# CENTRAL NERVOUS SYSTEM

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- ○ Anatomy
- ● Physiology
- ○ Pathology
- ○ Biochemistry
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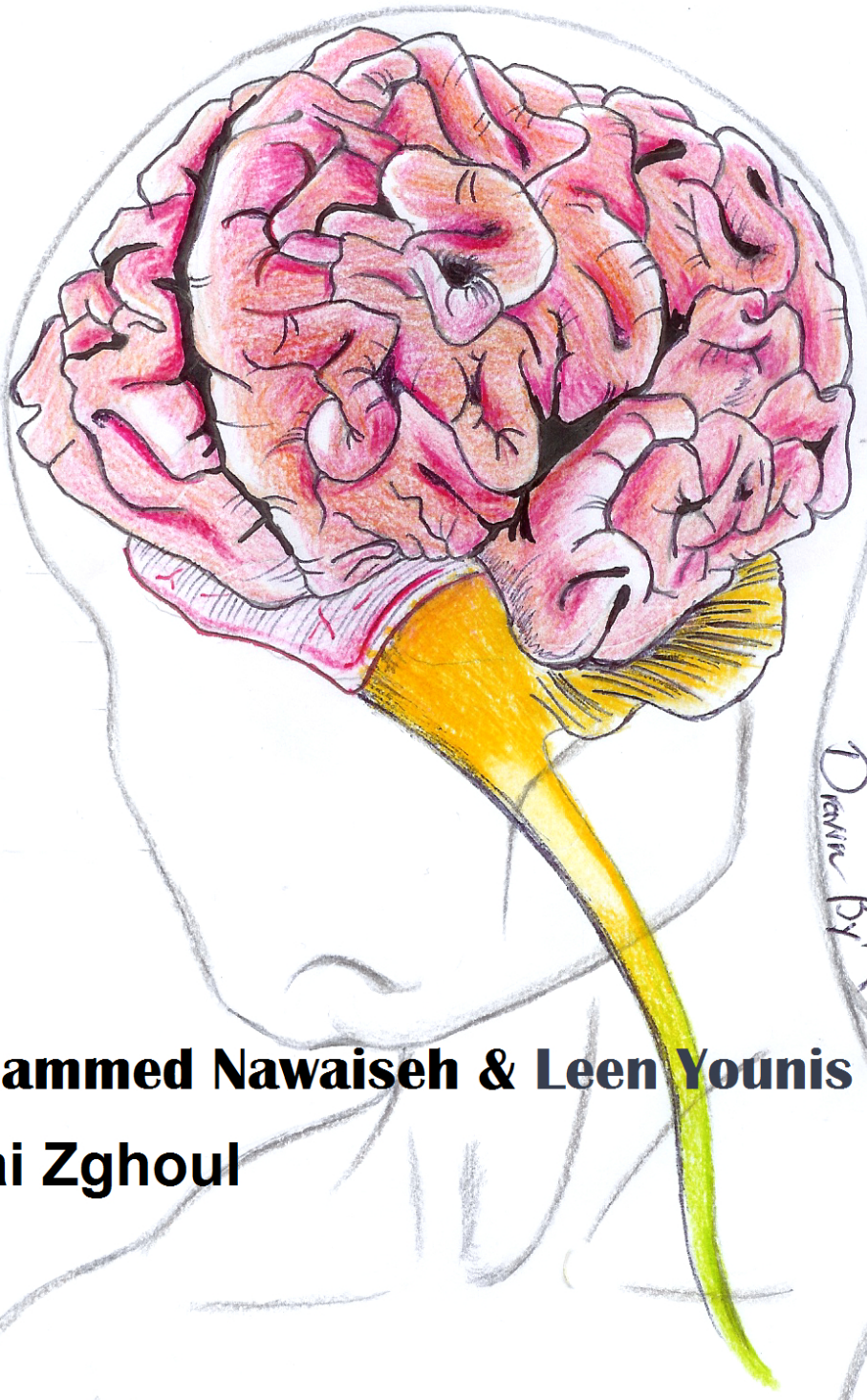

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# I.NEUROIMAGING

**Neuroimaging** is very important especially for those working in ER and neurology. It should be learned to be able to read **MRIs** (Magnetic resonance imaging) as there will be many questions involving them in the exam.

General form of the structures of the brain and spinal cord should be known to understand MRIs.

Looking at a picture of truck, you can identify it by its outline only, which gives its general form, it's important to memorize the structures of the brain and their general form taken in anatomy whether as sections or drawings and tries to identify them in an MRI pictures to be familiar with them. For example, midbrain should be recognized from its landmarks and defects (if present) should be identified also.

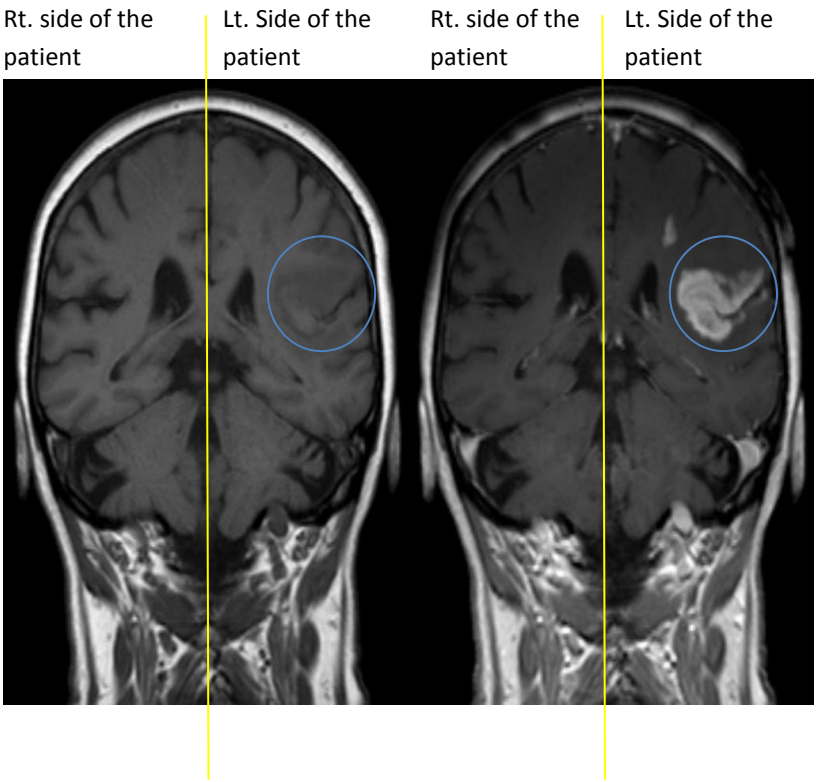
MRIs use magnetic fields and radio-waves, while CT scans use X-ray radiations.
They're both taken while the patient is lying on his/her back.

In order to read the MRI correctly, these two points must be taken in consideration:

1- The patient will be lying on his/her back while taking the images.
2-your left is the patient's right and vice versa.

Looking at the images, it's like looking at the patient from down upwards or as you're facing the patient ("head on" view of your body. You're looking at your features vertically from the front — as if you were standing facing the camera.).So the patient will always have his/her right as your left and his/her left as your right.

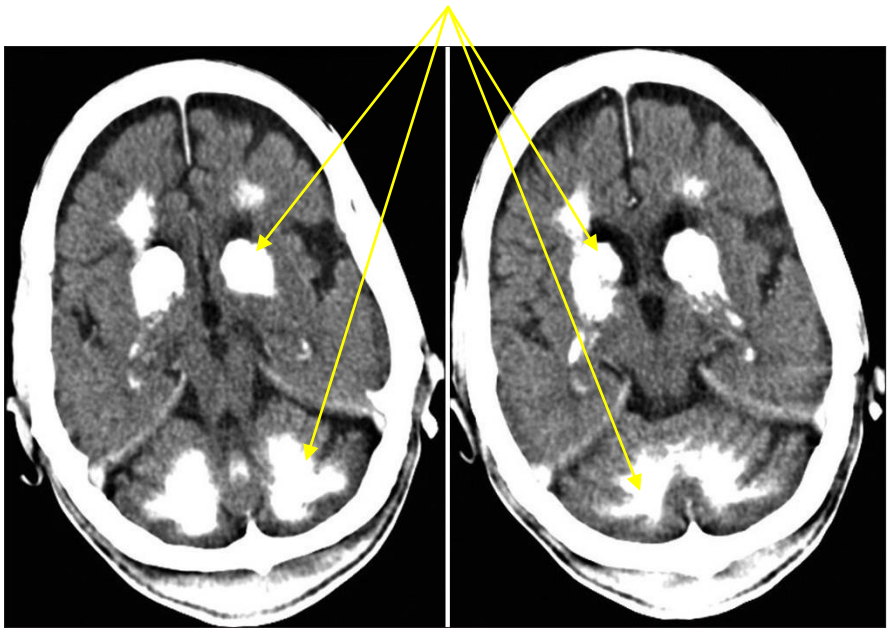
Defects can be seen as a change in color; appearing lighter in color or whiter than normal an–d that depends on the image being used, if it's enhanced or not. In this image of a tumor, the lesion cannot be clearly identified, so it will be enhanced by using a special dye to appear lighter in color or by using CT scans.




**#Left** picture represents MRI for a tumor (hard to detect; because there is **a small change in color**. **Right** picture represents **enhanced** MRI for the same tumor; here the tumor is easily detected, which is represented **as clear white** area.

#Notices that, your left is the patient's right side and vice versa.

White areas don't always mean tumors as calcifications usually appear white even in non-enhanced MRI.

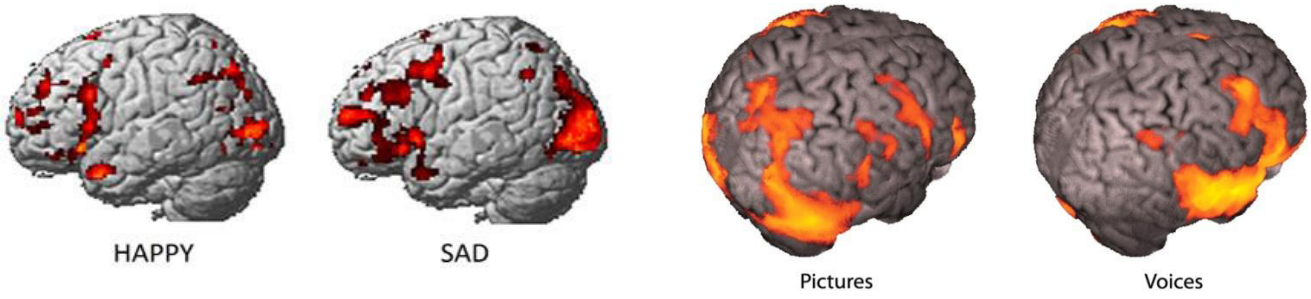


#MRI representing areas of calcification "white areas", note that this image is not taken by **enhanced** MRI.

#Areas of calcification appear as white areas even in normal"not enhanced" MRI.

## Functional MRIs

Another type of MRI machines depend on oxygenated blood, which is used as a marker to know which parts of the brain are functioning and working at that moment (depending on the oxygen consumption; while doing a certain task, the particular area that consumes the highest amount of oxygen is the functioning area); which is why they're called **functional MRIs**. They're useful in determining which area of the brain is executing and responsible for a certain function. It's used clinically for psychiatric diseases but that's limited and not available here.

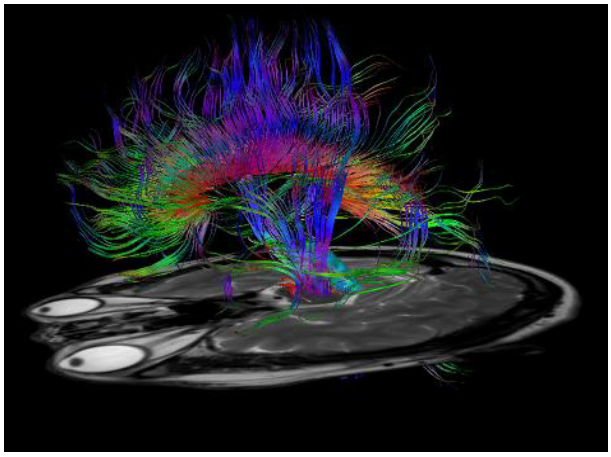



## Diffusion MRI

Another type of MRI is called **Diffusion MRI**, it identifies the ionization of water molecules and their direction ,so it helps to detect the **white matter's** location(other structures don't appear) , thickness, its direction, integrity and myelination. Clinically, it's mostly used for:

1. Detecting white matter problems after a head trauma like **concussions**.
2. **Tumor invasion**: Used by neurosurgeons to identify tumor's border; as it can push the white matter or diffuse in it.

If a patient is suffering from concussion, an MRI might look normal as sometimes there won't be any damage to the grey matter but diffusion MRI can show the white matter affected.



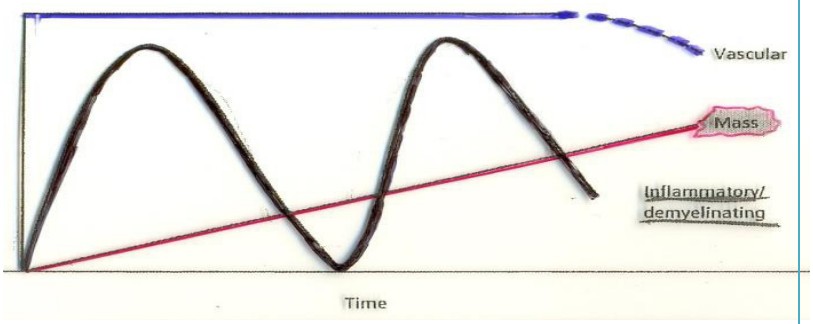
## Localization of symptoms

The Doctors normally look at the symptoms location and what they include, to determine the level of lesion. For example, **descending motor pathway** from the cortex will pass through the spinal cord to supply all the body and it will give branches at each level, so at higher levels in the brain stem, it will give a branch to the eye to control its movement, at lower levels it'll exit to supply the mouth or tongue, at the upper cervical level it'll exit to control the muscles of the hands and at the lower parts of the spinal cord it'll exit to control the lower limb. If the symptoms are found only in the lower limb and not in the upper limb, we conclude that the pathway was damaged after supplying the hand and before supplying the lower limb. If the symptoms include the upper and lower limbs and mouth, then the problem is localized after giving the branch to the eye and before giving to the mouth. If **all** of them are damaged then the problem is found before supplying the eye.

This is also applied when there are two pathways where each one indicates where the problem is found. This principle is used to solve cases that will be discussed in the upcoming lectures.

## II.Types of lesions in the CNS (3 types):

1. **Vascular** (Stroke or bleeding): acute and occur suddenly in normal patients.
2. **Tumor (mass)**: it's progressive where it starts as a certain symptom then it's followed by more and bigger symptoms, as the tumor develops.
3. **Inflammatory** (**demyelination**): there's alternating frequencies and the patients will suffer from symptoms, then after a while they'll be better and so on. There will be **fluctuation** between **myelination** episodes (better symptoms → body is trying to repair the myelin) and **demyelination** episodes (worse symptoms → myelin is destroyed again)
   and so on.



## III.Types of sensation

Sensation is the input for the CNS (brain),which will bring information to it, any sensation pathway must be started with a receptor (to receive the stimulus) , if there is no receptor there will be no sensation and if there is no stimulus there will be no sensation,also.

Sensory receptors are specialized cells or neurons that transduce environmental signals (as a form of energy) into neural electrical signals (as another form of energy). There are more than one type of receptors related to sensation, that are classified into general sensation (somatic sensation and visceral sensation) and special sensation.

#Pain receptor → changes chemical energy to electrical or neuronal signal.
# Vision receptor →changes light energy to electrical or neuronal signal.

**1) General sensation**; This type of sensation comes from the **body** (mainly from muscles and skin).

**a) Somatic**:

- Exteroceptor

- Proprioceptor: muscle length and tension, joint position and their motion.

**b) Visceral**

**2) Special sensation:** This type of sensation comes from the head only.

-Smell, taste, vision

These sensory receptors can't make AP (that is all-or-non)by itself, actually they make Graded potential; that is able to detect the magnitude of the stimulus unlike the AP because the Graded potential is proportional to the magnitude of the stimulus.
# Pain is an example of somatic sensation.
#**AP**; **A**ction **P**otential.

There are 4 types of **ion channels** on the cell membrane:

1) Voltage gated ion channels.
2) Ligand gated ion channels.
3) Mechanical gated ion channels.
4) Leakage (randomized) gated ion channels.

Because these sensory receptors don't make AP, there will be no need for voltage gated ion channels (as these are the function of axons), and there will be other types of ion channel receptors such as mechanical gated ion channels associated with touch, pressure, hearing (because hearing is a mechanical vibration) and others .And ligand gated ion channels associated with taste which detect chemical substances (ligands).

## IV.Receptor excitation and receptor potential

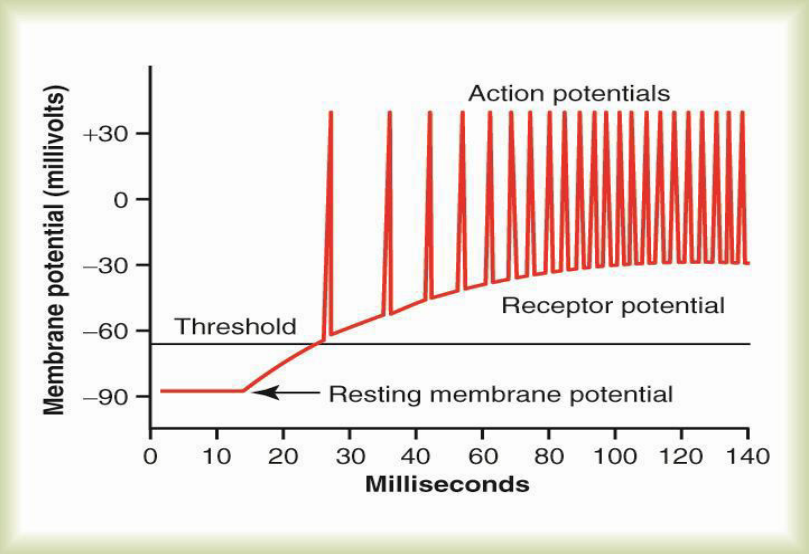
Example on the process of receptor excitation: a Mechanical stimulus will open the mechanical gated ion channels of the receptor, which will generate a graded potential (receptor potential). If the potential was higher than the threshold, the sodium voltage gated ion channels will be opened and an action potential will be generated and conducted to the brain, (Receptor is active). If the graded potential couldn't reach the threshold there will be no action potential.

- How can the brain distinguish if the skin is stimulated by low or high pressure?

Higher pressure stimulus will open more receptors of ion channels, so more sodium will enter, which means higher change in the potential. This leads to higher graded potential (much higher than threshold) and AP will be generated with higher frequency due to the shortening of refractory period (during relative refractory period the membrane potential will be high enough to induce other action potential instead of declining to resting membrane potential, as result of high receptor potential).

There is a relationship between receptor and stimulus, as the strength of stimulus increases →the opening of ion channels increase →increase gradient potential →increase AP frequency (rate).

# Relationship between membrane potential and frequency of action potentials. Note that all the APs have the same amplitude (all or none).




## V.Types of Sensory Receptors

1) **Mechanoreceptors**: detect mechanical pressure (mechanical displacement) or distortion (deformation)

A) Tactile: Touch, Pressure, Vibration, Tickle and itch.

B) Position or proprioceptive: Static position, Rate of change.

2) **Thermoreceptors**: detect change in temperature (heat and cold).

3) **Nociceptors**: detect damage (pain receptors), activated by any factor that damages tissue.

4) **Electromagnetic**: detect light.

5) **Chemoreceptors**: taste, smell.

There is different types of receptors, especially somato-sensory receptors, there are 10 types of receptors (there is no need to memorize them or to know there function).

## VI.Sensations receptors

- If a person touches something, there will be activation of multi-sensation in which he/she will know the temperature (cold or hot), smooth or rough, hard or soft, and the amount of pressure .If a person Catches a pen with his/her hand, he/she will recognize more than one sensation (like the ones mentioned above), and each one of these sensations will be felt by a special separate sensory receptor.

- Each sensory receptor will be connected directly to specific center in the CNS by special pathway, overlapping between those receptors is possible in which one receptor could affect other receptors through the pathway ,but usually each receptor will go to the brain (cortex) in a pathway (line ) of neurons , in which the brain knows that there is a current sensation occurring in that certain site in the body by activation of its pathway (line) to the brain ,so the brain makes a relationship between the receptor and its pathway ,in which the brain knows that the receptor is being active by receiving signals (AP) from its pathway.

- Thus every sensation has its specific receptors, which will be directly connected to the brain (cortex) by a special pathway and synapses in a series of neurons.
  Some sensations have more than one type of receptor and the interactions between those receptors are considered as one sensation by the brain.
  Pressure has more than one type of receptor, and the interaction between all these receptors will be understood by the brain as one sensation which is pressure.

- If in an experimental conditions the pathway of certain receptor is activated, the brain (cortex) will not be able to differentiate if the activation occurs in the receptor or in the pathway, as it (the brain) knows only that the sensation occurs, if it receives an AP from the pathway whether activation occurs in the pathway or in the receptors of that pathway.
  Certain conditions are associated with this concept →visceral pain, loss or damage to certain nervous structures and pathways that will cause some abnormal disorders like; phantom pain, Deafferentation Pain and hallucination.

#What is the difference between pressure and touch? sometimes, writers refer to some receptors as touch receptors and other receptors as pressure receptors; because one of them is activated easier than the other and because one is Slowly Adapting (Tonic) and the other is Rapidly Adapting (Phasic) although both are mechanical → actually there isn't much difference between them.

# The following receptors are the only ones to be memorized:

| **Receptor type** | **Function** | |
|---|---|---|
| Free nerve endings (nociceptive or pain receptor ) | Pain | Known as free nerve ending ;because it's a nerve ending has chemical receptors and there is no specialized type of receptor (no specialized structure) |
| Muscle spindles | Muscle length | |
| Golgi tendon organs | Muscle tension | |

#Other information about the location of receptor and its function are not for memorization.

# Adaptation of Receptors (slide 35-38) was skipped.

# A question related to the previous lecture:

**In your clinic, you have a hypoparathyroidism patient, which of the following neurological manifestations would you expect to see?**

A. Twitching. B. Lethargy. C. Negative Trousseau's sign

D. Hypoactive bowel sounds. E. Hypoactive deep tendon reflexes

The answer is **A**, because hypoparathyroidism leads to hypocalcaemia which causes more excitability of the muscles as there's less competition with Na.

Past papers

**1)During a voluntary movement, the Golgi tendon organ provides the CNS with information about**

a. The length of the muscle being moved.

b. The velocity of movement.

c. The blood flow to the muscle being moved.

d. The tension developed by the muscle being moved.

e. The change in joint angle produced by the movement.

**2)Repetitive stimulation of a skeletal muscle fiber will cause an increase in contractile strength because Repetitive stimulation causes an increase in**

a. The duration of cross-bridge cycling.

b. The concentration of Ca+2 in the myoplasm.

c. The magnitude of the end-plate potential.

d. The number of muscle myofibrils generating tension.

e. The velocity of muscle contraction.

**3) Free nerve endings contain receptors that encode the sensation of**

a. Fine touch.

b. Vibration.

c. Pressure.

d. Temperature.

e. Muscle length.

**4) All of the following regarding sensory receptors are correct EXCEPT:**

a. Sensory receptors are histologically non-specific.

b. Every receptor has one adequate stimulus.

c. In 'phantom limb' phenomenon, whenever a nerve fiber is stimulated, sensation is felt equally throughout all the receptors found in its area.

d. Signals from sensory receptors will ultimately reach the somatic sensory cortex in the brain.

e. The modality of sensation of a nerve fiber depends on which area in the cortex it stimulates.

**5) A patient suffers from anesthesia on the left side of the face and the right side of the body. Which of the following tests is most suitable and should be carried out immediately:**

a.Electrophysiological test. b. Electromyography

c. Spinal cord MRI and angiography d.MRI of the brain

e. fMRI

**6) Sensory receptor potentials**

a. are action potentials

b. always bring the membrane potential of a receptor cell toward threshold

d. always bring the membrane potential of a receptor cell away from threshold

d. are graded in size, depending on stimulus intensity

e. are all-or-none

| 1. | 2. | 3. | 4. | 5. | 6. |
|---|---|---|---|---|---|
| d | a | d | c | d | d |

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