Madenat Alelem University College
Medical physics dept.
Third Stage / 2nd Semester

MEDICAL INSTRUMENTS

Dr. Ruaa Almusa

Lec. 1 / Chapter One

Functional Magnetic Resonance Imaging

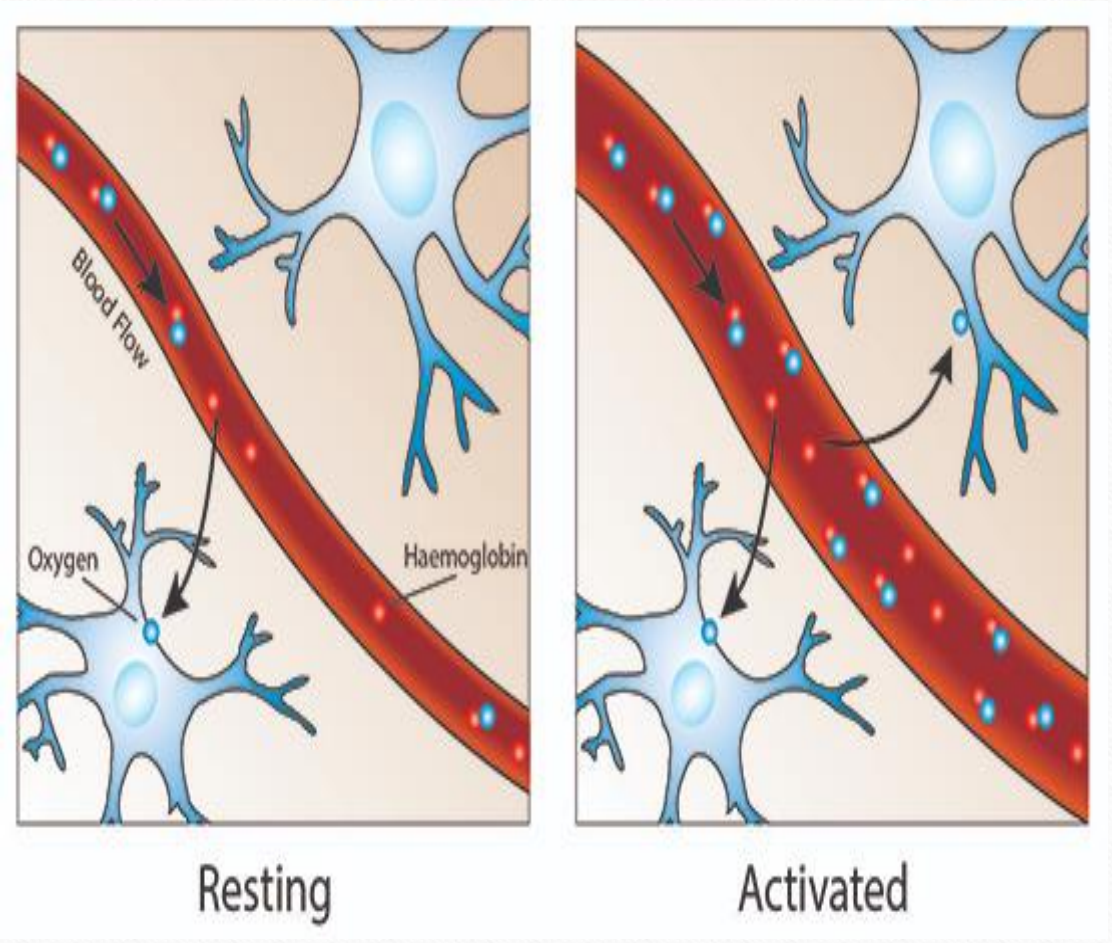
(fMRI)

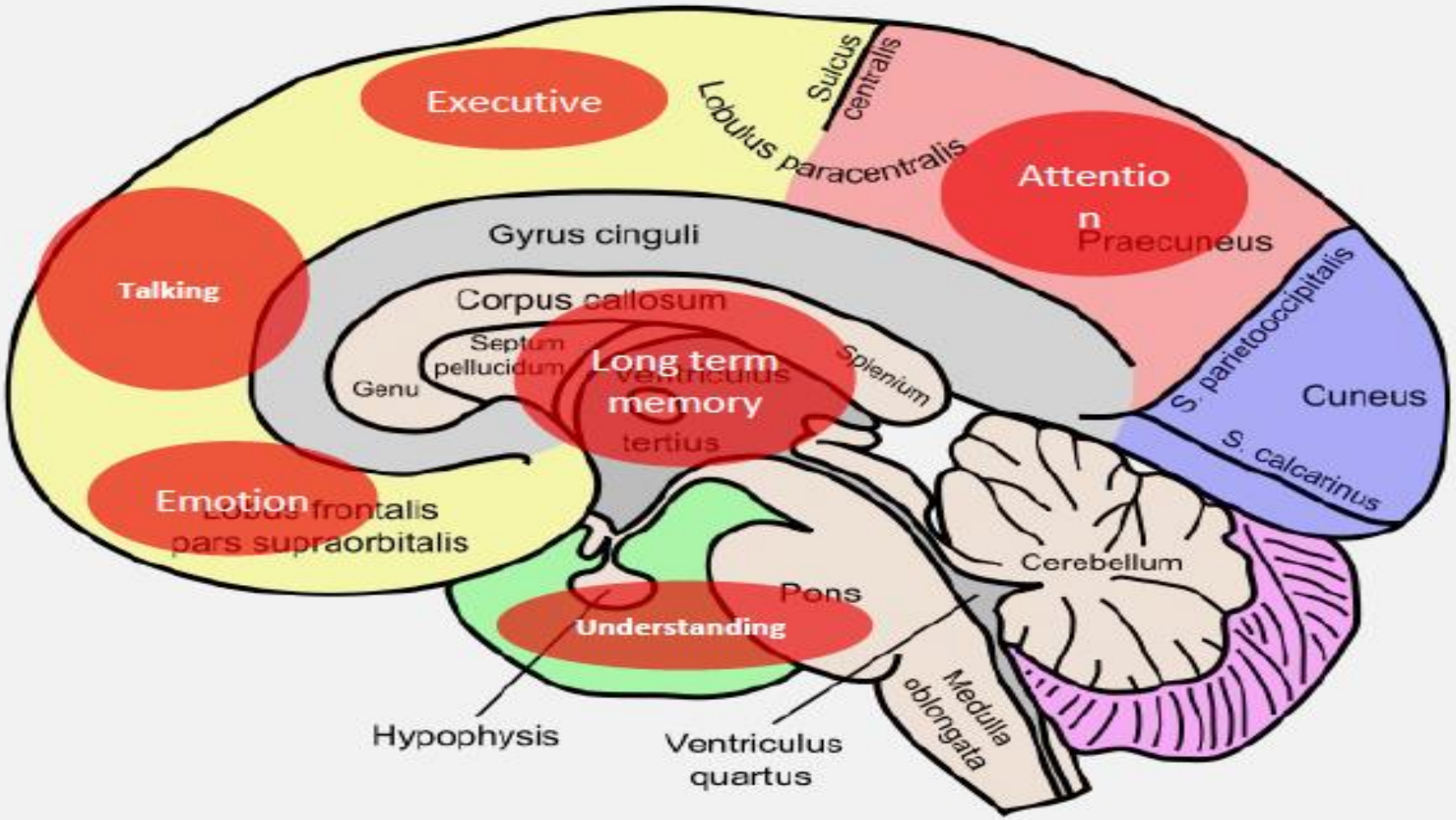
Blood **O**xygenation **L**evel **D**ependent (**BOLD**) functional **M**agnetic **R**esonance **I**maging (**fMRI**) is a powerful approach to defining activity in the healthy and diseased human brain.

- fMRI makes possible to see what's going inside the brain while people are thinking.

- fMRI is based on the same technology as MRI **but** instead of creating images of organs and tissues, its looks at blood flow in the brain to detect areas of brain activity.

fMRI is based on the idea that blood carrying oxygen from the lungs behaves differently in a magnetic field than blood that has already released its oxygen to the cells.




Executive
Sulcus centralis
Lobulus paracentralis
Attentio n
Praecuneus
Gyrus cinguli
Talking
Corpus callosum
Septum pellucidum
Genu
Long term memory
Splenium
S. parietooccipitalis
Cuneus
S. calcarinus
tertius
Emotion
pars supraorbitalis
Cerebellum
Pons
Understanding
Medulla oblongata
Hypophysis
Ventriculus quartus

Haemoglobin

There are **two** types of haemoglobin:

1 – **Oxyhaemoglobin** (a haemoglobin contained within the red blood cells with an oxygen molecule attached to it, have magnetic responses)

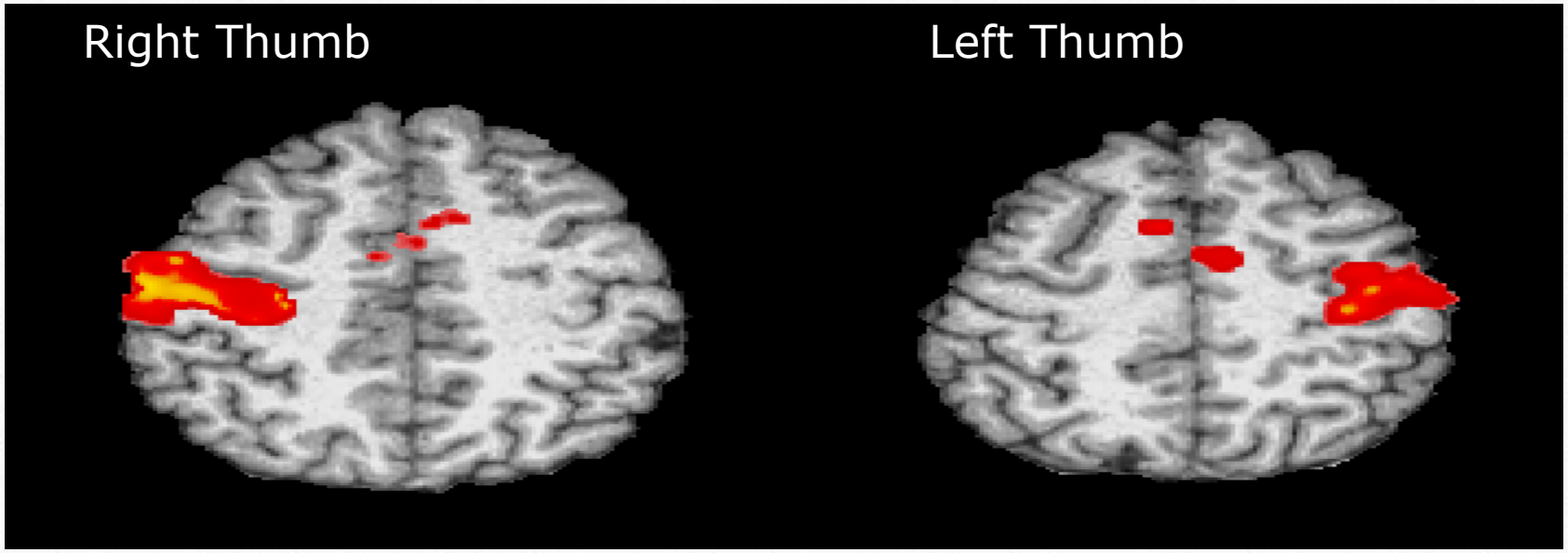
2 – **Deoxyhaemoglobin** (a haemoglobin contained within the red blood cells without an oxygen molecule attached to it, do not have magnetic responses).

- When a neuron is activated, it draws oxygen from blood stream, leading to more concentration of deoxygenated Hb in the blood.
- The BOLD fMRI technique basically measures changes of these magnetic field.

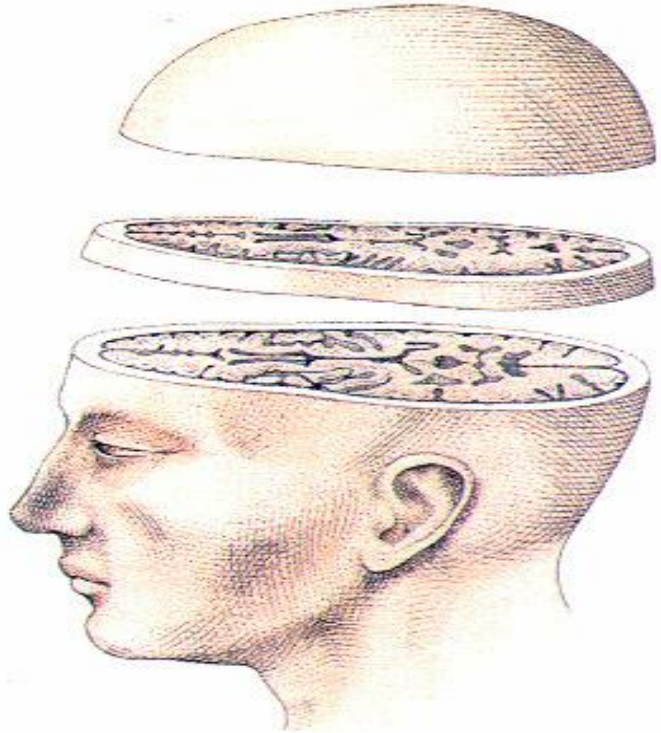
fMRI Image formation

During the imaging process, the patient performs a specific task to **stimulate** the **metabolism** of the responsible brain locations. Thus will increase oxygenated blood in these areas.

When the blood is oxygenated, the signal becomes stronger, and this nerve activity leads to a change in the rate of blood flow, that means the percentage of oxygenated blood increases with the increase in nerve activity.



Brain Imaging: Anatomy



CAT

radiography

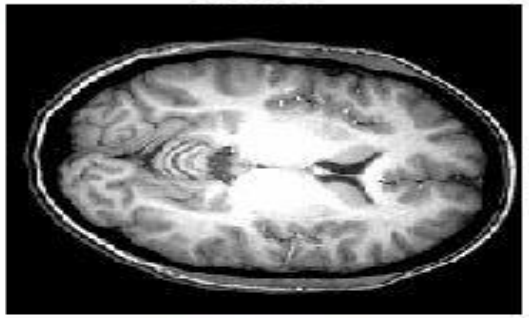
PET

MRI

MRI vs. fMRI

MRI

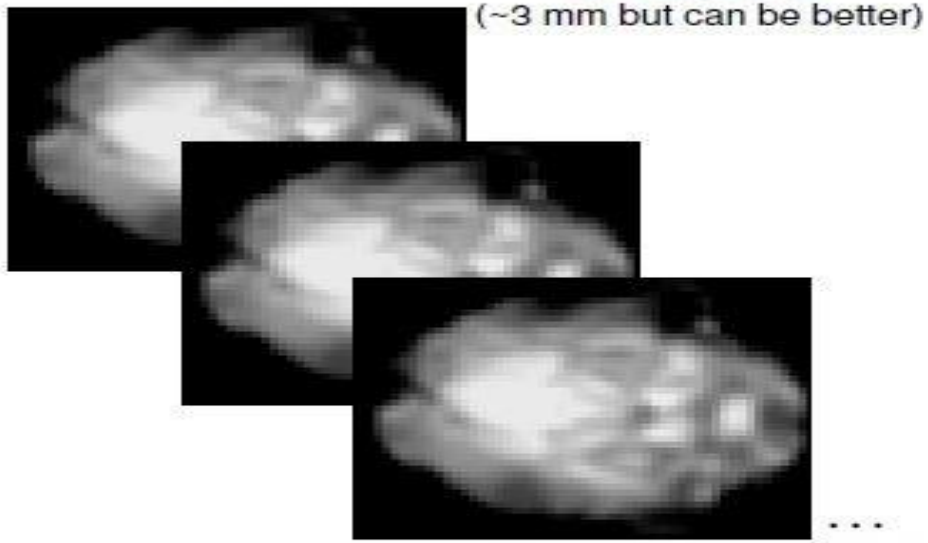
high resolution
(1 mm)



one image

fMRI

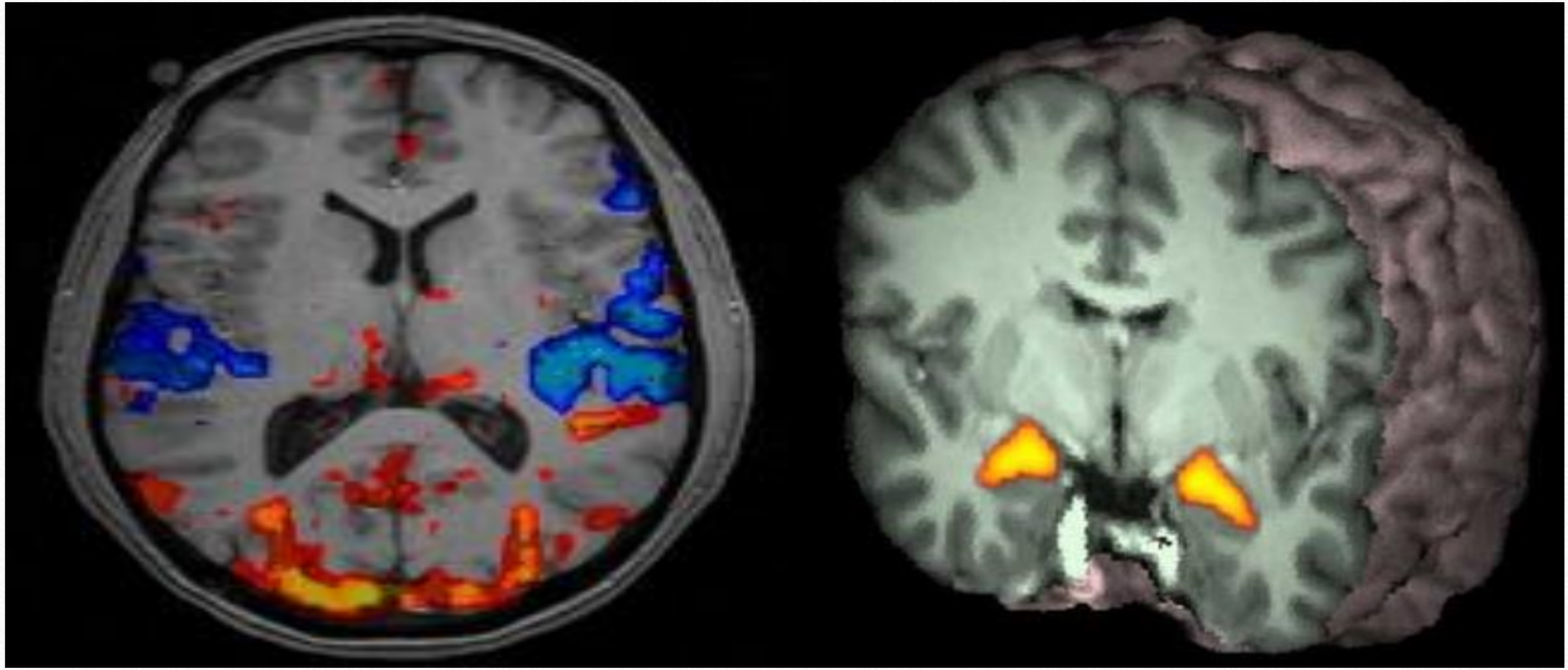
low resolution
(~3 mm but can be better)



...

many images
(e.g., every 2 sec for 5 mins)

↑ neural activity ➔ ↑ blood oxygen ➔ ↑ fMRI signal



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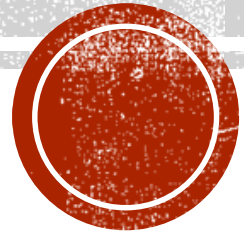
MEDICAL INSTRUMENTS

Dr. Ruaa Almusa

Lec. 2 / Chapter One

ULTRASONOGRAPHY



Ultrasound or **ultrasonography** is a medical imaging technique that uses high frequency sound waves and their echoes. These frequencies are between 1 MHz and 10 MHz, and such frequencies cannot be heard by humans.

Most modes of diagnostic ultrasonography are based upon the reflection of ultrasound at tissue interfaces.
A gel is used to minimize the presence of air between the transducer and the skin to avoid reflection at the skin surface.

Large, smooth surfaces in a body cause specular reflection, whereas rough surfaces and regions cause non-specular reflection or diffuse scatter.

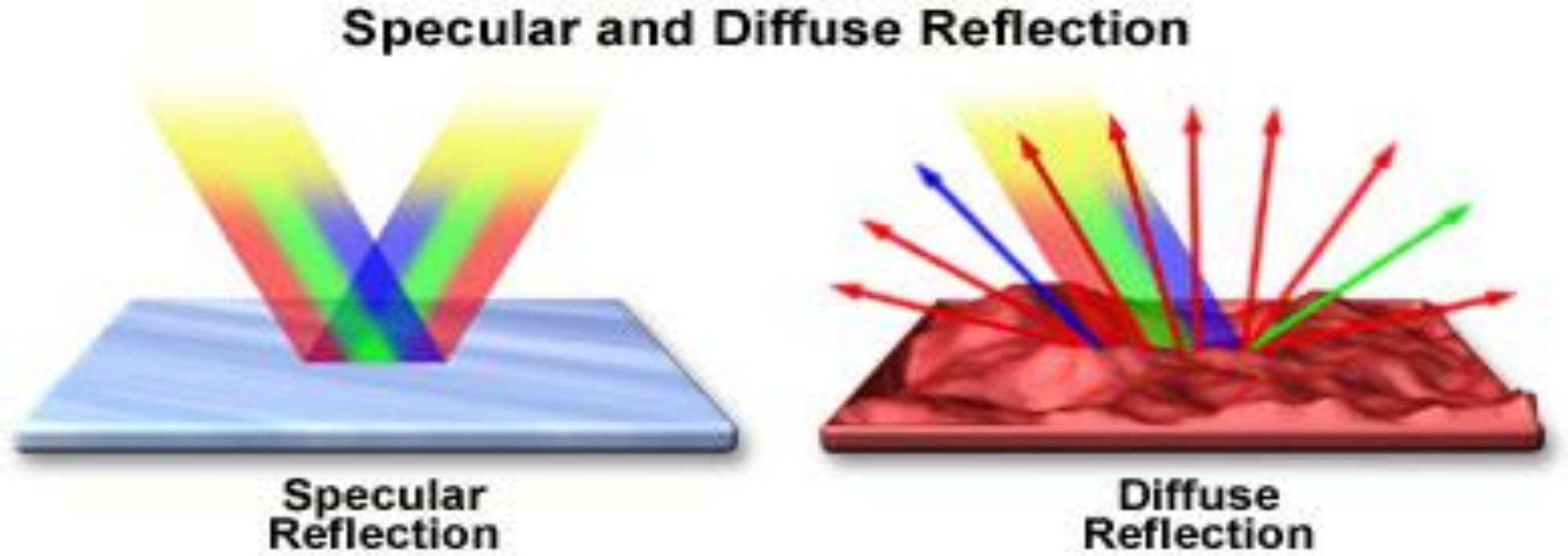
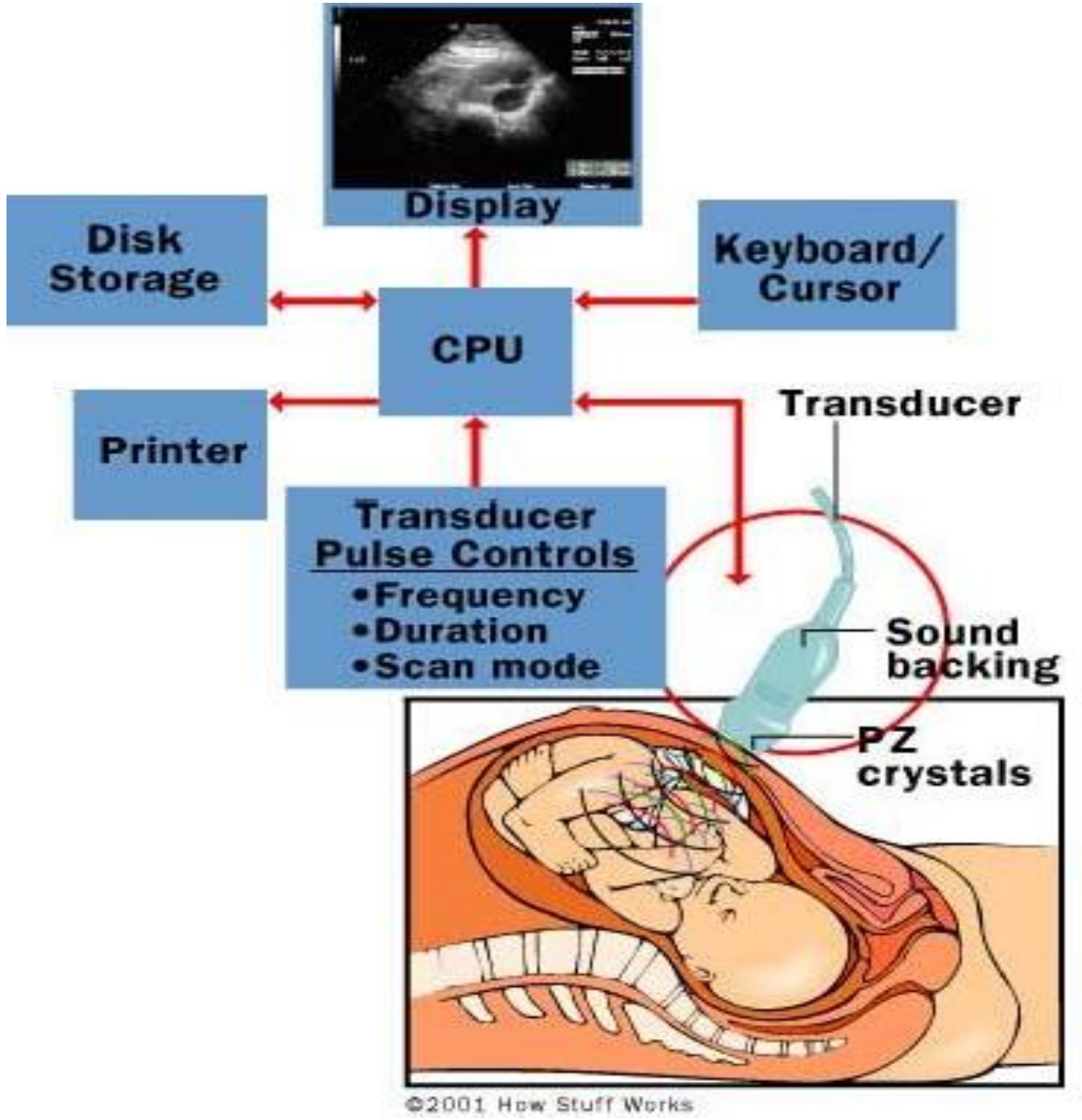


Figure 1

ULTRASOUND PARTS

Ultrasound machine has the following parts:

1. Transducer probe
2. Central processing unit (CPU)
3. Transducer pulse controls
4. Display
5. Keyboard/cursor
6. Disk storage device
7. Printer



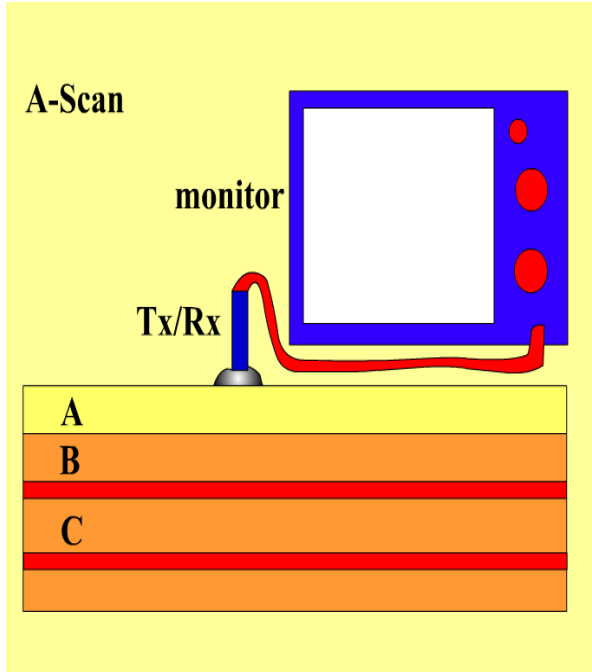
APPLICATION OF ULTRASONOGRAPHY

1. Ultrasound can use to check the development of an unborn baby.
2. Doppler ultrasound can be use to view blood flow through the heart and diagnose circulation problems.
3. Ultrasound is a ‘non-invasive’ imaging method with instant results, relatively inexpensive, with little or no health risks.
4. Recent advances, including 4D with surface rendering have increased the resolution and detail of ultrasound scans.

ULTRASONOGRAPHY WORK

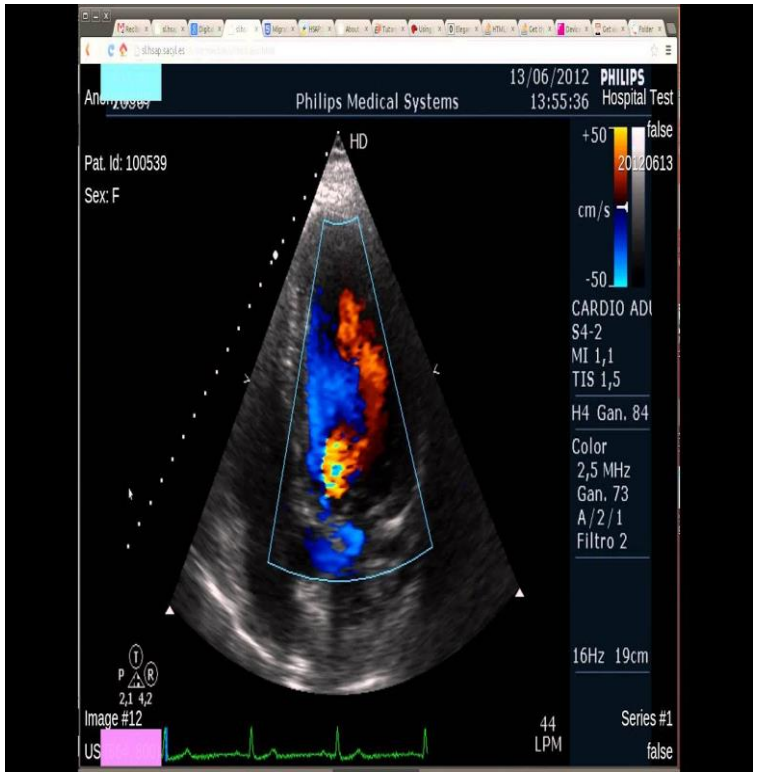
1. The ultrasound machine transmits high-frequency (1 to 10 megahertz) sound pulses into the body using a probe.
2. The sound waves travel into the body and hit different tissue, fluid or bone.

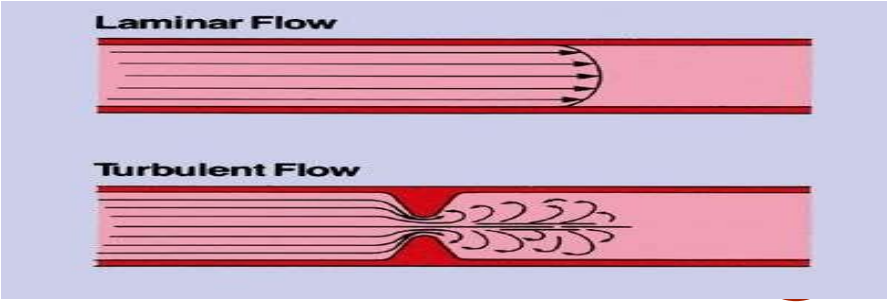
3. Some of the sound waves get reflected back to the probe, The reflected waves are picked up by the probe and sent to the machine.
4. Using speed = distance x time the machine calculates the distance from the probe to the tissue or organ.
5. The machine displays the distances and intensities of the echoes on the screen, forming a 2D image.



DOPPLER ULTRASOUND

- Doppler Ultrasound can be used to analyse the flow of blood in an artery or through the heart.
- A Doppler ultrasound, also known as a **echocardiogram**, can be used to diagnose artery blockages and other heart problems with the valves or the hearts rhythm.






2D
4D
3D

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MEDICAL INSTRUMENTS

Dr. Ruaa Almusa

Lec. 3

GALLIUM NUCLEAR MEDICINE

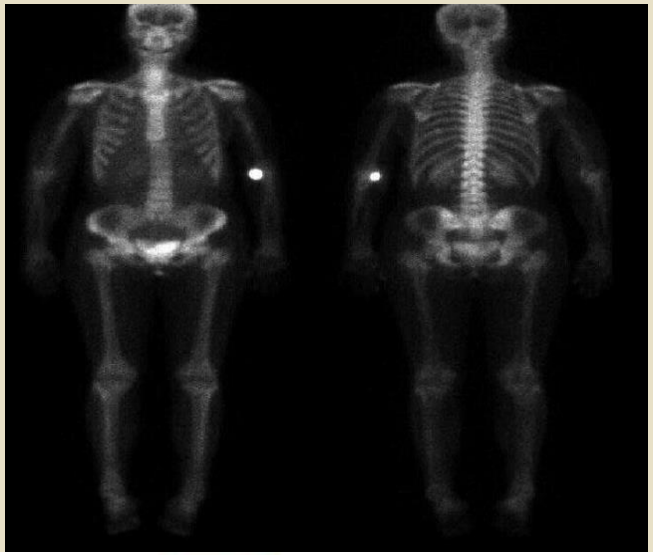
NUCLEAR MEDICINE

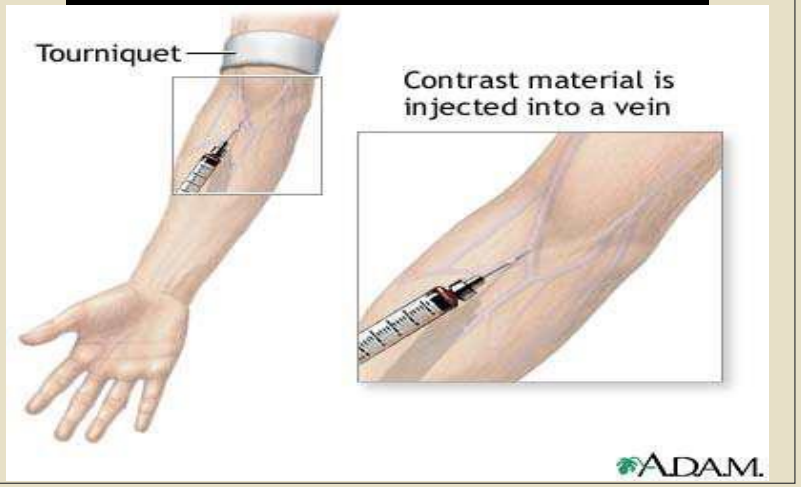
- Nuclear Medicine (PET, SPECT) is based on emission data from radioactive materials injected in to the body.
- Nuclear signals penetrated through the body are detected to form images.

1. Pharmaceuticals that are labeled with radionuclides
2. Accumulate in organs of interest
3. Emit gamma radiation
4. Detection system sensitive to this obtain images

APPLICATIONS OF NUCLEAR IMAGING

1. Tumor staging to assess metastasis
2. Investigation of salivary gland function
3. Evaluation of bone grafts
4. Investigation of thyroid and brain scans





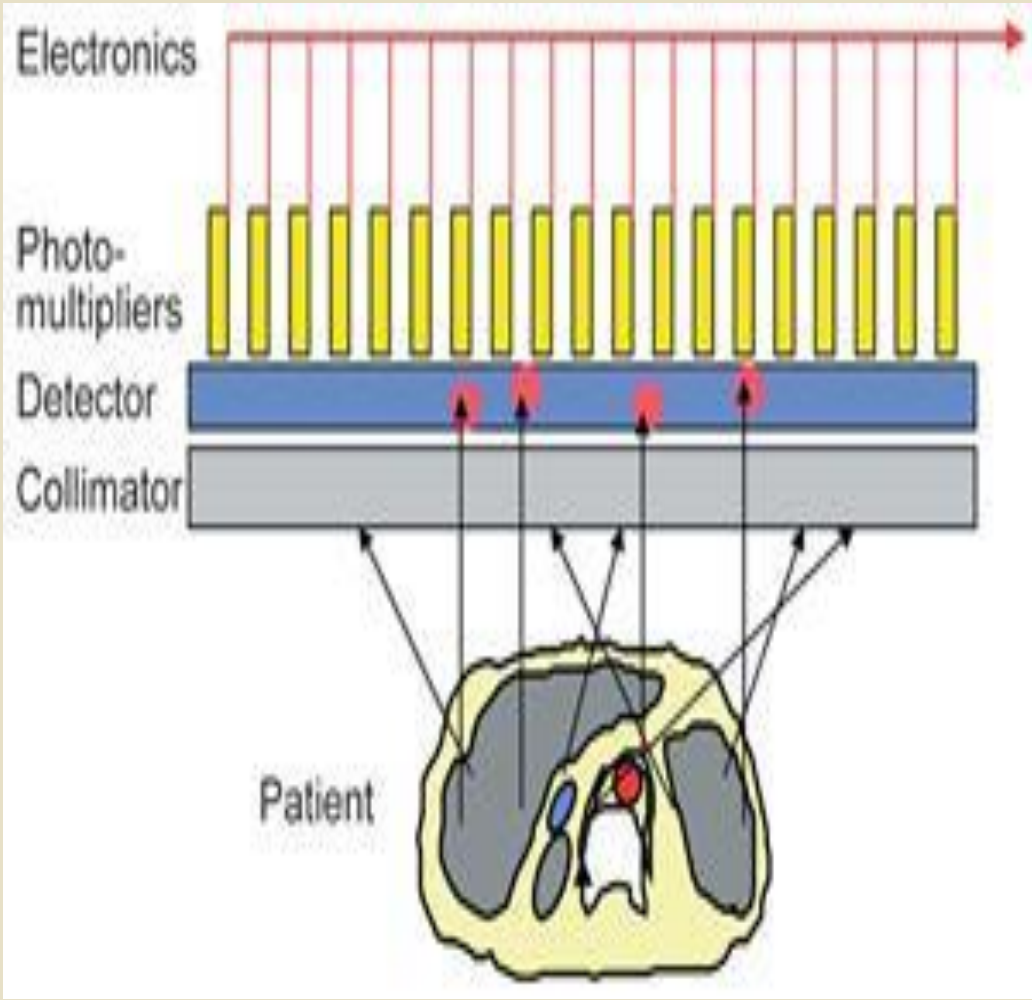
- **Nuclear Medicine imaging is also called Scintigraphy.**

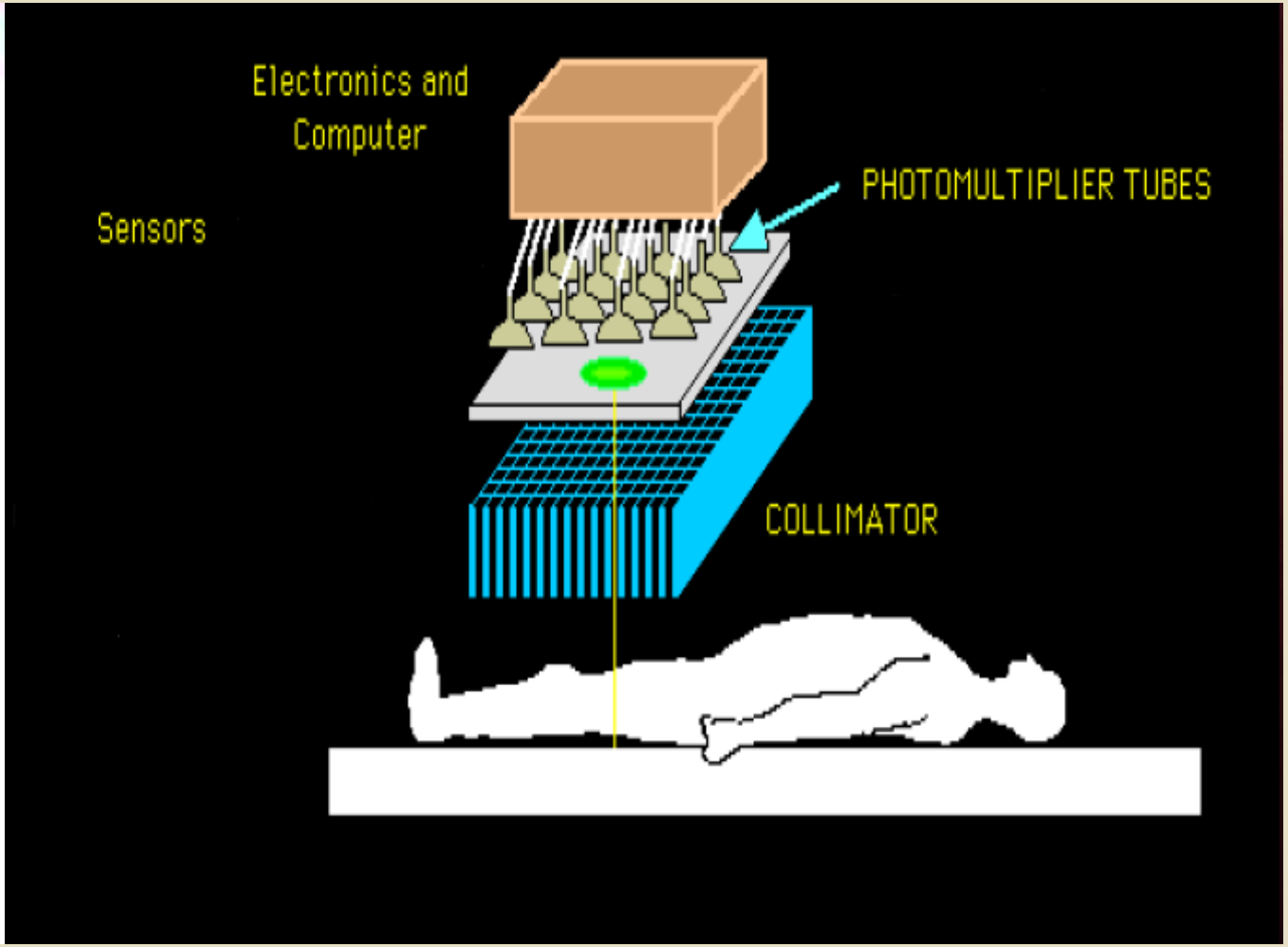
Radionuclides	Half-life	Uses
Technetium-99m	6 hrs	Skeleton and heart muscle imaging, brain, thyroid, lungs (perfusion and ventilation), liver, spleen, kidney (structure and filtration rate), gall bladder, bone marrow, salivary and lacrimal glands, heart blood pool, infection
Xenon-133 Krypton-81	5 days	Used for pulmonary (lung) ventilation studies.
Ytterbium-169	32 days	Used for cerebrospinal fluid studies in the brain.
Carbon-11 Nitrogen-13 Oxygen-15 Fluorine-18		They are positron emitters used in PET for studying brain physiology and pathology, cardiology, detection of cancers and the monitoring of progress in their treatment.
Iodine-131	8 days	Imaging of thyroid
Gallium-67	78 hrs	Used for tumour imaging and localization of inflammatory lesions (infections).
Indium-111	2.8 days	Used for brain studies, infection and colon transit studies
Rubidium-82	65 hrs	PET agent in myocardial perfusion imaging
Thallium-201	73 hrs	Used for diagnosis of coronary artery disease other heart conditions and for location of low-grade lymphomas.

GALLIUM SCAN

- A gallium scan is a type of nuclear medicine test that uses either a gallium-67 (^{67}Ga) or gallium-68 (^{68}Ga) radiopharmaceutical to obtain images of a specific type of tissue, or disease state of tissue.
- The gamma emission of gallium 67 is imaged by a gamma camera, while the positron emission of gallium 68 is imaged by positron emission tomography (PET).

GAMMA IMAGING



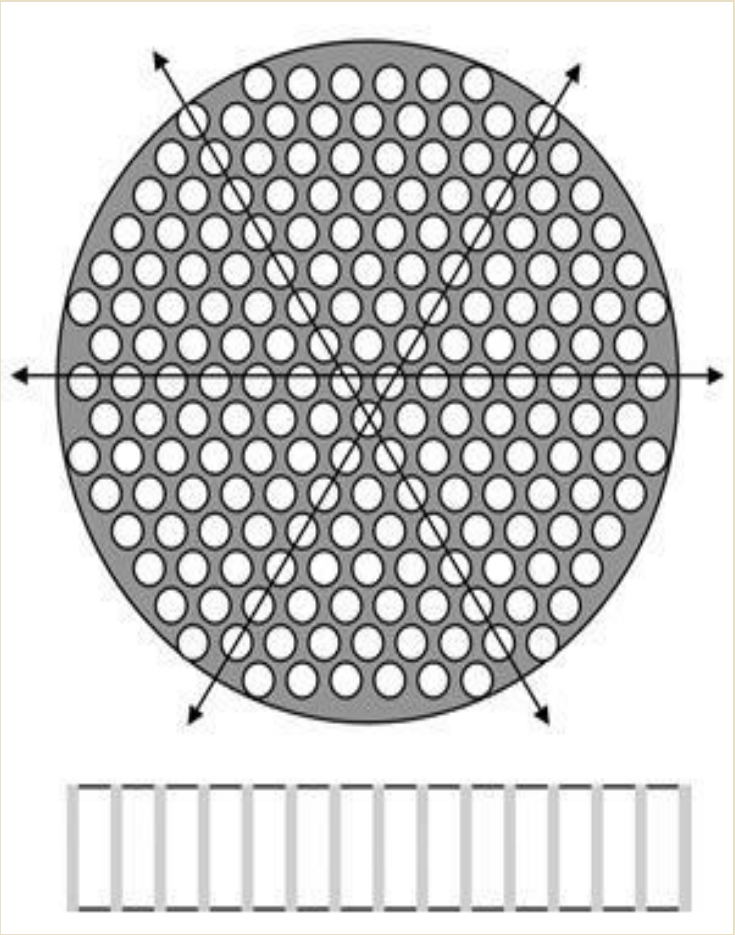


Gamma imaging is an imaging device used in nuclear scanning, it was invented by Hal Anger in the 1960s and thus is also frequently called the Anger camera.

Photons are selected by a collimator and produce light flashes which are detected by the photomultipliers.

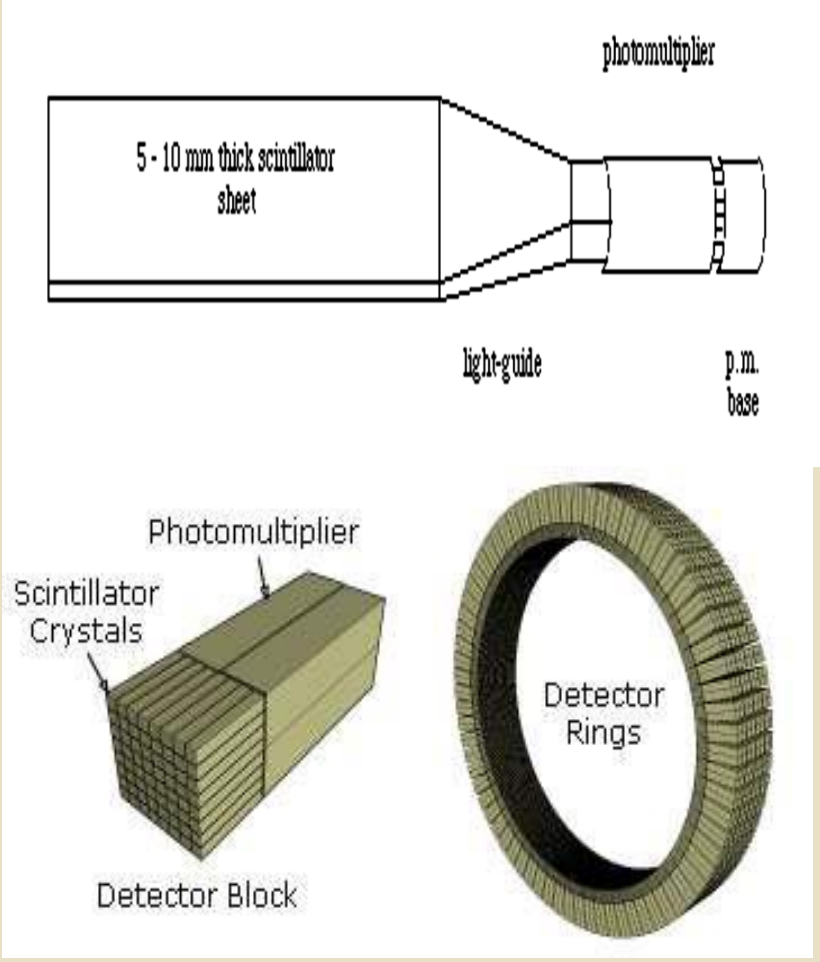
1. COLLIMATOR

- This is a device made of a highly absorbing material such as lead contain parallel holes, which selects gamma rays along a particular direction.
- They serve to stop scatter and select a ray orientation.



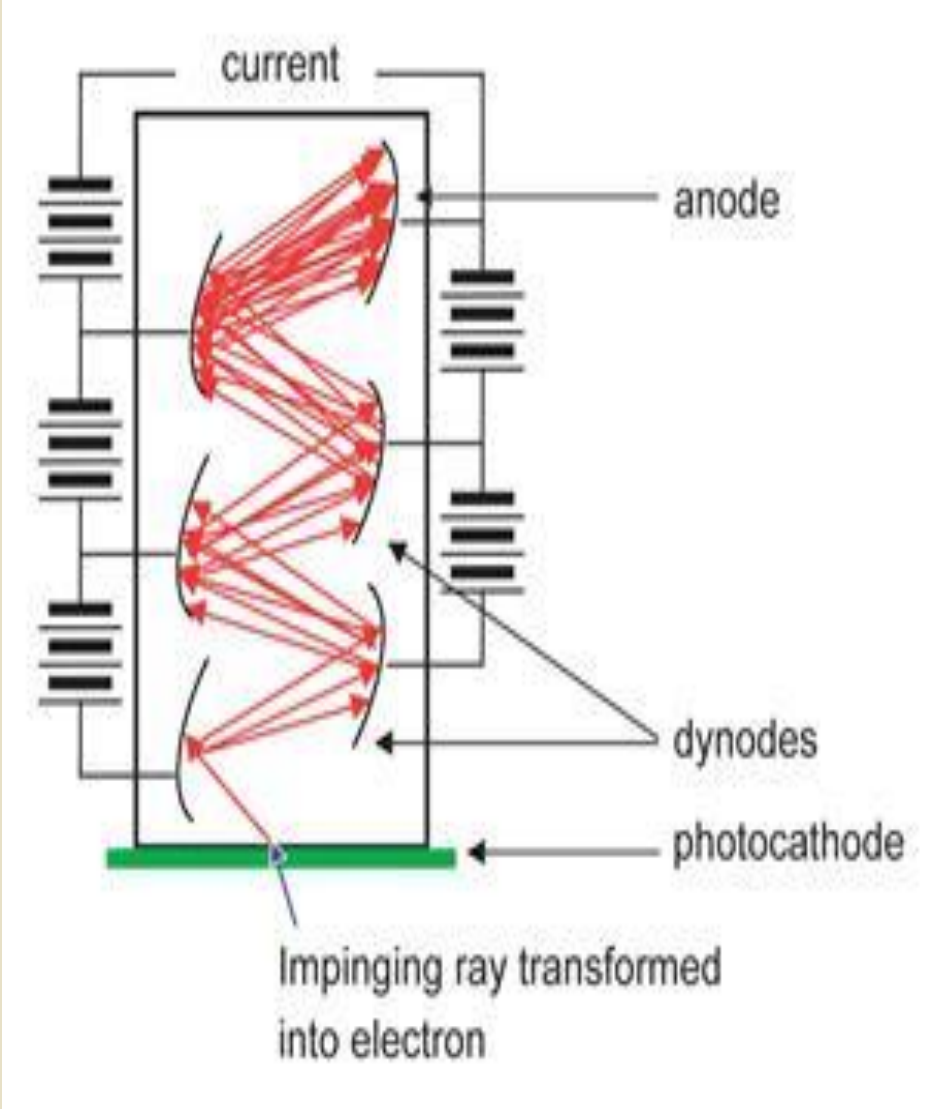
2. DETECTOR / SCINTILLATOR

- Made up of sodium iodide crystals.
- It produces multi-photon flashes of light when a gamma ray interacts with the single sodium iodide crystal.



3. PHOTOMULTIPLIER TUBE (PMT)

This is an extremely sensitive photocell used to convert light signals of a few hundred photons into a usable current pulse.



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MEDICAL INSTRUMENTS

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Lec. 4

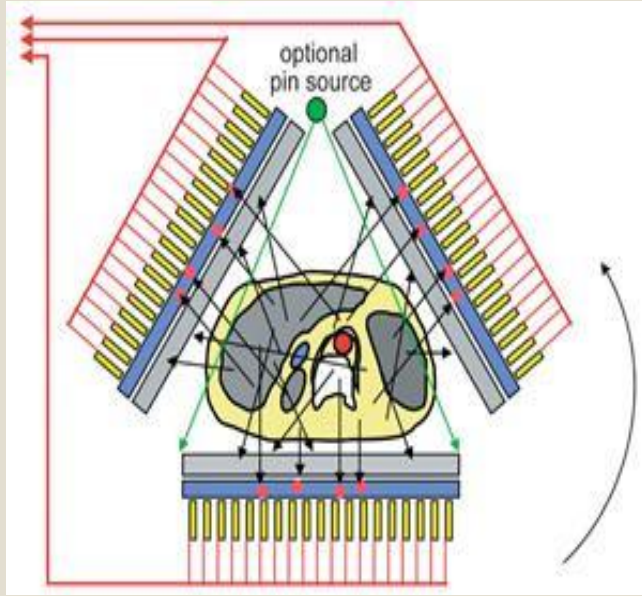
SINGLE PHOTON EMISSION COMPUTED TOMOGRAPHY (SPECT)

What is SPECT

- Detect single photons emitted by radionuclide tracers.
- Determine the origin and direction of emitted gamma.
- Reconstruct 3D images of the source or anatomy.
- Used as a diagnostic tool to image tumors, disease, and perform bone scans.
- Works with Gamma rays emission (NOT Transmission like X-ray or Reflection like Ultrasound).

Principles of SPECT

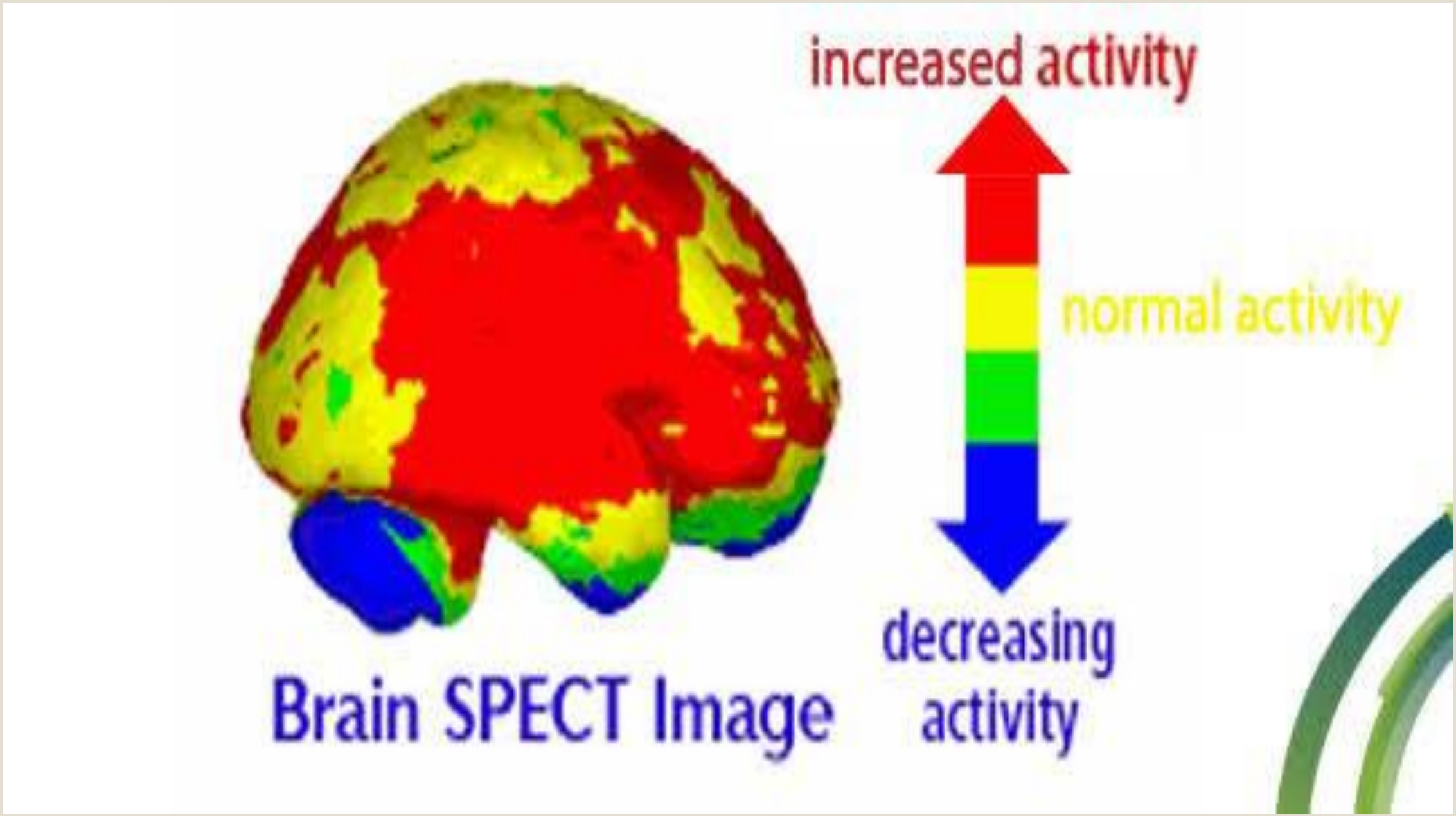
- Gamma-ray photons emitted from the internal distributed radiopharmaceutical (tracer) penetrate through the patient's body.
- Detected by a single or a set of collimated radiation detectors.
- Most of the detectors used in current SPECT systems are based on a single or multiple NaI(TI) scintillation detectors.



HOW SPECT WORKS?

1. A radiopharmaceutical is injected into the patient's body.
2. It travels into the blood stream, and concentrates in the Region of Interest.
3. There, it decays, emitting gamma rays.
4. The gamma rays travel out of the patient's body, and are detected by the gamma camera head of the SPECT machine.
5. The gamma ray is collimated by the collimators to minimize scatter, and improve image quality.

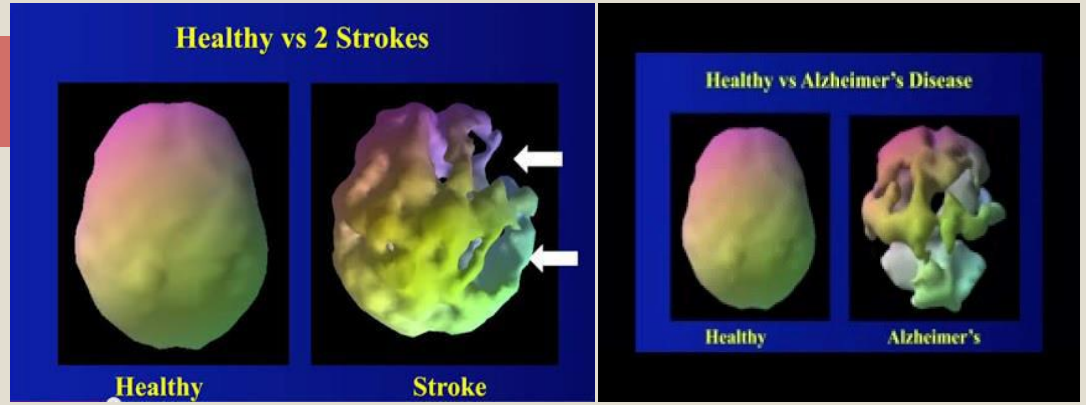
6. The collimated gamma rays hit the crystal detector NaI(Tl), which converts the energy of the gamma rays to visible light.
7. As visible light travel through the Photo Multiplier Tubes (PMT), they absorb the light and emit electrons.
8. The electrons emitted are used for image formation.
9. Hot spots (areas of increased uptake) and cold spots (areas of decreased intake) may indicate arthritis, infections, fractures, tumours.


increased activity
normal activity
decreasing activity
Brain SPECT Image

ADVANTAGES OF SPECT

1. Non-invasive technique and Localization of defects is more clearly seen.
2. The longer SPECT half-life afford longer times and greater flexibility to administration of radiotracers.
3. SPECT is available because of lower cost and greater accessibility of SPECT radionuclide

DISADVANTAGES OF SPECT



1. Radiation exposure
2. Limited time.
3. Relatively expensive to build and maintain (compared to CT, MRI).

Positron Emission Tomography (PET)

Anatomic vs. Functional Imaging

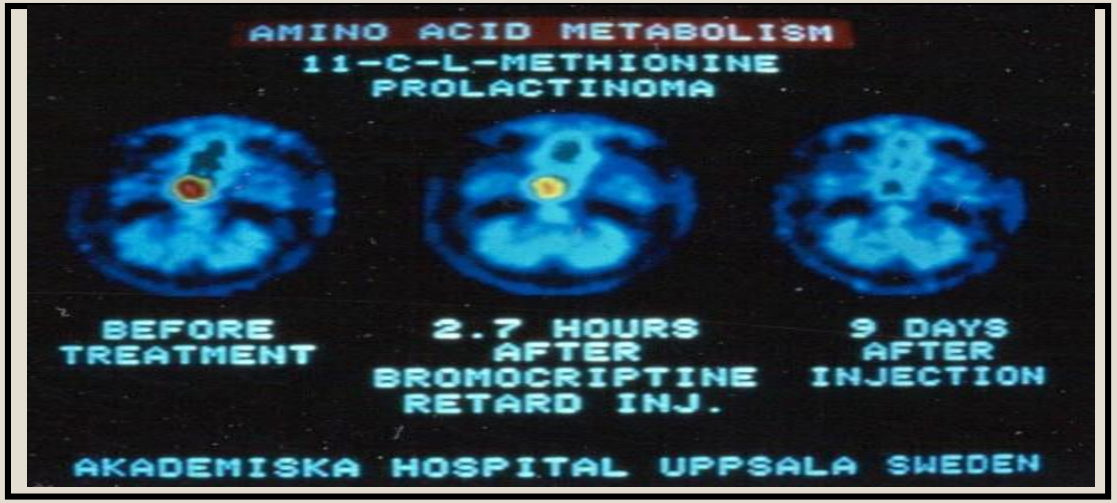
- Anatomic Imaging
  - Physical Structures, Bulk Properties of Patient
  - Generally Very High Resolution Images (~1mm or less)
  - X-Ray/CT, MRI, Ultrasound
- Functional Imaging
  - Biochemical Processes Ongoing in Patient
  - Generally Poorer Resolution (~4-5mm or more)
  - Radioisotope Techniques: NM /SPECT, PET
  - Other Techniques: MR (MRS, fMRI), MEG (MSI), ...

What is PET

- **Isotope production** → **CYCLOTRONS**
- **Tracer production** → **CHEMISTRY SYSTEMS**
- **Imaging** → **SCANNER**

A positron emission tomography PET is a nuclear medical imaging technique which produces a three dimensional image of functional processes in the body by detecting the radiation emitted by photons .

- The tracers are introduced into the body, by either injection or inhalation of a gas and they bind to the tumor.
- Example: **Prolactinoma** is often responsive to chemotherapy, avoiding surgery for patient.
- Effects of therapy on tumor metabolism seen in hours and the anatomic change (size reduction) will take weeks.

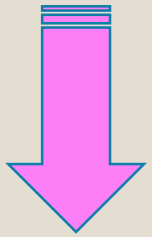


Main System Components

1. Scanner Gantry
   - Detector
   - Septa
   - Coincidence Circuit
2. Table
3. Computer
4. Cyclotron

How it works

1. A short lived radioactive tracer isotope, is injected in to the living subject (usually in to blood circulation). The tracer is chemically incorporated in to a biologically active molecule.

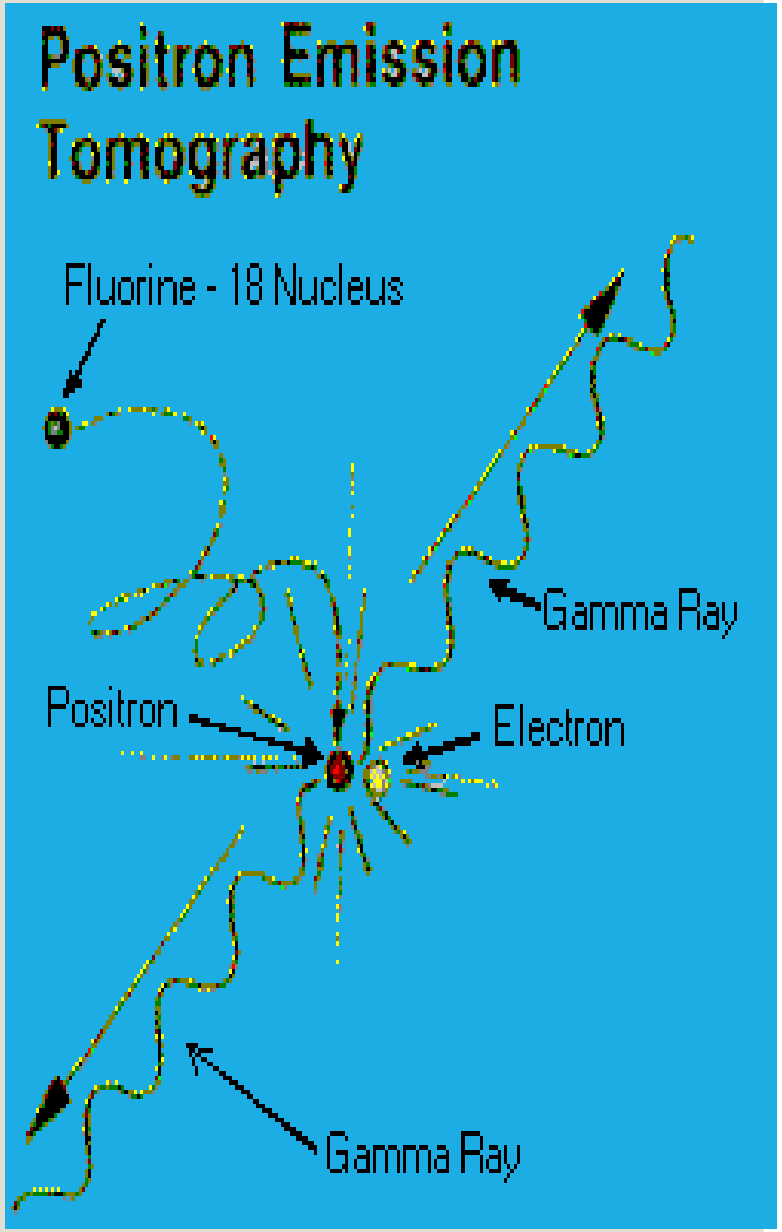


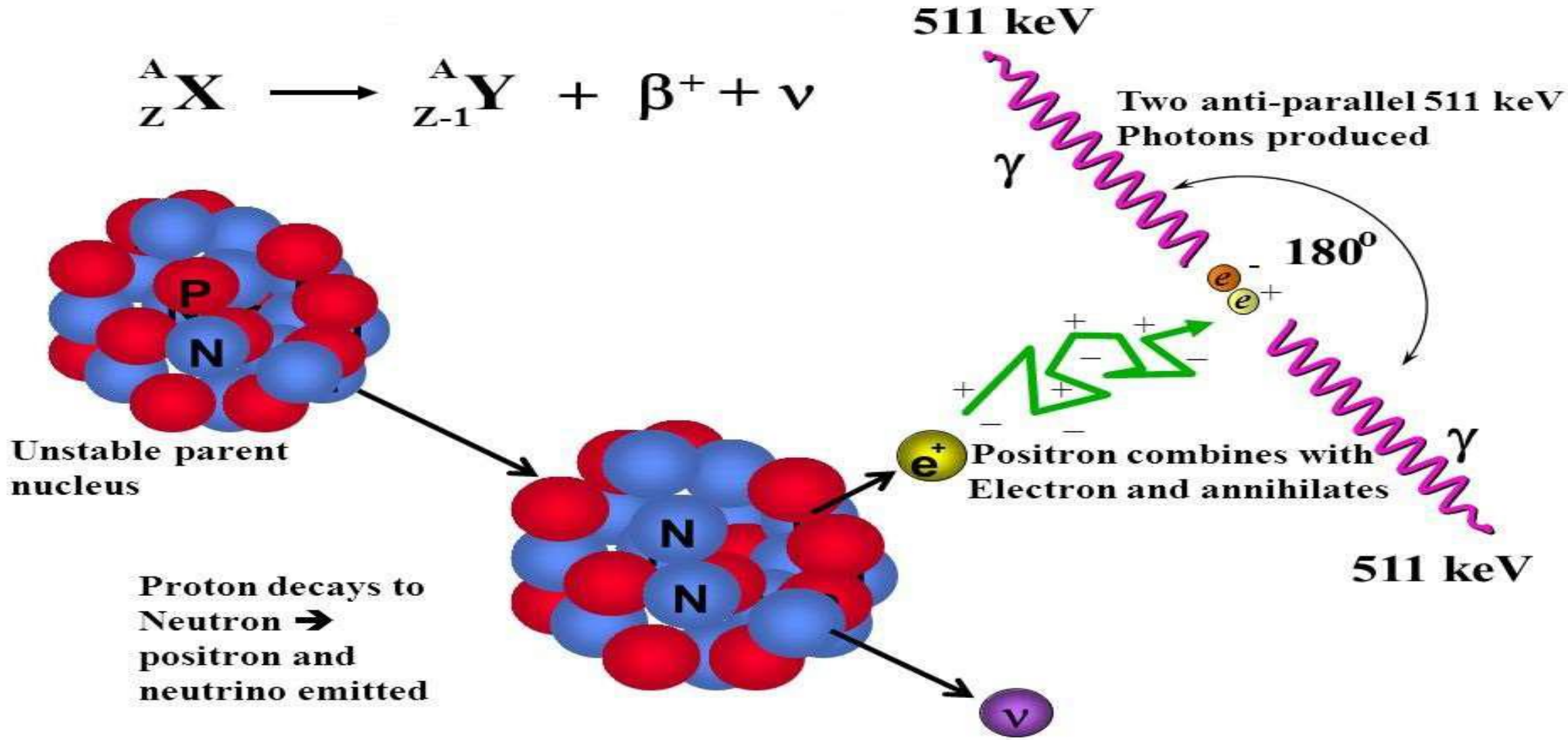
2. There is a waiting period while the active molecule becomes concentrated in tissues of interest.

1. As the radioisotope undergoes positron emission decay (also known as positive beta decay), it emits a positron, an antiparticle of the electron with opposite charge.

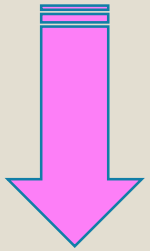
2. After traveling up to a few millimetres the positron encounter an electron.

3. The encounter annihilates them both, producing a pair of (gamma) photon moving in opposite directions.

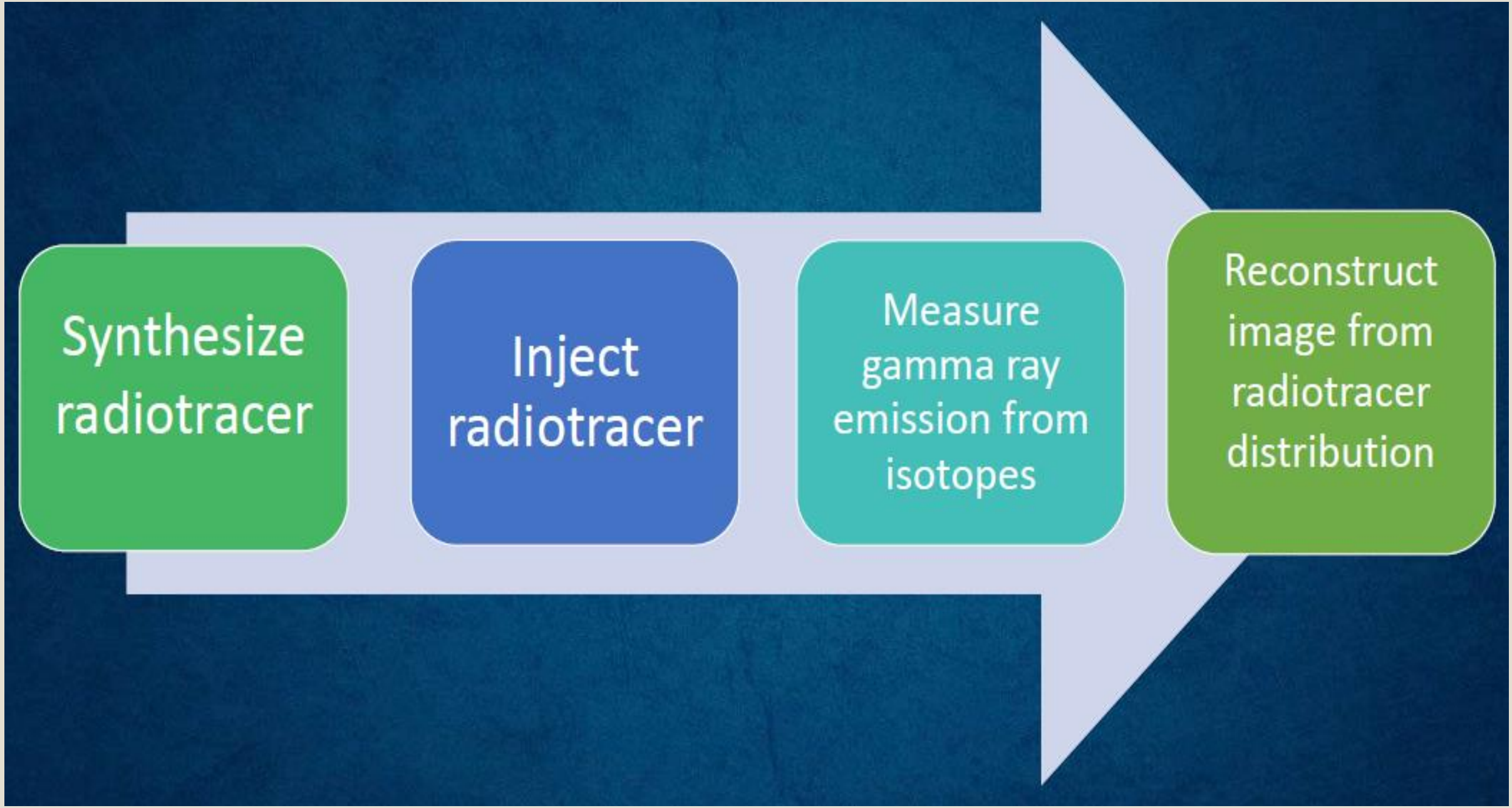



$^{A}_{Z}X \longrightarrow {}^{A}_{Z-1}Y + \beta^{+} + \nu$
511 keV
Two anti-parallel 511 keV Photons produced
γ
180°
P
N
Unstable parent nucleus
N
N
Proton decays to Neutron ➔ positron and neutrino emitted
e+
Positron combines with Electron and annihilates
γ
511 keV
ν

6. These are detected when they reach scintillator in the scanning device creating a burst of light which is detected by photomultiplier tubes.



7. The technicians can then create an image of the parts of your brain, for example which are overactive.


Synthesize radiotracer
Inject radiotracer
Measure gamma ray emission from isotopes
Reconstruct image from radiotracer distribution

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MEDICAL INSTRUMENTS

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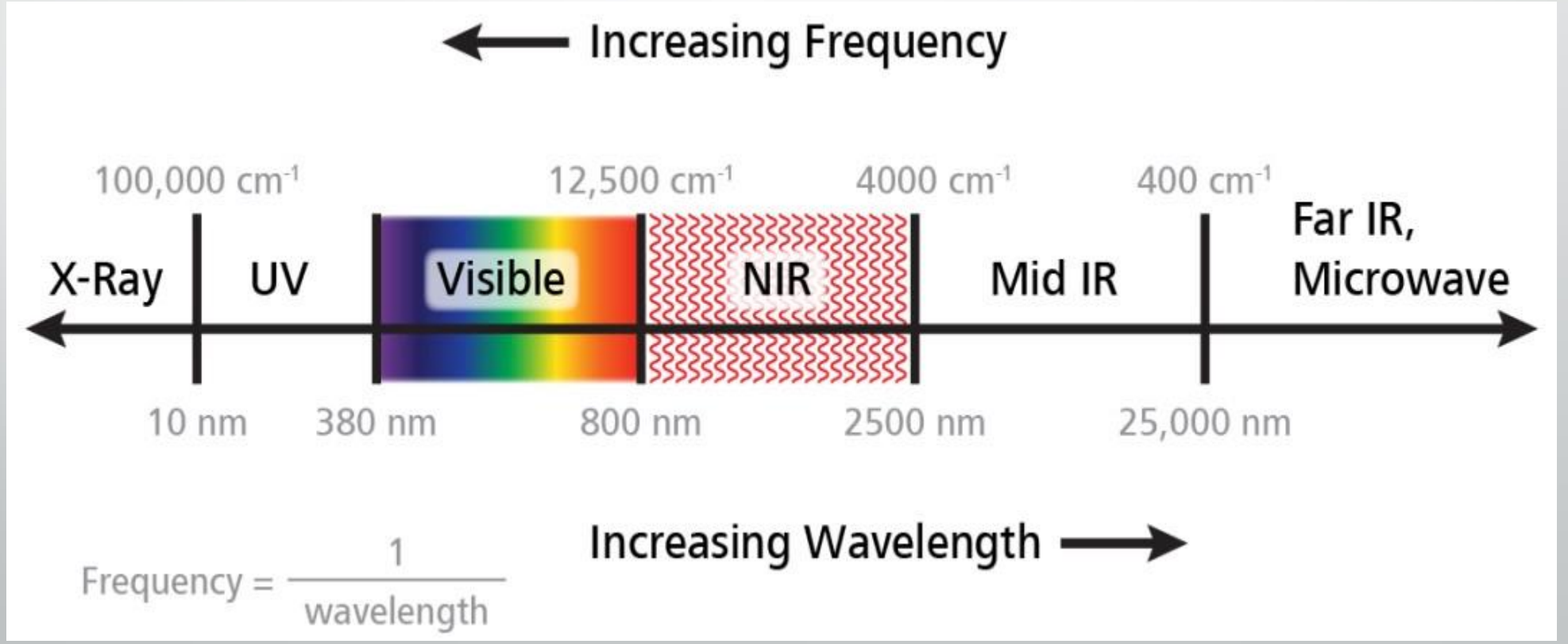
Lec. 5

Optical Tomography (OT)

What is Optical Tomography?

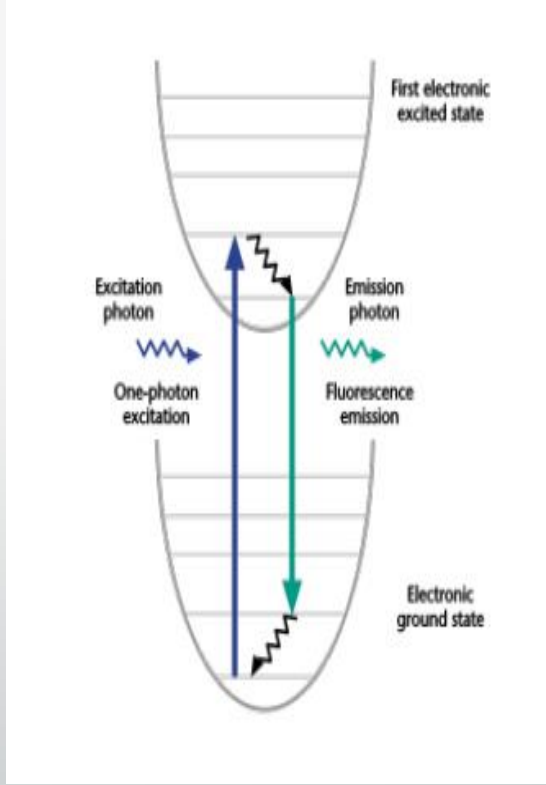
- Optical tomography (OT) is a form of computed tomography that creates an images made from light transmitted and scattered through an object.
- OT deals with objects that is at least partially light-transmitting or semi-transparent, so it works best on soft tissue, such as brain tissue.

- Soft tissues are scattering and absorbing the infrared and visible parts of the spectrum and UV, so that this is the wavelength range usually used.



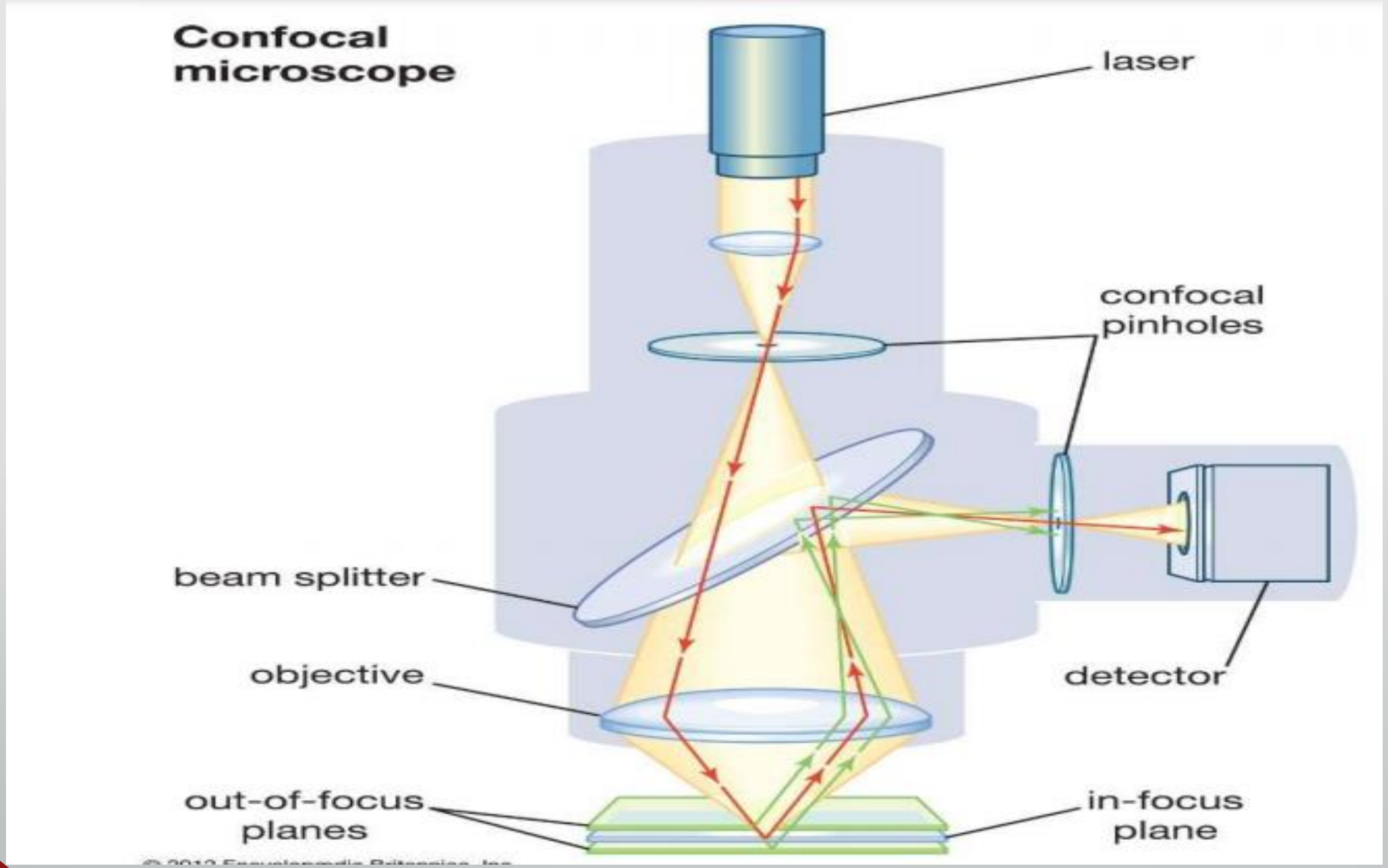
Single-photon and Confocal Fluorescence Microscopy

- When a fluorophore (a molecule that is able to fluoresce) is illuminated with the light of the wavelength in the range of absorption spectra, it absorbs a photon. Photon absorption excites an electron from the ground state to the first electronic state. It relaxes to the lowest excited state and dropping back to the ground state.

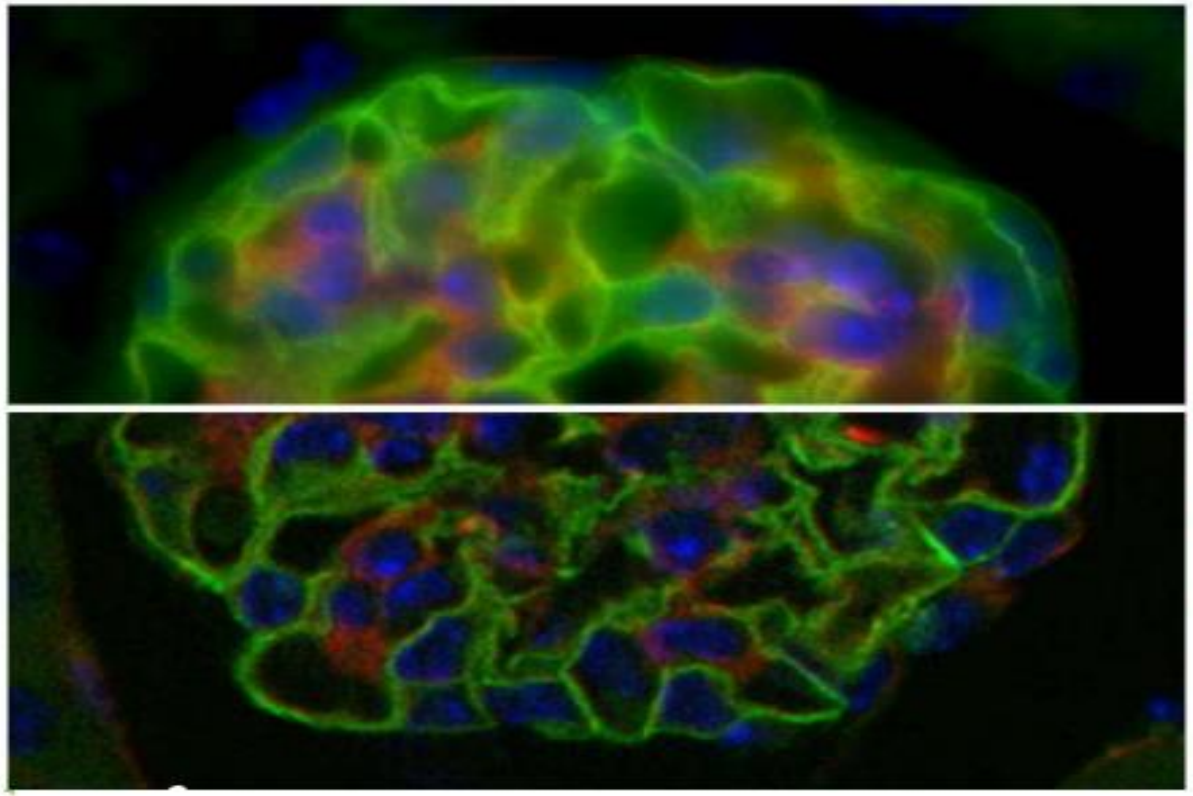


- During the electron transition to the ground state the molecule emits light of longer wavelength (lower energy).
- This enables the filtration of the scattered excitation light and thus only measure the emitted fluorescence. Consequently, we only obtain high-contrast images where the bright labelled structures appear on a dark background.

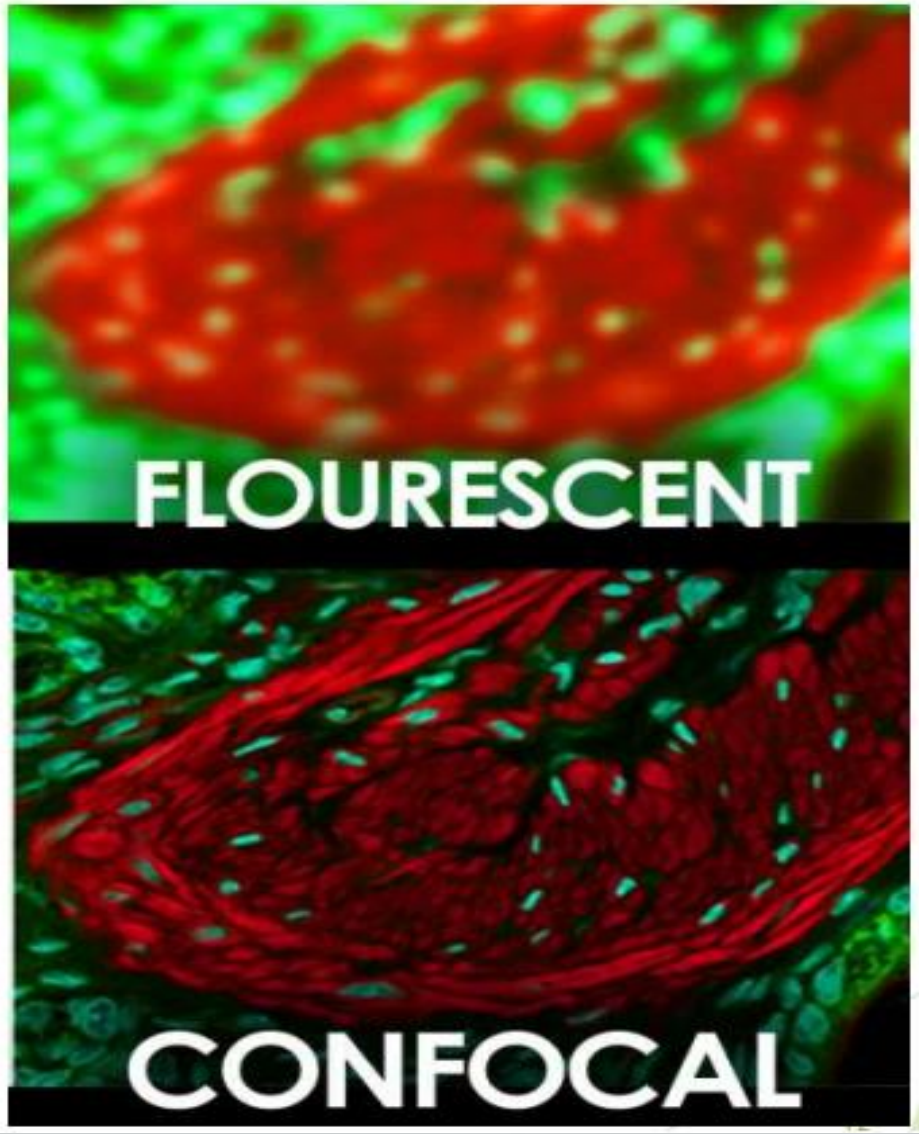
- **Confocal Fluorescence Microscopy** is an optical imaging technique for increasing optical resolution and contrast of a micrograph when laser cause sample to fluoresce.
- Its an updated version of fluorescence microscopy. A series of thin slices of the specimen are assembled to generate a 3-dimensional image.


Confocal microscope
laser
confocal pinholes
beam splitter
objective
detector
out-of-focus planes
in-focus plane

Improved Resolution

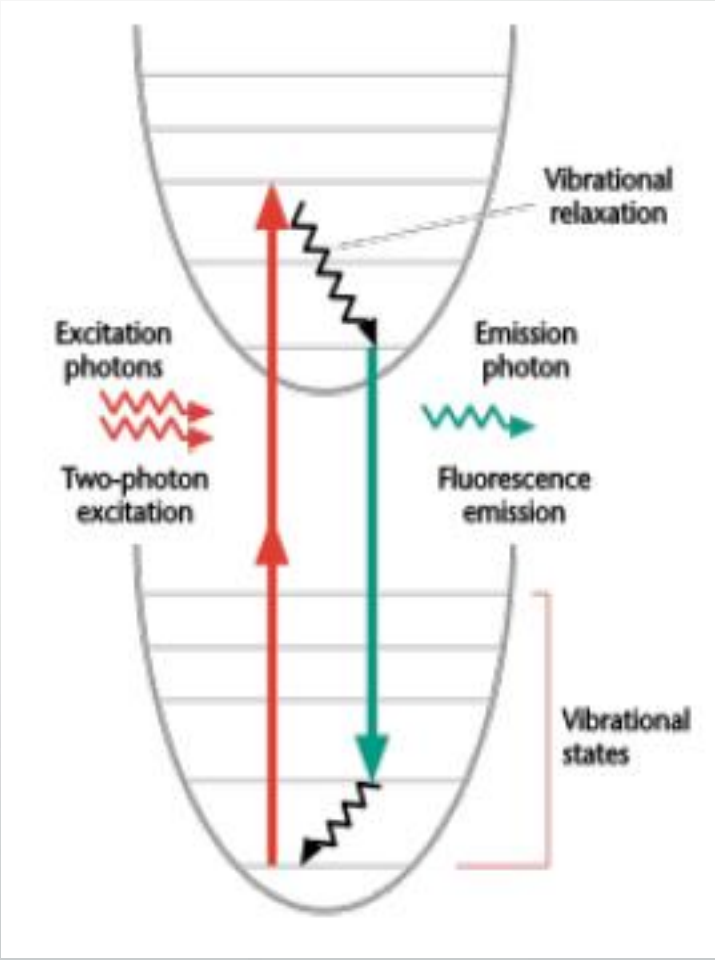


Kidney cells (fluorescence vs Confocal microscope



Two-Photons Microscopy

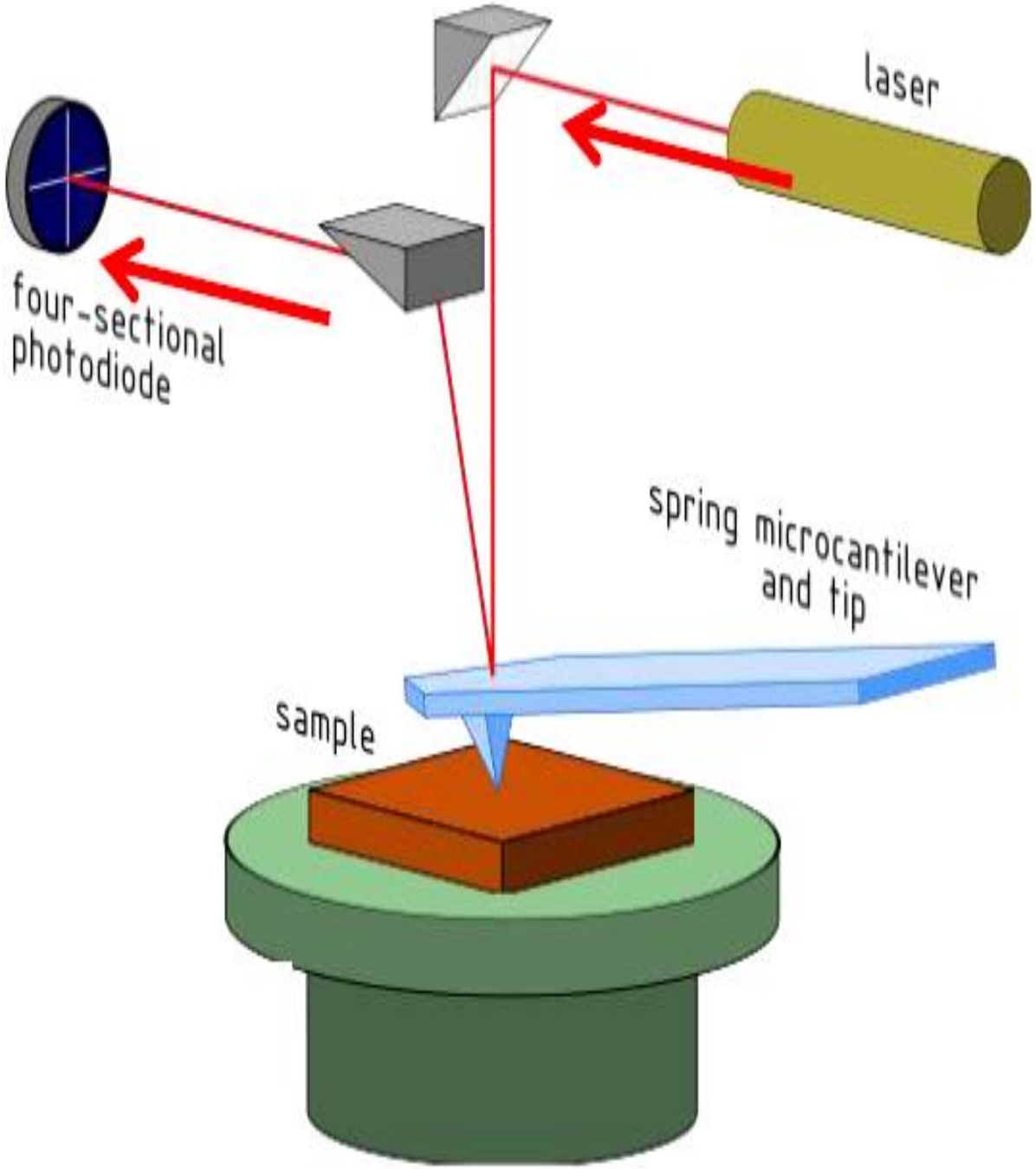
- Exciting the fluorophore with two photons instead of one.
- These two photons of approximately twice the wavelength of single photon excitation to excite the fluorophore to the excited state.

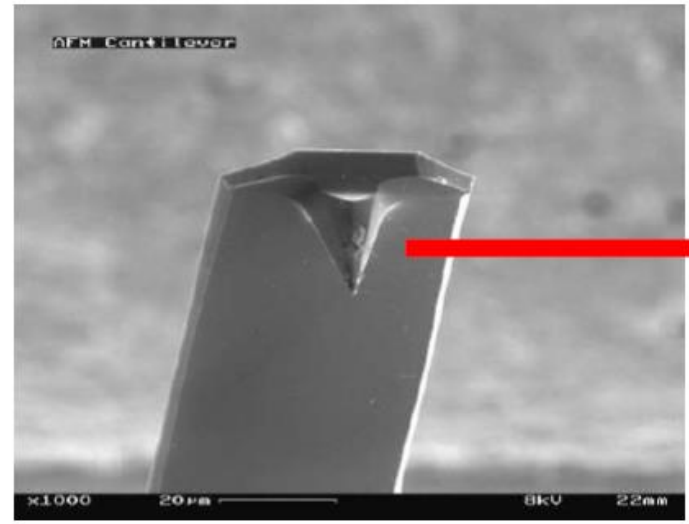


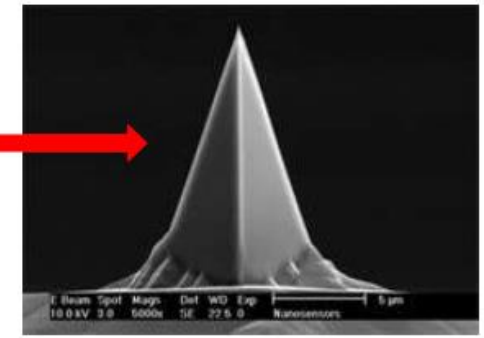
- The higher intensity of light needed for fluorescence to happen as the fluorophore is able to absorb two photons only if they hit the molecule at approximately the same time. The probability for that to occur is much lower than for the single-photon excitation, thus the need for a high-power light source.

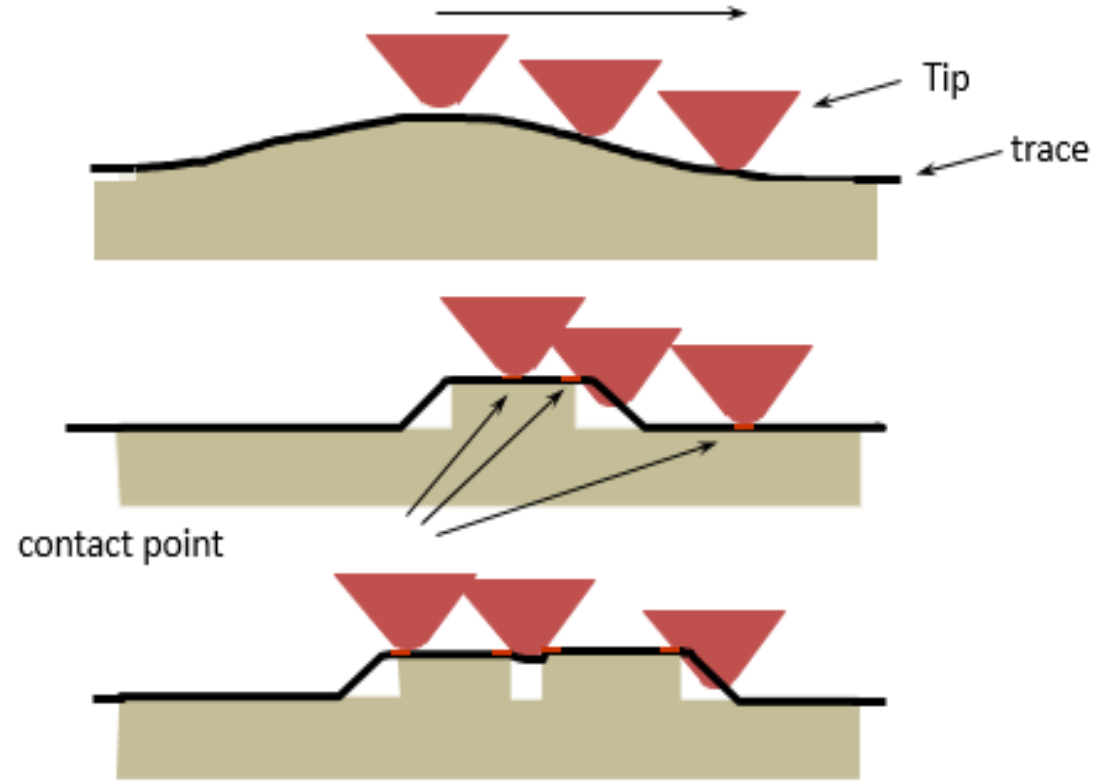
Atomic Force Microscopy (AFM)

- **AFM** is one kind of scanning probe microscope that possesses a very high resolution (on the order of fractions of nanometres)
- Operates by measuring force between its probe and the sample to provides a 3-D surface profile


laser
four-sectional
photodiode
spring microcantilever
and tip
sample


AFM Cantilever
x1000
20µm
8kV
22mm




Tip
trace
contact point

- An AFM images the topography of a sample surface by scanning the cantilever over a region of interest.
- The raised and lowered features on the sample surface influence the deflection of the cantilever, which is monitored by the photodiodes.

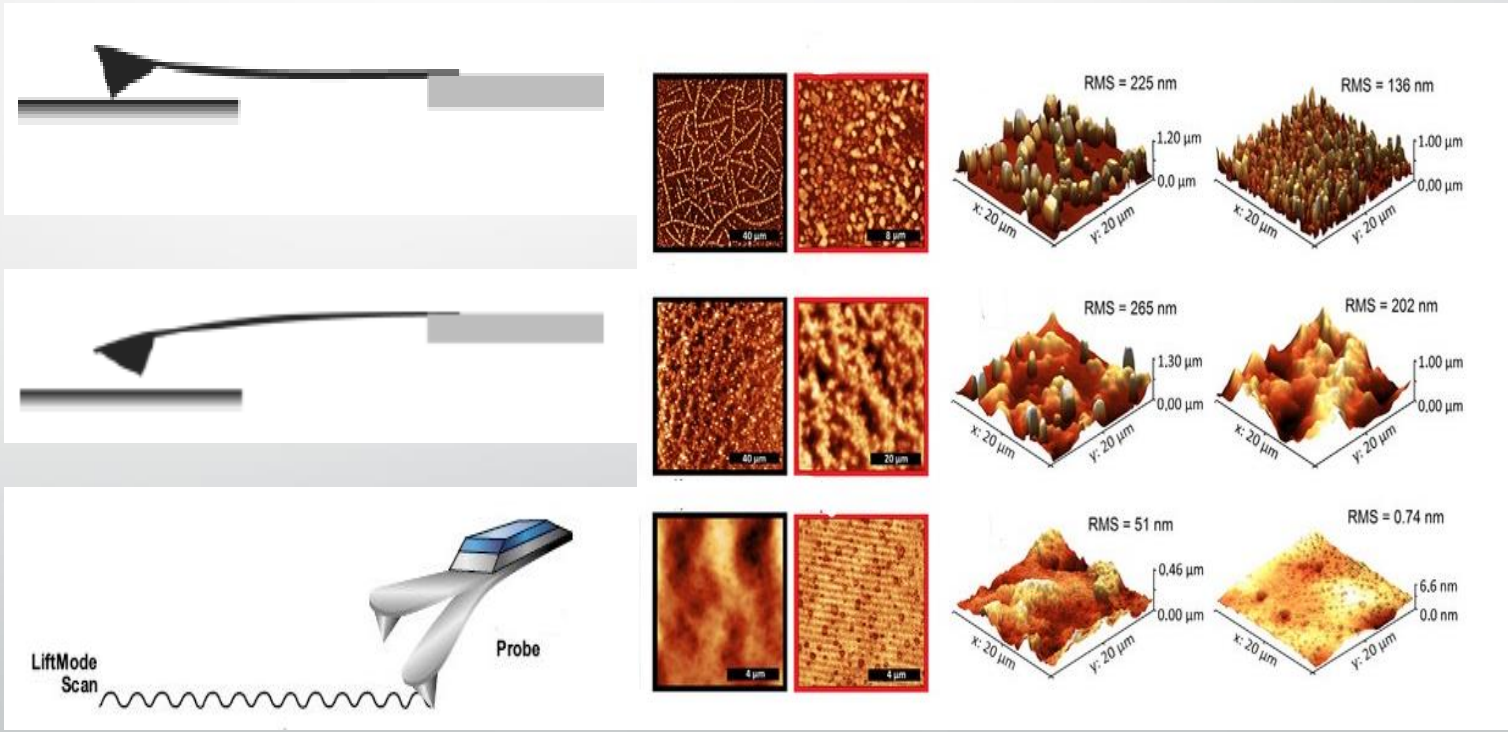
AFM Medical Applications

- In cellular biology, AFM can be used to distinguish cancer cells and normal cells based on a hardness of cells.
- Soft surfaces are analysed by this technique without damaging it like Lipids.

AFM Modes

AFM has 3 modes of operation:

1. Contact mode
2. Non contact mode
3. Tapping mode



Madenat Alelem University College
Medical physics dept.
Third Stage / 2nd Semester

Medical Instruments

DR. RUAA ALMUSA

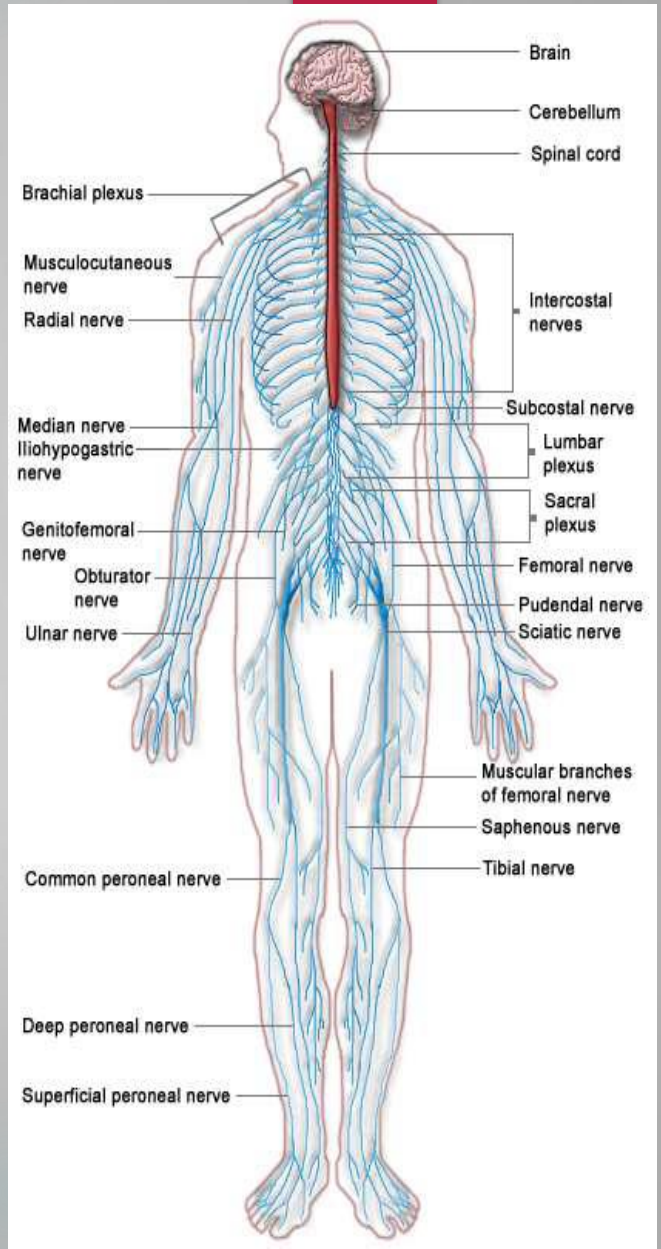
LEC. 6

Electro-Neuro-Gram (ENG) and Electro-Myo-Gram (EMG)

ENG & EMG

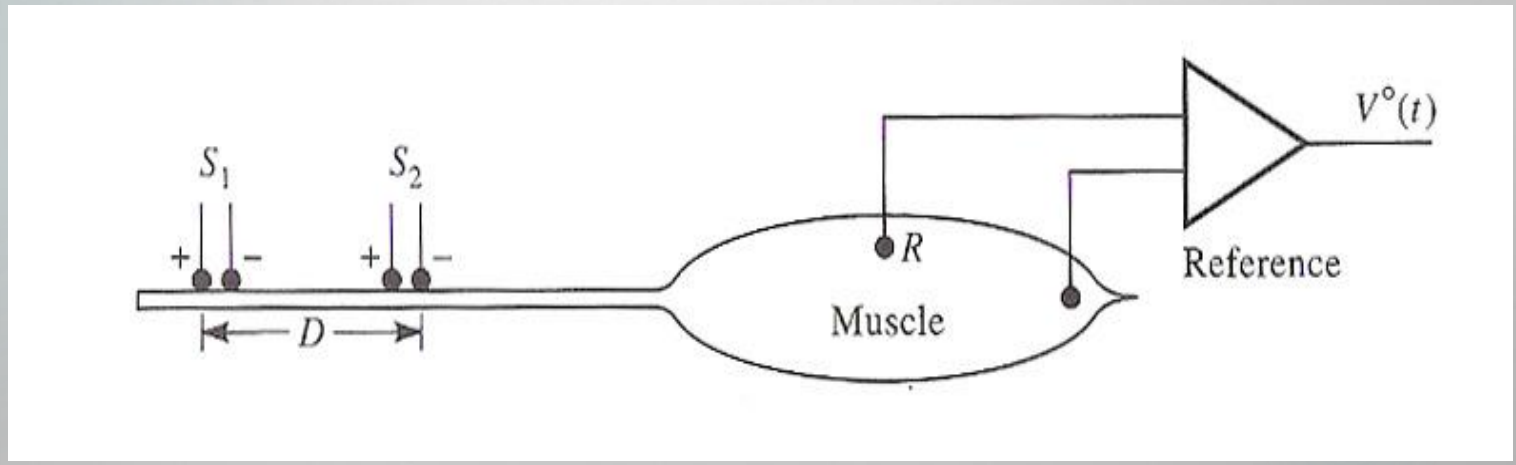
- An electroneurogram ENG is a method used to visualize directly recorded electrical activity of neurons in the central nervous system (brain, spinal cord) or the peripheral nervous system (nerves, ganglions).
- An electroneurogram is similar to an electromyogram (EMG), but EMG is used to visualize muscular activity.

- Electroneurography is a non invasive, diagnostic test to measure the conduction velocity of peripheral nerves.
- • An electroneurogram is usually obtained by placing an electrode in the neural tissue.
- It is the most accurate test for detecting and locating peripheral nerve injury of about 100 kinds of peripheral neuropathies, such as Diabetic polyneuropathy.

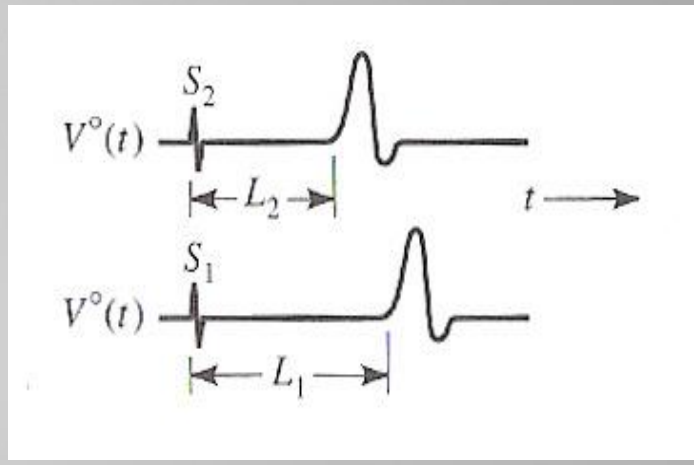


ENG Working Principal

- **Conduction velocity is the rate of propagation of nerve impulse (action potential) along a nerve fiber.**
- **Conduction velocity in a peripheral nerve can be measured by stimulating a motor nerve at two points a known distance apart along its pass.**



- These are done through subtraction of shorter from longer latency, which gives the conduction time.
- Using the known distance, the conduction velocity can be obtained.

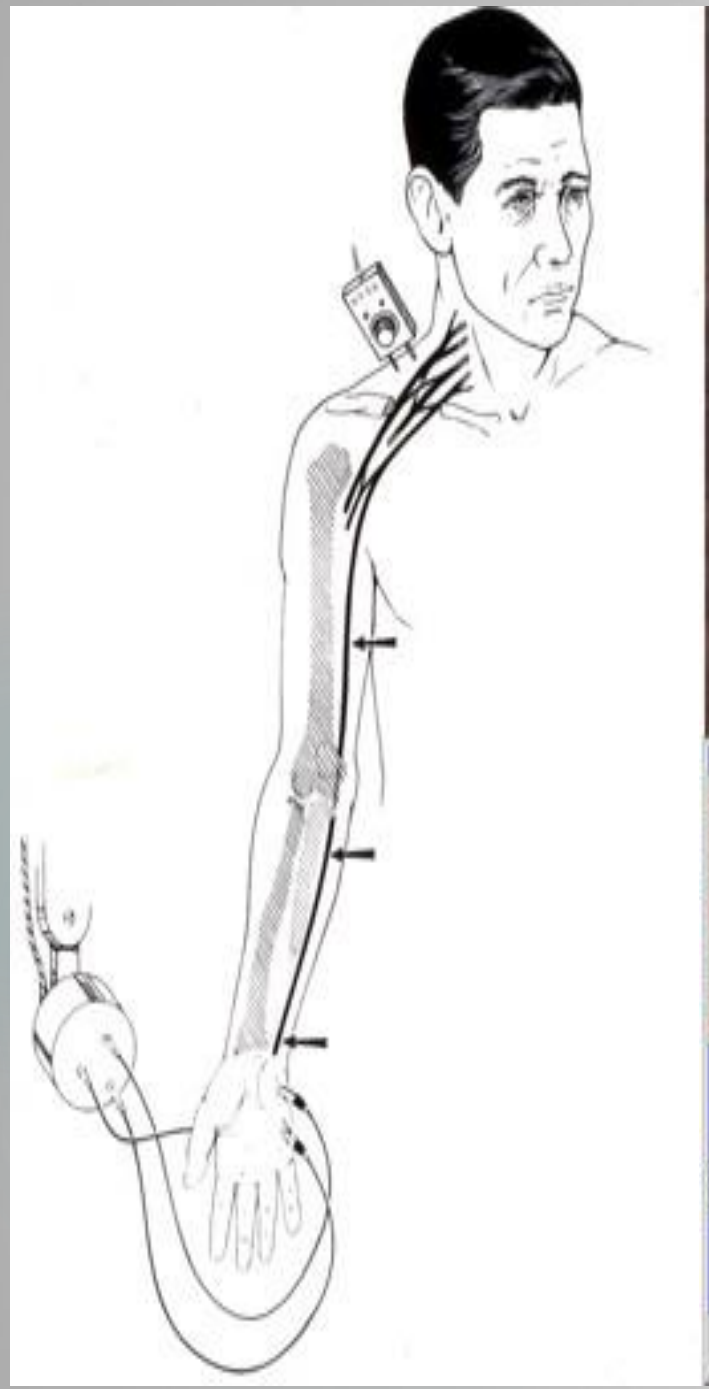


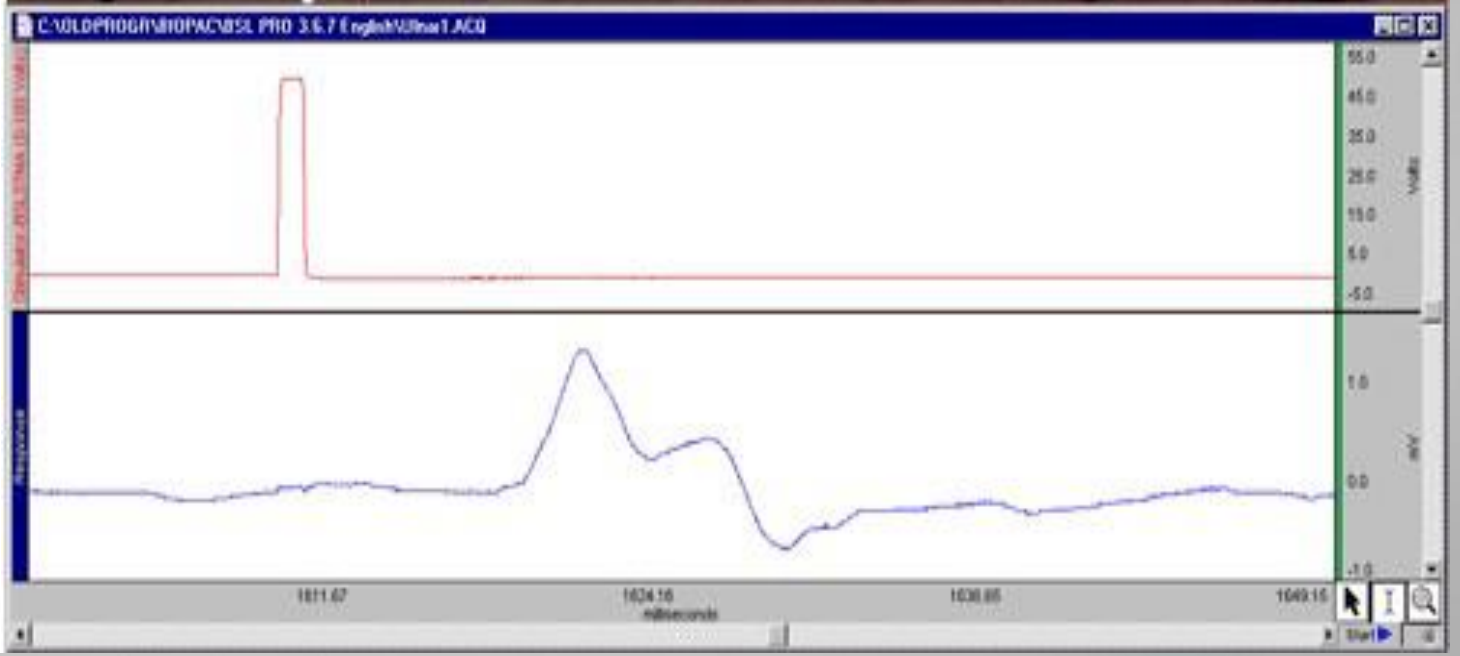
$$V = \frac{d}{L_1 - L_2}$$

where v : Velocity, D : Distance between electrodes, L_1: Time of longer latency and L_2: Time of shorter latency

THE TEST PERFORMING

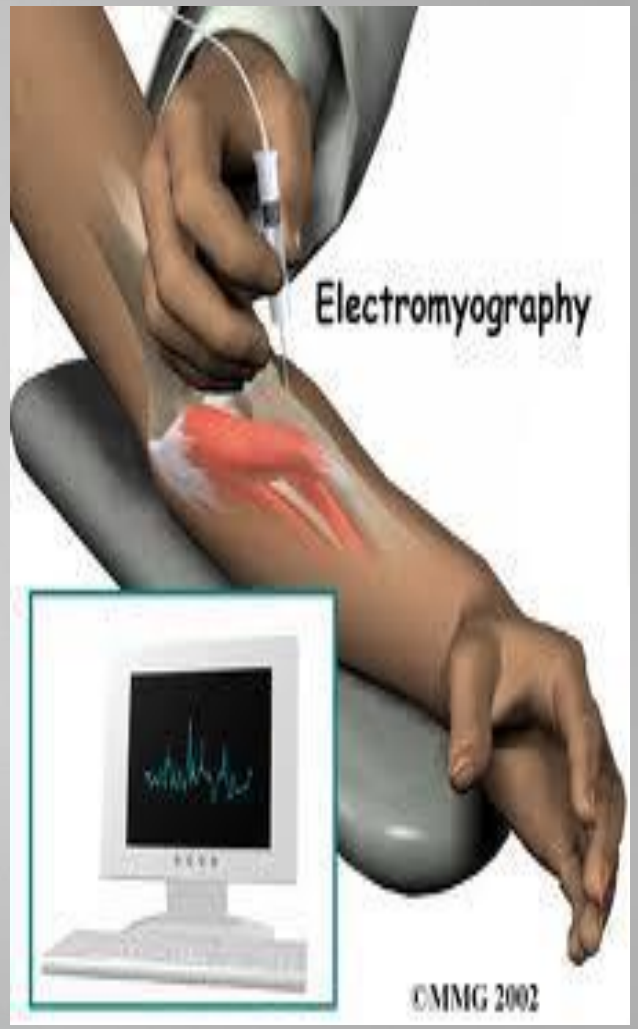
1. **Strong but brief stimulation at one point under the skin and at the same time recording the electrical activity at another point of nerve trajectory in the body.**
2. **The response is displayed on the video monitor of computer or cathode ray tube.**
3. **The stimulus and recordings are carried out by electrodes which are placed over the skin after applying the conducting gel.**




C:\OLDPROGR\BIOPAC\BSL PRO 3.6.7 English\Ulnar1.ACQ
1611.67
1624.16
1636.65
1649.15
milliseconds

EMG

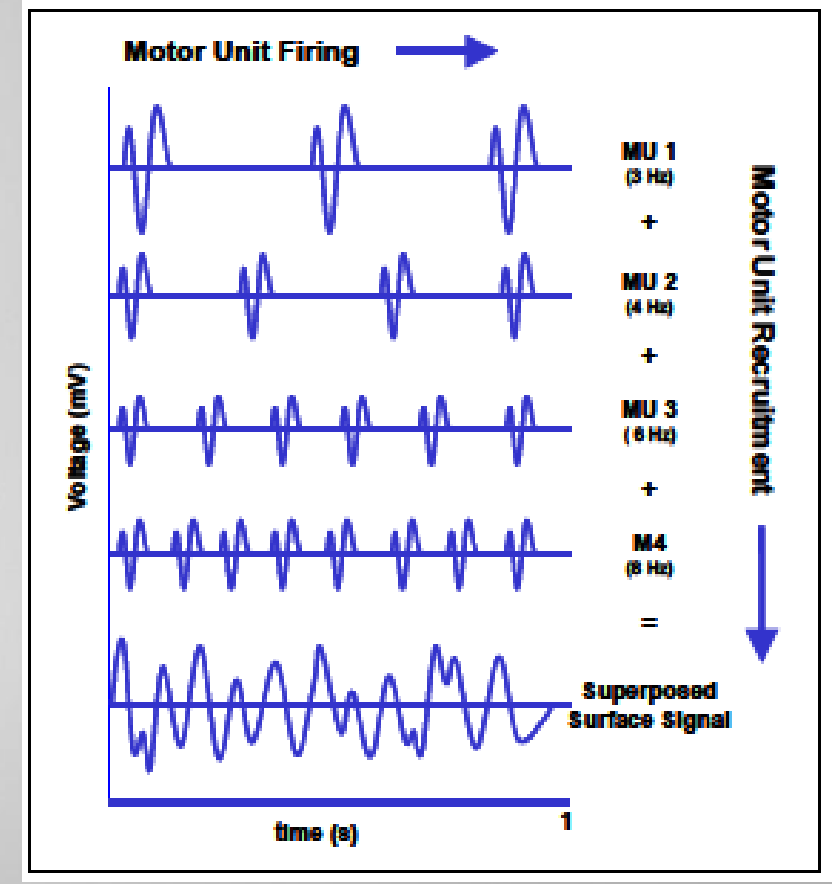
- Is a technique for evaluating & recording the electrical activity produced by skeletal muscles
- Sometimes EMG is combined with ENG for accurate diagnosis called as electromyoneurography
- Is performed using an instrument called an electromyograph, to produce a record called an electromyogram



- A resting muscle does not show recordable electrical potential but with increase force of contraction, amplitude of potential increases
- An electromyography detects electrical potential generated by muscle cells when these cells are electrically or neurologically activated

Motor unit potential (MUP)

- The sum of the action potentials produced in the muscle
- Characterized by its duration, number of phases, amplitude, & rate of rise of first component



Factors that effect MUP

- **Technical factors**

✓ **Type of needle electrode**

✓ **Characteristics of recording surface**

✓ **Electrical characteristics of cable**

✓ **Preamplifier & amplifier**

✓ **Method of recording**

- **Physiological factors**

✓ **Age of the patient**

✓ **Muscle examined**

✓ **Temperature**

Madenat Alelem University College
Medical physics dept.
Third Stage / 2nd Semester

Medical Instruments

Dr. Ruaa Almusa

Lec. 7

Electrocardiography (ECG)

Heart Electricity

- The contraction of any muscle is associated by electrical currents called depolarization, and these currents can be recorded by electrodes. These electrodes are attached to the surface of the body.
- Although the heart has 4 chambers, only two chambers appear in the electrocardiogram because the atria contract together and the ventricles together.

ECG

- Is the interpretation of the electrical activity of the heart over a period of time, as detected by electrodes attached to the outer surface of the skin and recorded by a device external to the body.
- The recording produced by this procedure is termed as Electrocardiogram.

Significance of ECG

- ECG gives information about rate and rhythm of the heart.
- Its a diagnostic tool for various heart conditions like hypertrophies, ischemia, infarction, arrhythmias conduction problems and pacemaker activity.
- Helpful with non-cardiac diseases (e.g. pulmonary embolism or hypothermia.

Main Components of ECG Machine

1. Calibration
2. Sensitivity
3. Thermal indicator
4. Speed
5. Monitor
6. Electrodes

HOW TO DO ELECTROCARDIOGRAPHY

1. Place the patient in a flat position. If the patient cannot tolerate being flat, you can do the ECG in a more upright position.

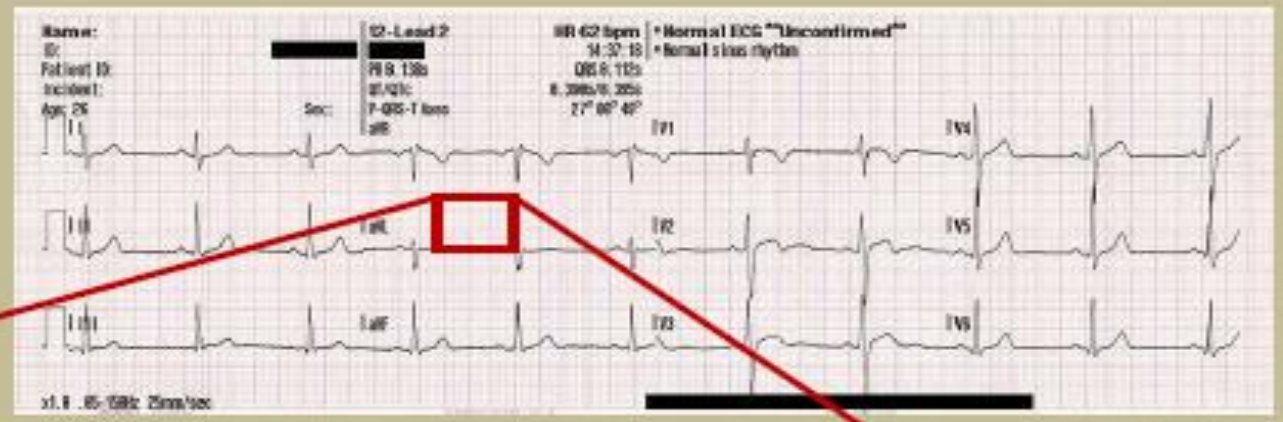
2. Instruct the patient to place their arms down by their side and to relax their shoulders and legs are uncrossed.

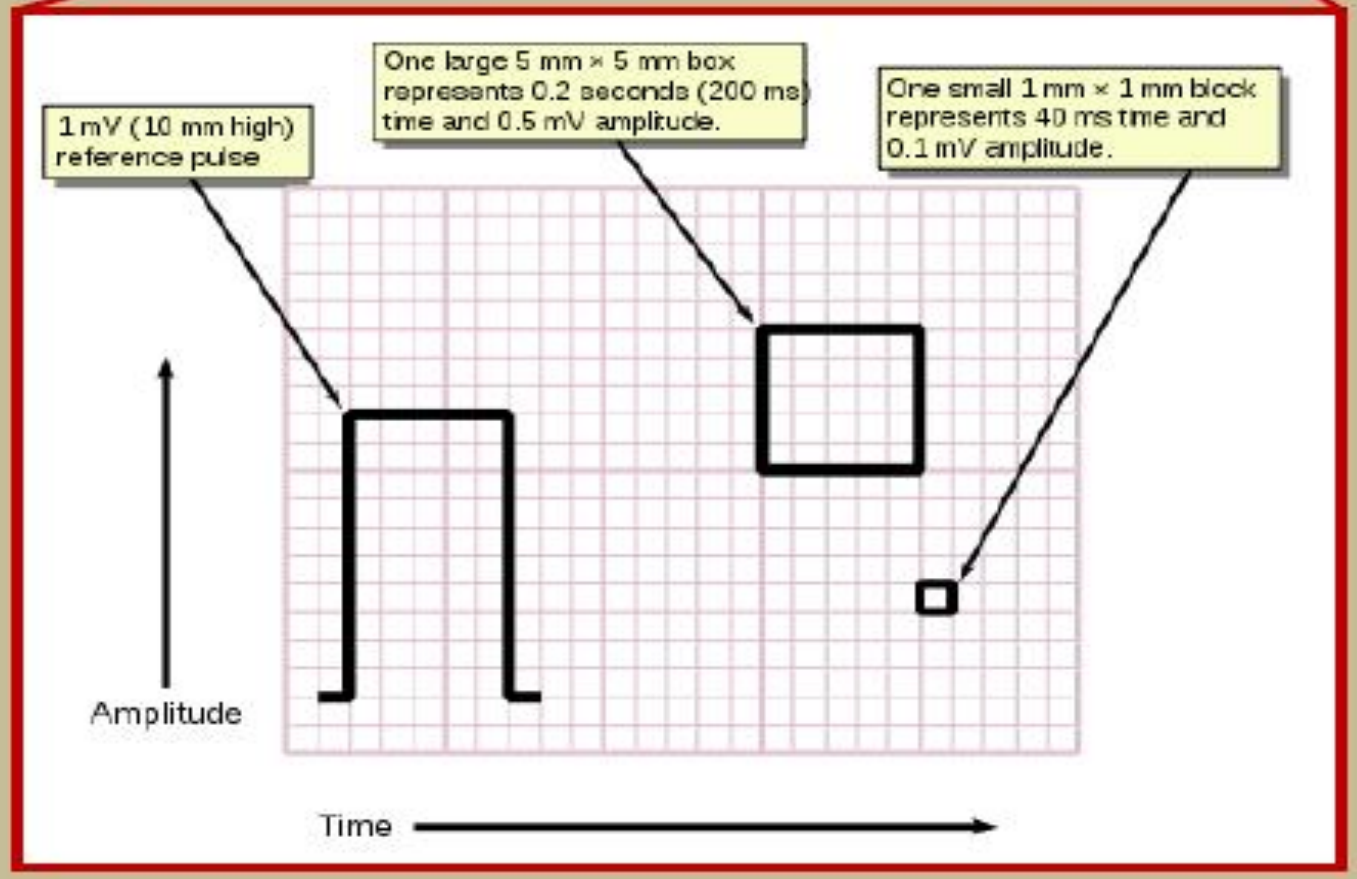
3. Remove any electrical devices, such as cell phones, as they may interfere with the machine.

4. The ECG works mostly by detecting and amplifying the tiny electrical changes when the heart muscle "depolarizes" during each heart beat.

The ECG Paper

- ECG machines record changes in electrical activity by drawing a trace on a moving paper strip.
- The electrocardiograph uses thermal paper, which is a graph paper & runs normally at a speed of 25mm/sec
- Time is plotted on the X axis & voltage is plotted on the Y axis.





STANDARD CALLIBRATION

Speed = **25mm/s**

Amplitude = **0.1mV/mm**

1mV → 10mm high

1 large square → 0.2s(200ms)

1 small square → 0.04s (40ms) or 1 mV amplitude

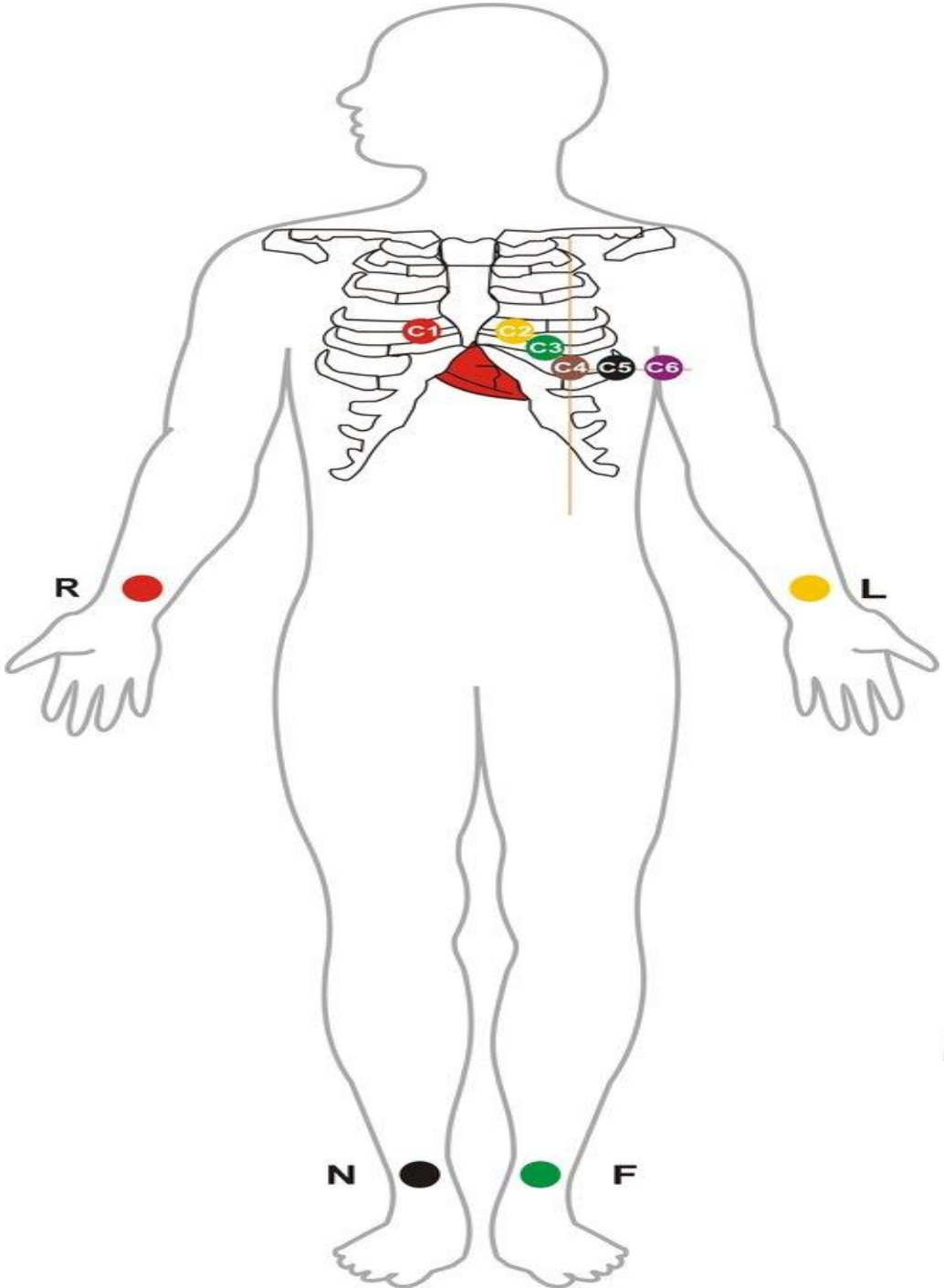
ECG leads

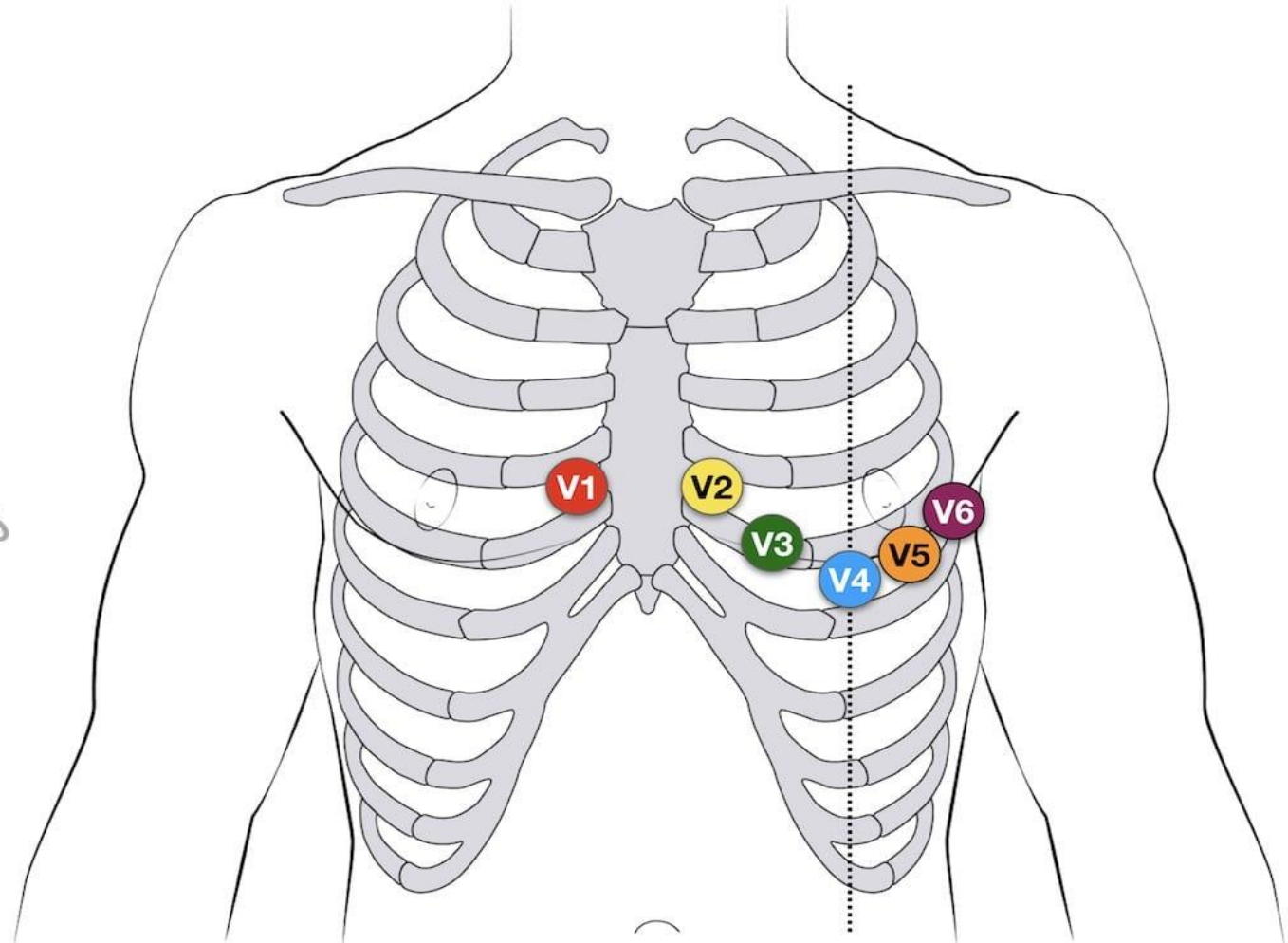
- There are two types of lead (electrodes) – Limb leads and chest leads.
- The reason we use these two leads is that the heart is a 3d structure, thus a single lead will not be able to describe its electrical activity properly.
- Hence the standard ECG consists of **12 leads**. Each leads views the heart at a unique angle of the heart.

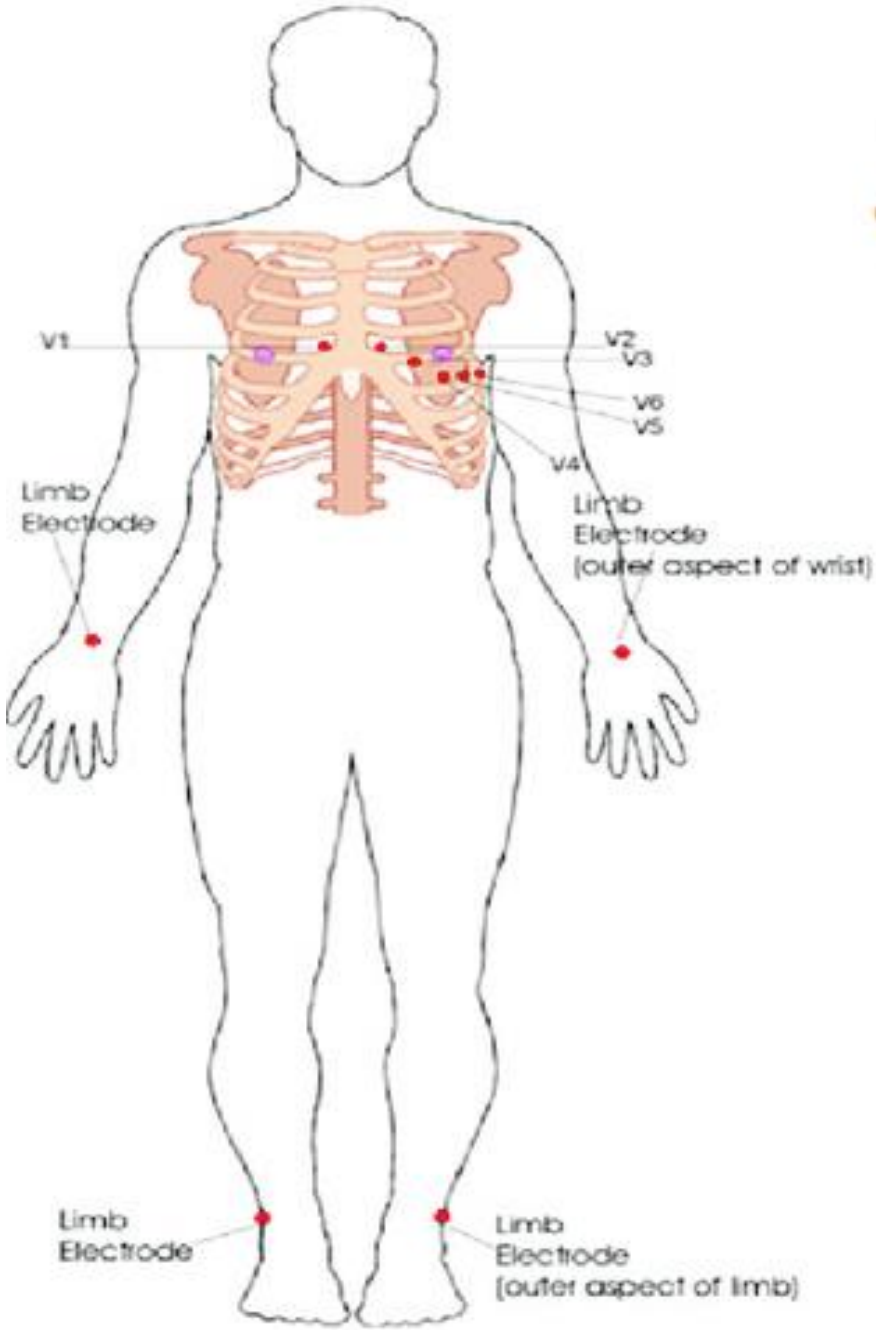
a) 3 bipolar limb leads.

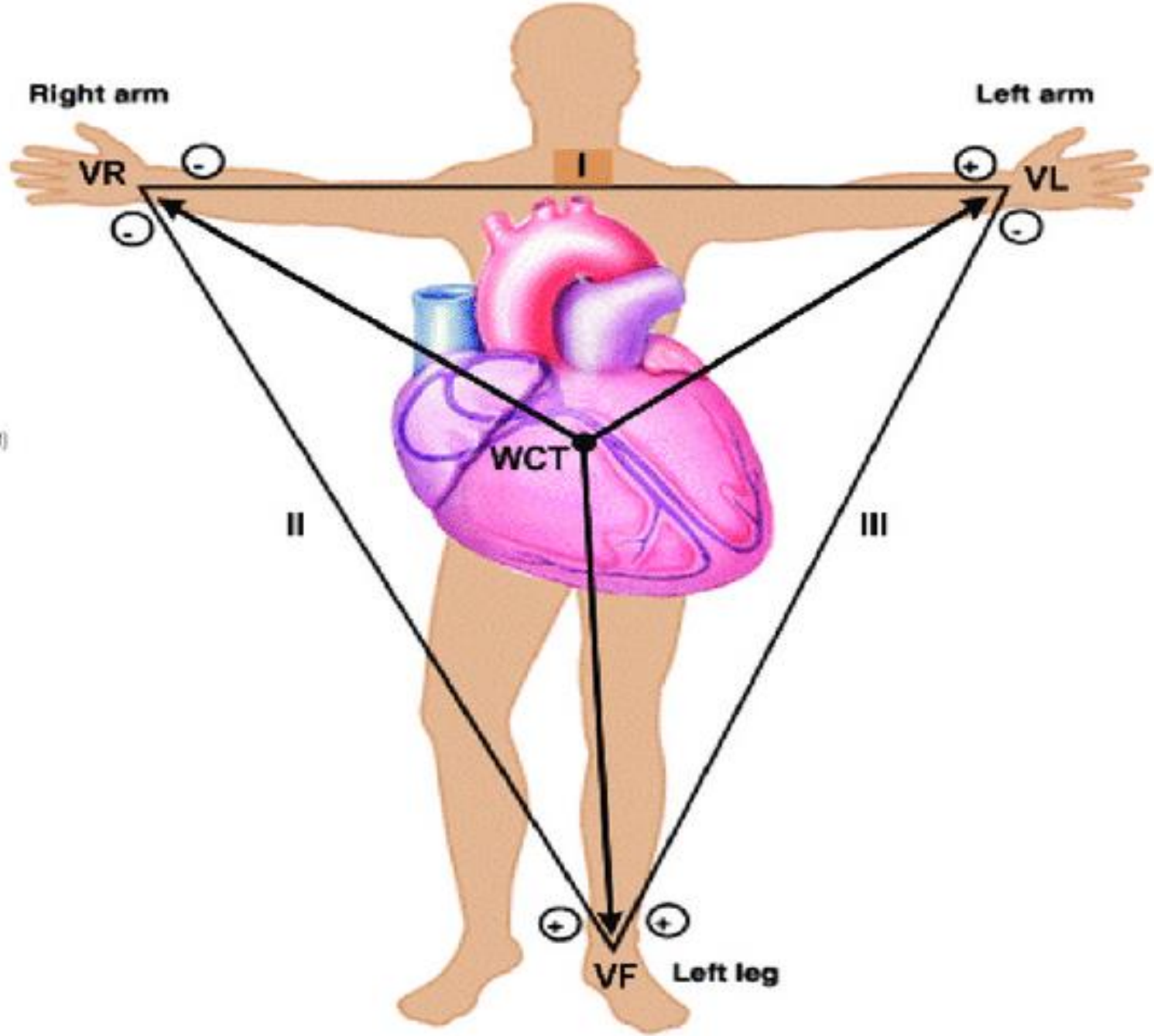
b) 3 unipolar limb leads.

c) 6 chest leads.


C1
C2
C3
C4
C5
C6
R
L
N
F

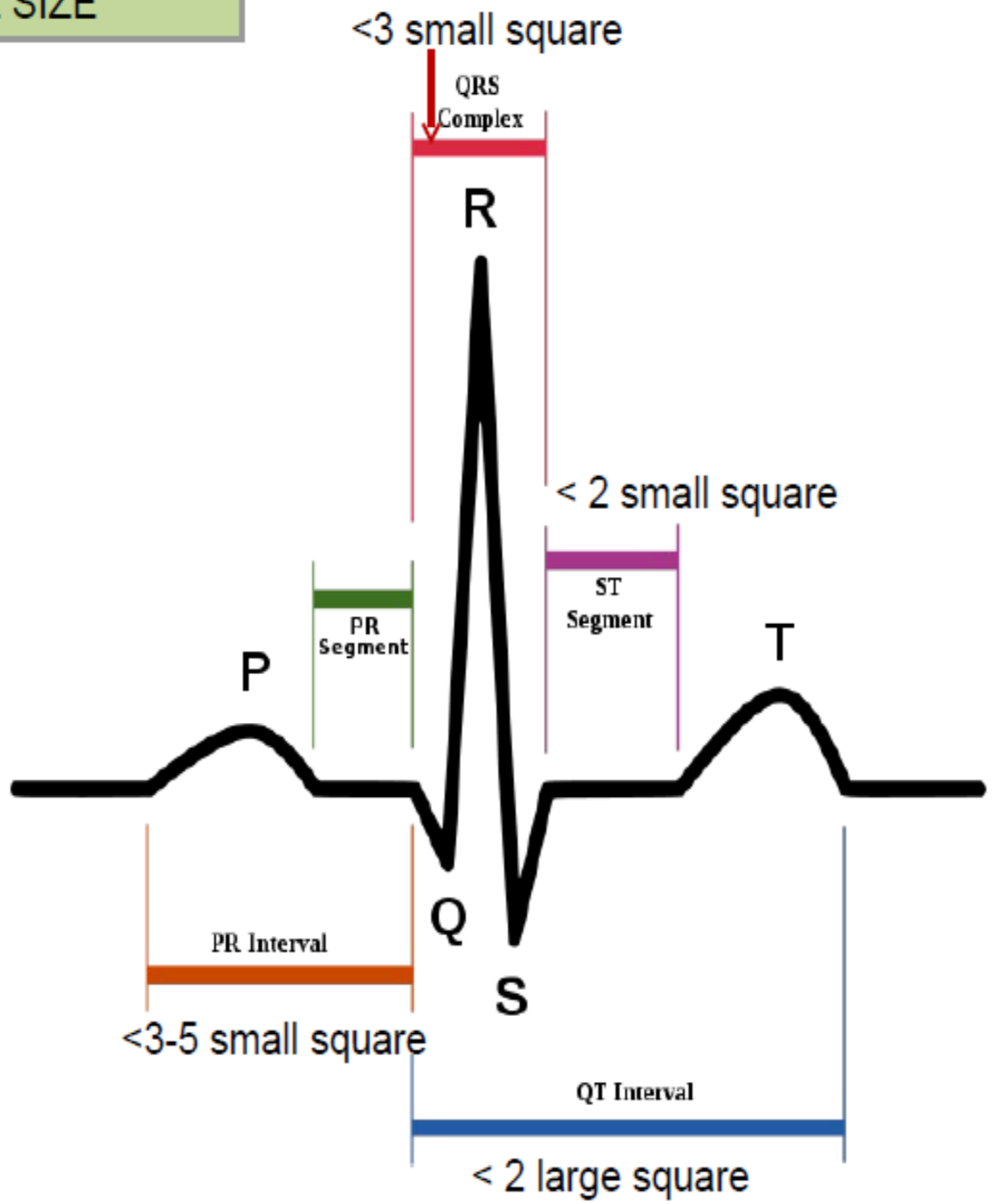

V1
V2
V3
V4
V5
V6


V1
V2
V3
V6
V5
V4
Limb Electrode
Limb Electrode (outer aspect of wrist)
Limb Electrode
Limb Electrode (outer aspect of limb)


Right arm
Left arm
VR
VL
I
WCT
II
III
VF
Left leg

A NORMAL ECG WAVE

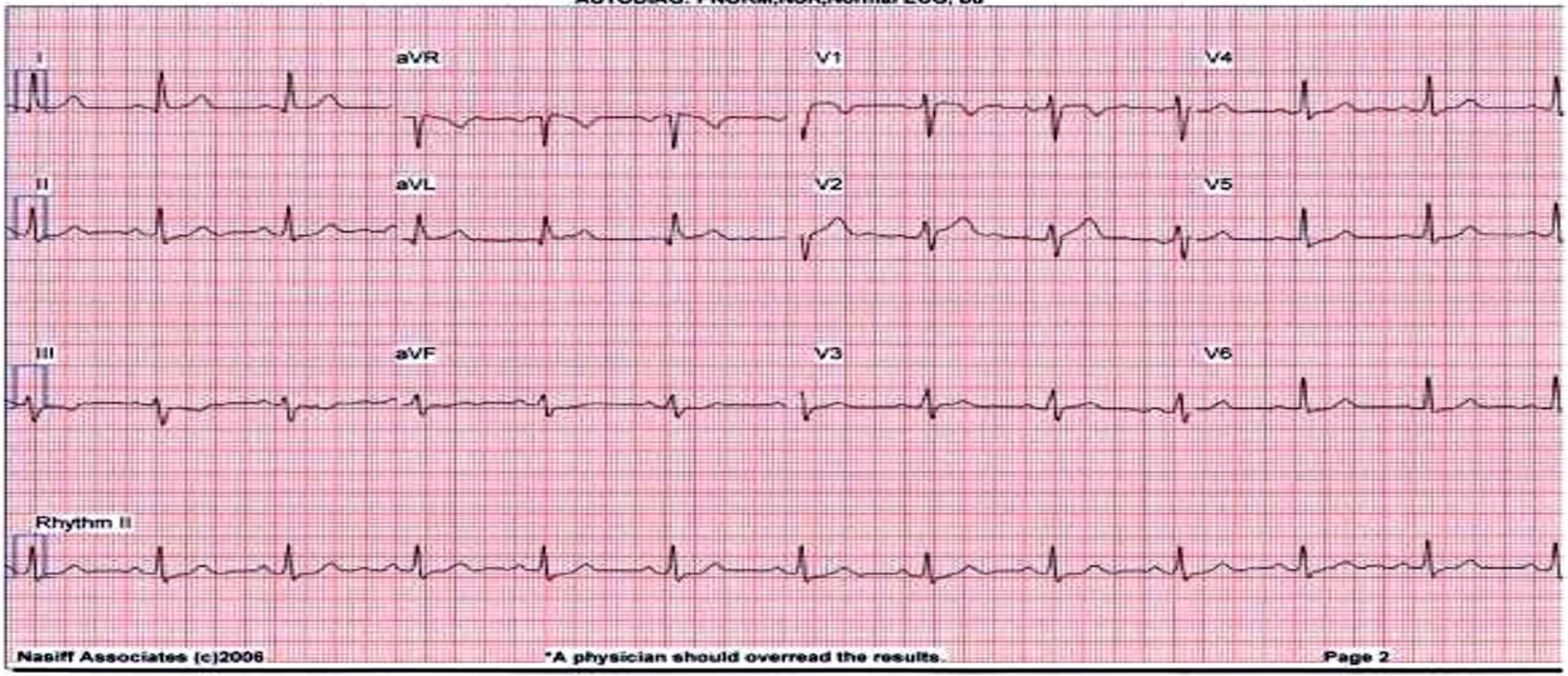
THE NORMAL SIZE



Example of a complete 12-lead EKG (ECG)

Age:39,Sex:F,Ht:5 6,Wt:170
10mm/mV, 0.05-100Hz, 25mm/sec
Medications:
Meds (con't):
Blood Pressure:

HR (bpm): 70 (lead II)
R-R (ms): 857
P dur (ms): 89
PR int (ms): 176
QRS dur (ms): 104
P/R/T axis: 58/8/18
QT/Qtc (ms): 424/438
Referring:
*** Confirmed by (required):
*** AUTODIAG: PNORM,NSR,Normal ECG, bu



Nasiff Associates (c)2006 *A physician should overread the results. Page 2

Madenat Alelem University College
Medical physics dept.
Third Stage / 2nd Semester

MEDICAL INSTRUMENTS

DR. RUAA ALMUSA

LEC. 8

ELECTRORETINOGRAPHY (ERG)

ERG

- Electroretinography (ERG) is an eye test used to detect abnormal function of the retina (light detecting portion of eye).
- It measures the electrical response of the light sensitive cells such as rods and cones.

EYE

The eye consists of 3 layers:

- Outer Fibrous

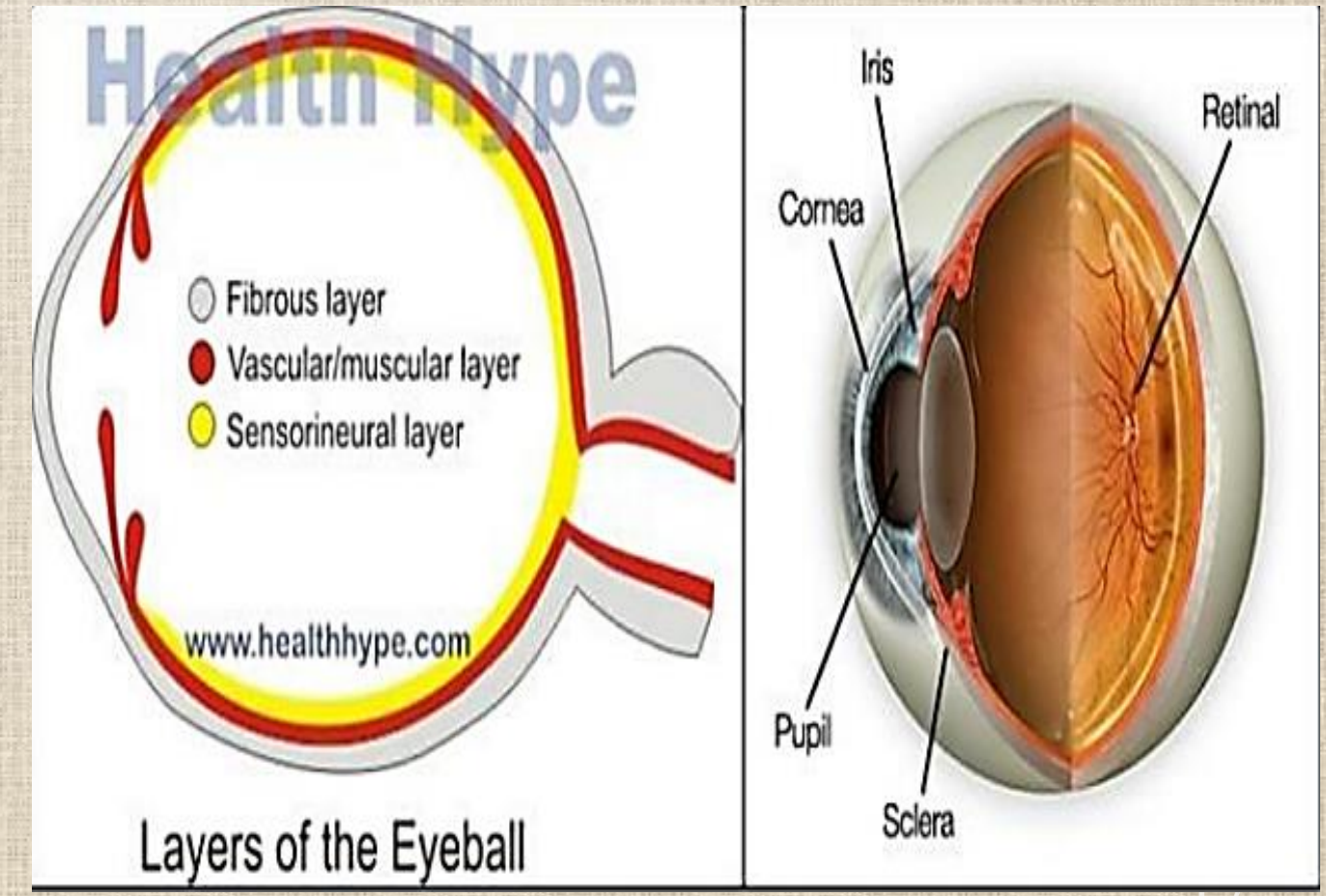
Tunic sclera, cornea, limbus

- Middle Vascular Tunic

Iris, Ciliary body, choroid

- Inner Nervous Tunic

Retina



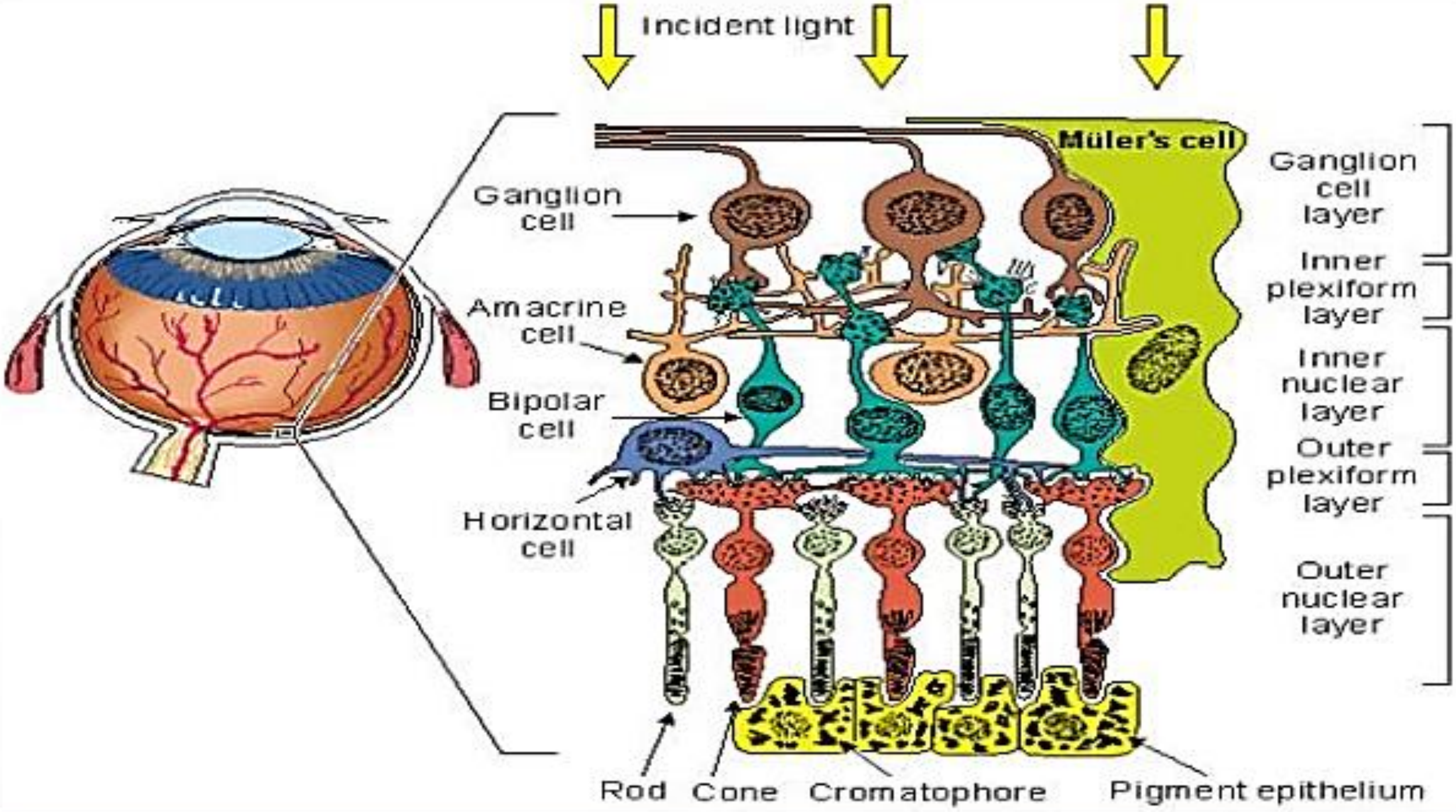
RETINA

It is delicate two layered membrane:

- Pigmented Layer : which absorb light and prevent it from scattering
- Neural Layer : which contains photoreceptors to transduce light energy

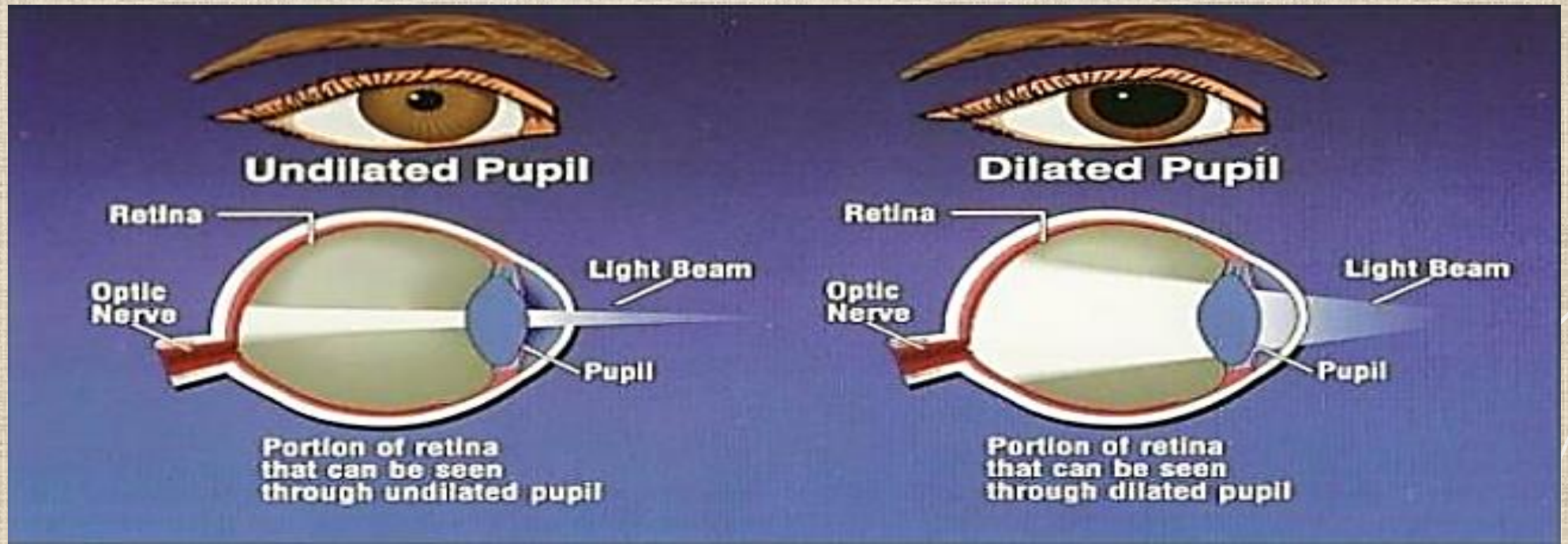
The **photoreceptors** are:

1. Rods : respond to dim and bright light
2. Cones: respond to colours


Incident light
Müler's cell
Ganglion cell
Amacrine cell
Bipolar cell
Horizontal cell
Ganglion cell layer
Inner plexiform layer
Inner nuclear layer
Outer plexiform layer
Outer nuclear layer
Rod
Cone
Cromatophore
Pigment epithelium

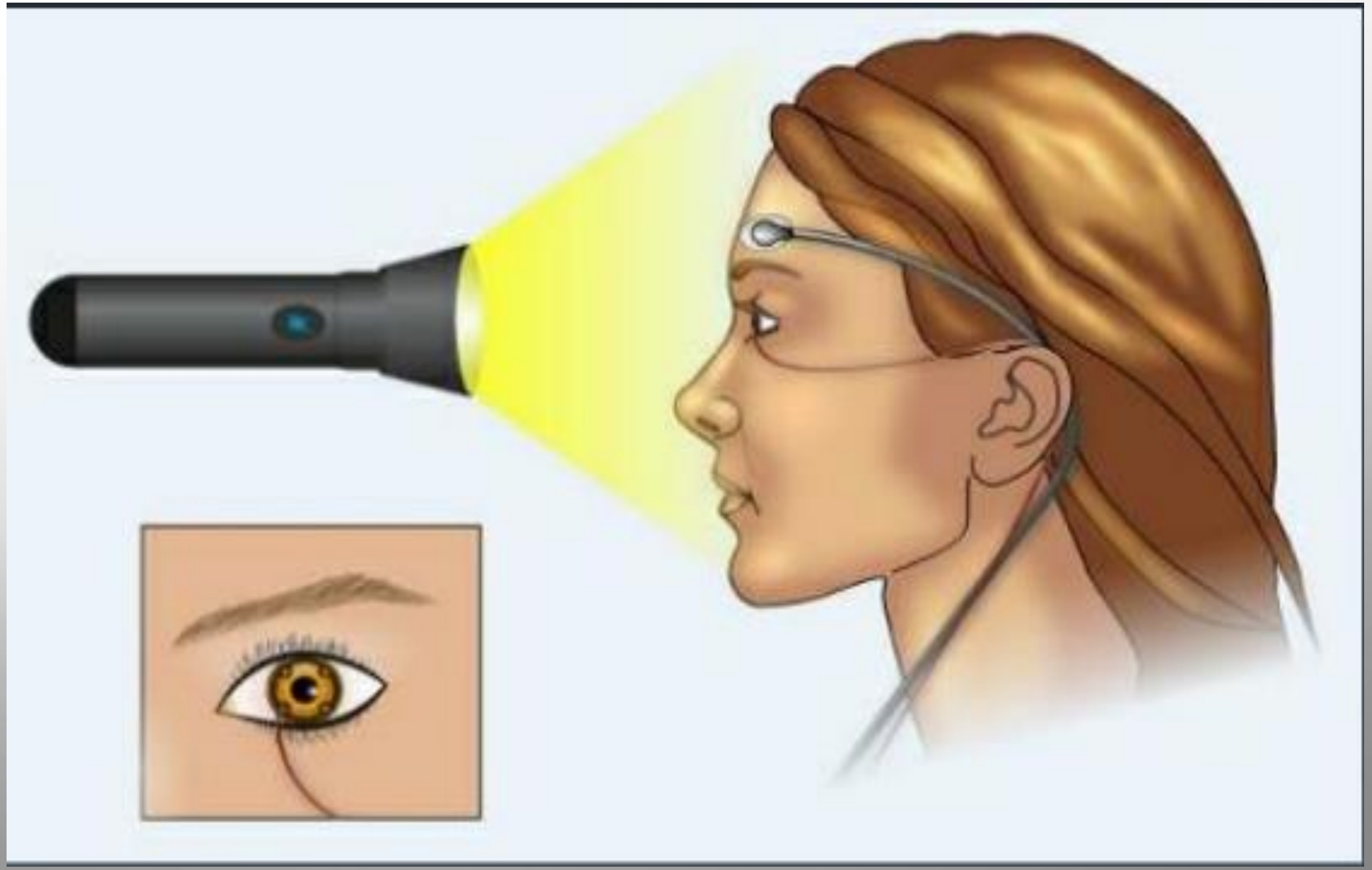
ERG PROCEDURE

- Usually the patient's eyes are dilated beforehand with standard dilating eye drops.
- Anesthetic drops are then placed in the eyes, causing them to become numb.



ERG PROCEDURE

- An electrode is gently placed on each eye with a device very similar to a contact lens. An additional electrode is placed on the skin to provide a ground for the very faint electrical signals produced by the retina.
- During an ERG recording session, the patient watches a standardized light stimulus, and the resulting signal is interpreted in terms of its amplitude (voltage) and time course.



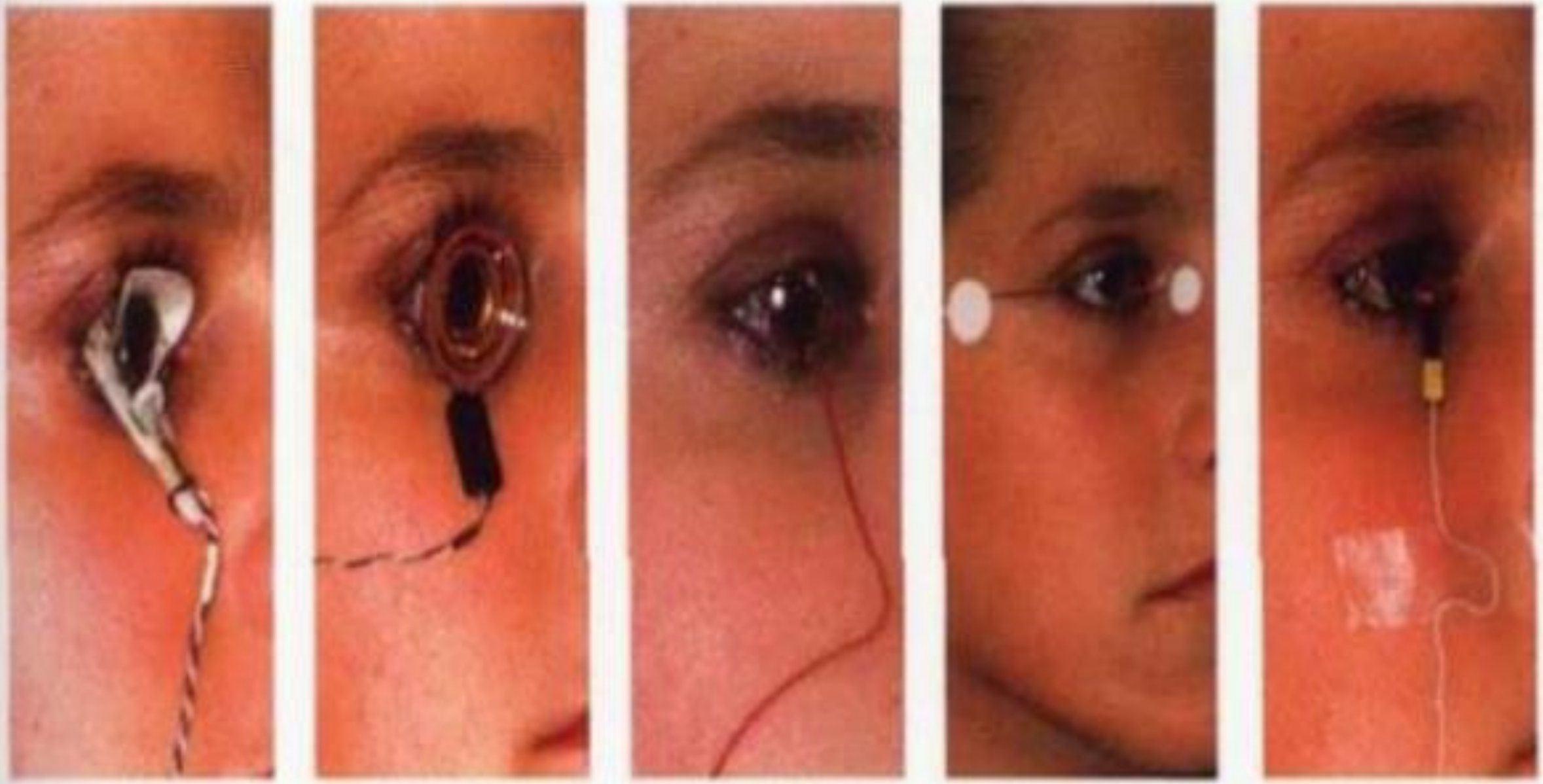
EQUIPMENT

1. Electrodes

The electrodes measure light response of the retina . The information that comes the electrical activity from each electrode is transmitted to a monitor where it is displayed as two types of waves, labelled the A waves and B waves.

Several types of electrode used are:

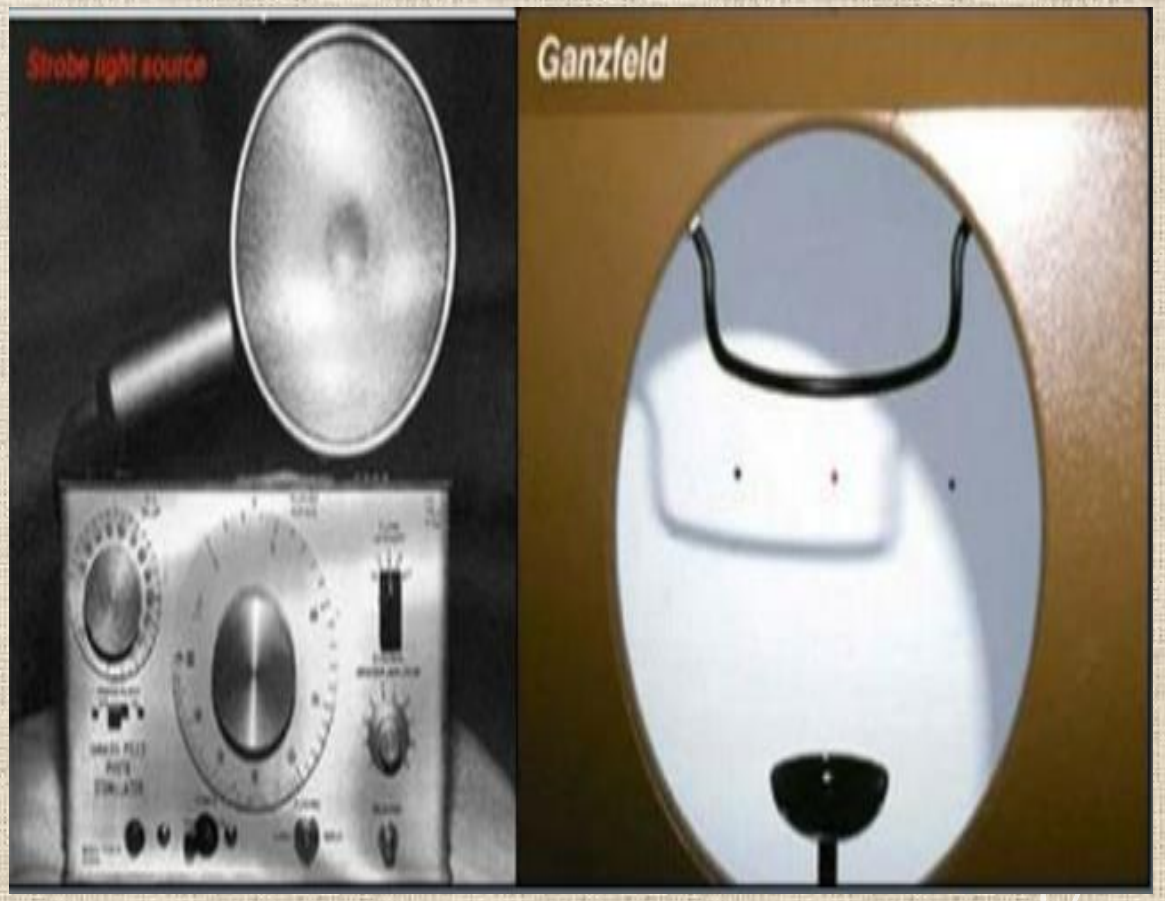
1.speculum structure 2.Gold mylar tape 3.Jet 4. DTL


Burian-Allen
Goldlens
Jet
DTL
Gold-Foil

LIGHT SIMULATORS

Two Type of light simulators are used in test

- Strobe light source (Mobile and simple)
- The Ganzfeld Simulation Globe (Best control of intensity)

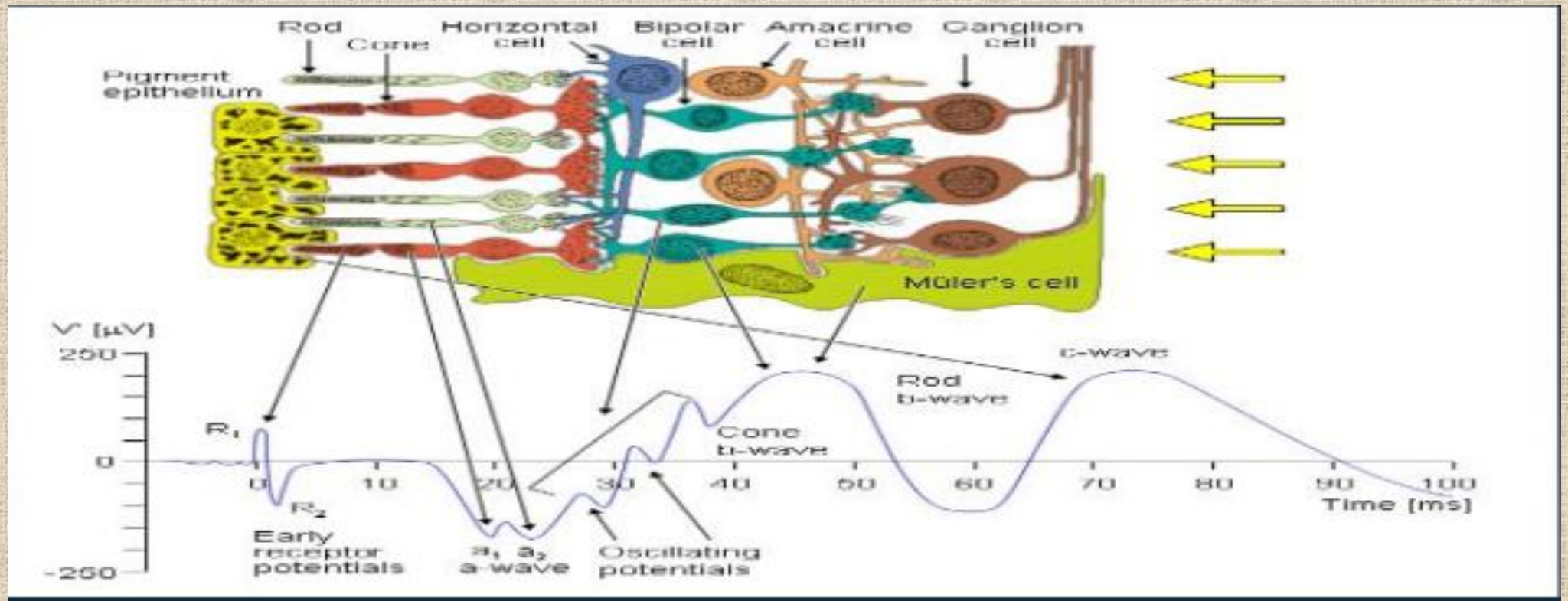


ELECTRORETINOGRAPHY READINGS

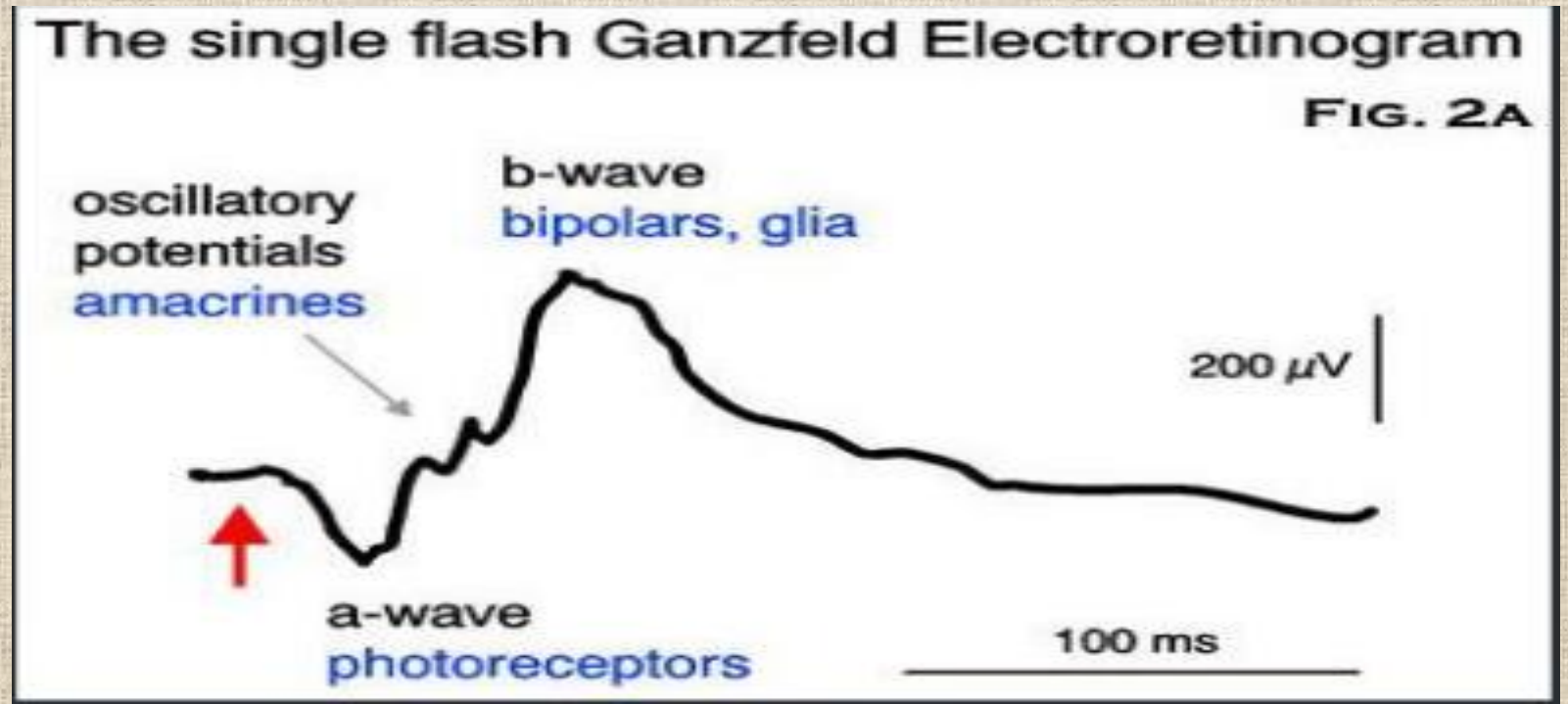
Readings during electroretinography are usually taken first in normal room light. The lights are then dimmed for 20 minutes, and readings are again taken while a white light is shined into the eyes. The final readings are taken as a bright flash is directed toward the eyes.

NORMAL ELECTRORETINOGRAPHY

A normal ERG shows a normal A- and B-wave pattern with appropriate increases in electrical activity with increased light intensities.



- A-wave : Both rods and cones contributes to it. This is produce due to the hyper-polarisation of rod and cones
- B-wave : Generated by ON and OFF bipolar cell activity, probably containing contributions from the glial Müller cells.



Madenat Alelem University College

Medical physics dept.

Third Stage / 2nd Semester

Medical Instruments

Dr. Ruaa Almusa

Lec. 9

ELECTROENCEPHALOGRAM

(EEG)

EEG

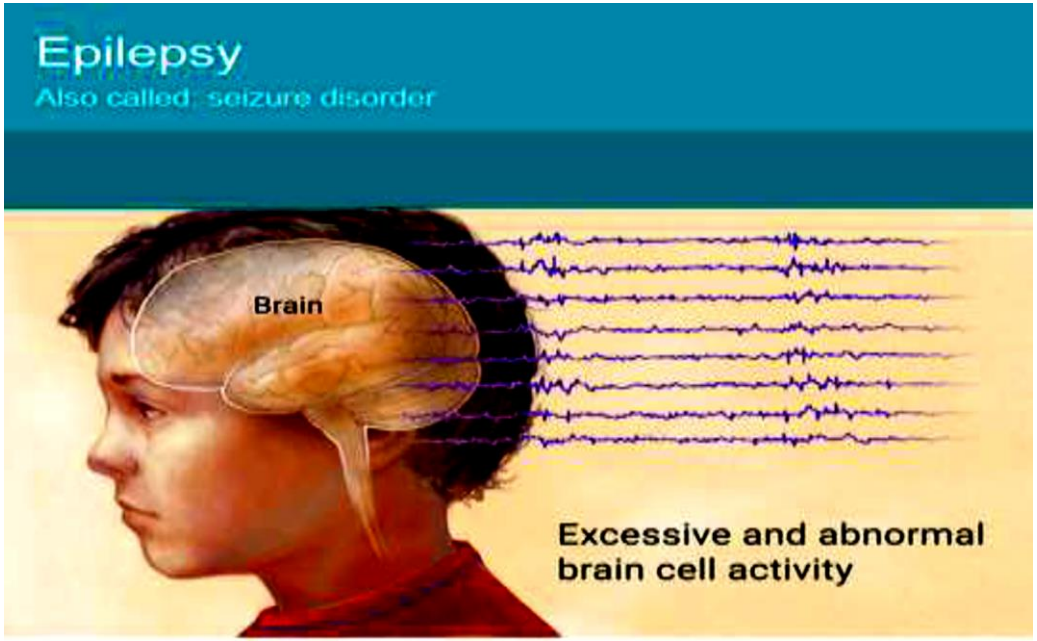
- EEG is a medical device for analysing the electrical activity of the brain.
- It can detect Epilepsy or Alzheimer's diseases. .
- Used in humans by Hans Berger in 1924.
- The general mechanism is picking up the charge of electrical potentials.
- The neurons are negative (-) when they are at rest and become positive (+) at action state.

- During an EEG test , small electrodes like cup or disc type are placed on the scalp.
- They pick up the brain’s electrical signals and send them to the amplifiers because the power of brain signal is very small and then for the machine called **Electroencephalogram**.

- It records the signals as wavy lines on to a computer screen or paper.
- EEG wave frequency range = 0.1 to 100 and amplitude = 2 to 200 micro volt.
- The neurologist can compare them with normal EEG recording.

EEG USES

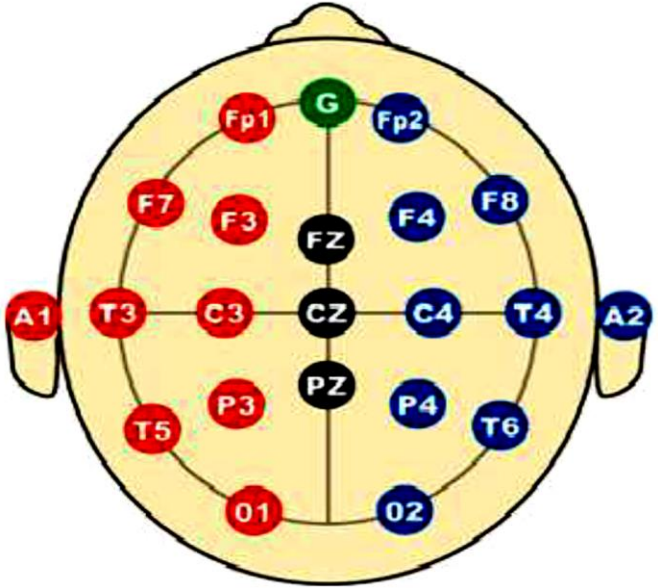
- Epilepsy
- Head injury
- Encephalitis (inflammation)
- Brain tumour
- Encephalopathy
- Memory problems
- Sleep disorders
- Brain activity through coma.
- During brain surgery.



COMPONENT OF EEG

1. Electrodes

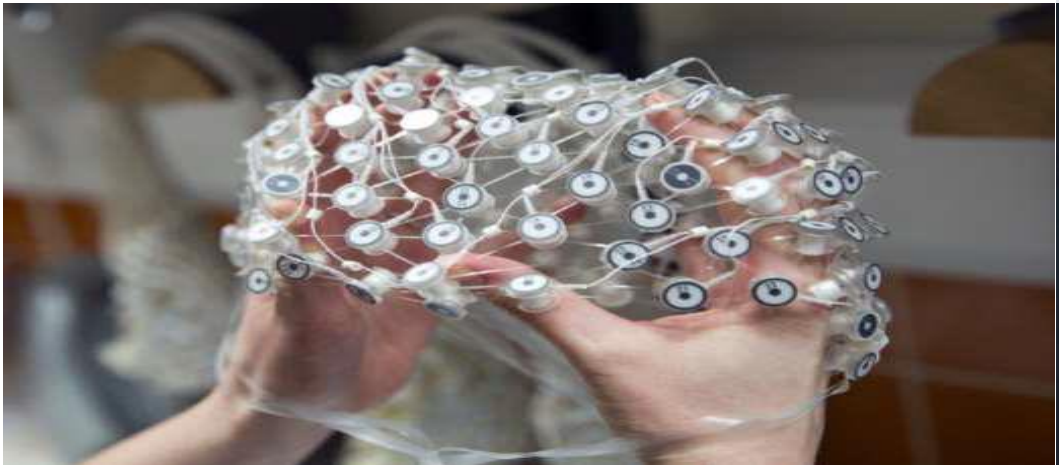
- Small metal discs placed on the scalp in special position these position is specified using the international 10/20 system.
- Each electrode site is labelled with a letter and a number, refer to the area of brain underlying the electrode.
- Even numbers denote the right side of the head and odd numbers denote the left side of the head.

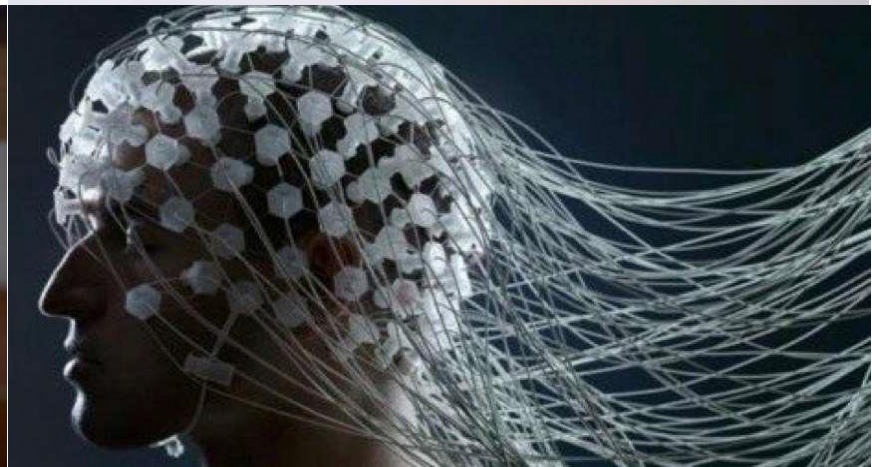


The letters used are:

F - Frontal lobe
T - Temporal lobe
C - Central lobe
P - Parietal lobe
O - Occipital lobe

"Z" refers to an electrode placed on the mid-line.



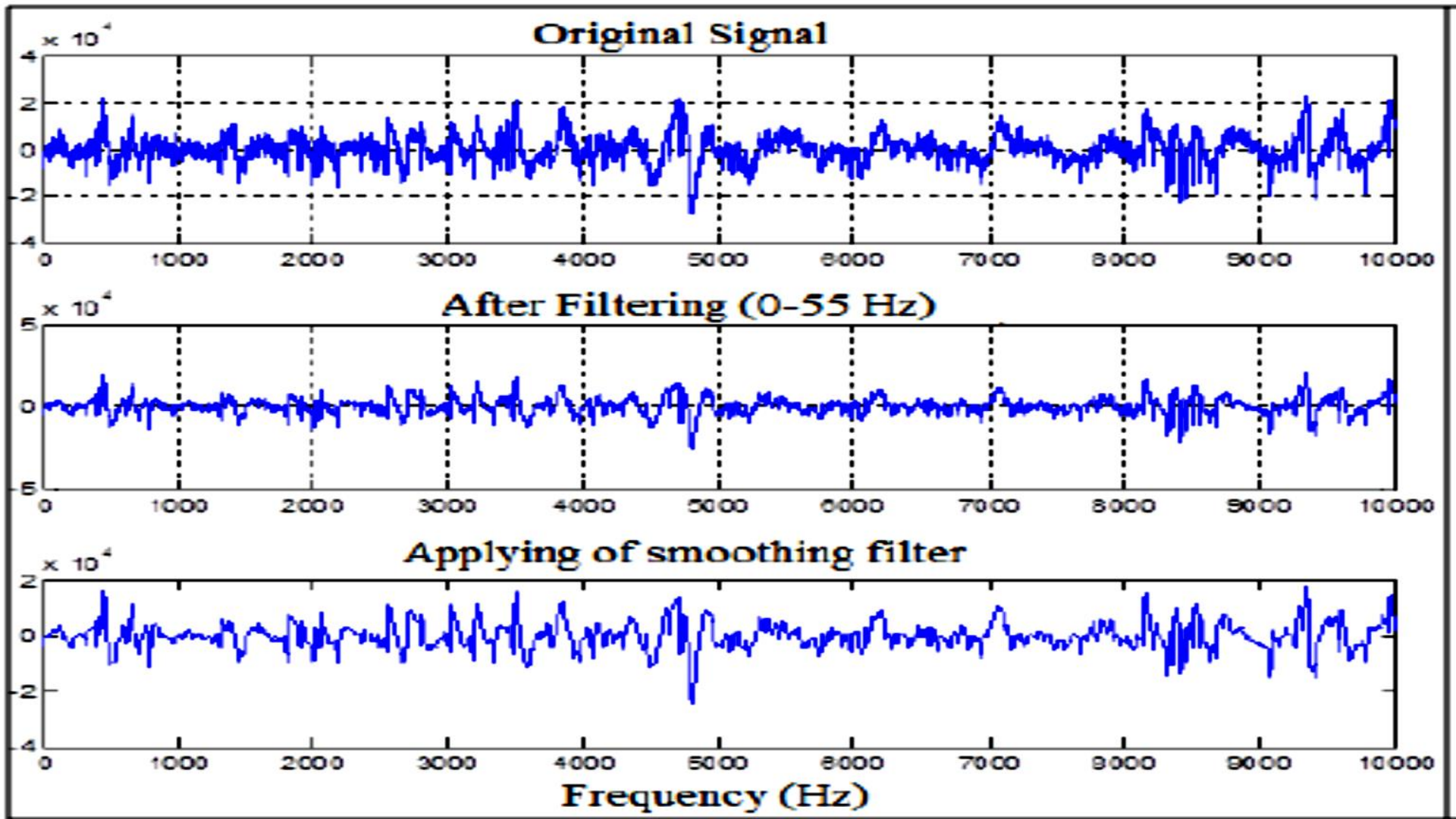


2. Amplifier

It is an electronic device that increases the power of a signal by taking energy from a power supply and controlling the output to match the input signal shape but with a larger amplitude. Human brainwave activity is too subtle to read unless the signal is amplified.

3. Filters

The use of filters in recording and displaying EEG data is an important tool in producing interpretable EEG tracings. Without filters, many segments of EEG would be essentially unreadable. The main benefit of filters is that they can appear to “clean up” the EEG tracing, making it easier to interpret and generally more pleasing to the eye.


Original Signal
x 10^-4
4
2
0
-2
-4
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
After Filtering (0-55 Hz)
x 10^-4
5
0
-5
Applying of smoothing filter
x 10^-4
2
0
-2
-4
Frequency (Hz)

4. Writing unit

A pen-ink-paper system is employed. The speed of the paper mechanism should include 30 mm/s with at least the additional speeds of 15 mm and 60 mm/s selectable during operation.

The writing unit may be replaced by a digital screen in modern EEG devices.

EEG Waveform

EEG waveforms are generally classified according to their frequency, amplitude, and shape, as well as the sites on the scalp at which they are recorded. The most familiar classification uses EEG waveform frequency (alpha, beta, theta, and delta).

- Frontal lobes:

Emotional & motor control.

- Parietal lobes:

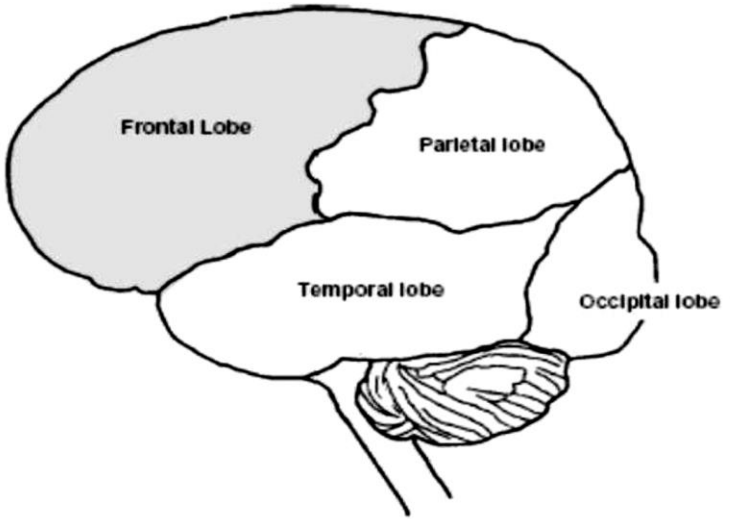
Sensory purpose (pain, touch, pressure).

- Temporal lobes:

Auditory system (hear & sound).

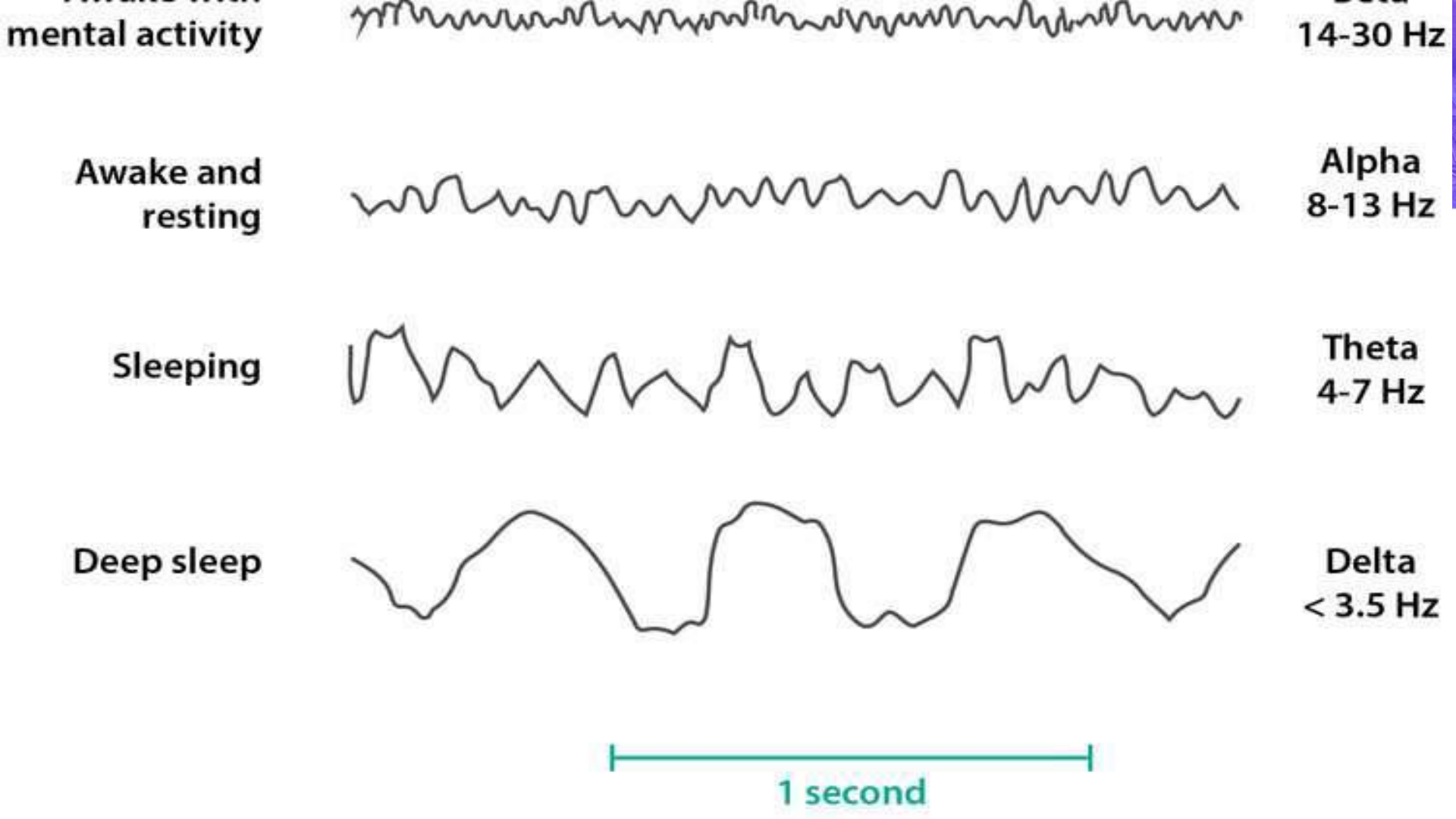
- Occipital lobes:

Visual purpose (see & eye).



- ✓ The slowest waves are called **delta**, and they occur at 1 to 4 cycles per second. Delta occurs in sleep and during anaesthesia.
- ✓ The next frequency is called **theta**, and it occurs at 4 to 8 cycles per second. Theta is seen when a person is trying to keep many different things, such as numbers or words, in memory. It is also seen when a person is drowsy.
- ✓ After theta comes **alpha**, a wave occurring at 8 to 12 cycles per second. Alpha is seen over the back of the head when a person has his or her eyes shut. It is also seen when a person is resting or meditating.

- ✓ Faster than alpha is **beta**, a wave that occurs at 12 to 30 cycles per second. It is seen when a person is getting ready to move or no longer resting. It is also seen when a person takes a particular drug (benzodiazepine) drugs.
- ✓ Finally, **gamma** is the fastest wave seen in EEG, occurring at 30 to 100 cycles per second. It is seen when a person is thinking or paying attention to something.


mental activity
14-30 Hz
Awake and resting
Alpha
8-13 Hz
Sleeping
Theta
4-7 Hz
Deep sleep
Delta
< 3.5 Hz
1 second

Madenat Alelem University College
Medical physics dept.
Third Stage / 2nd Semester

Medical instruments

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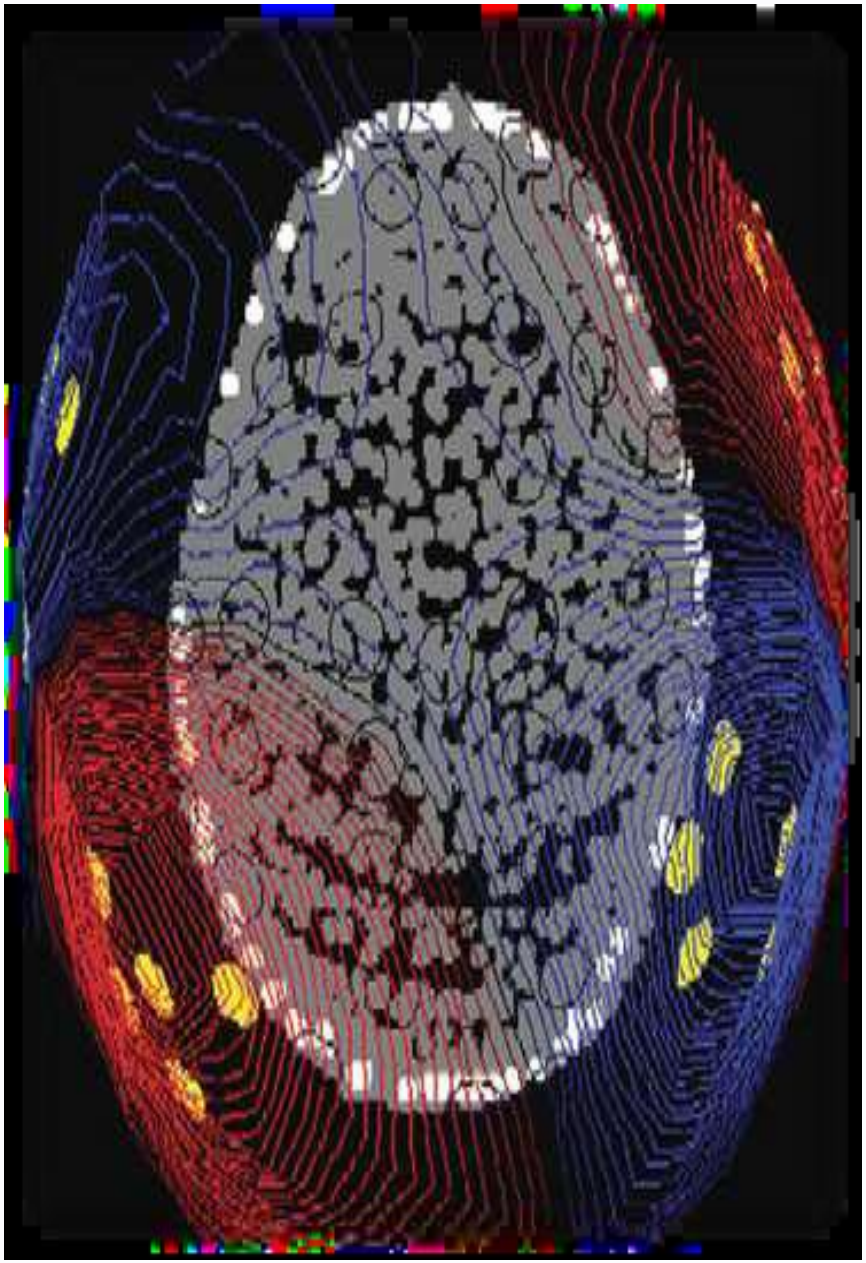
Lec. 10

MAGNETOENCEPHALOGRAM (MEG)

(MEG)

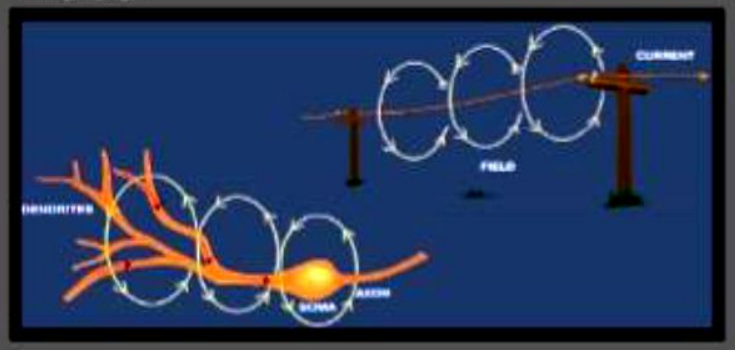
- Magnetoencephalography (MEG) is a non-invasive neurophysiological technique that measures the magnetic fields generated by neuronal activity of the brain using very sensitive magnetometers.
- The distributions of the magnetic fields are localize the sources of the activity within the brain and appeared on anatomical images to provide information about both the structure and function of the brain.

- Since magnetic fields are recorded from the naturally occurring electrical currents in the brain. It is an Natural Signal.

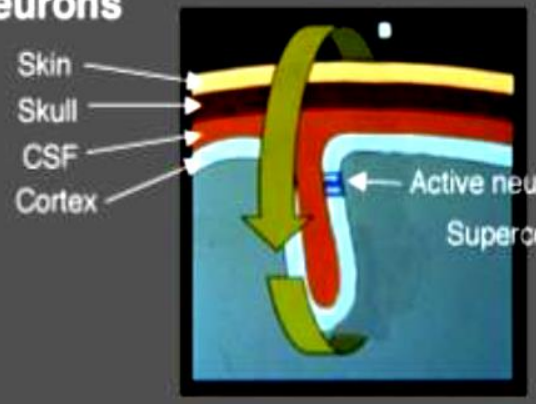


Basic Principles of MEG

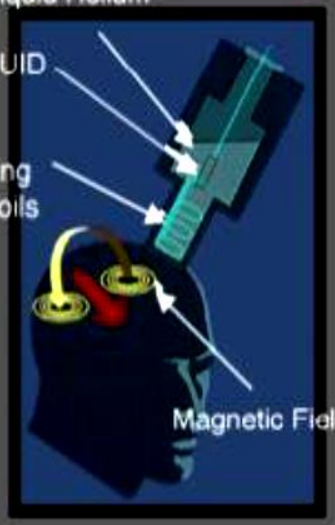
Sources of Magnetic Fields



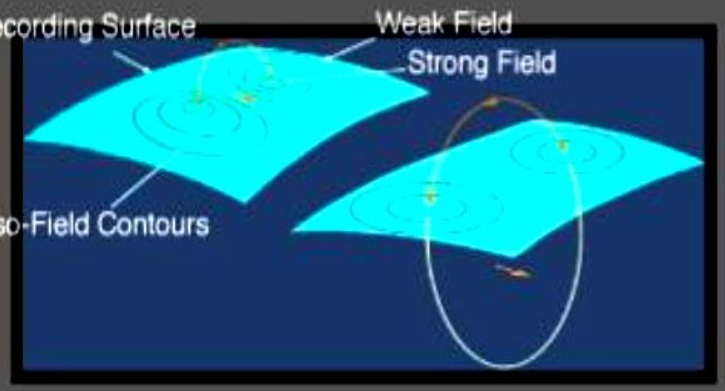
Orientation of Neurons



Detection Device

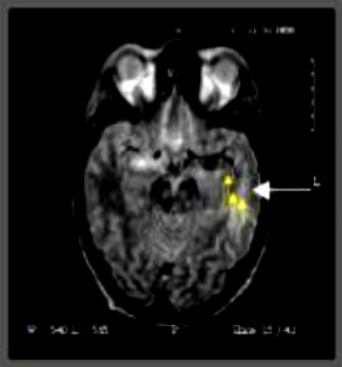


Magnetic Field Pattern

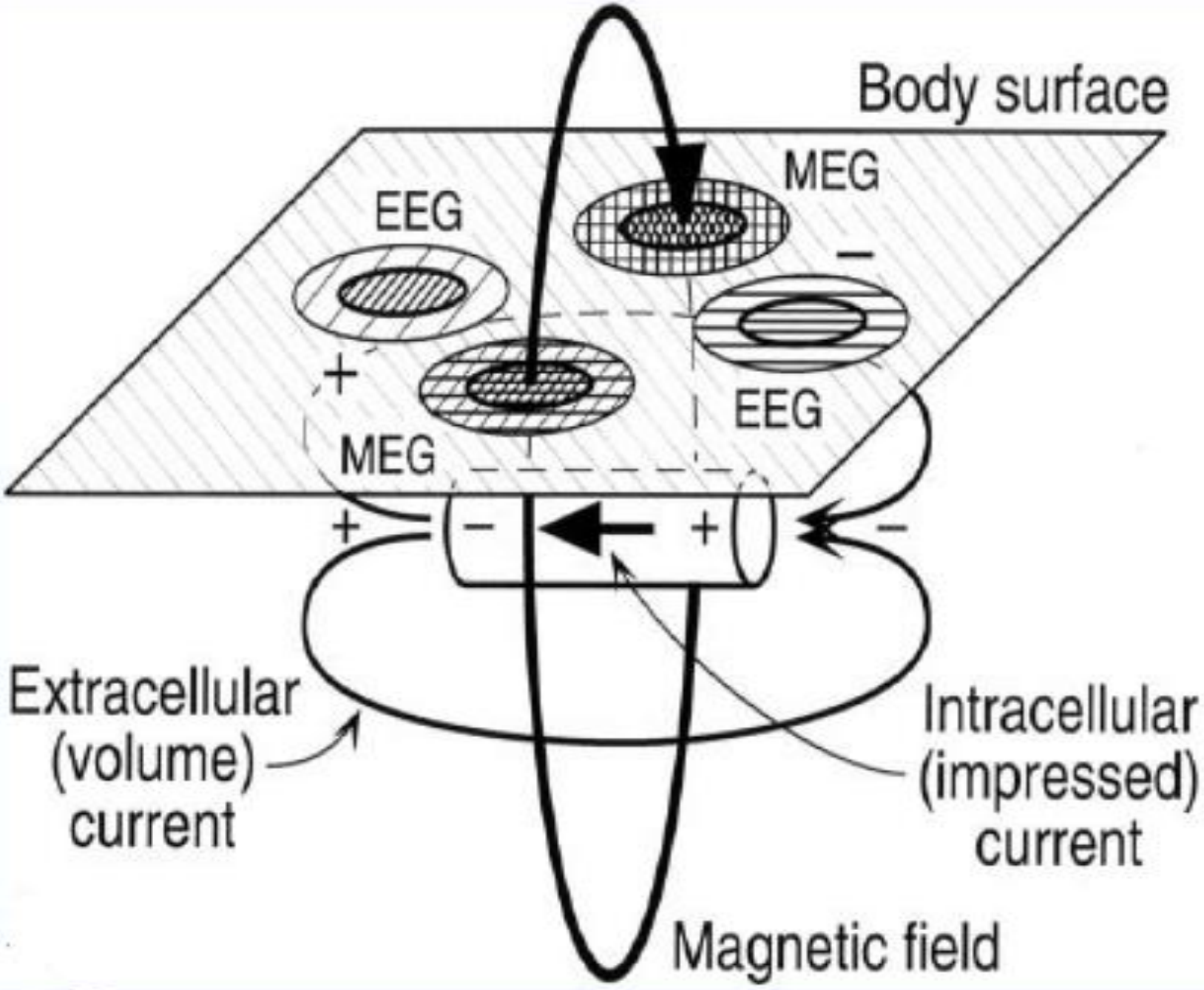


Model

Result



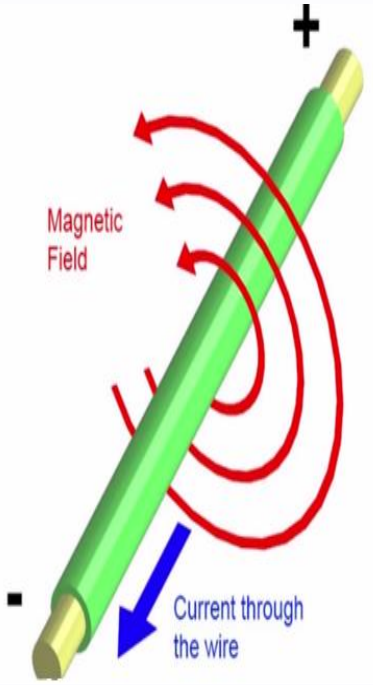
Sources of epileptic spikes

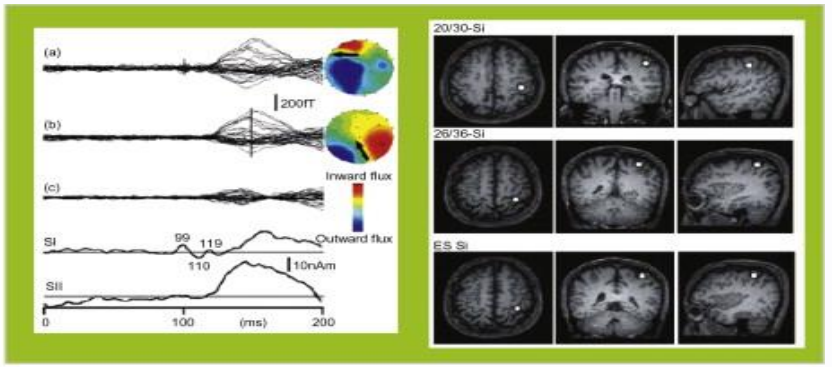

Body surface
MEG
EEG
−
+
EEG
MEG
+
−
+
−
Extracellular
(volume)
current
Intracellular
(impressed)
current
Magnetic field

(MEG) WORKING

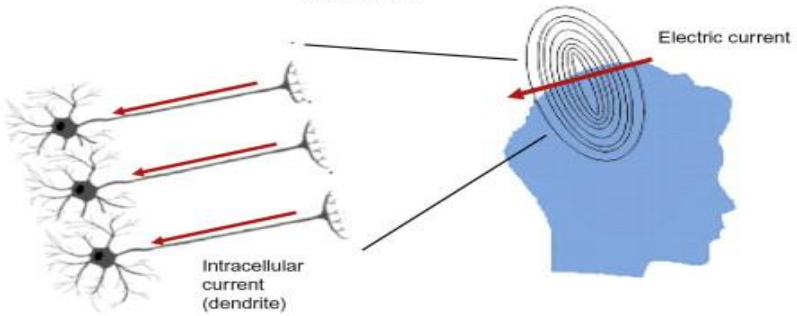
- At the cellular level, individual neurons in the brain have electrochemical properties that result in the flow of electrically charged ions through a cell.
- Electromagnetic fields are generated by the net effect of this slow ionic current flow.

- While the magnitude of fields associated with an individual neuron is negligible, the effect of multiple neurons (50,000–100,000) excited together in a specific area generates a measureable magnetic field outside the head.



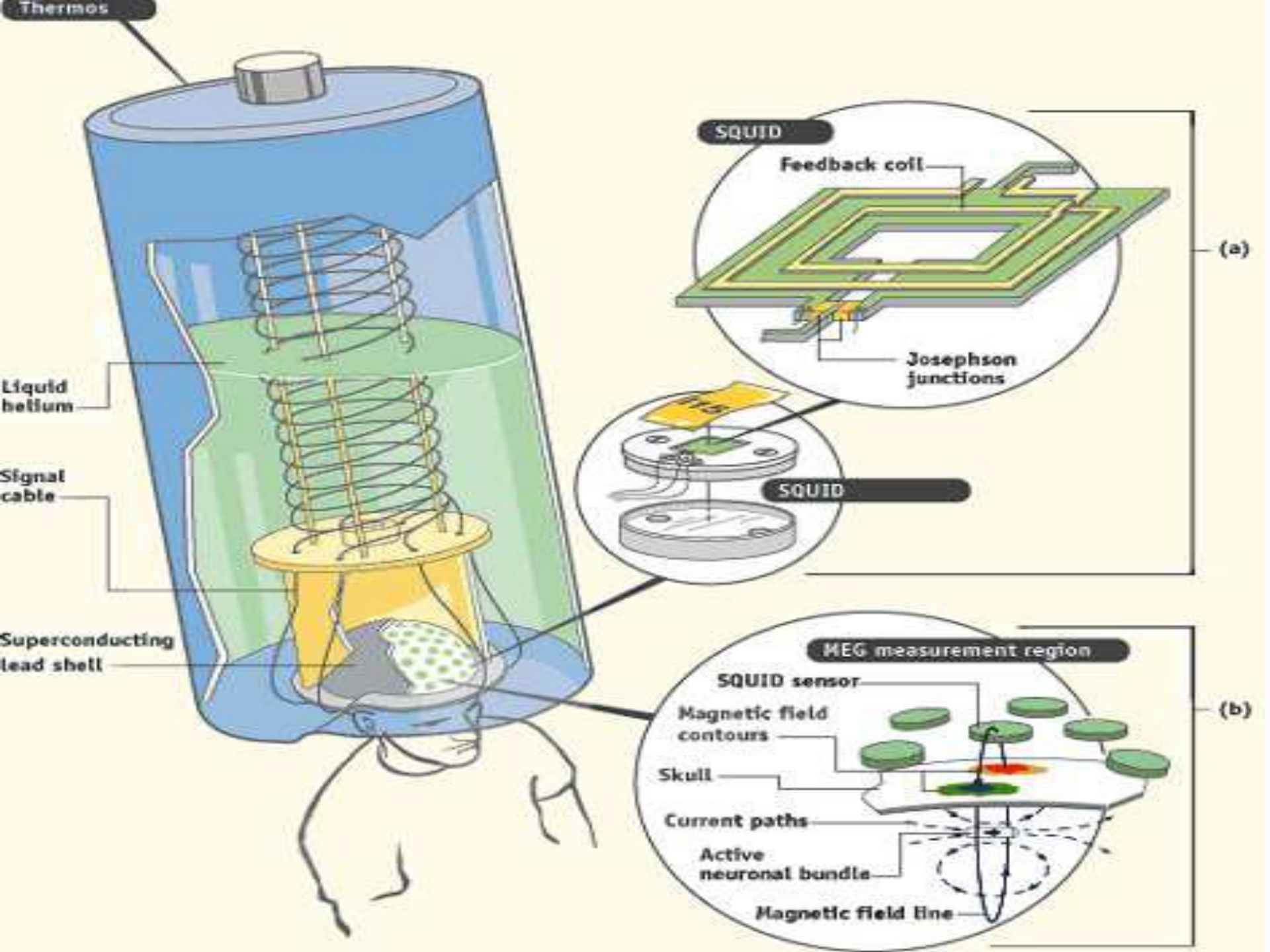


Magnetic field



- These neuron magnetic signals generated by the brain are extremely small — a billionth of the strength of the earth's magnetic field. Therefore, MEG scanners require superconducting sensors SQUIDs (a devices used in particular in sensitive magnetometers, which consists of a superconducting ring; A change of magnetic flux produces a sharp change in its impedance)

- Rooms for MEGs have walls made of Aluminium and MU-metal (a type of nickel-iron alloy with extremely high magnetic permeability).
- Aluminium shields from high frequency Noise.
- MU-metal shields from low frequency noise.


Thermos
Liquid helium
Signal cable
Superconducting lead shell
SQUID
Feedback coil
Josephson junctions
(a)
SQUID
MEG measurement region
SQUID sensor
Magnetic field contours
Skull
Current paths
Active neuronal bundle
Magnetic field line
(b)

RECORDING OF THE MAGNETIC FLUX

- Recorded by special sensors called *magnetometers*
- A magnetometer is a loop of wire placed parallel to the head surface
- The strength (density) of the magnetic flux at a certain point determines the strength of the current produced in the magnetometer
- Present day machines have 248 magnetometers

- Because the magnetic fields are extremely small, the magnetometers must be superconductive (have extremely low resistance) and resistance in wires is lowered when the wires are cooled to extremely low temperatures
- The liquid helium keeps the wires at a temperature of about 4 degrees Kelvin
- The magnetometers are superconductive at this temperature

- The magnetometers and their SQUIDS are kept in a dewar, which is filled with liquid helium to keep them at an extremely low temperature