physiology

faculty of medicine - JU2017

◉ Sheet ○ Slides

Number

19

Done by:

Mohammad Tarek – Wahab Al-tekreeti

Corrected by:

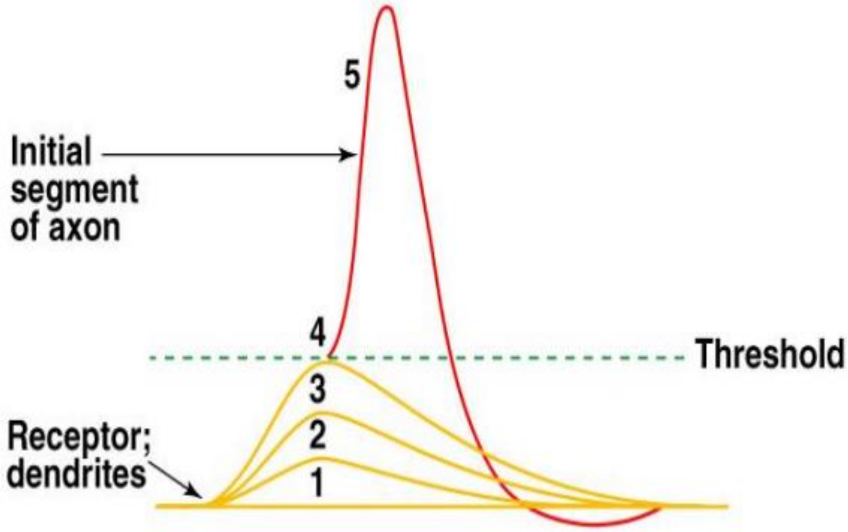
Tala M Quteishat

Doctor

Faisal Mohamma

Before we start:-

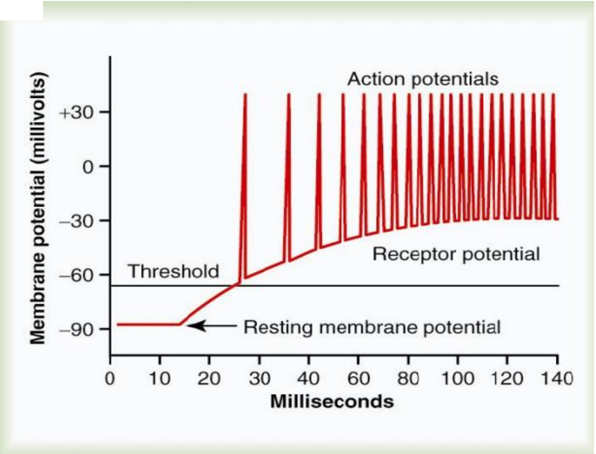
- The channels that are stimulated on the receptor are called stimulus gated channels, they are the same as ligand gated channels and the receptor potential is local (graded or summated) potential.
- Spike generating region has the lowest threshold(highest amount of Na+ channels), it's the first part of axon in the receptor region and it's the same as the axon hillock.
- The rate of action potential is the number of action potential per a unit of time (frequency).
- The amplitude is the distance from x axis (0) to the peak of the wave (سعة الموجة).
- The amplitude of action potential is **fixed**, but the rate can be changed depending on the strength of the stimulus.
- The amplitude of local potential is changeable depending on the strength of the stimulus ⟶ the greater the intensity of the stimulus, the greater the receptor potential.
- Each receptor is sensitive to its adequate (specific) stimulus.



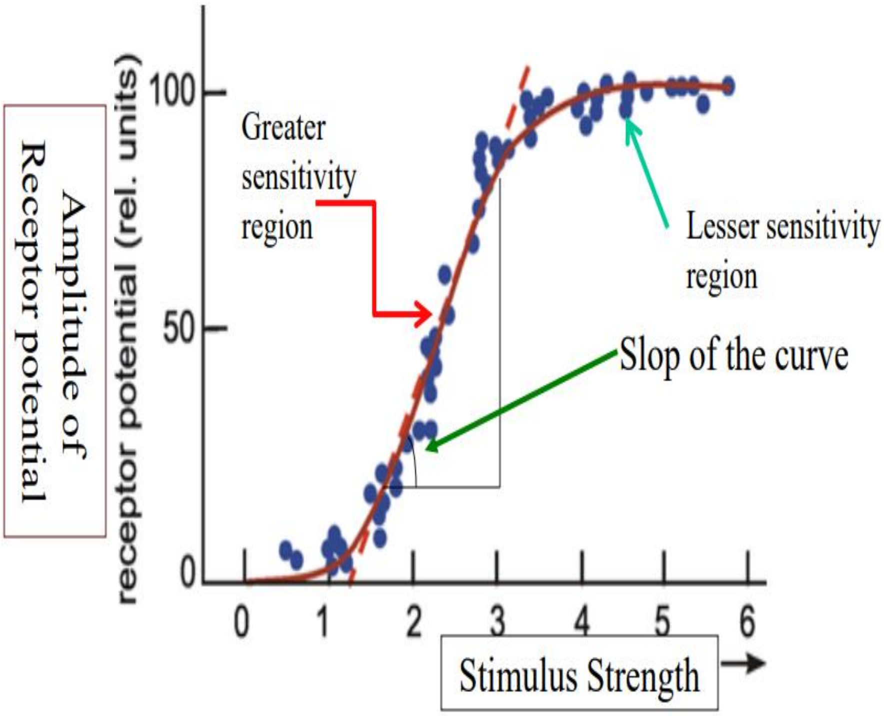
In 1 and 2 it is below the threshold so there is no action potential.

In 3 it is equal to the threshold, there is an action potential.

As you can see: We can increase the amplitude of the receptor potential and this causes increase in the rate of action potential (more spikes). However, the amplitude of the action potential is fixed (+30 in the figure). At the end we reach the maximal rate and maximal receptor potential because of the absolute refractory period.



*Relation between stimulus intensity and the receptor potential:-

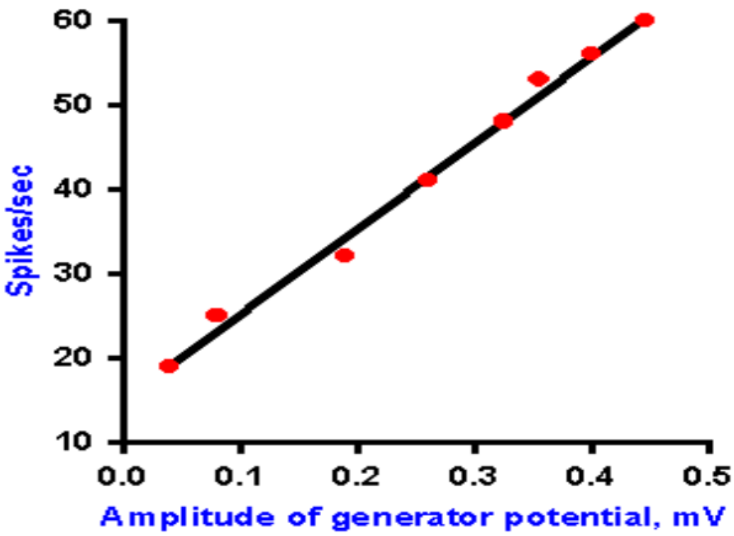


Here we have the relationship between the strength of the stimulus and the amplitude of the receptor potential.

It's hard to change the amplitude (or the change is small) from (3-6), it's considered less sensitive area.

From (2-3) it's easy to change the amplitude (or the change is more drastic), its considered greater sensitivity area.

When the receptor potential is in the lesser sensitivity area, we try to get it back to the greater sensitivity area (to be more sensitive), this is done by negative feedback (from the brain **CORTICOFUGAL** tries to reduce the receptor potential to increase the sensitivity).



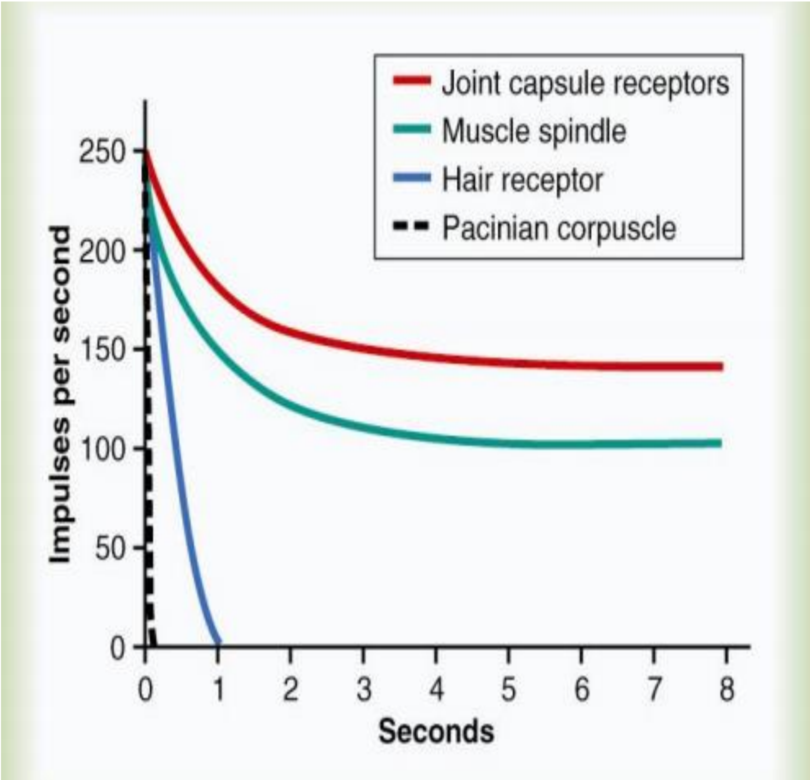
Here, when you increase the amplitude of generator potential, you will get more spikes/sec (rate of action potential).

At a certain area the rate (like the amplitude) will be constant because of the absolute refractory period.

*Adaptation:-

- When a continuous stimulus is applied, receptors respond rapidly at first, but response declines until all receptors stop firing (It means that there is no action potential even though the stimulus is still present).
- Rate of adaptation varies with type of receptor.

Here we have four kinds of receptors:



-The first one (in black) is rapidly adapting receptor (we don't feel it, it took milliseconds to become zero) like vibration.

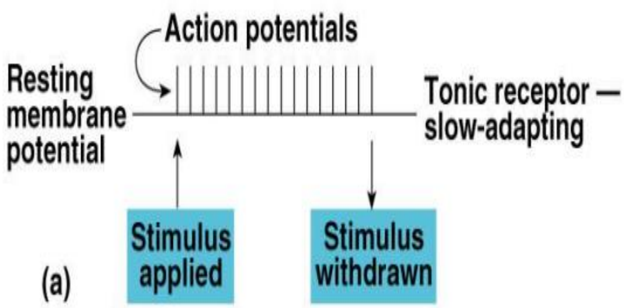
-The second one (in blue) is less adapting; it took 1 second for the impulse to become zero.

-The red and green have two phases (rapid and slow) like the temperature, when you go under hot water, you fell it at first(rapid phase) and then you adapt to it (slow phase).

- Pain receptors and proprioceptors (position and movement) do not exhibit adaptation.

* Types of receptors in terms of adaptation:-

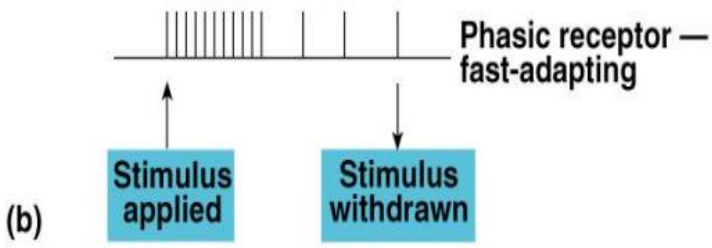
1-Slowly adapting (tonic receptors)



- Continue to transmit impulses (action potential) to the brain for long periods of time, and produce a constant rate of firing <u>as long as the stimulus is present.</u>
- Keep brain appraised of the status of the body with respect to its surrounding.
- Will adapt to extinction, however this may take hours or days. ***

- Examples: pain receptors muscle spindle, Golgi tendon apparatus, Ruffini's endings, Merkels discs, Macula, chemo- and baroreceptors.

2-Rapidly adapting (phasic receptors)

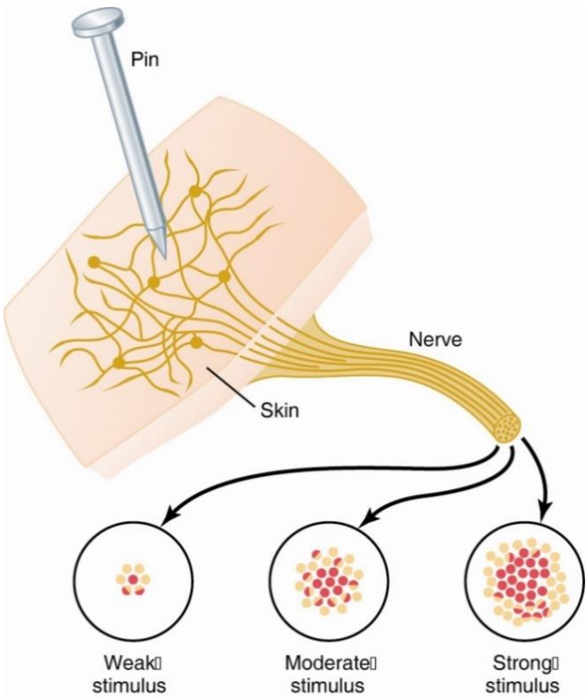


- Also called on-off receptors.
- The stimulus is still there, but there is no action potential reaching the cerebral cortex, therefore, you won't feel it.
- Burst of activity but quickly reduce firing rate if stimulus strength is maintained.
- Respond only when change is taking place.
  A) If there is stimulus or not (like in the picture)
  B) They also respond to the rate and strength of change, if we change quickly or slowly the number of discharges are changed.

The number of discharges depends on the speed of stimulation, so when it reaches the brain it knows that it is on-off receptor and how fast the stimulus is (velocity), then it multiplies the velocity with the time and gets the distance.

- That's why phasic receptors are very important to <u>predict the future position</u> or condition of the body and for balance and movement.
- Adaptation occurs when the <u>stimulus strength is the same</u>, if the strength changes then this is considered another stimulus and you will feel it.
- Examples: Pacinian corpuscle and Meissner's corpuscle, semicircular canals in the inner ear and smell (chemoreceptors) which are the fastest.

*coding in the sensory system:



Intensity

Signal intensity is codded for by:

1) Number of impulses (rate of action potential) which is called **<u>Temporal summation.</u>**

2) Number of fibers transmitting the signal, the stronger the stimulus the greater the number of fibers signalling to the cerebral cortex, this is called **<u>spatial summation.</u>**

Modality

Modality is coded for by:

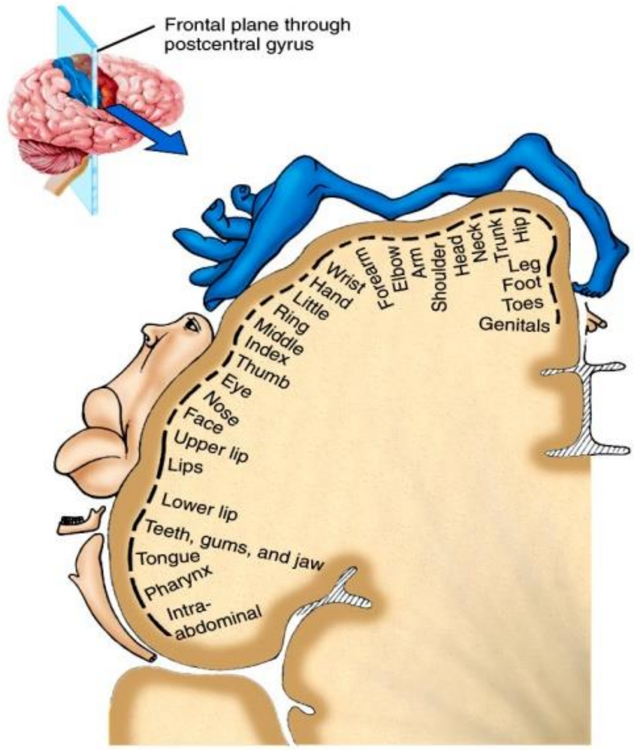
1) Type of receptor (mechanoreceptors, thermoreceptors,..) activated.
2) Specific pathway over which this information is transmitted to cerebral cortex.

Location

Location is coded for by:

1) Labeled line principle, each region or part of the body has a specific pathway of neuronal fibers.
2) Our body is represented on the cerebral cortex (topographic representation) for example if you stimulate your right leg a specific area on the cerebral cortex will be stimulated.

- This representation is <u>contralateral,</u> meaning that the left side of the body is represented on the right part of the brain and vice versa.
- The size of cortical region representing a body part is proportional to the number (or density) of receptors on that part.
- Density of receptors on the finger tips and lips is high, but it is low on the back and lower limp which means That the area representing them on the cortex is smaller.

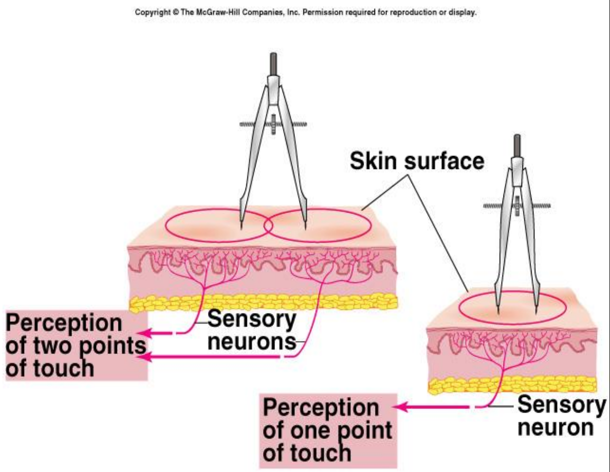


(a) Frontal section of primary somatosensory area in right cerebral hemisphere

Figure 16.08 Tortora - PAP 12/e

This will lead us to receptive fields

- A receptive field is 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 the greater the number of receptors the smaller the area.
- Similar concept is the **Two-Point Touch Threshold** which is the Minimum distance at which 2 points of touch can be perceived as separate.



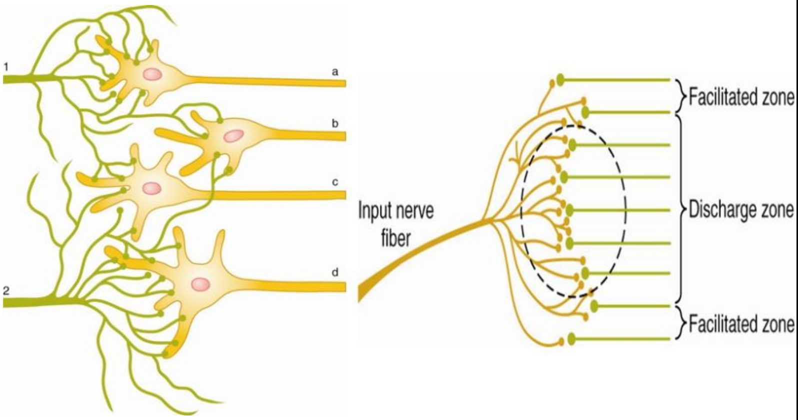
-On your fingertips this distance is very small (2mm) because the density of receptors is high and the receptive field is also small so you will feel it as 2 stimuli (you stimulated 2 receptors) this is called <u>2 points discrimination</u>.

-On your back however this distance has to be at least 5cm for you to feel it as 2 stimuli because as mentioned before the density of receptors is low in that region.

- If distance between 2 points is less than the minimum distance, only 1 point will be felt.

*Neuronal processing:-

- **Neuronal pool** is a group of neurons with special characteristic organization comprising different types of neuronal circuits, and have the same function.
- Example: The entire cerebral cortex could be considered to be a single neuronal pool.

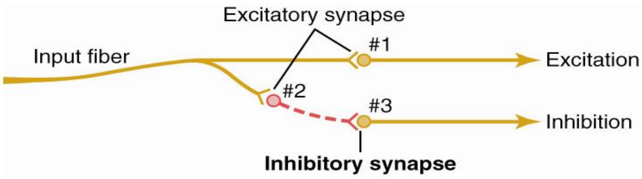


-In the figure is a neuronal pool if the stimulus is weak it is going to stimulate only the central neuron if it is stronger it will stimulate more neurons.

-The area in the center is called **discharge zone** it has action potential.

-the area on the periphery is called **facilitated or excited zone**; (it could be a discharge zone if the stimulus is strong).

Lateral Inhibition



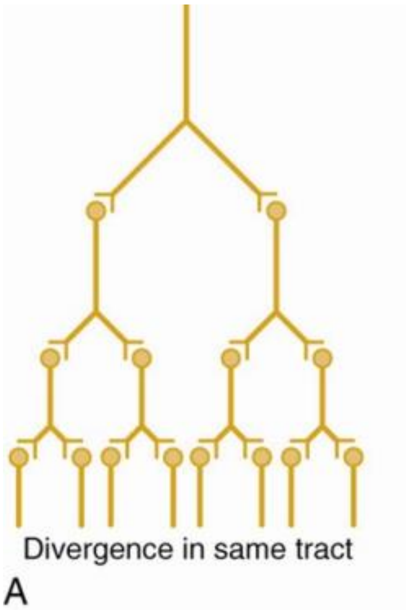
- Lateral inhibition is achieved by inhibiting the surrounding area to the stimulus while keeping the Center stimulated creating a high contrast between the two areas.
- Lateral inhibition is important for <u>sharpness of sensation</u> (good localization).

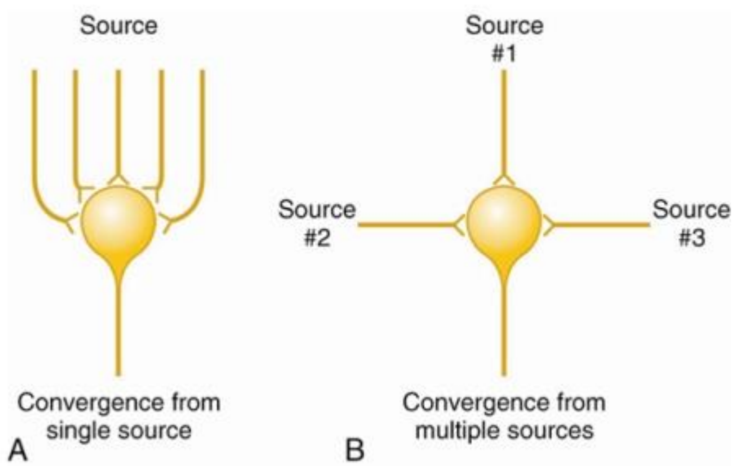
-in the figure the first neuron diverge and stimulates inhibitory inter neuron (red) so the sides are inhibited and the center is stimulated.

- If there is no lateral inhibition you will feel the stimulus in a large area.

*Neuronal circuits:

- **Divergence** means that an input signal spreads to an increasing number of neurons as it passes through a neuronal pool.
- Divergence can cause loss of localization ⟶ if a <u>small area</u> on the hand for example was stimulated the signal will be transmitted to a large area on the cerebral cortex because of divergence so you won't be able to specify the exact location of the stimulated area (you will think the stimulated area is larger than it really is).
- **Convergence** means signals from multiple inputs converging to a single neuron The <u>inputs could be from one source or multiple sources</u>.
- An advantage to convergence is that a single presynaptic neuron might not be able to





stimulate a postsynaptic neuron enough to generate action potential (it would be EPSP) but if multiple neurons stimulate one neuron at the same time it will generate action potential (special summation).

- Convergence can also cause loss of localization in an opposite manner to divergence The stimulated area is large but because of convergence it will stimulate a small area on the cerebral cortex (again you will think the stimulated area is smaller than it really is).

- **Reverberatory circuit** this circuit is caused by a positive feedback ➡ the neuron that has action potential could send back a signal to re-excite the input of the same circuit.
- In the simplest form of reverberatory circuit a neuron could re-stimulate itself.
- The reverberation can't continue forever.
- <u>Synaptig fatigue</u> which is a depletion in the neuro transmitters will eventually make the reverberatory cercuit stop firing.
- Important for preventing epilepsy.