CNS1: RECEPTOR

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SOMATOSENSORY SYSTEM

- SENSATIONS:

  Appreciation of changes in external environment.

SENSATIONS

1) Special senses: e.g. vision, hearing, taste, smell.

2) General senses: SUPERFICIAL, DEEP, VISCERAL.

i) SUPERFICIAL OR CUTANEOUS SENSES:

a) Epicratic (mild or light) sensations: are perceived more accurately. : e.g. fine touch, tactile localization, tactile discrimination, temperature with fine range
(25 C to 40 C)etc.

b) Protopathic (primitive or crude) sensations: e.g. pressure, pain, temperature within wide range (below 25 C, above 40C)

ii) DEEP SENSES or proprioceptive and kinaesthetic sensations:

e.g. sensations of joints, muscles or tendons.

* Proprioceptive: concerned with physical state of body i.e. sense of position, tendon and muscle sensations, deep pressure and sense of equilibrium.

* kinaesthetic: Concious recognition of rate of movement of different parts of body. These can be conscious or unconscious.

iii) VISCERAL SENSES: e.g. pain from visceral structures, concentration of glucose in blood.

- COMPONENTS OF SENSORY SYSTEM:

* Receptors: Special cells that receive sensations and convert them into nervous (action potential) signal.
* Afferent neuron: Neurons that carry sensations from receptors to cerebral cortex.
* Sensory cortex: Area of cerebral cortex that receives sensory neurons is called as sensory cortex.

RECEPTORS

- DEFINITION:

RECEPTORS ARE CHEMICAL TRANSUDERS WHICH CONVERT VARIOUS FORMS OF ENERGIES (EG. STIMULUS IN ENVIRONMENT)INTO ACTION POTENTIALS IN NERVE

CLASSIFICATION

1) EXTEROCEPTORS:

* Cutaneous receptors-
  - Touch-Meissner's corpuscle,merkel's disc
  - Pressure-Pacinian corpuscles
  - Temperature-Cold : Krause's end organ
    Hot : Ruffini's end organ
  - Pain- Free nerve endings
* Chemoreceptors:
  - Taste: taste buds
  - Smell: Olfactory receptors

2) INTERORECEPTORS

* PROPRIOCEPTORS: Muscle spindle, golgi tendon organs
* Viscероreceptors: baroreceptors, chemoreceptors, osmoreceptors

3) TELERECEPTORS:

hearing, vision

- Mechanoreceptor

  Mechanical stimulus e.g. touch, pressure.

  Meissner's corpuscle, merkel's disc, pacinian corpuscle
- Chemoreceptor

  Chemical e.g. taste, smell
- Thermoreceptors

  Thermal e.g. warmth and cold

  Ruffini's end organs, Krause end bulb
- Nociceptors

  Pain: free nerve endings
- Photoreceptors

  light e.g. rods and cones in retina

DEPENDING ON THE RATE OF ADAPTATION

- Slow adapting receptors :

  Pain, joint and muscle receptors.

- Rapidly adapting receptors :

  Touch receptors, Pacinian receptors, olfactory receptors

CLINICAL CLASSIFICATION

- Superficial receptors: Receptors present in skin ad mucous membrane.
- Deep receptors: Receptors present in muscles, tendons, joints and subcutaneous tissue.
- Visceral receptors: Receptors present in visceral structures.

CUTANEOUS RECEPTORS

- MECHANORECEPTORS:

  MERKEL'S DISC, MEISSNER'S CORPUSCLE, PACINIAN CORPUSCLE

- THERMORECEPTORS:

  WARM- RUFFINI END ORGANS,

  COLD- KRAUSE END BULBS

  FREE NERVE ENDINGS

* PAIN RECEPTORS: FREE NERVE ENDINGS

TACTILE RECEPTORS: MERKEL'S DISC, MEISSNER'S CORPUSCLE

- sensation of touch.
- encapsulated and form expanded tips on sensory nerves belonging to type A (beta and delta).
- -Maximum density is on finger tips, lips and around the base of hair follicles.
- -Both have a small receptive field and are sensitive to movements of light objects over the surface of the skin.
- - They are rapidly adapting receptors

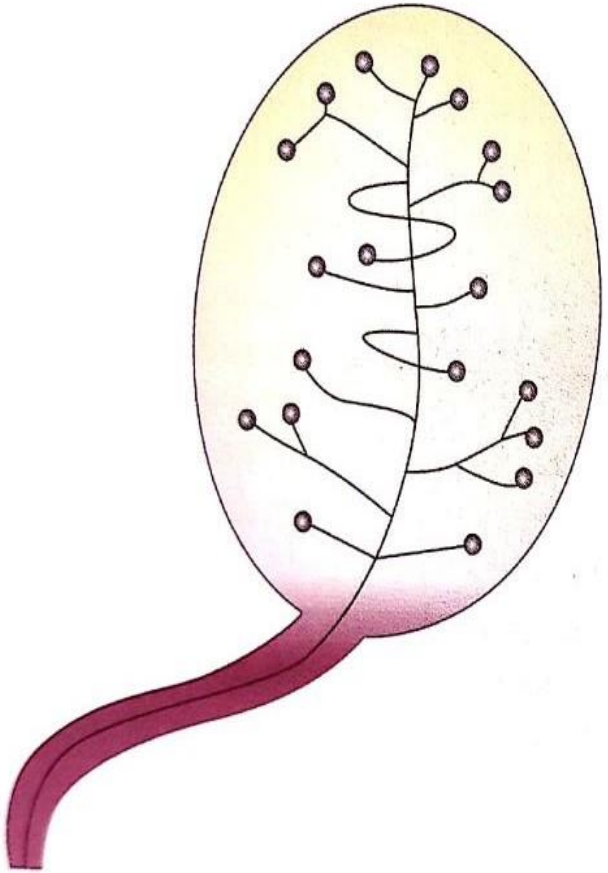

Fig. 117.2: Meissner corpuscle.

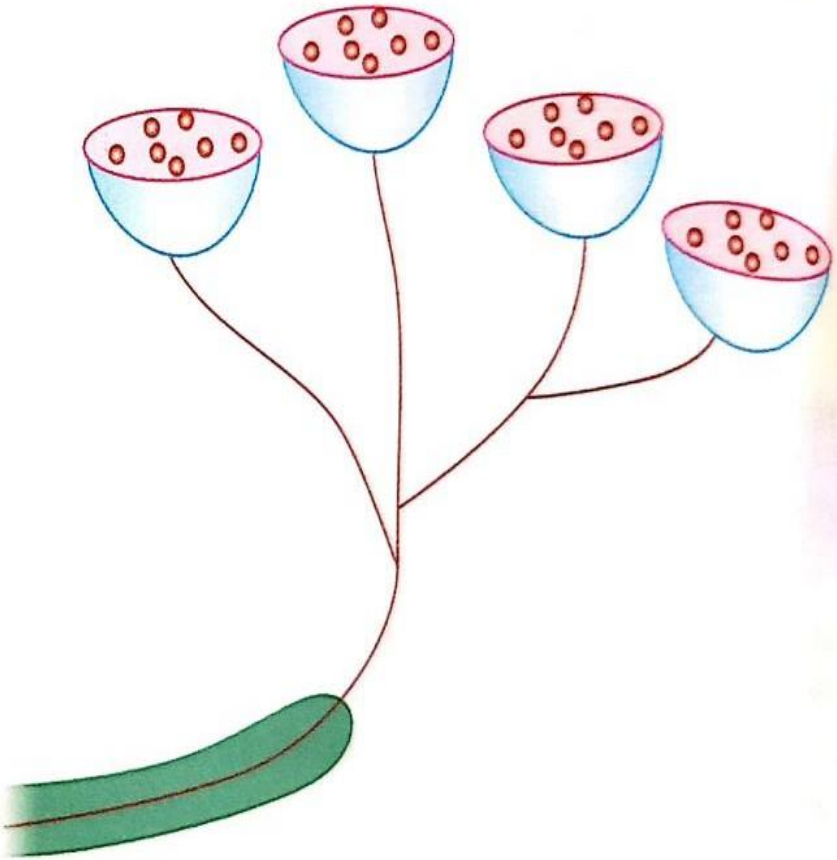

Fig. 117.3: Merkel disk.

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PACINIAN CORPUSCLE

- They are large (1mm), onion shaped, having many layers and encapsulated.
- found in large numbers in skin, subcutaneous tissues and in tendons and joints.
- sensation of pressure or sustained touch like vibration. They are rapidly adapting and that is why we do not feel seat pressure while sitting.
- They are nerve terminals of A beta nerve fibers.
- They have got a large receptive field.

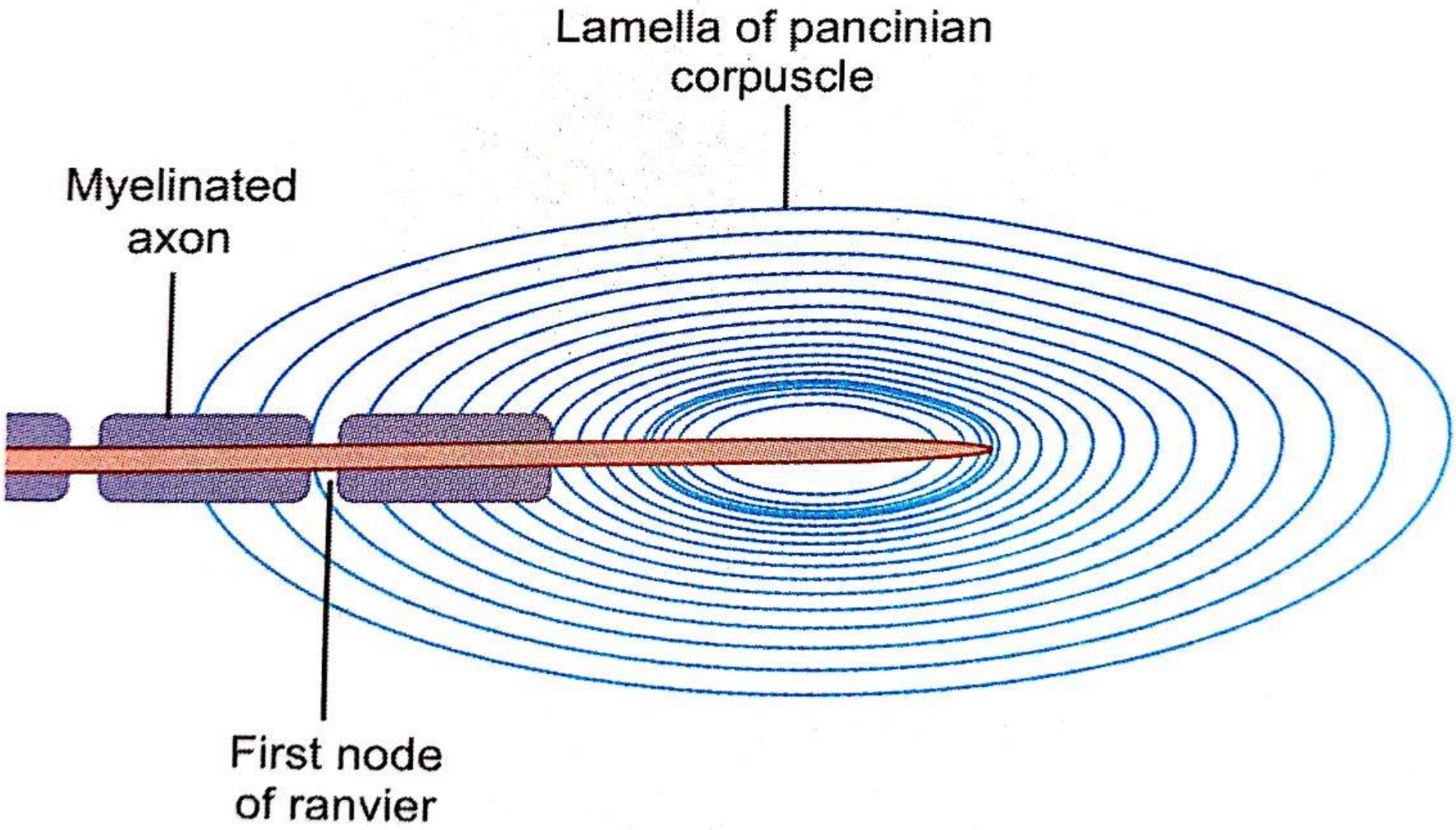

Fig. 117.1: Types of synapses. Pacinian corpuscle. Usually, first node of Ranvier remains within the lamella of the corpuscle.

Krause's end bulbs

- spherical in shape.
- They occur in conjunctiva, lips, tongue etc.
- Their sensory nerve belongs to A delta type.
- They detect cold temperature ,touch and pressure.

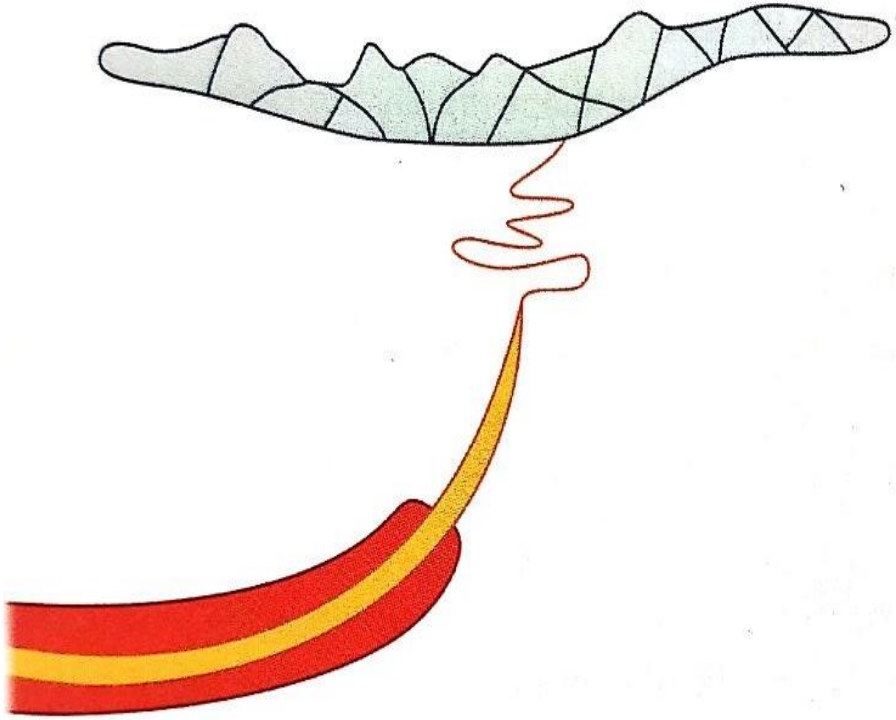

Fig. 117.4: Ruffini ending.

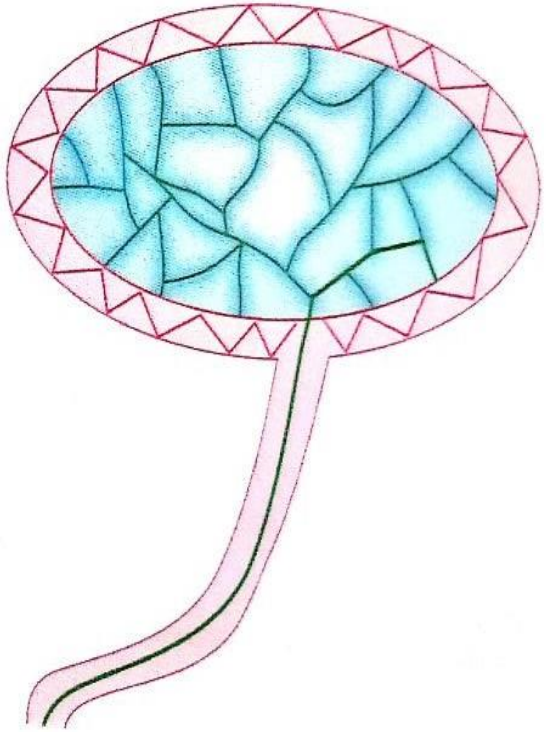

Fig. 117.5: Krause end-bulb.

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RUFFINI'S END ORGANS

- multibranched, expanded encapsulated endings of myelinated A delta or unmyelinated type C.
- They are present in deeper layers of skin and also in deeper tissues, where they detect degree of joint rotation.
- They respond to warm temperature.
- slowly adapting receptors.

Pain receptors

- nociceptors.
- located at the ends of small ‘C’ unmyelinated or myelinated A delta fibers.
- free nerve endings.

-1) Erlanger Gasser's classification: most important classification

	TYPE	FUNCTION	DIAMETER (MICRO METERS)	CONDUCTION VELOCITY (MTS/SEC)
Myelinated fibers of spinal nerves (motor & sensory)	A alpha A beta A gamma A delta	Proprioception (A), somatic motor(E) Touch, pressure (A) Motor to muscle spindle (E) Fast pain, touch, cold (A)	12-20 5-12 3-6 2-5	70-120 30-70 15-30 12-30
Myelinated efferent preganglionic	B	Preganglionic autonomic nerve fibers (E)	<3	3-15
unmyelinated	C	Slow pain, touch, hot temperature (A) Postganglionic autonomic (E)	0.4-1.2	0.5-2

SENSORY TRANSDUCTION

- Conversion of environmental signals (sensations) into neural signals by receptors is called as sensory transduction. Steps :

- * Arrival of stimulus to receptor.
- * Production of generator or receptor potential.
- * Production of action potential in sensory nerve.

PROPERTIES

- RECEPTOR POTENTIAL
- SPECIFICITY OF RESPONSE
- ADAPTATION
- MULLER'S DOCTRINE OF SPECIFIC NERVE ENERGIES
- LAW OF PROJECTION
- INTENSITY DISCRIMINATION:

  RESPONSE TO INCREASE IN STRENGTH OF STIMULUS: WEBER FECHNER LAW, POWER LAW

RECEPTOR POTENTIAL: LOCAL POTENTIAL

- Each receptor produces receptor or generator potential when stimulated by adequate stimulus.
- When receptor potential rises above threshold, action potential is produced in the nerve fiber attached to the receptor.
- Studied in PACINIAN CORPUSCLE

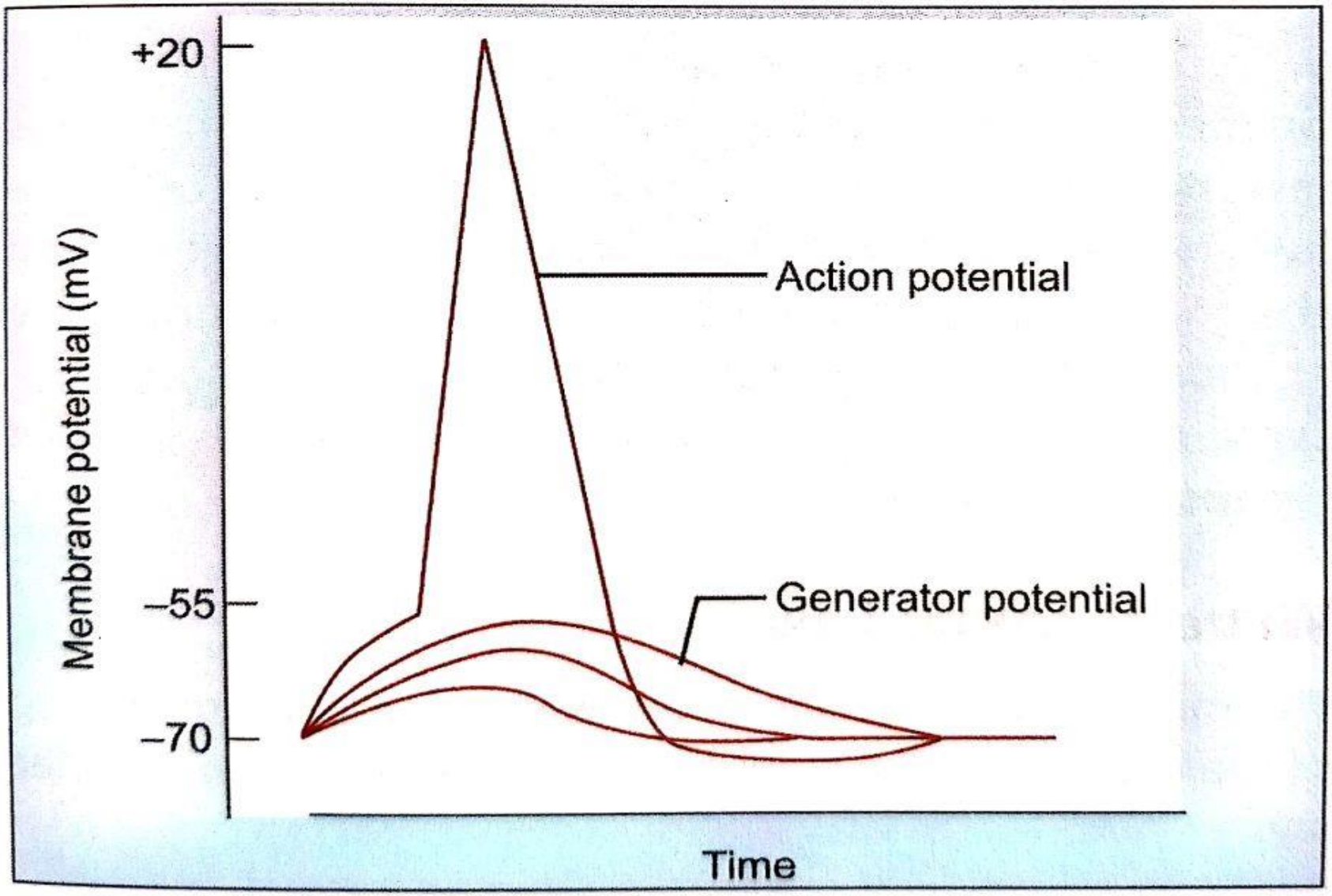
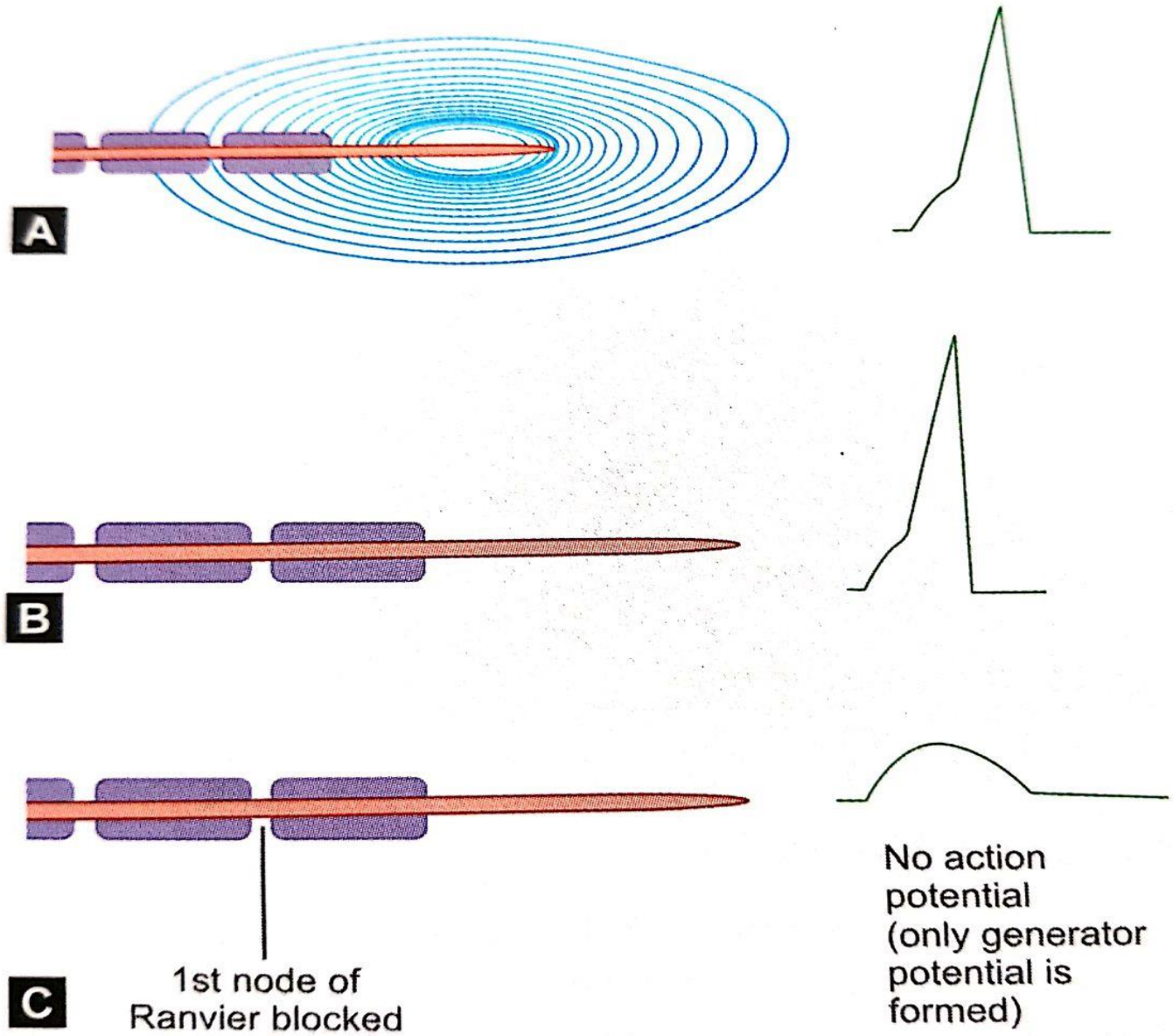


Fig. 117.6: Receptor (generator) potential and action potential, formed in receptors.



Figs. 117.7A to C: Demonstration of site of action potential genesis in Pacinian corpuscle. Note, action potential is formed following removal of lamella of Pacinian corpuscle (B); but, action potential is not formed following blockade of first node of Ranvier (C).

Specificity of response (law of adequate stimulus)

- Receptors respond maximally only when appropriate specific stimulus is applied.
- The sensation to which a receptor is most sensitive is called its adequate stimulus.
- E.g. tactile receptors respond to touch, pain to free nerve endings etc.

ADAPTATION

- When a stimulus of constant strength is applied to a receptor, the response goes on decreasing over a period of time.

- Rapidly adapting receptors (phasic receptors):

  Adapt fast if the intensity of stimulus is kept constant.
  Respond only when the intensity of stimulus changes.

  E.g. touch, olfactory and pressure receptors etc.

- Slow (non) adapting receptors (tonic receptors) :

  Continue to respond at the same rate even if the intensity of stimulus is kept constant over many days.

  E.g. muscle spindle, free nerve endings, baroreceptors, chemo receptors etc.

CODING OF SENSORY INFORMATION

Muller's doctrine of specific nerve energies or labelled line mechanism (QUALITY OF SENSATION):

- Stimulation of touch receptor causes sensation of touch only and not that of pain or cold.
- sensation produced by impulses generated in a receptor depends upon the specific part of the brain they activate.
- these specific pathways are separate from sense organ to cortex and are achieved during development of CNS.
- If there is *pressure* by growth (tumor etc) in the pain pathway in spinal cord, the patient feels sensation of *pain* and not of pressure.

Scientist contributed

Johannes Müller (1801–1858) was a great teacher in Physiology at Bonn. He distinguished himself by expounding the principle of **receptor properties** and specific nerve effect, which is popularly known as **Muller's doctrine of specific nerve energy**. He also studied the mechanism of secretion, showing the relation of blood capillaries to glandular structures. He discovered chondrin and glutin, studied digestion and recognized cellular characteristics.

J Müller
(1801–1858)

Encoding of stimulus location

LAW OF PROJECTION:

- When a sensory pathway is stimulated along its course to the cerebral cortex, the sensation produced is felt to the location of the receptor.
- The stimulus location is recognized accurately due to point to point representation of the body in the sensory cortex.
- This point to point representation is also called as topographical representation:

  SENSORY HOMONCULUS.
- E.g. Phantom limb (ghost limb or limb which does not exist).

- RECEPTIVE FIELD OF NEURON, LATERAL INHIBITION

Law of intensity discrimination

a) By variation in frequency (no. of stimuli per second) of the action potentials generated in a receptor

- **Weber Fechner Law**: magnitude of sensation felt is proportional to the log of intensity of stimulus.

  If the magnitude of stimulus felt is 1, intensity of stimulus is 10. But if the magnitude is 2, the intensity of stimuli should be 100 (not 20), and if the magnitude is 3, the intensity of stimulus should be 1000 (not 30).

Law of intensity discrimination

b) By change in number of receptors activated.

- As the strength of stimulus is increased, it spreads over a large area activating more and more receptors.
- This phenomenon is called as recruitment of sensory units.

THANK YOU