Physiology Sheet

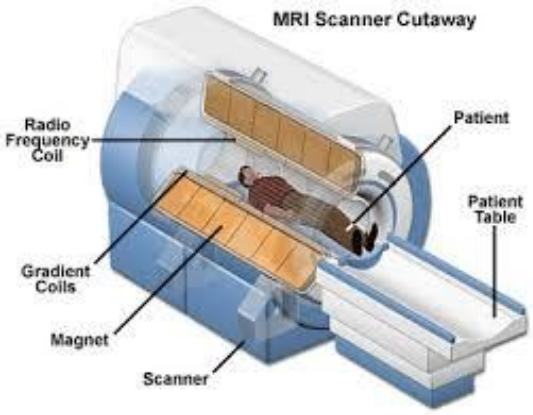
Lect. Num. (3)

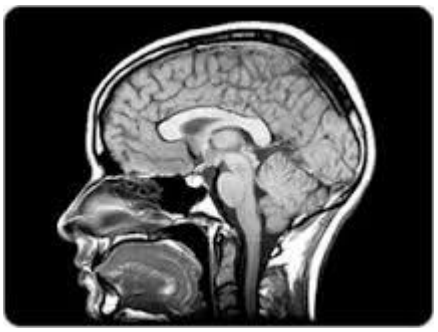
MRI and sensory receptors

MRI (Magnetic resonance imaging)

MRI is a medical imaging technique used in radiology to investigate the anatomy and physiology of the body in both health and disease. MRI scanners use strong magnetic fields and radio waves to form images of the body. The technique is widely used in hospitals for medical diagnosis, staging of disease and for follow-up without exposure to ionizing radiation. **Since MRI does not use any ionizing radiation its use is recommended in preference to CT when either modality could yield the same information**.[1]

It is very important to apply the anatomy and the physiology of the brain on MRI, because in the clinical practice you are not going to deal with the brain directly but with the MRIs and CT scans.





Note: the doctor advised us to study the anatomy of the brain on MRI sections and illustrations, since some of the exam questions will be based on them –we have to integrate our anatomical and physiological knowledge in order to solve clinical problems presented on MRI.

- In order to read the MRI correctly, you need to know the following two points:

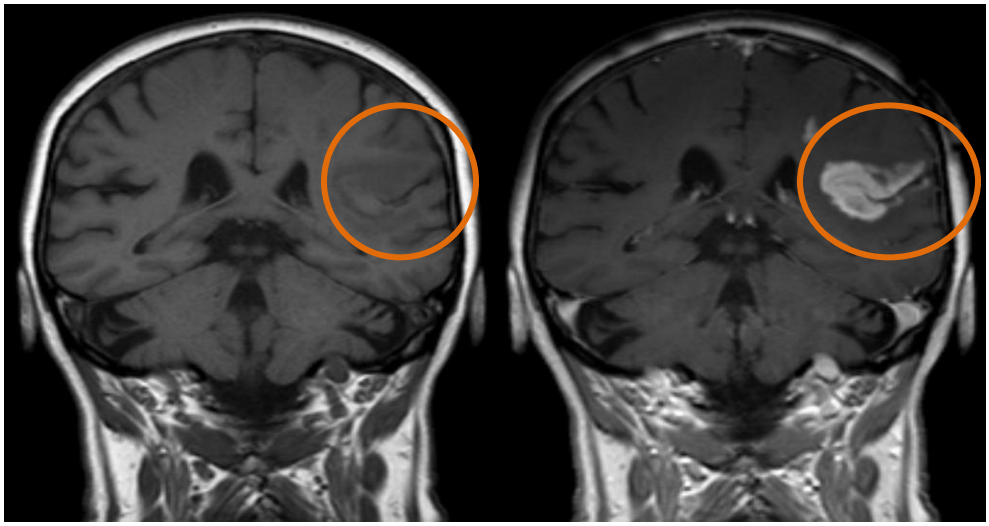
1- The patient will be lying on his back while taking the image.

2-your left is the patient's right.

- There are two main types of images (**T1** and **T2** weighted images).

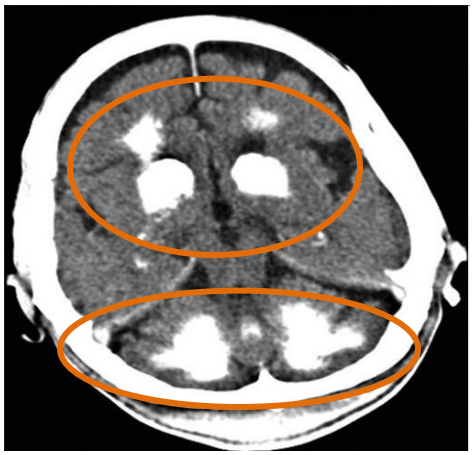
[1] http://en.wikipedia.org/wiki/Magnetic_resonance_imaging

- Legions on MRIs or CT scans may appear **more or less radiopaque**[2].
  For example: Infarction appears as less radiopaque.
  In sometimes a tumor is almost iso-opaque; you cannot detect less or more radiopaque areas, so here in order to detect the mass doctors have to do **enhanced MRI or CT** scan. Clear **white** area will represent the tumor – <u>also ischemia and infarction could be represented</u>- in enhanced MRI. Enhanced MRI is done after giving **contrast agents** to patients either **IV** or **orally**.



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

- Areas of **calcification** appear as white areas even in normal -**not enhanced-** MRI.
- So, only the technician or the doctor who took the image can distinguish areas of calcifications from other areas (tumor, ischemia, and infarction) - all of them appear as white areas-.



MRI representing areas of calcification –white areas- , please note that this image is not taken by **enhanced** MRI.

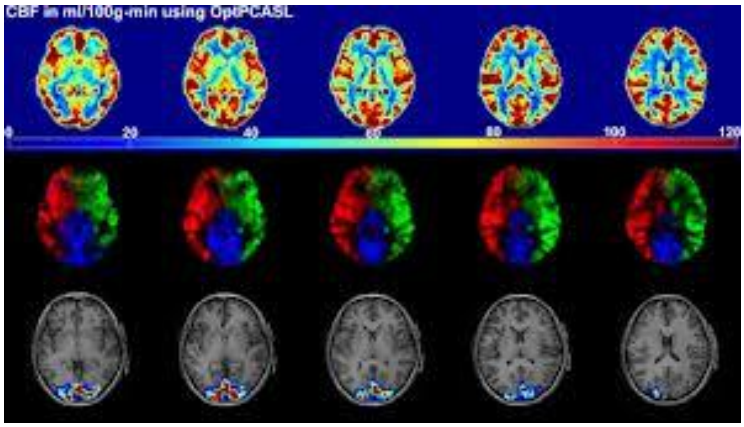
[2] Radiopaque: not allowing the passage of x-rays or other radiation.

- **Functional MRI:**

  It is used mainly in **research** to detect the **functions** of **specific areas** in the brain, or to detect the functioning and non-functioning areas of a patients brain, depending on the **oxygen consumption** (while doing a certain task, the particular area that consumes the **highest** amount of oxygen is the **functioning** area).

  The procedure is similar to MRI but uses the change in magnetization between oxygen-rich and oxygen-poor blood as its basic measure. The resulting brain activation can be presented graphically by color-coding the strength of activation across the brain or the specific region studied. [3]

  So, it is the same MRI machine but with an **axis or a projection** that presents the **most functioning** areas of brain while doing certain **tasks** in the functional MRI.



- **Diffusion MRI** or **DTI (Diffusion tensor imaging)**

  This type of MRI detects only the **white matter and fiber bundles** (other structures don't appear). It is used mainly in research –but **less** than the functional MRI- and it is also used in clinical practice mainly in:

  1- **Concussion**[4]: to see if there was **shearing** or **damage** in the white matter of the affected area.

  2- **Tumor invasion**: to see if the tumor **displaces** the white matter or **diffuses** through it.

[3] http://en.wikipedia.org/wiki/Functional_Magnetic_resonance_imaging

[4] Concussion: is a traumatic brain injury that alters the way your brain functions. Effects are usually temporary but can include headaches and problems with concentration, memory, balance and coordination.

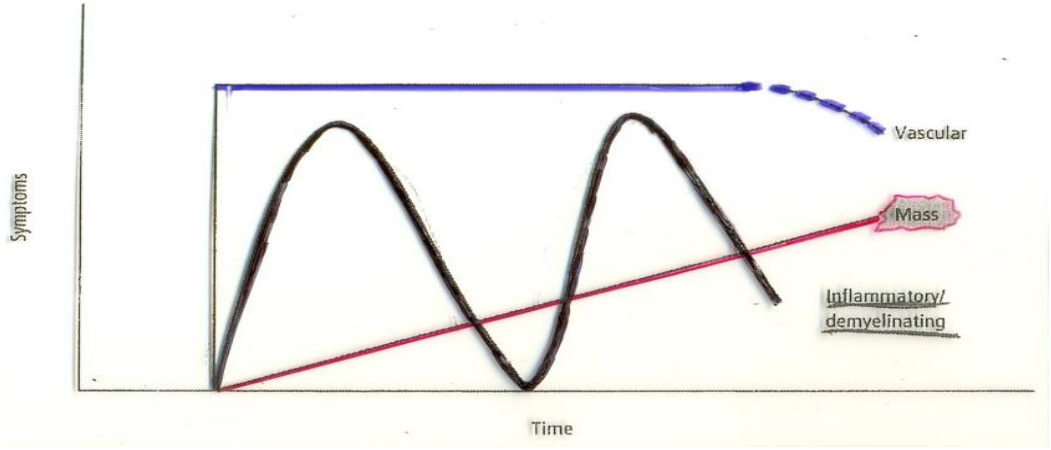
- **Using the symptoms to localize legions**

  Any problem in the motor or sensory pathways will cause a deficit. In order to **localize** the problem within the pathway **accurately**, we need to look for **other symptoms**. For examples:

  1- The main localizing symptom for **motor** pathway lesions is **face expression** (normal or abnormal face expression).

  2-Mid brain lesion ---- loss of eye muscles (oculomotor nerve palsy).

- **There are 3 types of lesions in CNS :**



1- **Vascular** (duo **to thrombus or bleeding): acute and** it appears **suddenly**.

2- **Mass**: **progressive**, **increasing** in the areas which are affected by the tumor. The symptoms will **increase** as the tumor develops.

3- **Inflammation** (especially **demyelination** syndrome): the symptoms will **fluctuate** between **myelination** episodes –better symptoms because the body is trying to repair the myelin– and **demyelination** episodes –worse symptoms because myelin is destroyed again- and so on.

- **Types of sensation**

  There are **two** types of sensation:

- **General sensations (somatosensory):**
  This type of sensation comes from the **body** (mainly from **muscles** and **skin**).Anything you can feel with your body is somatosensory.
  General sensations also can be divided into **two** types:
    - **Somatic sensation: from outside the body.**
    - ❖ Mechanoreceptive - stimulated by mechanical displacement.
      - ➢ tactile
        - o touch
        - o pressure
        - o vibration
        - o tickle and itch
      - ➢ position or proprioceptive : muscle length and tension, joint position and their motion
        - o static position.
        - o rate of change.

    - ❖ Thermoreceptive.
      - ➢ detect heat and cold.
    - ❖ Nociceptive.
      - ➢ detect pain and are activated by any factor that damages tissue.

    - **Visceral sensation:**
      Stimulus comes from **internal** sources (visceral organs), like blood vessels in the hand.
- **Special sensation:**
    - Touch
      2 types with **different** pathways and functions: **fine** touch (**two point discrimination** or discriminative touch) and **crude** touch.
      Notes:
      1- Some people try to distinguish between touch and pressure but actually there isn't much difference between them.
      2-Two point discrimination usually comes following pressure but we cannot call it fine pressure because we **cannot distinguish** it from crude touch.
    - Olfaction
    - Vision
    - Taste
    - Hearing

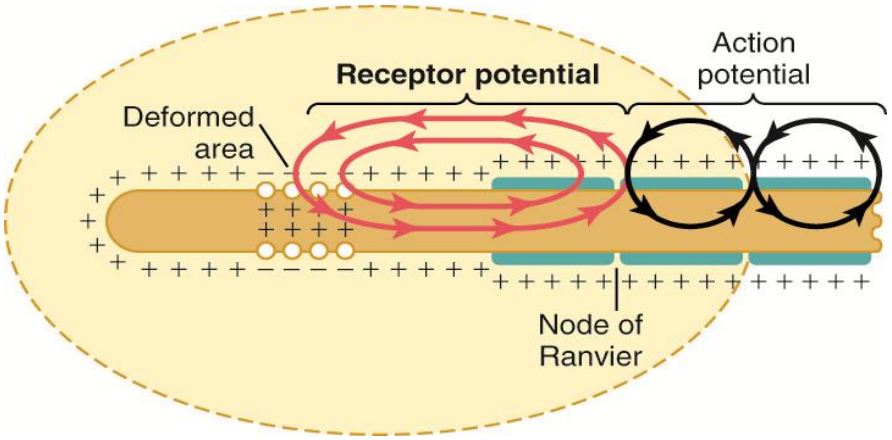
- All sensory pathways start with a **receptor**, each type of receptors can convert certain type of stimuli (**Chemical, thermal, electromagnetic, mechanical**) in to **electrical** changes by its certain channels which are **specific** to the type of the stimuli.

Types of Sensory Receptors

- Mechanoreceptors
  - ❖ detect deformation.
- Thermoreceptors
  - ❖ detect change in temperature.
- Nociceptors
  - ❖ detect damage (pain receptors).
- Electromagnetic
  - ❖ detect light (found in the eye).
- Chemoreceptors
  - ❖ Taste, smell (found in special senses other than the eye).

- **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 **open** 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.

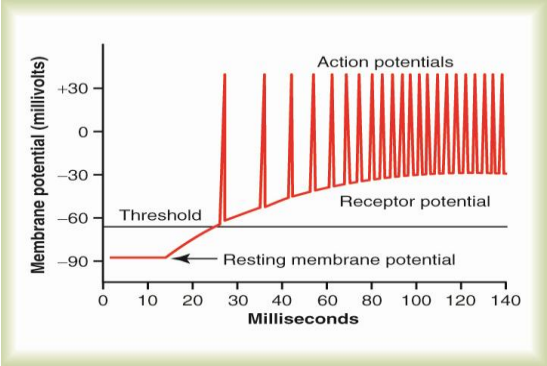


- **How can the brain distinguish if the skin is stimulated by low or high pressure?**

  High pressure stimulus will open **more** of the receptor 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**).

  In other words –as written in the slides-:

  The greater the intensity of the stimulus, the greater the receptor potential, and the greater the rate of action potential generation.



This figure shows the relationship between **membrane potential** and **frequency of action potentials**. Please note that all the APs have the same amplitude (**all or none**).

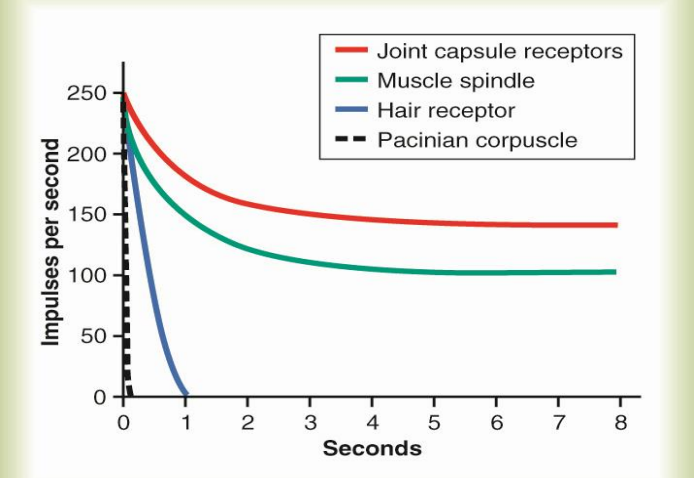
- **Receptor adaptation:** internally; by production of new enzymes, change in the expression of certain ion channels or internalization of some the ion channels. When a continuous stimulus is applied, receptors respond rapidly at first, but the response **declines** until all receptors stop firing.

  There are **2 types** of receptor adaptation:

  - **Rapidly adapting (Phasic receptors)**
    - Works only at the beginning of a new stimulus then it adapts fast.
    - For **changing** information (responds only when change is taking place – ex: **vibration**-).So, it is very important for:
      - Predicting the future position or condition of the body.
      - Balance and movement.
    - Produces APs for **short periods** (Rate and strength of the response is related to the rate and intensity of the stimulus).

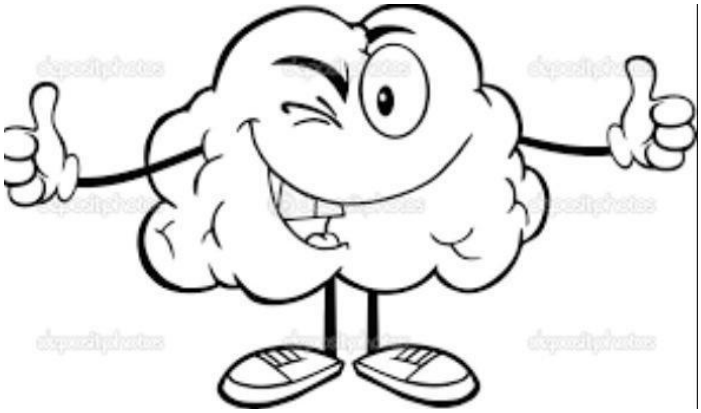
  - **Slowly adapting (Tonic receptors)**
    - Produces **high frequency** of APs for **long periods** (**continue** to transmit impulses to the brain **for long periods** of time while the stimulus is present-this may take **hours to days**-).
    - For **fixed** information which is very important to know about (ex**: pain is the slowest, followed by pressure**).
    - Keep brain **appraised** of the **status of the body** with respect to its surroundings.

- ***Note:*** Touch, proprioception and pressure have both **slow and fast** receptor adaptation.



- In the upper graph the upper 2 receptors are slow adapting receptors while the lower 2 are fast adapting.

- The following receptors are the **only ones to be memorized** :
  Receptor type ----- Function
  - **Free nerve endings ----- Pain**
  - **Muscle spindles ----- Muscle length**
  - **Golgi tendon organs ----- Muscle tension**



Good Luck ☺