SENSORY NERVOUS SYSTEM

Coding of Sensory Information And transmission of signals in nervous system

By
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Learning Outcomes.

Learning Objectives are to know;

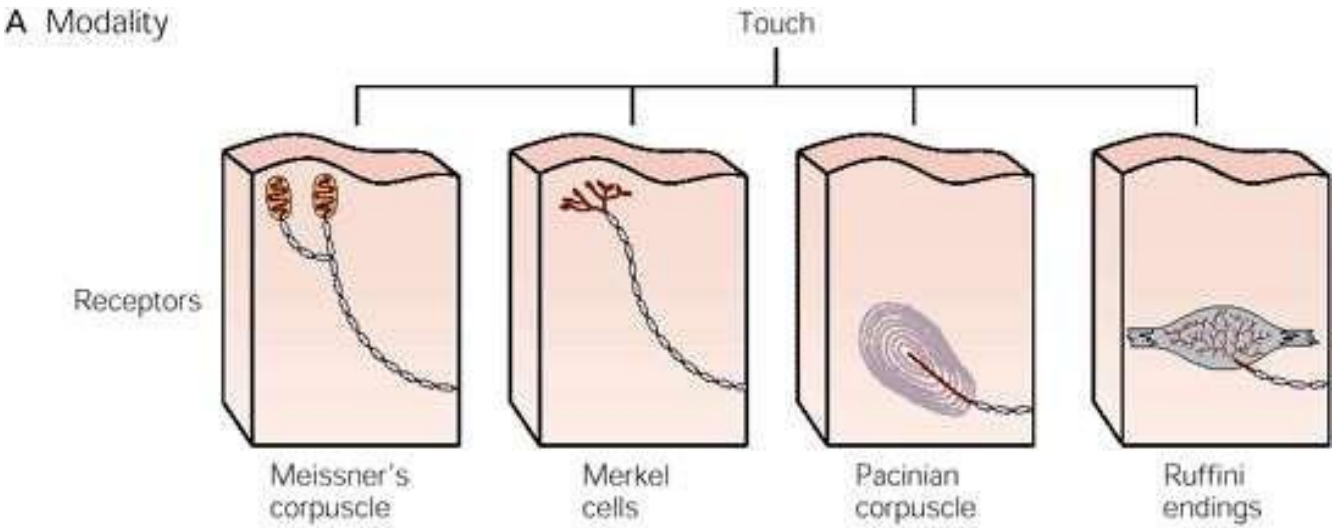
- Sensory coding.
- The processes involved in SENSORY CODING.
- The components of any Sensory modality
- How the sensory coding takes place from receptors up to the Cortex ?
- transmission of signals in nervous system
- Applied physiology or clinical aspect of any defect in sensory transmission.

Coding of sensory information

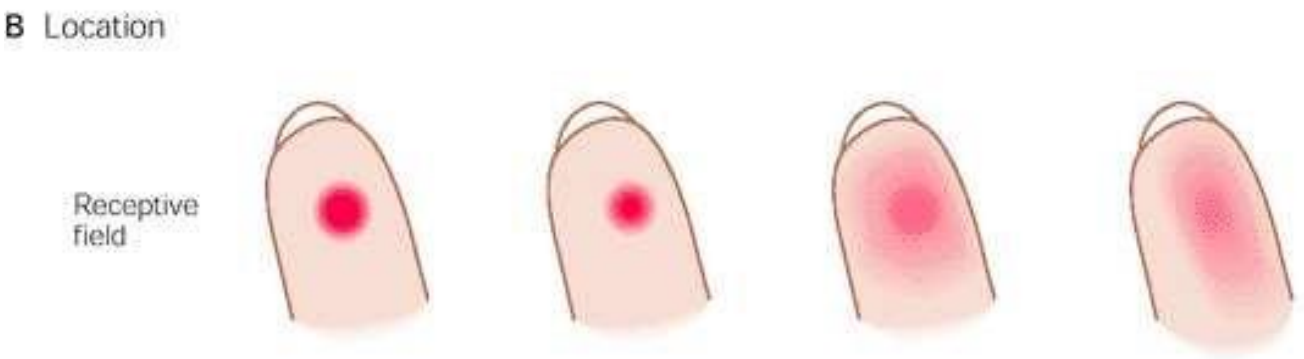
- Perception of sensations or transformation of different stimuli (mechanical, chemical) into nervous impulses (action potential)

Sensory coding

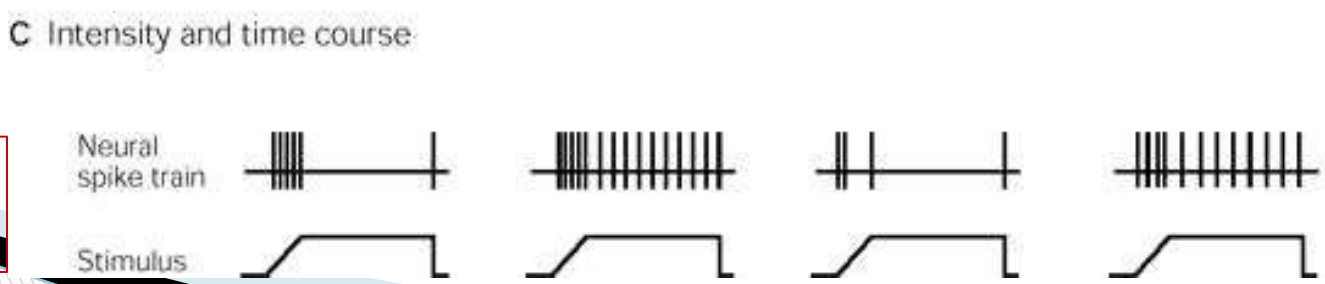
- **MODALITY :**



- **LOCATION:**



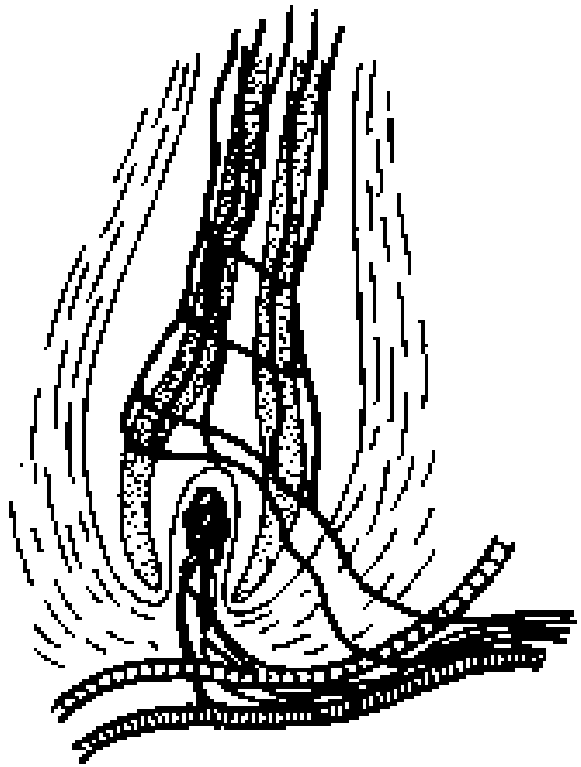
- **INTENSITY:**
- **DURATION:**



Classification of receptors

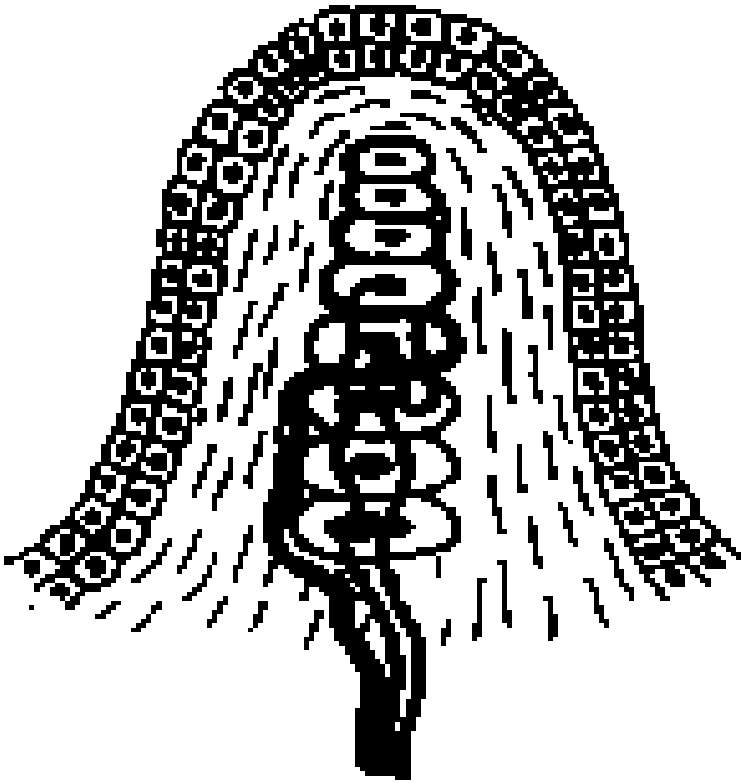
- Numerous, none is perfect
- Mechanoreceptors: for touch and pressure
- Nociceptors codes for potentially harmful stimuli such as extreme heat and extreme cold
- Chemoreceptors: mediates coding chemical changes
- Photoreceptors like the cones and rods responds to light

Touch receptors - Hair Follicle Ending



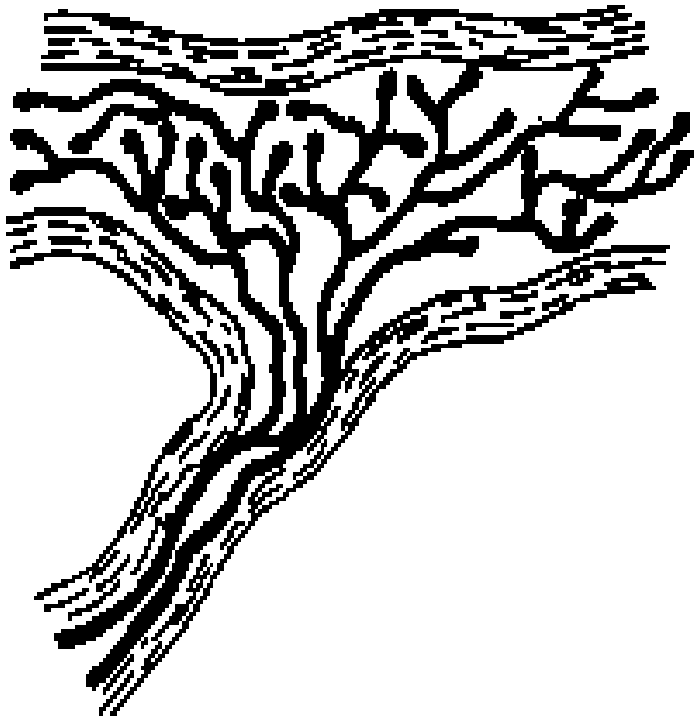
Responds to hair displacement. Wraps around hair follicle in hairy skin.

Touch receptors - Meissner corpuscle



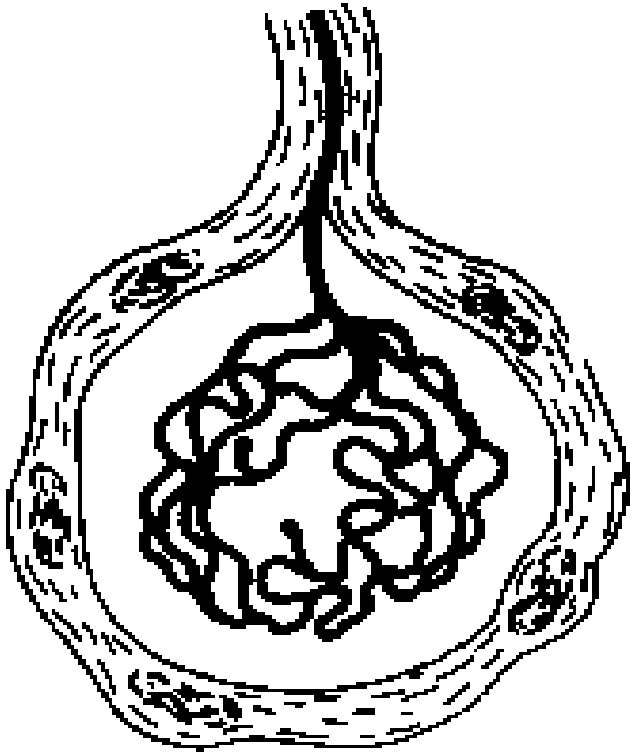
Responds to vibration. Most sensitive in 20-40 Hz rangeDermis of glabrous skin.

Receptors of pressure -Ruffini ‘s endings



Dermis of both hairy and glabrous skin

Receptors of pressue -Krause corpuscle

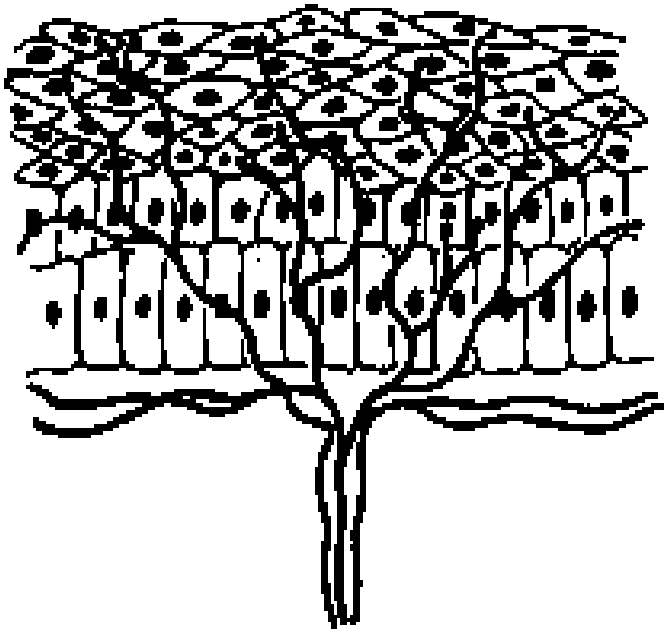


Lips, tongue, and genitals.

Vibration receptors -Pacinian corpuscle

Responds to vibration. Most sensitive in 150-300 Hz range Deep layers of dermis in both hairy and glabrous skin. Deep layers of dermis in both hairy and glabrous skin.

Free nerve endings



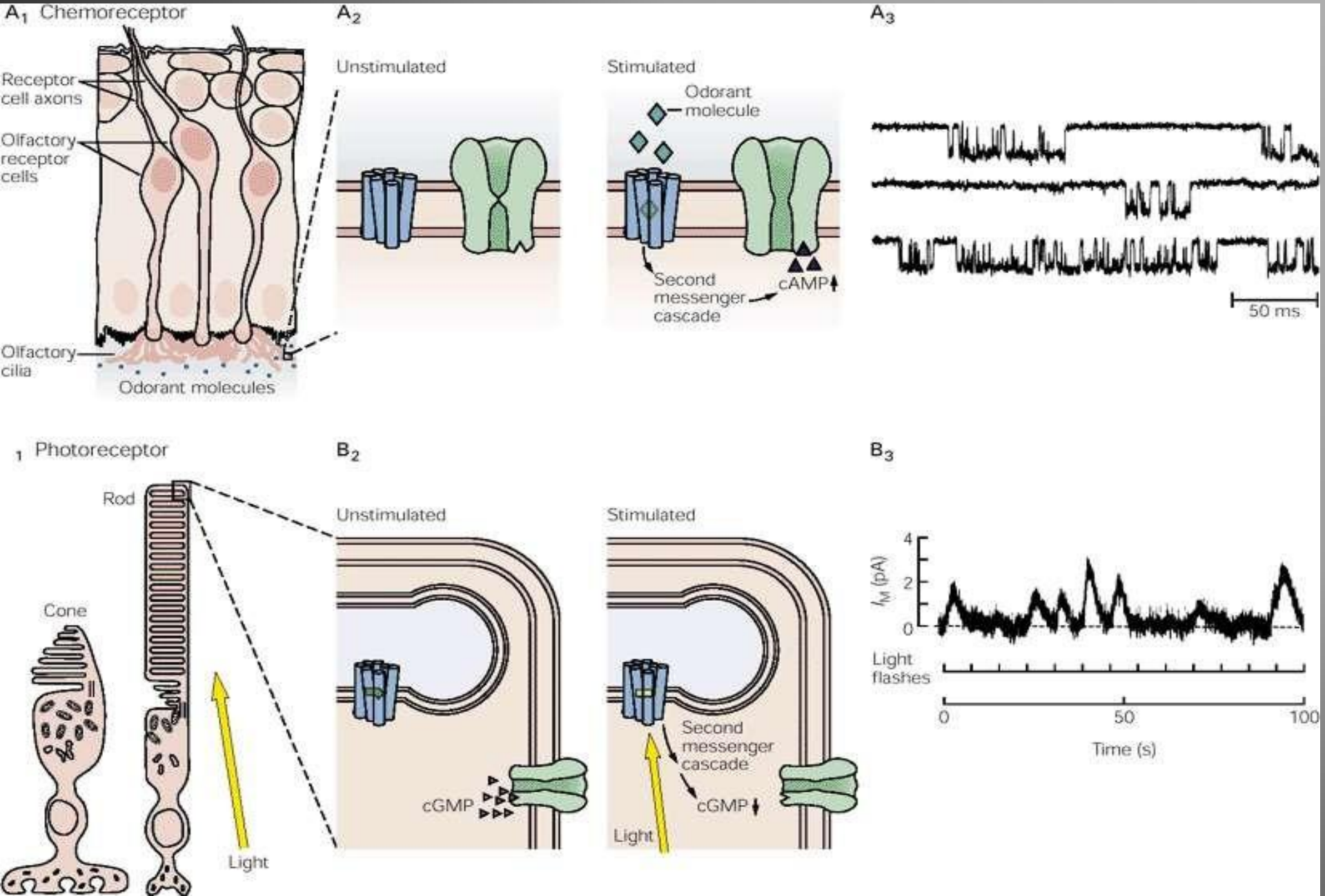
Different types of free nerve endings that respond to mechanical, thermal or noxious stimulation.

Principles of Sensory Coding.

Events taking place in the form of specific CODES of sensation.

1. **Reception: Specialised cells called receptors absorb the physical energy.**
2. **Transduction: Physical energy is converted into electrochemical energy represented by the firing pattern of different neurons.**
3. **Coding is the correspondence between specific parameters of the stimulus and specific parameters of the neuronal firing that represents it.**
4. **Awareness through Reticular Formation**
5. **Recognition/Perception/ Analysis /strength (Sensory cortex)**
6. **Response (from somatic or autonomic) through effectors**

Transduction of stimulus into



Pacinian Vibration Detector

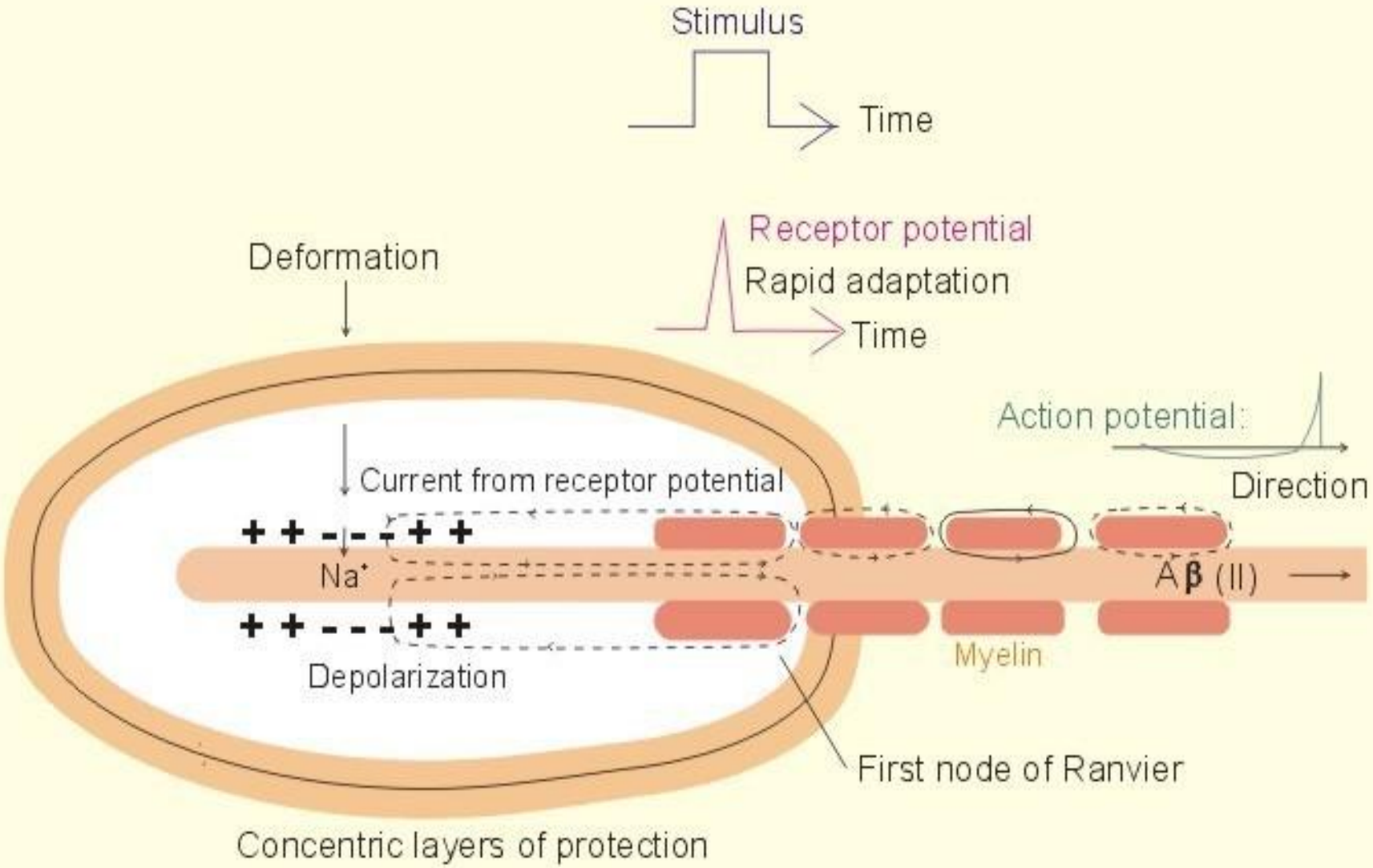


Fig. 3-1

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Coding

This refers to as one-to-one correspondence

- **Same stimulus with same frequency through same neuron and to the same brain area is a "key aspect of sensory coding"**

e.g Optic nerve------ vision

Olfactory nerve ---- smell

and so on, pain, touch, temperature etc

Coding of Information in the receptors

- **Coded parameters:**
  - **force of the stimulus**
  - **(frequency & spacial coding)**

- **Duration of the stimulus**

Quantifications

Strength and recognition of stimulus

- Cells with a spontaneous firing rate may signal one kind of stimulus by increasing their firing rate, and
- a different kind of stimulus by a decrease in their firing rate.

As, fine touch. Crude touch, pressure sensation. Sharp pain, deep pain, etc

Adequacy = Absolute threshold

minimum force of stimulus causing sensation is called adequacy

Example: Coding in the Retina.

- The human retina contains around 120 million rods and 6 million cones but we do not individually process 126 million bits of information.
- Each ganglion cell has a receptive field whose size and sensitivity depends upon how many rods or cones converge upon it.
- In the macula only a few cones converge upon each ganglion cell so visual acuity is enhanced.
- In the periphery, many rods converge upon each ganglion cell so sensitivity is reduced.
- The receptive fields of the ganglion cells converge to form the receptive fields at the next neural level and so on.

Rules of Sensory Coding

Each receptor is specialised to absorb and transduce only one kind of stimulus i.e. visual receptors in the retina are not activated by sound or pain receptors will not be activated by vibration.

And same areas in the brain as well

This is the *law of specific nerve energies, (Müller, 1838).*

Awareness
(the sense of sensation)

- **Most stimuli that are received, transduced and are then perceived with specific code, called modality**

  E.g, when smelling a flower, scent molecules strike olfactory receptors in the nose (reception).
- **This produces a chemical reaction that depolarizes the resting potentials of the olfactory receptors, they fire (transduction) and**
- **this information is passed via the olfactory nerve to the olfactory bulb at the base of the brain (coding).**
- **The olfactory bulb then sends connections to various parts of prefrontal cortex where smells are recognised (awareness).**
- **Response (effectors)**

Law of specific nerve energies

First explained by Müller in 1835

One of the cornerstones of sensory physiology

- The specific sensory pathways are discrete from sense organ to cortex
- The modality of sensation is not determined by the proximal stimulus
- “when the nerve pathways from a particular sense organ are stimulated, the sensation evoked is that for which the receptor is specialised no matter how or where along the pathway the activity is initiated”

Law of projection

"No matter where a particular sensory pathway is stimulated along its course to the cortex, the conscious sensation produced is referred to the location of the receptor"

Transmission of signals in Sensory system

- ***Functional system of neurons*** **which enables perception of external or internal environment changes,**
- **Conduction of impulse to CNS,**
- **Its analysis and**
- **formation of sensation**

Summery of transmission
Example: Pain and Temperature

- Afferent starts from respective receptors in skin
- Through respective sensory fibres (first order neuron)
- Reach spinal cord posterior root, posterior horn cells
- 2nd order neurons crossing the side, going up through antero-lateral spinothalamic tract.
- Reaching thalamus, through R.F for awareness of sensation
- Somatic-sensory are in parietal lobe, analysis
- Motor, memory, area

Departments of sensory system

- **Peripherial (receptors)**
- **Conducting pathways**
- **Central (sensory cortex)**

Functions of peripheral systems

- **Primary analysis,**
  - **Adequate**
  - **Strength**

- **Coding of information**
  - **Type (at receptor level)**
  - **Awareness (at Reticular**
  - **information/analysis, thalamus and**
  - **Response (higher centre)**

Reception by the higher centre

- **Conveys impulse to the cortex**
- **Performs secondary analysis to form reflex reactions (withdrawal, orientational reflex) & define important information (lateral inhibition in thalamus)**

Functions of cortex (higher centre)

- **Higher analyses – transformation of nervous impulse energy into perceptions**
- **Recognizing**
- **Decision making**
- **Adequate behaviour (associative cortex)**

Effector functions of Nervous System

- **Defence reflexes (blinking, lacrimation, withdrawal)**
- **Orientational behaviour**
- **Homeostasis**
- **Maintaining state of awakefulness for the brain (activation of RF)**

Applied physiology / Clinical significance

test for vibratory sensibility is done by applying a vibrating(128Hz) tuning fork to the skin of the fingertip

- **Pallesthesia** is the ability to feel mechanical vibration (Pacinian corpuscles) involved in pernicious anaemia
- **Stereognosis**: perception of the form and nature of an object without looking at it. Depends on intact touch and pressure sensation carried by dorsal column

Applied physiology / Clinical significance

Stereoagnosia: defect along the sensory pathway, even lesion in parietal lobe posterior to postcentral gyrus i.e in Visual, tactile, auditory, color, position …. agnosia

Applied physiology / Clinical significance (Synaesthesia)

- If it would possible to swap the auditory and optic nerves then we may 'see' sounds and 'hear' lights.
- A neurological disorder called synaesthesia may actually indicate that such rewiring is possible.

- Some times a touch is felt vibration and vibration may be felt painful as in burn, acid electric shock etc.

- Altered taste and sensation, common physiological or pathological i.e

Drugs, after tooth paste, Malaria, Cancer, uremia, mouth breathers,

THANK YOU