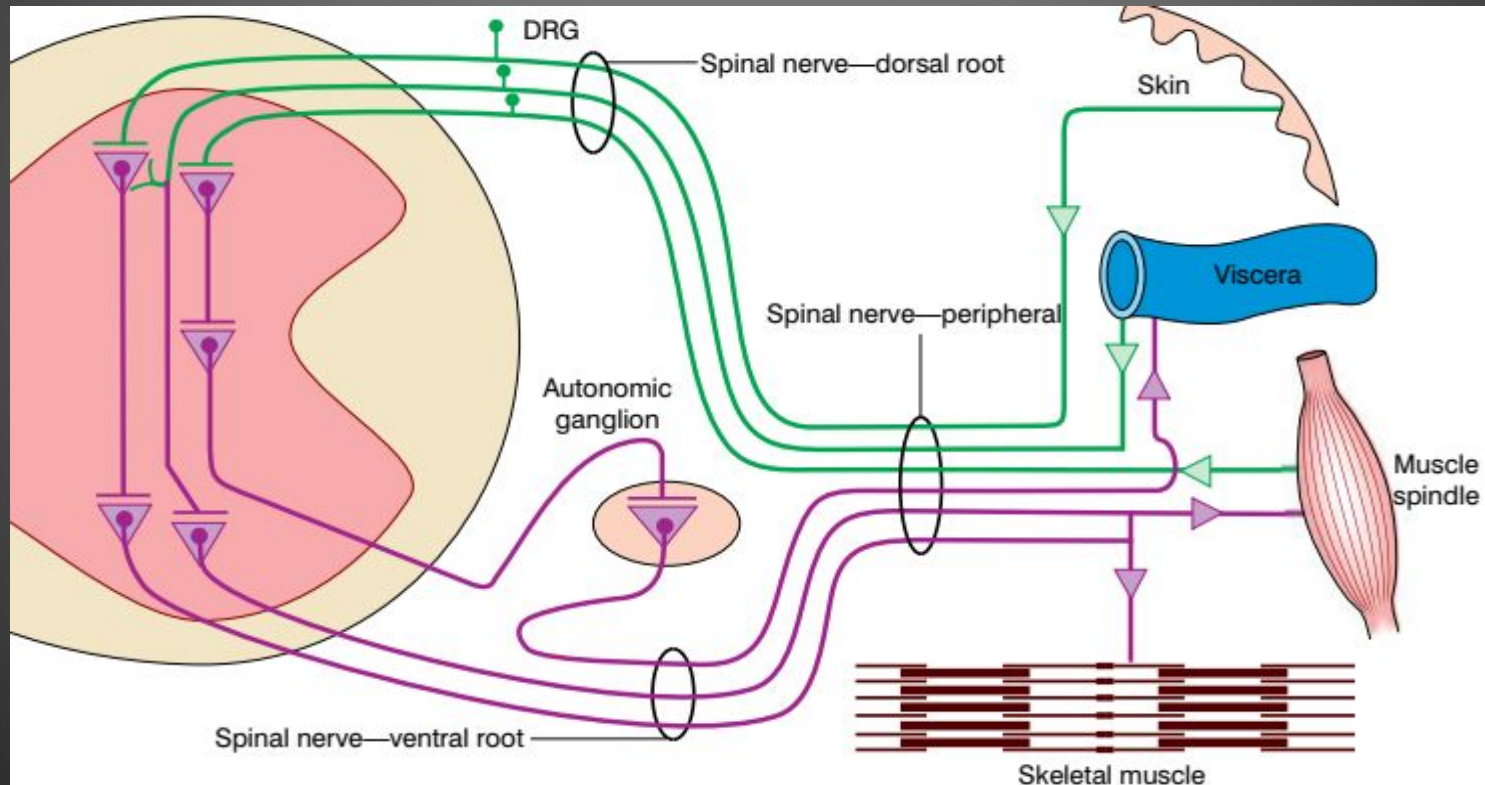
LOCALISATION OF SENSATION:

- Ability to assign to sensation both — a quality & originating position in space/body
 - ❖ Point-to-point body-representation in sensory cortex
 - ❖ Also an acquired experience

- Sensory (afferent) impulses:
 - Signal destination — cerebrum, e.g., exteroceptor & telereceptor signals
 - Result in consciousness
- Non-sensory (afferent) impulses:
 - Signal destination — cerebellum and subcortical centres, e.g., proprioceptor & enteroceptor signals
 - To cause reflex control of motor/visceral activity
- Speed signals are conveyed, based on the priority in their ability to serve vital function
- **Consciousness** Defined as the *discriminative awareness of the surrounding environment, contributed by sensory receptors*

TRANSMISSION OF SENSORY SIGNALS: *SENSORY NERVE*

- **Peripheral spinal nerve** — a mixed nerve (sensory & motor components)
 - Decussation near the spinal cord
- **Bell-Magendie Law:**
 - Dorsal root: Sensory
 - Ventral root: Motor



TRANSMISSION OF SENSORY SIGNALS: *RECEPTIVE FIELD*

- *Region that, when stimulated, affects the discharge of a sensory neuron*
- Receptive field may comprise;
 - Only excitatory neurons
 - ❖ General excitation & vague localisation
 - Combined excitatory & inhibitory neurons
 - ❖ Lateral inhibition by the interneurons
 - ❖ Results in sharp, localised sensation
- Receptive field in CNS:
 - Unlike in peripheral sensory receptors, they are larger
 - Typically combined types, unlike the peripheral

Relaying Signals through Neuronal Pools

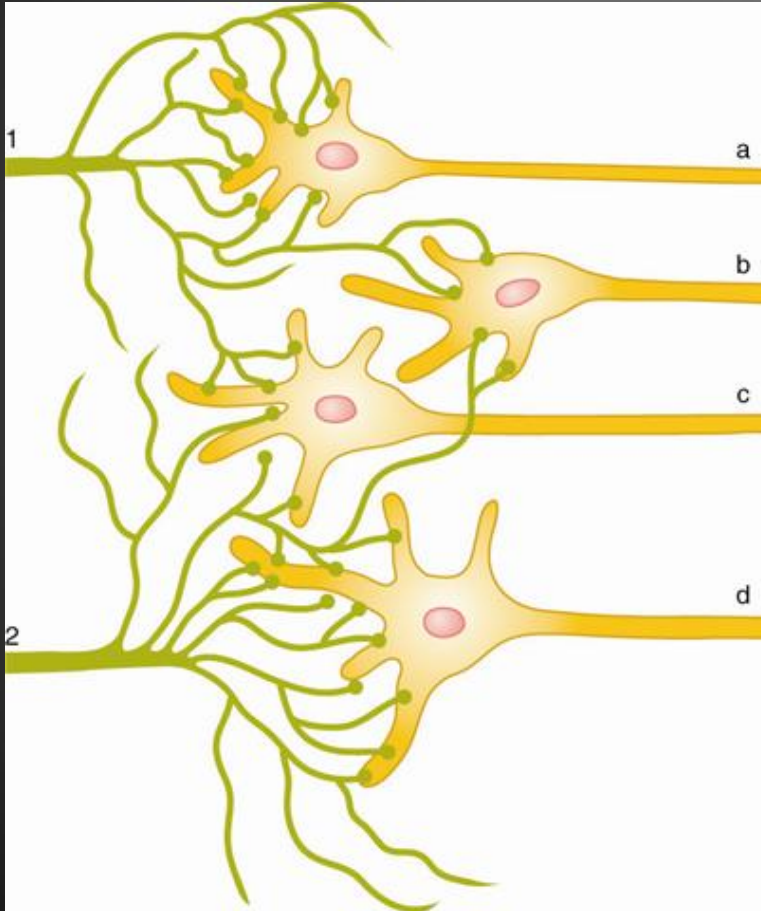


Figure 46-9; Guyton & Hall

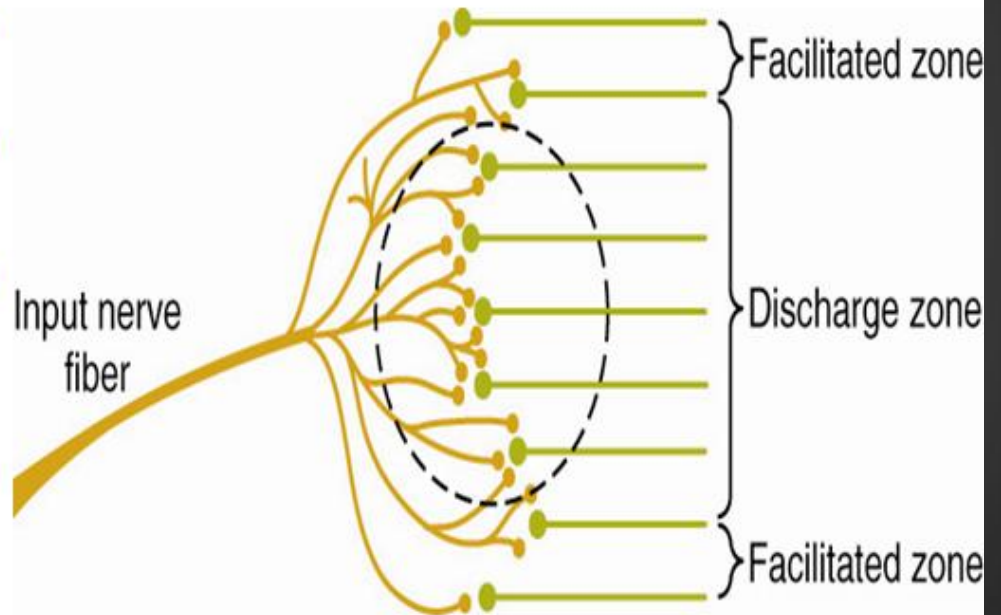
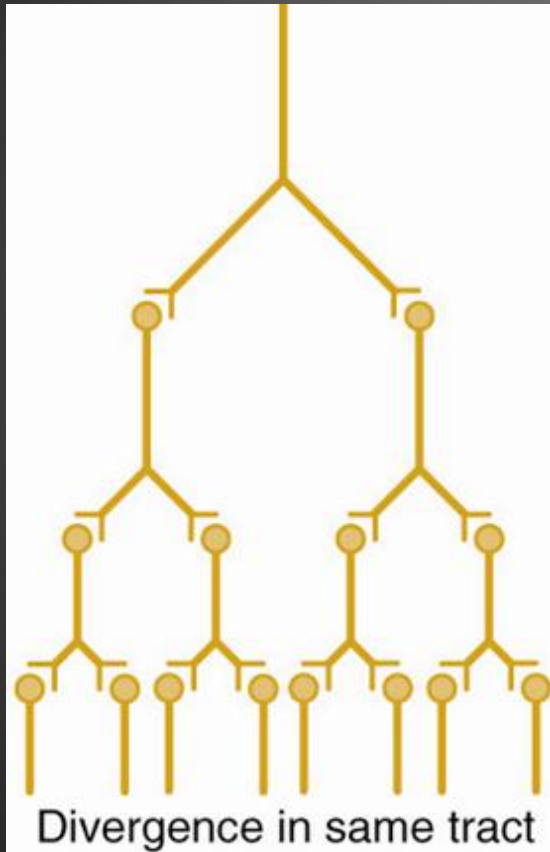


Figure 46-10; Guyton & Hall

Neuronal Pools

- groups of neurons with special characteristics of organization
- comprise many different types of neuronal circuits
 - converging
 - diverging
 - reverberating

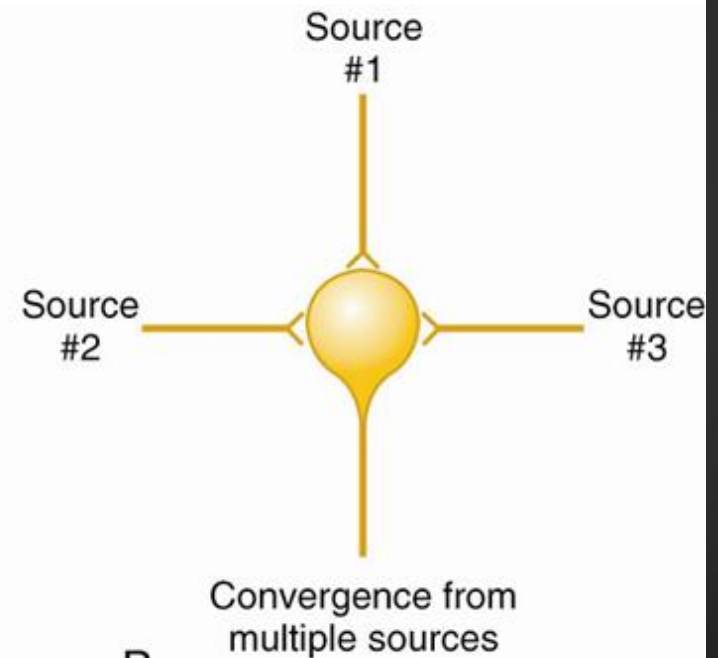
Neuronal Pools



A



A



B

Neuronal Pools

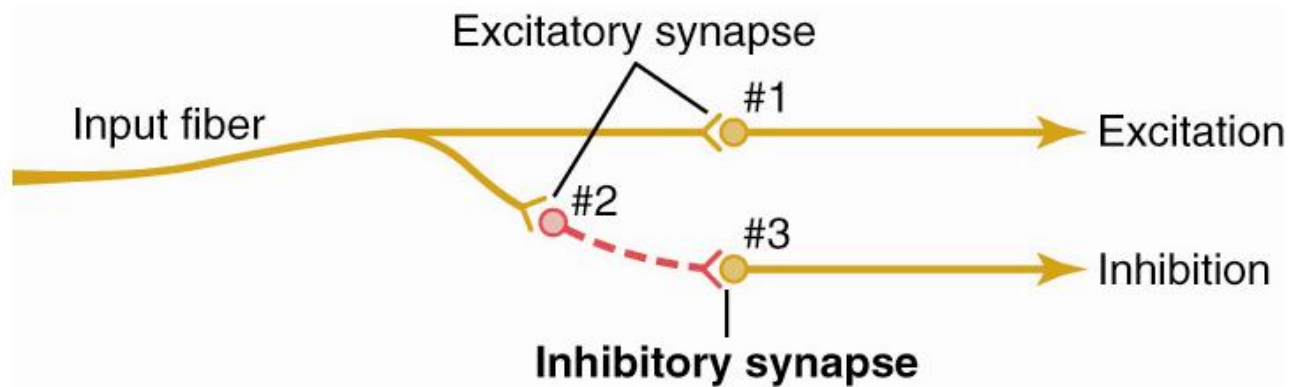


Figure 46-13; Guyton & Hall

Lateral
inhibition

Reverberating Circuits

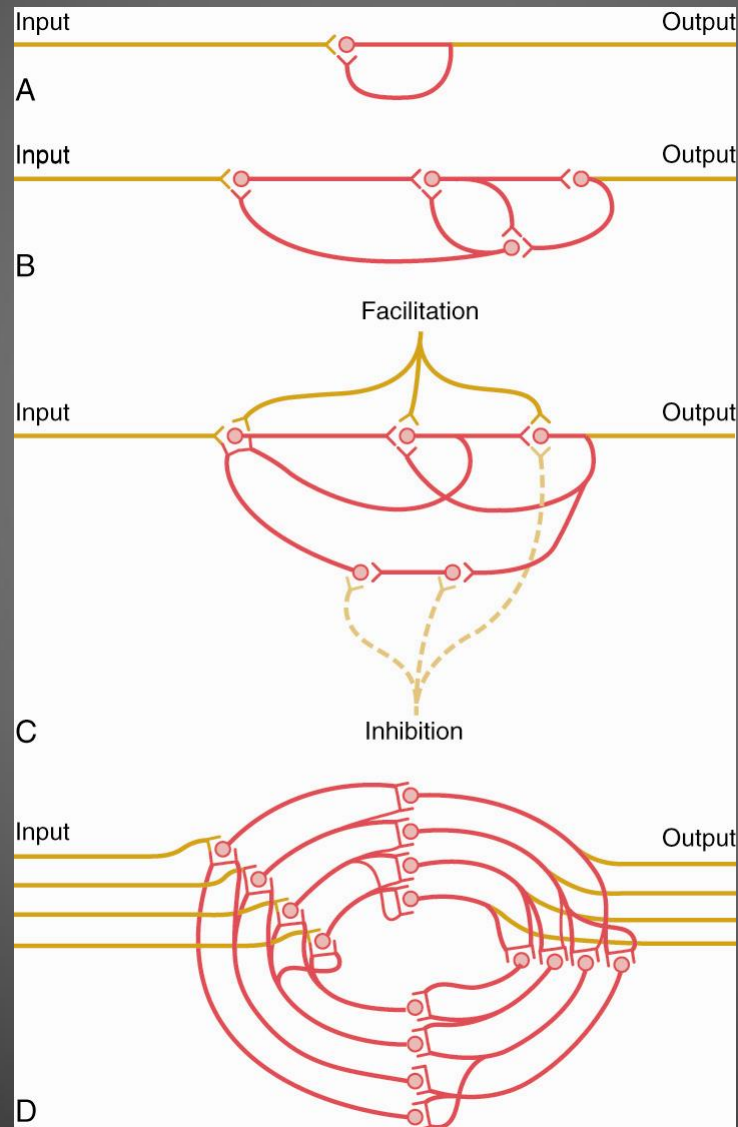


Figure 46-14;
Guyton &
Hall

Summary

- Classification of receptors
- Functions and properties of receptors

Assignment :-

Q. Classify Receptors & explain its properties in detail

Thank you