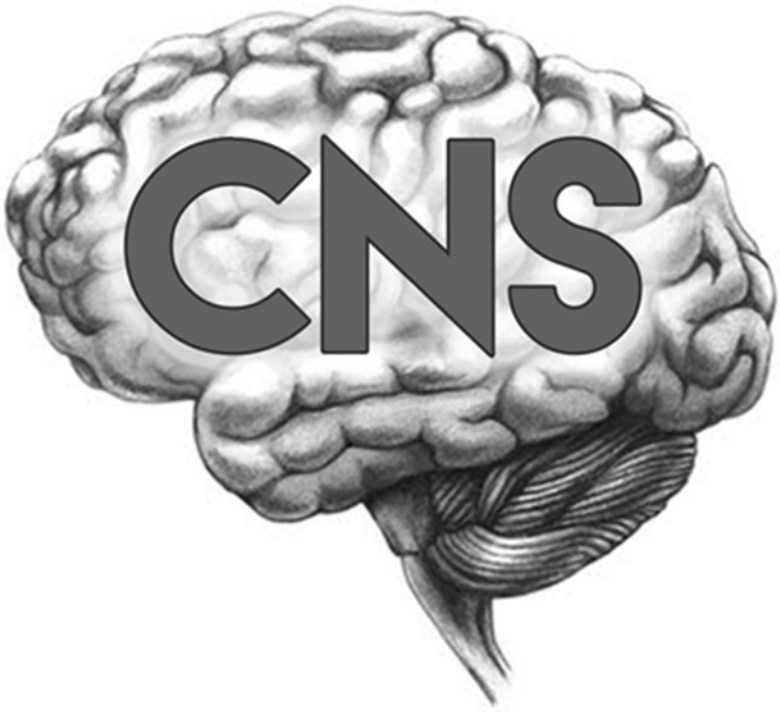

PHYSIOLOGY

☑ Sheet ○ Slide ○ Handout

Number

11

Subject

.....

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Date: 00/00/2016

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By the name of Allah the compassionate the merciful

sheet was Written according to Section 1 recording .

Types of The Sensory Receptors :

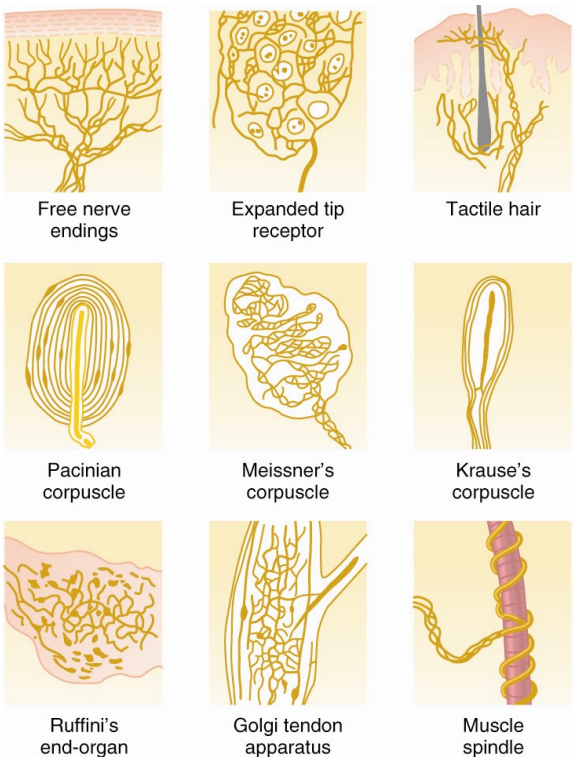
- **Classification by Modality (Stimulus they transduce)**
  1. Mechanoreceptors >>> detect deformation, Touch and Prssure
  2. Thermoreceptors >>>> detect change in temperature
  3. Nociceptors >>> detect tissue damage (pain receptors)
  4. Electromagnetic (Photoreceptors) >>> detect light (Rods and Cones)
  5. Chemoreceptors >>> taste, smell, CO2, O2, etc.

- **Classification by Location**
  1. Exteroceptors – sensitive to stimuli arising from outside the Body { Located at or near body surfaces } >>> Include receptors for touch, pressure, pain, and temperature
  2. Interoceptors – (visceroceptors) receive stimuli from internal Viscera >>> Monitor a variety of stimuli (distension of viscera, pain)
  3. Proprioceptors – sense of position- monitor degree of stretch Located in musculoskeletal organs (muscle, tendons and skin around joints)

- **Some notes concerning the figure:**

I. The figure shows us the types of sensory receptors :

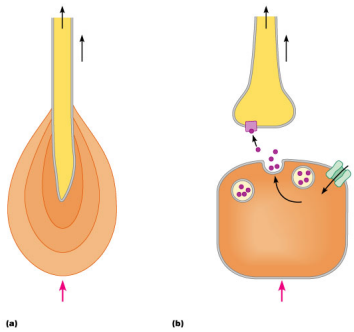
- ✓ Free nerve endings that are responsible for pain , temperature , itch and tickle sensation .
- ✓ Expanded tip receptors >> for touch sensation .
- ✓ Tactile hair >>> sensation of the hair movement .
- ✓ Pacinian corpuscle >> encapsulated receptors >> pressure and high frequency vibration (1000 HZ) >>> found in the dermis .
- ✓ Meissner's corpuscle >>> encapsulated receptors >>> fine touch , pressure and low frequency vibration (500-700 Hz) >>> found in dermis and epidermis



- ✓ Ruffini's receptors >>> sense the deep pressure and proprioception >>> found in the dermis and around the joints .
- ✓ Golgi tendon organ >> sense the tension >> remember the inverse reflex (sheet #9).
- ✓ Muscle spindle >>> sense the change in the length of the muscle >> remember the stretch reflex .

- The **encapsulated** receptors are **rapidly** adapting receptors >>> the pacinian and meissner's corpuscles . These two types of receptors are different in the **frequency of vibration** they are able to sense, depending **on their adaption { the pacinian corpuscles are faster than the meissner's corpuscle then they are able to sense higher frequency vibration (1000 HZ) }** .
- three proprioceptors :
  1. Muscle Spindle
  2. Golgi tendon organ .
  3. Ruffini's end_organ .
- In General , if the receptor is found epidermis >>> touch .
  If the receptors are found in dermis >>> pressure .

Transduction of sensory stimuli into nerve impulses



- The General structure of the receptors could be :
  1. Separate from the afferent neuron they transmit the signal through .
  2. Terminal part of the afferent neuron.
- The receptor area should **be non-excitable ??!**
  - ➢ To understand that let's discuss the meaning of excitable and the effect if the receptor is excitable ….
  - ➢ **Excitable** means having the **ability to generate the Action potential**

    If the receptor area is **excitable** then *the stimuli that reach the threshold* , **whatever their intensity,** will generate the **same frequency** of action potential { because of the "All or None" principle } then the brain **cannot** differentiate between intensity of different stimuli .
  - ➢ To make that easier let's take this example :
    Assume that there are different stimuli :
    1st one is weak stimulus but it reaches the threshold then action potential is generated.

2nd one is stronger than the 1st one then also the action potential is generated because it reaches the threshold .
These two stimuli reach the cerebral cortex , both stimuli give the same frequency of action potential { All or None principle } **, then the brain cannot differentiate between them and thinks of them as having the same intensity !!!**

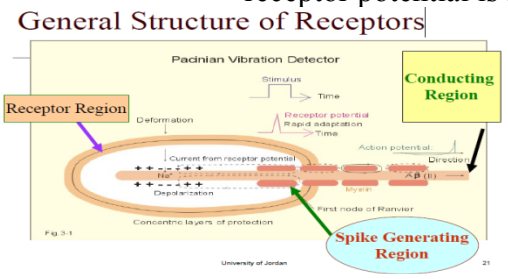
- Remember , the intensity of the stimuli is determined by the frequency of the action potential {the number of discharges}

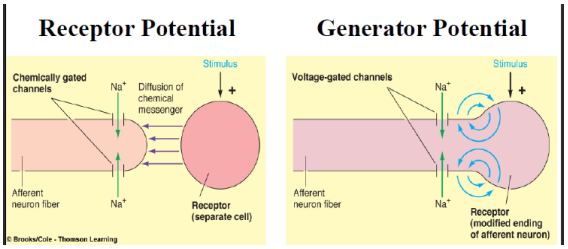
- Now, return back to what we really have! the receptor area **isn't excitable** then there is **no action potential in the receptor area** , but according to the stimulus there would **be a change in the permeability of the stimulus-gated channels** {mainly the sodium channels}, this causes a change in the membrane **potential without generating action potential in the receptor are**a , and this change is **called Receptor Potential.**

- Note : the change in the permeability could **be either an increase or a decrease !**

- ***But, what is the relationship between the receptor potential and the action potential that is generated in the afferent fiber and transmitting the sensation to the brain ?!***
  - ✓ The **action potential in the afferent neuron** depends on the **receptor potential** , when the receptor potential is **strong enough (i.e reaches the threshold) ,** then **an action potential is generated** in the axon . this action potential is conducted to the brain .
    Note that, in case the receptor was the terminal part of an afferent neuron, and the **generator potential** was strong enough to excite an action potential, the action potential is generated **in the 1st node of Ranvier** of the axon.
  - ✓ so , the action potential in the axon depend on the amplitude of the receptor potential; **the stronger the stimulus (the word "stronger" here is used to express the higher amount of energy the stimulus holds), the larger the receptor potential is, and the more** chemical messengers and neurotransmitters affecting the Chemical and voltage gated channels in the afferent neuron are released (as shown in figures below)
    stronger stimuli>>> higher amplitude of receptor potential >> more spikes in the axon >> the brain knows that this is strong stimulus .

✓ Note / the stimulation to generate the action potential depending on the receptor potential is limited by the absolute refractory period (cannot exceed it).





➢ *To understand the idea , assume there are different stimuli :*

1st is weak** >> change the permeability >>> change the membrane potential of the receptor to become -40 mV, then **the receptor potential = 30 mv** >>> generating certain number of spikes *

***2nd is stronger** >> change the permeability **more than the first one** then the membrane potential becomes zero mV . **then the receptor potential = 70 mV** >>> generating **more** spikes .*

3rd is stronger than the 2nd** >>> the membrane potential becomes +10 mV then the receptor potential = **80 mV** then generating **more spikes than 1st and 2nd stimuli .

So on…

*According to the **No. of spikes the brain can differentiate between these stimuli { stimulus 3 is stronger than 2nd and 1st stimuli , the 1st stimulus is the weakest one }.***

**** **t**he receptor potential is the change in the potential , the normal membrane potential = -70 mV , then the receptor potential = -70 – the new membrane potential*

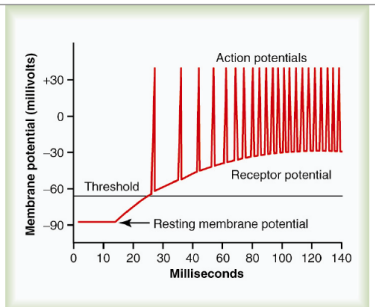
- The Receptor Potential is similar to the Excitatory postsynaptic potential in terms of being **local , graded , can be summated and not following the all/Non action potentials** .

- After taking this general idea let's repeat some main things with figures :

1. According to figure 1 ,when there is weak stimulus , then small receptor potential if it's not reach the threshold then no action potential in the axon . but when the receptor potential reach the threshold then action potential will be generated in the axon .

5

Relationship between Receptor Potential and Action Potentials



eshold

Figu

2. According to figure 2, more action potentials (higher frequency) are generated in the axon when the receptor potential is higher.

3. According to the figure 3 , when the stimulus is too strong or too weak, then the change isn't too much. { Lesser sensitivity regions } .
   in the greater sensitivity region >>> any change in intensity of the stimulus will lead to great change in the amplitude of the receptor potential .

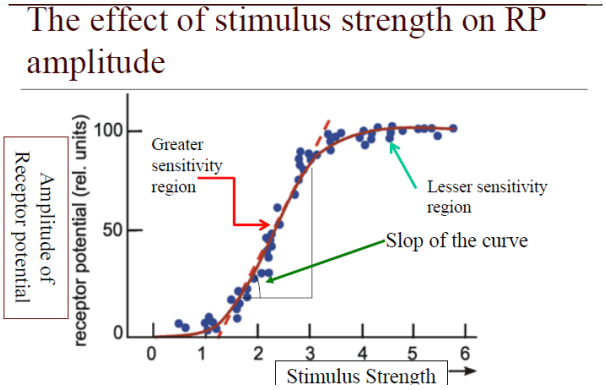


Figure 3

4. According to the figure 4 , higher amplitude of the receptor potential, leading to more generated spikes .

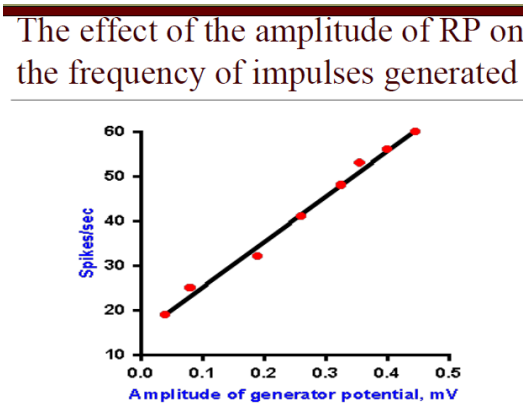


Figure 4

- Remember : The maximum peak of the **action potential** is 30 mV but theoretically the maximum peak can be 61 which is the equilibrium potential of the sodium >>> cannot be reached in reality because there are other ions that interact with sodium in the generation of the action potential .
- **The maximum amplitude of the *receptor potential* is 100 mV.**

Adaptation of the receptors

- Another characteristic of all sensory receptors is that they adapt either partially or completely to any constant stimulus after a period of time .
- Two types of receptor in term of adaptation :

A. Rapidly adapting phasic receptors :

1. respond **only when change** is taking place
2. Rate and Strength of the response is related to the Rate and Intensity of the stimulus, then it's important for **predicting the future position or condition of the body**

3. **Very good for vibration sense** .
4. Similar to dynamic response in the muscle spindle(sheet 9).
5. very important for balance and movement are the types of rapidly adapting receptors: the *pacinian corpuscle, and semicircular canals* in the inner ear.

B. Slowly adapting, tonic receptors :

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

- **Sensory Adaptation**

  o **Tonic receptors**: Produce constant rate of firing as long as stimulus is applied .
  o **Phasic receptors**: Burst of activity but quickly reduce firing rate (adapt) if stimulus maintained.

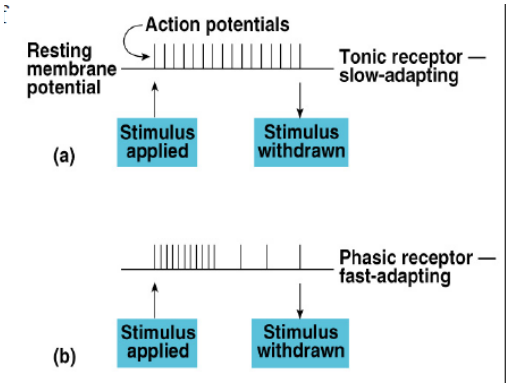


Figure 5

- **depending on figure 6 :**

1. Pacinain corpuscle is rapidly adapting >> rapid firing and falling >> remember it's encapsulated .
2. Hair receptors are rapidly adapting but not like the pacinain and meissner's corpuscles .
3. Both muscle spindle and joint capsule receptors have two phases ; the first one is a little bit rapid then slowly adapting phase . >>> they are in general Slow adapting receptors.

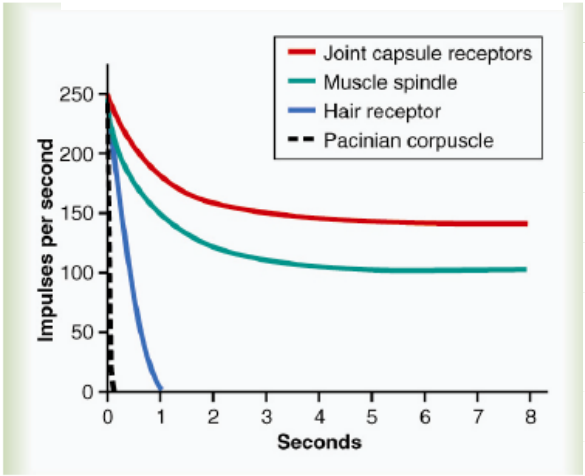


Figure 6

- **Mechanism of Adaptation varies with the type of receptor :**
  1. *photoreceptors* change the amount of light sensitive chemicals

2. *mechanoreceptors* redistribute themselves to accommodate the distorting force (i.e., the pacinian corpuscle) , some mechanoreceptors adapt slowly, some adapt rapidly .

Nerve fibers that transmit signals

- Types of Nerve Fiber
  1) Myelinated fibers – Type A (types I, II and III)
     A α / A β / A γ / A δ { depending on their diameter size }
  2) Umyelinated Fibers- Type C (type IV)
- Neurons attached to A β / A γ / A δ / A α {{ very little attached to A α **}}** **rapidly** transmit the signals .
- Neurons attached to C **fibers slowly** transmit the signals.

- the larger the nerve fiber diameter the faster the rate of transmission of the signal
- velocity of transmission can be as fast as 120m/sec or as slow as 0.5 m/sec

- The **rapid** transmission of the signals makes it **good oriented in term of time and place** >>> when the transmission is rapid then there is **no interconnection between the signal and the next one** { the 1st signal reach the brain then the 2nd one reach ; there is space and time between them } >>> **Good Spatial and Temporal Orientation { Faithfulness }**
  " ما بتّطلّع يمين و شمال بروح دغري "
  **This is important to help the brain interpret the signal.

Transmission of signals of different intensity in nerve tract .

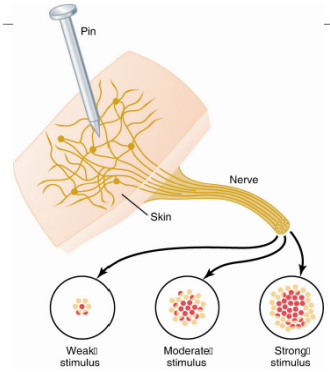
- Gradations in signal intensity can be achieved by:
  1) increasing the number of fibers stimulated, **spatial summation**
  2) increasing the rate of firing in a **limited number** of fibers ; increase the frequency of the nerve impulses in each fiber , **temporal summation**.

- **The Spatial Summation :**

  figure 7 shows us three sections of a nerve bundle from skin, each with different intensity of the stimulus.
  From the left :
  1st section >>> representing weak stimulation >> only a single nerve fiber in the middle of the bundle is stimulated strongly (reaches threshold) (red colored fiber) whereas the

adjacent fibers are facilitated { that means their membrane potential is close but does not reach the threshold } .

2nd section >>> the effect of moderate stimulation, the number of strongly stimulated fibers increases { the fibers that were facilitated previously become stimulated now } and the fibers that surround the stimulated become facilitated .



An example of spatial summation

Figure 7

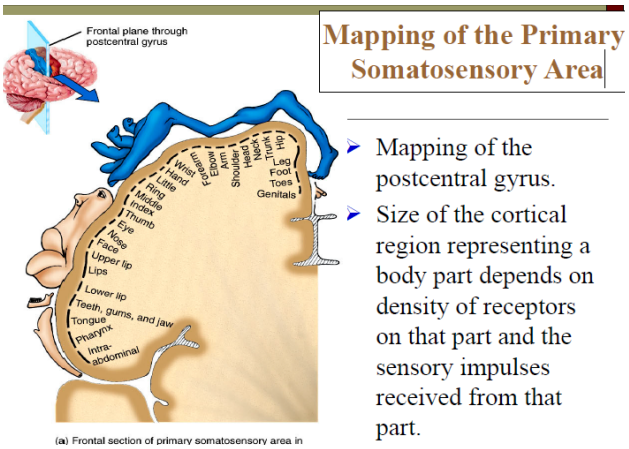
3rd section >>> the effect of stronger stimulation, {stronger than 2nd stimulus } >> progressively more fibers being stimulated

From this example >>> the stronger signals spread to more and more fibers >> that is called spatial summation.

Coding in the sensory system

- **Intensity is coded for by:**
  1. Frequency of action potential
  2. The No. of neurons stimulated

- **Location** is coded for by the labeled line principle ,,
  The body is represented in the cerebral cortex { somatic sensory area 3,1,2 }, this representation is :
  1. Upside-down .
  2. Contra lateral except the face is bilateral .
  3. The size of the representing region depending on the size of the receptive field { the density of the receptors } ; the smaller receptive field >>> more receptor density >>> larger representing are and vice versa .



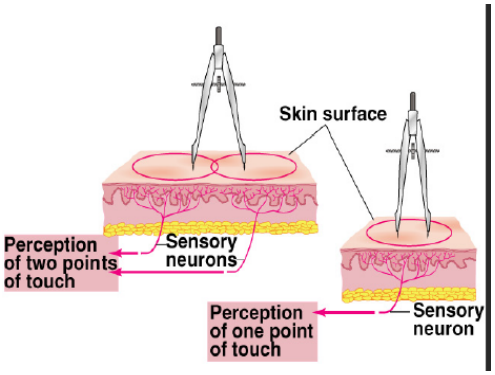
- **Type { Modality }** of stimulus is coded for by the kind of receptor stimulated (Adequate stimulus) and specificity of the receptors ; the touch receptor is responsible for touch mainly { the receptor is specific } But it may respond to another type of sensation but with higher threshold {the stimulus should be very strong} .

Receptive Field.

- Area of skin whose stimulation results in changes in the firing rate of the neuron . Area of each receptor field varies inversely with the density of receptors in the region.
- **Back and legs have few** sensory endings >>> Receptive field is **large**>> **crude** sensation .
- **Fingertips have large number** of cutaneous receptors >>>Receptive field is **small >>fine** sensation

- **Two-Point Touch Threshold**

  - Minimum distance at which 2 points of touch can be perceived as **separate**.
  - Measures of distance between receptive fields.
  - Indication of tactile acuity.
  - If distance between 2 points is less than the minimum distance required for 2 point discrimination, then only 1 point will be felt.
  - If we make the distance between the two heads of the compass tool about 2mm and put it in the lips or finger tips then we can feel them as separate , but if we put it in the back we will feel as they are one thing unless we increase the distance to about 50mm (5 cm) now we may feel them as separate >>>> that depends on the size of the receptive field .

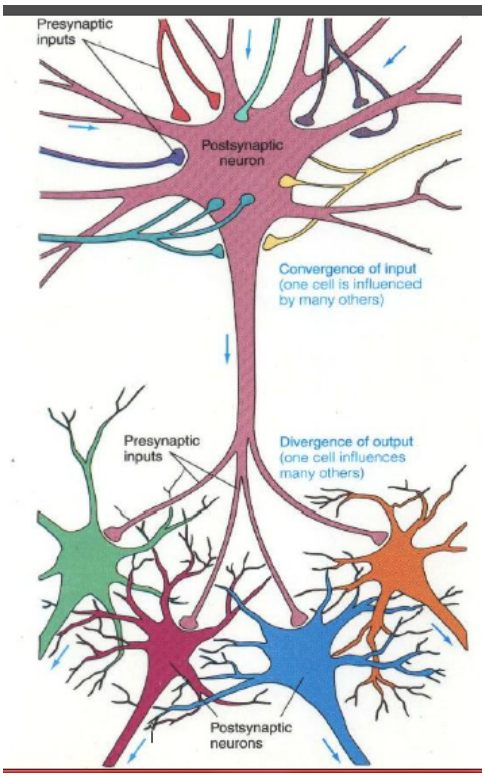


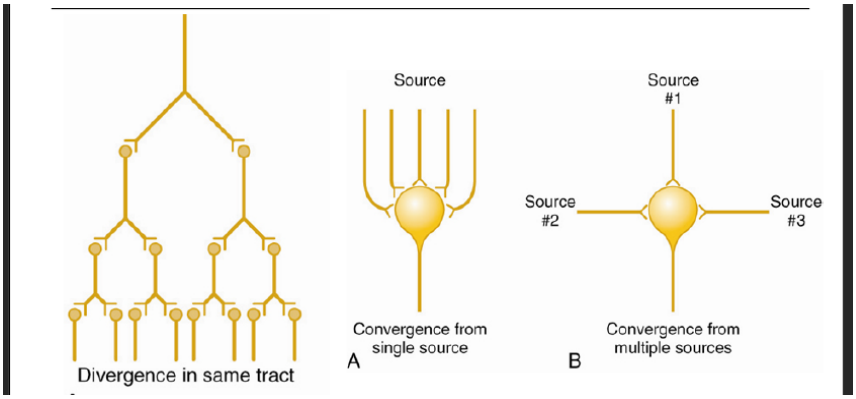
Neuronal Pools:

- **Localization of sensory Information modification**

1. The divergence leads to loss of localization , it's important for weak signals entering the neural pool to excite far greater numbers of nerve fibers leaving the pool.

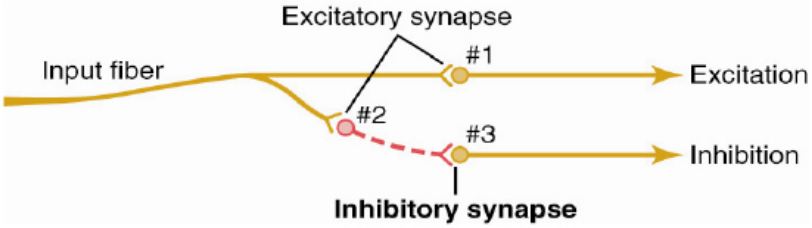
2. The convergence may lead to loss in the localization but less than the divergence . this pattern is important because the neurons almost never get excited by an action potential from a single input terminal but the convergence from multiple terminals provide enough spatial summation to bring the neuron to the threshold required for discharge.





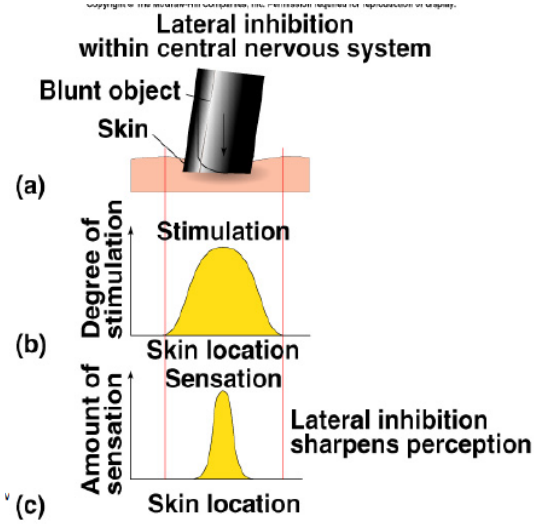
- **Modification of Localization: Sharpening of signals / Lateral Inhibition**

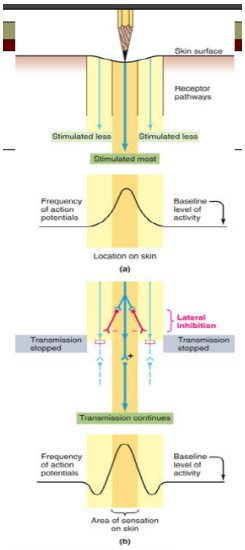
- As you see in the figure , the input directly excite activation but it stimulates an intermediate inhibitory neuron which secrets different types of transmitters that inhibit the second output from the pool .



- This type of circuit is important for sharpening the stimulus and preventing the over activity in many parts in the brain.

- Sharpening of sensation.
  - When a blunt object touches the skin, sensory neurons in the **center areas are stimulated** more than neighboring fields { inhibited }.
  - Stimulation will gradually diminish from the point of greatest contact, without a clear, sharp boundary.
  - Will be perceived as a single touch with well defined borders.>>> demarcating
  - Occurs within CNS not in the receptors .





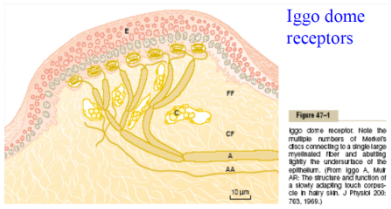
The Sensory System (this part is ***NOT*** included in the midterm exam)

❖ **Classification of Somatic Sensations**

* **Mechanoreceptive** - stimulated by mechanical displacement
Tactile **:** touch**,** Pressure, vibration , and tickle and itch
position or proprioceptive **:** static position**,** and rate of change (dynamic)
* **Thermoreceptive** >>> detect heat and cold
* **Nociceptive** >>> detect pain and are activated by any factor that damages tissue

❖ **Tactile Receptors :**
* **Free nerve endings** (A'delta' and C fibers) detect touch and pressure(mechanoceptors) , found everywhere in the skin and other tissues

* **Meissner's corpuscles** (A'beta') rapidly adapting (within a fraction of a second) and detect movement of light objects over skin , found on non-hairy skin (glabrous skin), fingertips and lips
* **Merkel's discs (**A'beta') respond rapidly at first and then slowly adapt, detect the "steady state" found on hairy as well as glabrous (non hairy) skin
>>> send projections just like fingers below the epidermis producing dome which is called Iggo Dome (Iggo according to who described it)



* **Hair end organ** adapts rapidly and detects movement over the body
* **Ruffini's end organ** slowly adapting and respond to continuous deformation of the skin and joint rotation
* **Pacinian corpuscle** very rapidly adapting and is stimulated only by rapid movement detects vibration and other rapid changes in the skin.

❖ **Tactile Sense Transmission**

- Meissner's corpuscles, hair receptors, Pacinian corpuscles and Ruffini's end organs transmit signals in type Ab nerve fibers at 30- 70 m/sec.
- Free nerve endings transmit signals in type Ad nerve fibers at 5-30 m/sec, some by type C unmyelinated fibers at 0.5-2 m/sec.
- **The more critical the information the faster the rate of transmission.**

Pathways for the Transmission of Sensory Information :

1) dorsal column-medial lemniscal system
2) anterolateral system.

❖ Dorsal Column System

- In the dorsal column of the spinal cord .
- Contains large myelinated (A beta) nerve fibers for fast transmission (30-110 m/sec).>>> very fast, then a high degree of spatial orientation maintained throughout the tract
- Transmits information rapidly and with a high degree of spatial and temporal fidelity (faithfulness) (i.e., discrete types of mechanoreceptor information).
- ***Fine touch, vibration, position, fine pressure , stereognosis .>>> Fine means precise , well localized just like the two point discrimination .***
- ***The stereognosis : the ability to recognize what you touch while your eyes are closed >>> blind people use that in Brill language .***
- ***Two tracts :***
  - ***Gracile tract >> from the lower limb***

- ***Cuneate tract >>> from the upper limb .***

✓ Start from the receptor , the afferent fibers enter the spinal cord to the 1st order neuron in the dorsal ganglia then they ascend in the dorsal column in the spinal cord as Gracile and Cuneate tracts until they reach the gracile and cuneate nuclei in the medulla oblongata (2nd order neuron) >>> cross to the opposite side forming the Medial leminscus , then end in the Ventrobasal complex nuclei in the thalamus (3rd order neuron) , from the thalamus to the primary somatosensory area (are 3,1,2) in the parietal lobe .

✓ The body is represented in the cerebral cortex (mentioned before in the sheet) .

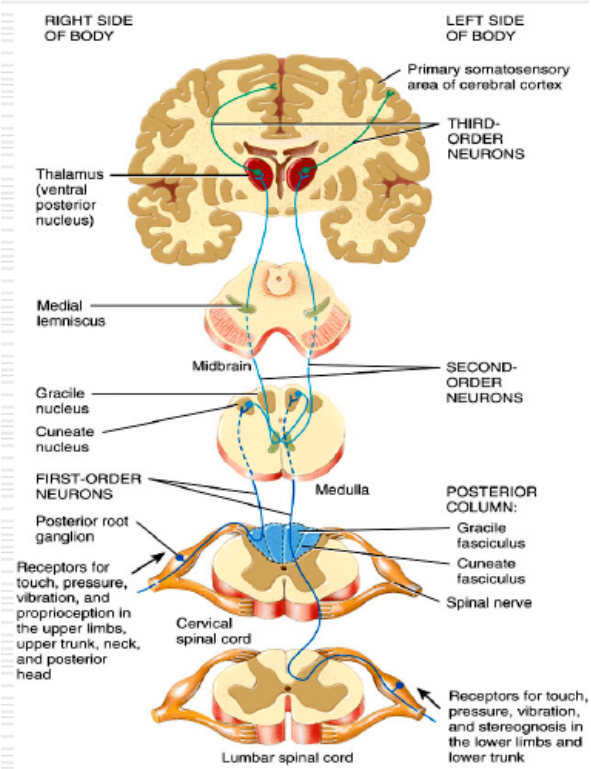


Figure 16.05 Tortora - PAP 12/e

❖ ***Anterolateral system :***

- ***In the lateral and anterior columns of the spinal cord .***
- ***Slow fibers (A delta and C) and a lot of divergence circuits, then loss of the localization .***
- ***Responsible for Crude (poorly localized) touch ,Temperature and pain.***

Wish you all best of luck =)
sorry for any mistake ^^