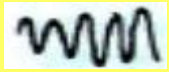
Electroencephalogram (EEG)

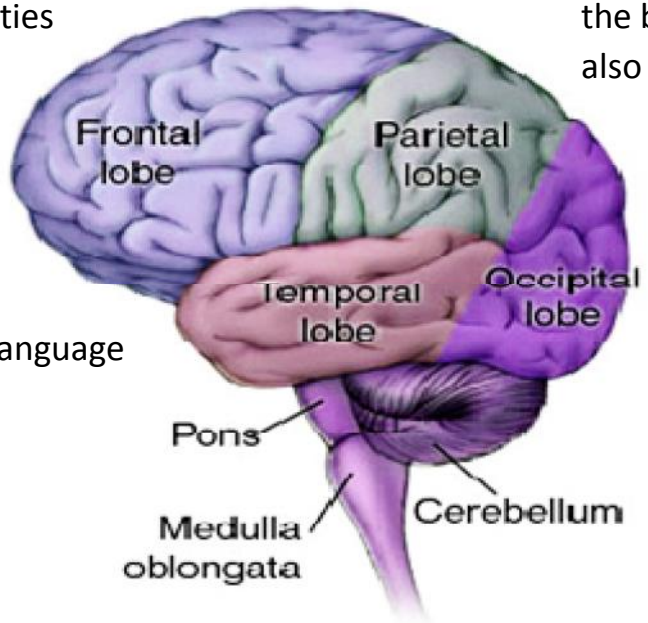
- The electroencephalogram (EEG) is a recording of electrical activity originating from the brain
- Analyzed in four frequency bands associated to certain activities as follows

Type of Wave	Shape	Frequency per second	Amplitude in pV	Physiologic variations of potential		
				In waking EEG		In Sleeping EEG
				Ault	Child	All ages
beta		14-30	5-50	Frontal and precentral prominent, in clusters	Seldom prominent	Beta-activity ("spindles") sign of light sheep
alpha		8-13	20-120	Predominant activity	Predominant activity, age 5 and above	Not a sign of sleep
theta		4-7	20-100	Constant, not prominent	Predominant activity, from 18 mos. To 5 years	Normal sign of sleep
delta		0.5-3	5-250	Not prominent	Predominant activity until 18 mos.	Concomitant sign of deep sleep
gamma		31-60	-10	Laws governing predominance and localization not fully known		

Brain Lobes

Frontal lobe
control skilled muscle movements, mood, planning for the future, setting goals and judging priorities

Parietal lobe
receives and processes information about temperature, taste, touch, and movement coming from the rest of the body. Reading and arithmetic are also processed in this region



Occipital lobe
process visual information

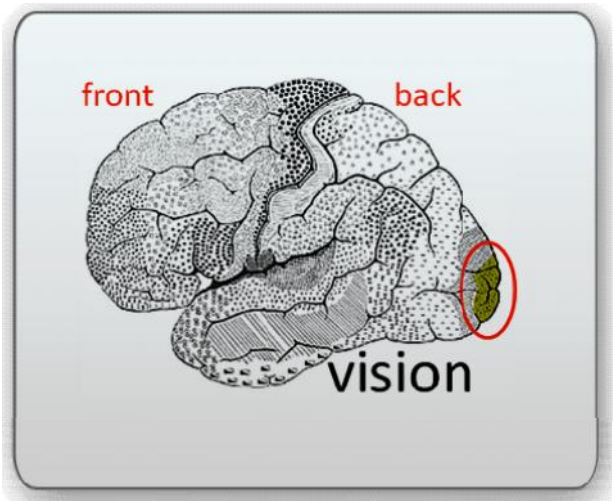
Temporal lobe
hearing, memory and language functions

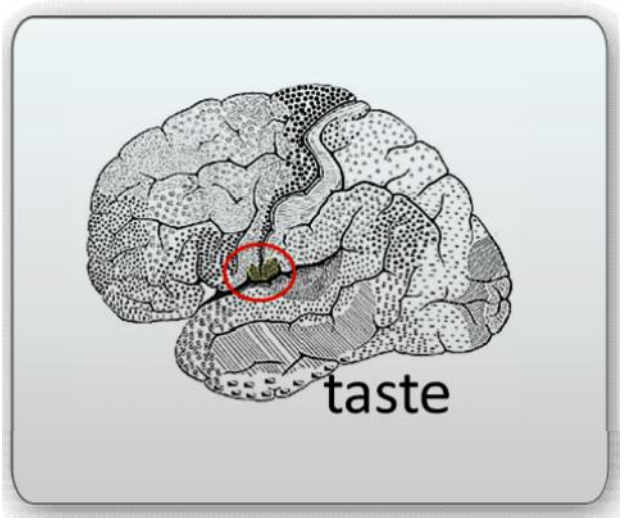
Cerebellum
coined as the "little brain", it governs movement, postural adjustments and stores memories for simple learned motor responses

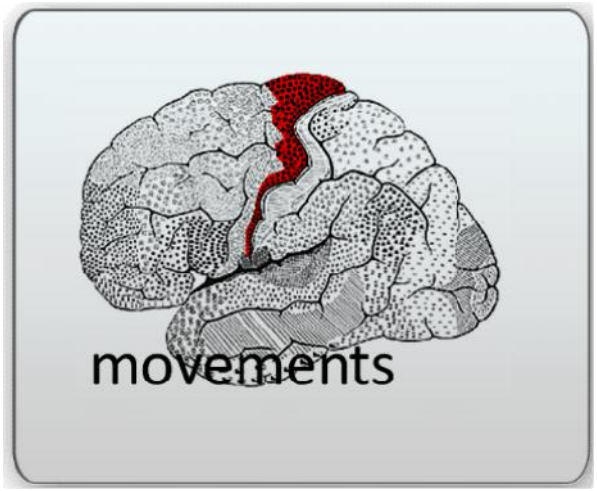
Pons
contains centres for the control of respiration and cardiovascular functions. It is also involved in the coordination of eye movements and balance

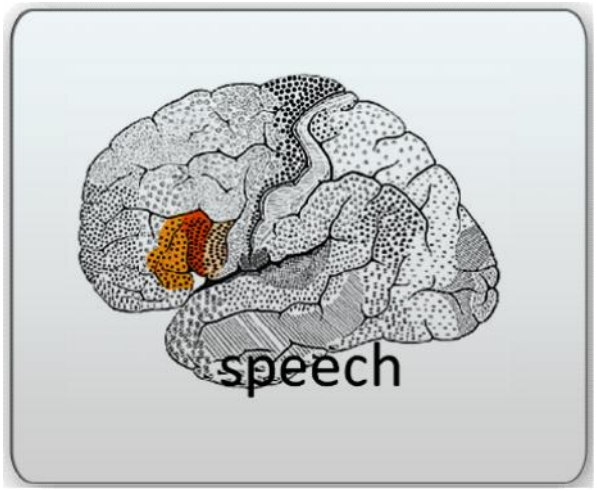
Medulla oblongata
contains centres for the control of heart rate, respiration, blood pressure and swallowing

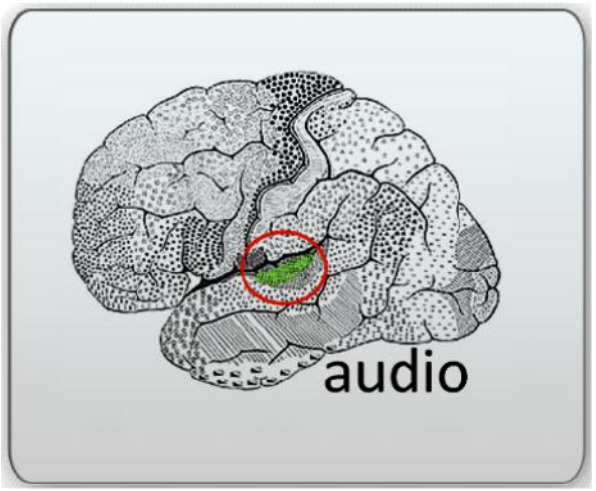
Brain Lobes







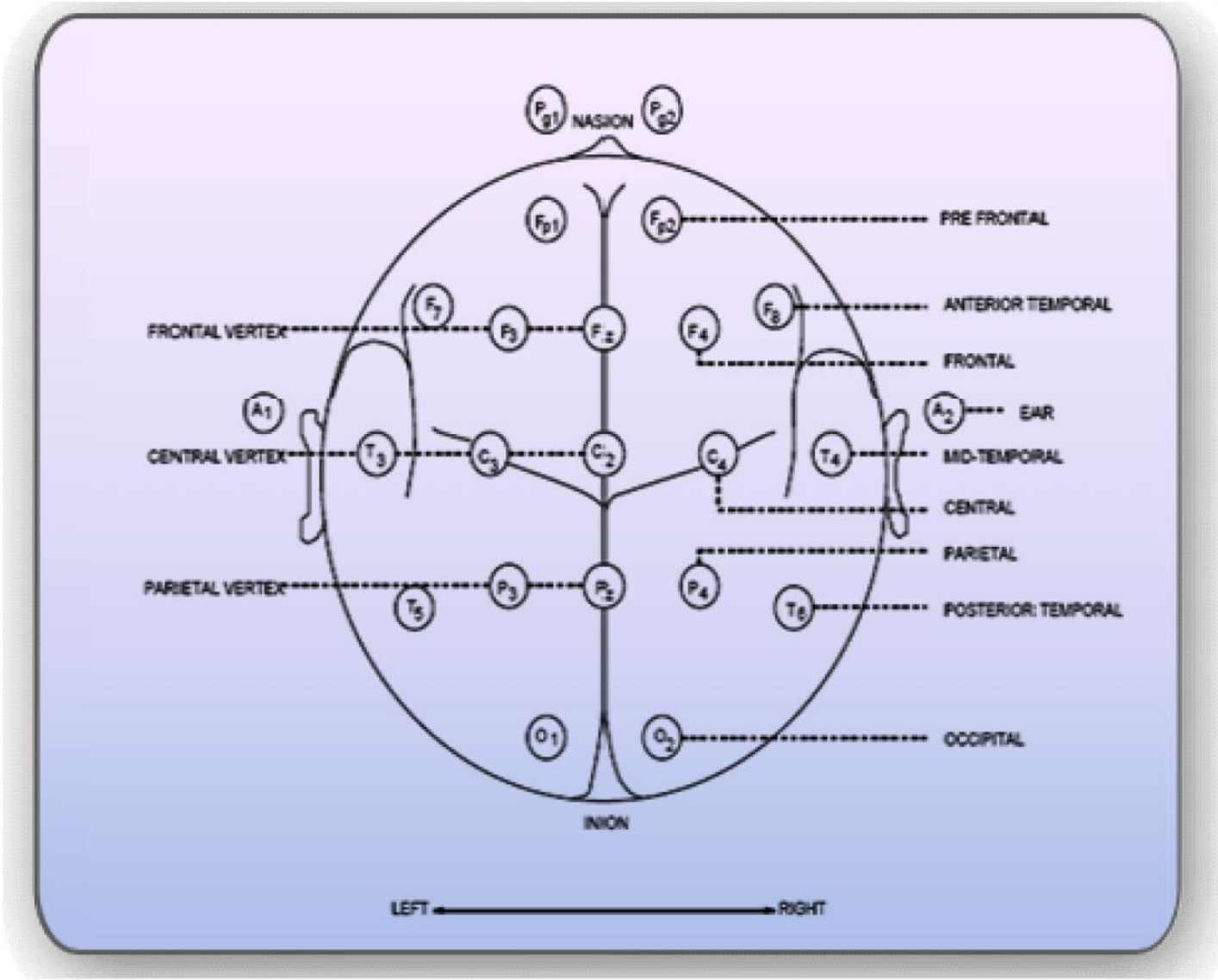




Recording of EEG

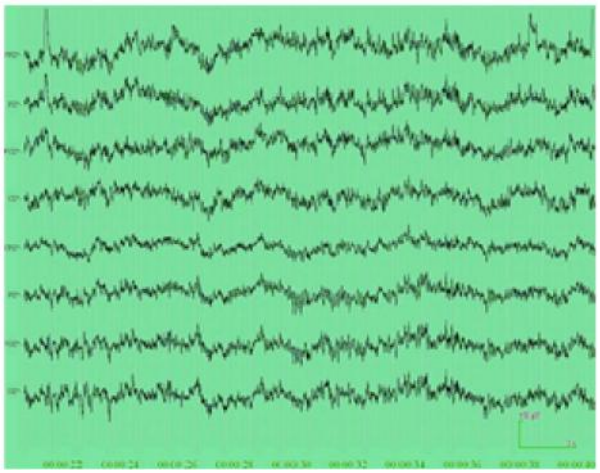
- The recording can be performed non-invasively (scalp EEG), directly on the brain cortex (cortical EEG) or within the brain (depth EEG).
- The placement of EEG electrodes on the scalp usually follows a standard arrangement known as the 10-20 system.
- This system was devised by the International Federation of Societies for Electroencephalography and Clinical Neurophysiology.

10-20 system

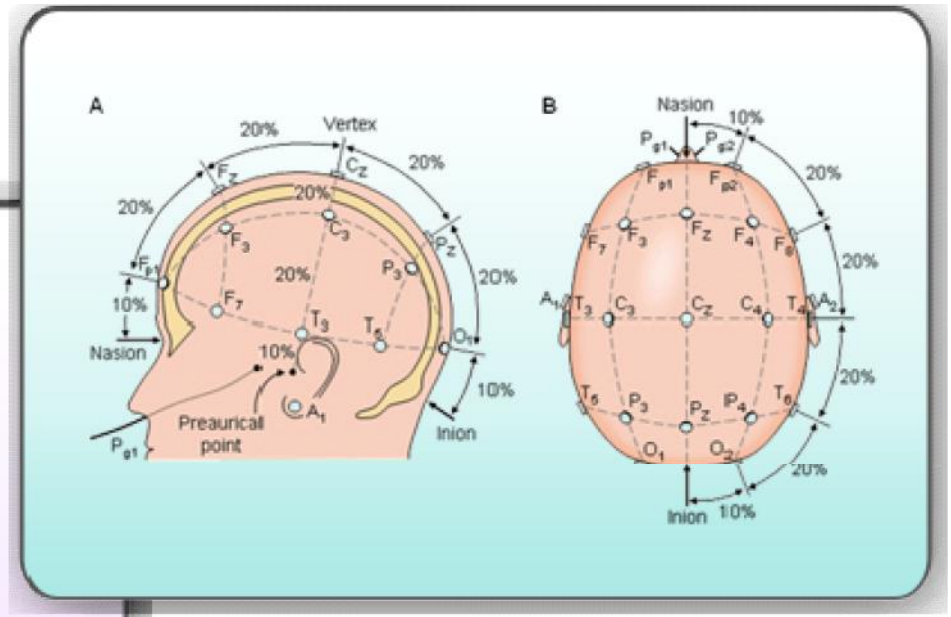

NASION
PRE FRONTAL
ANTERIOR TEMPORAL
FRONTAL VERTEX
FRONTAL
EAR
CENTRAL VERTEX
MID-TEMPORAL
CENTRAL
PARIETAL
PARIETAL VERTEX
POSTERIOR TEMPORAL
OCCIPITAL
INION
LEFT
RIGHT

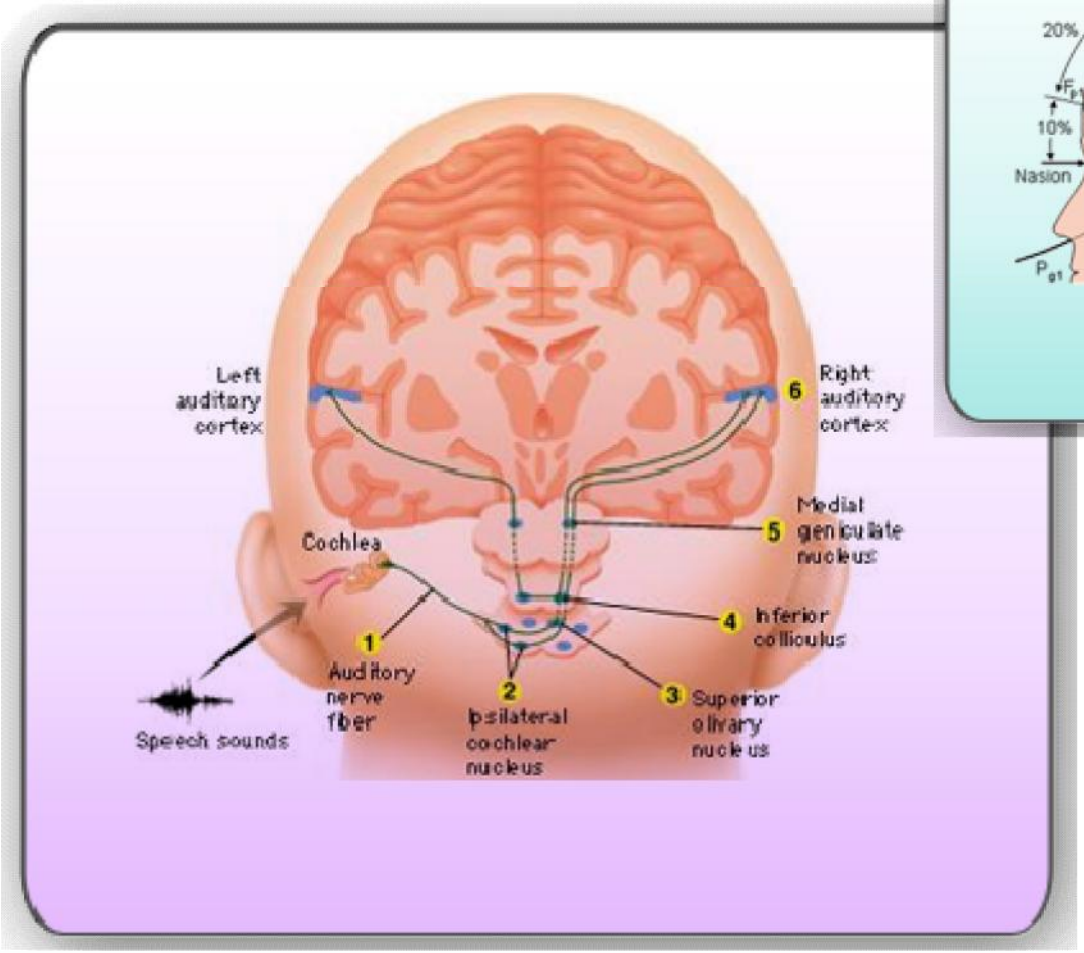
10-20 system

- Even numbered electrodes are placed on the right side of the head, and odd are placed on the left.
- The electrodes in this arrangement are placed along a bisecting line drawn from the nose (nasion) to the back of the head (inion), first at the position 10% of the distance along the line, then at 20% intervals.
- The notation F stands for frontal lobe, C for central sulcus, P for parietal lobe, and O for occipital lobe, Pg is the nasopharyngeal point (nose) and A is on the ear lobe.



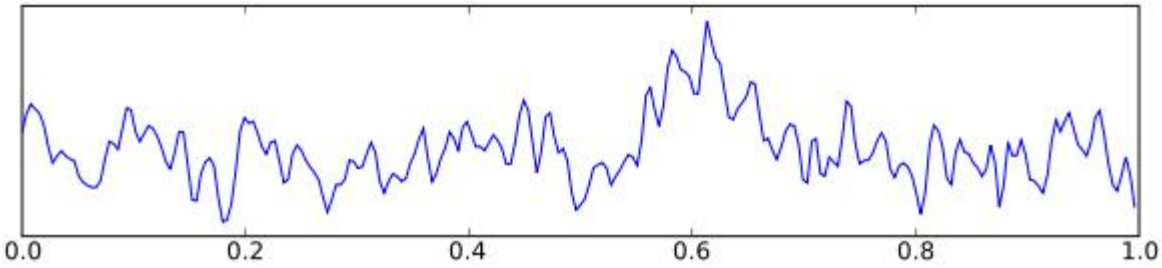
Sensor Placement : EEG



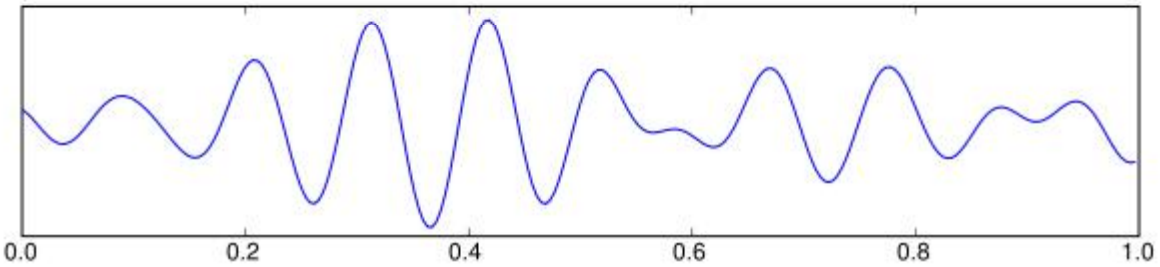


EEG Signal

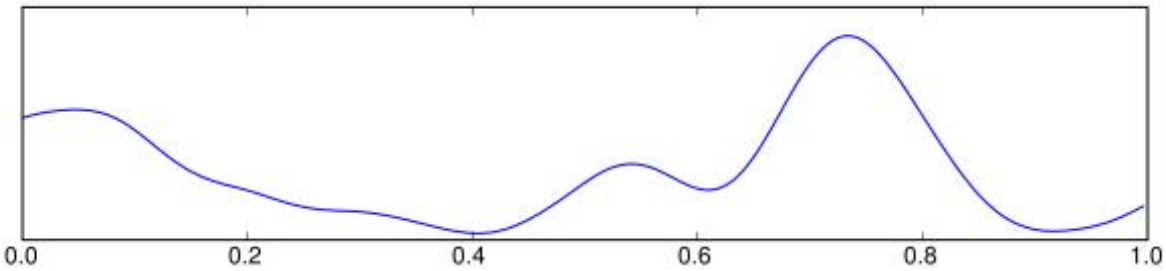
- EEG Signal



- Alpha waves

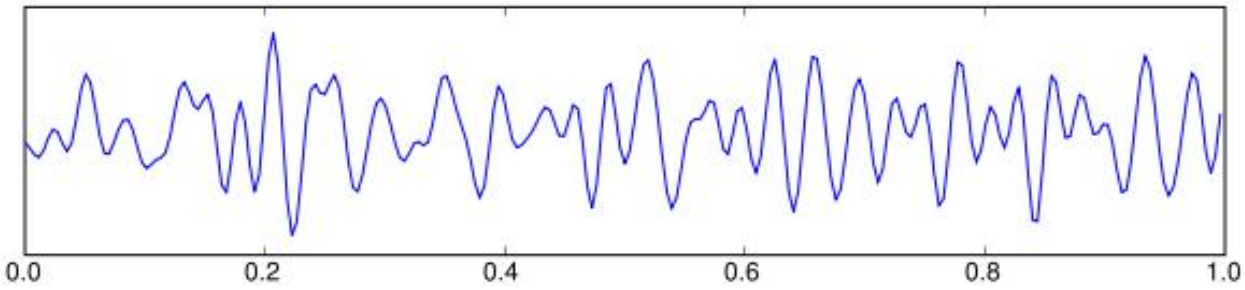


- Delta waves

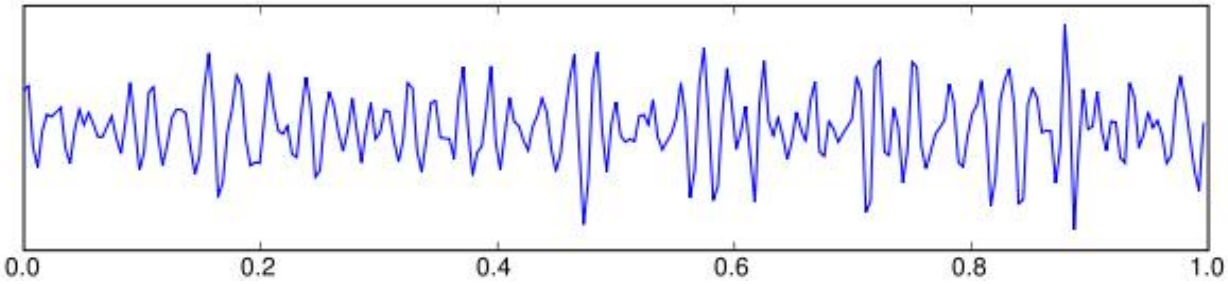


EEG Signal

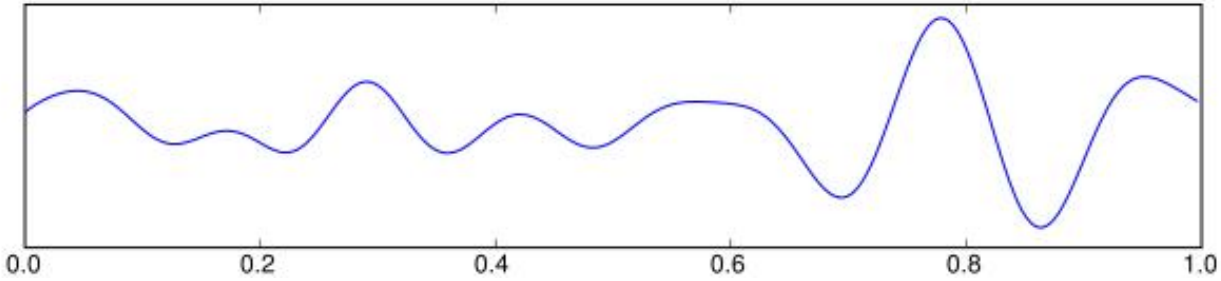
- Beta waves



- Gamma waves



- Theta waves

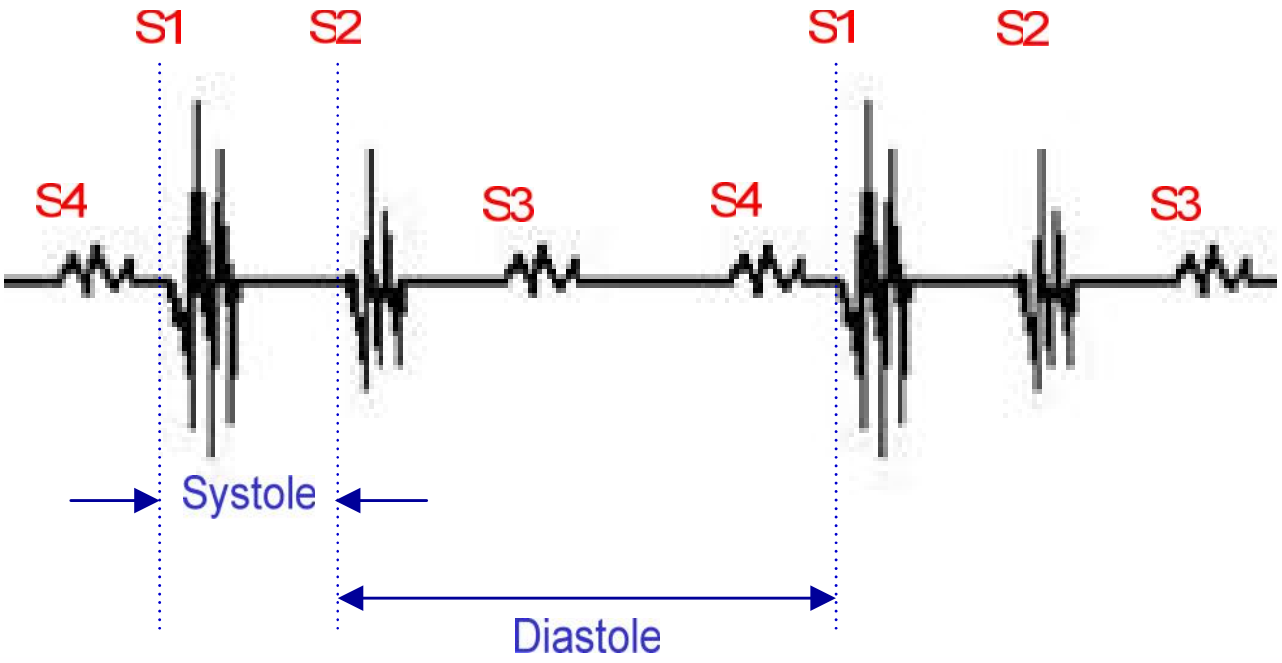


Phonocardiogram (PCG)

- The phonocardiogram (PCG) – audio recording of the heart's mechanical activity
- Known simply as record of heart sound and murmurs
- Can be easily heard using a stethoscope or can be converted into an electrical signal using a transducer
- Typically used to determine the disorders related to the heart valve, since their routine opening and closing create the well-known sounds.

Characteristics of Heart Sound

- In normal heart condition there are four possible components of heart sounds.
  - ➢first heart sounds (S1), second heart sounds (S2), third heart sounds (S3) and fourth heart sounds (S4)



Characteristics of Heart Sound

- First heart sound, S1 is produced by a sudden closure of mitral and tricuspid valve at the beginning of systole.
- S1 is composed of two major components which are closing of mitral and tricuspid valve and it is designated as M1 and T1 (Tilkian and Conover, 1993).
- Typically M1 and T1 are separated between 30ms and S1 last approximately 0.10s to 0.16s (Wartak, 1972).
- Second heart sound, S2 is produced by vibrations set up by the closure of aortic and pulmonary and it marks the beginning of diastole.
- S2 is consists of two components which are aortic and pulmonary component which noted as A2 and P2 respectively. A2 occurs earlier than P2. S2 lasts approximately 0.08s to 0.14s.

Characteristics of Heart Sound

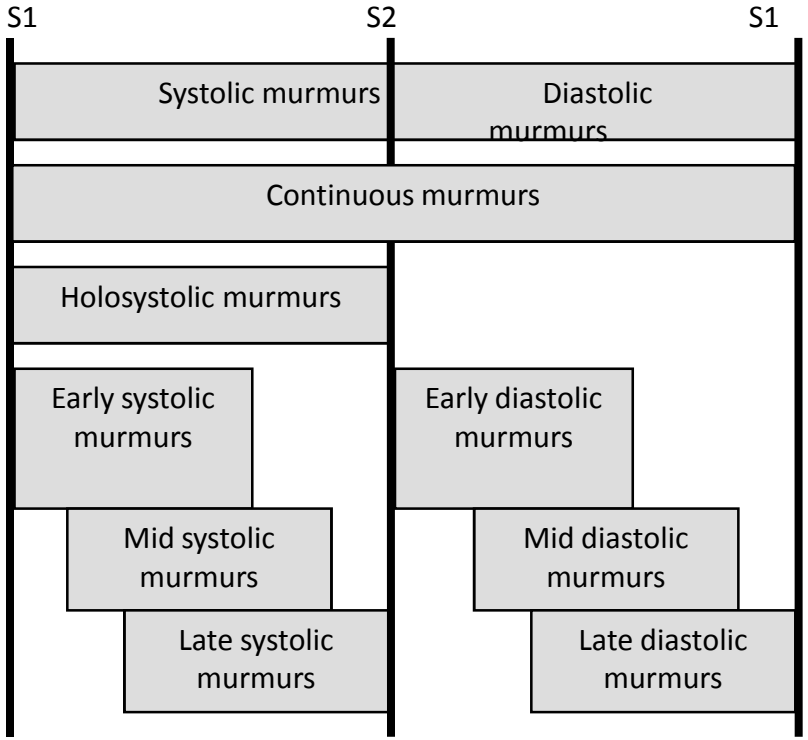
- Third heart sound, S3 is produced by vibrations set up by the ventricle walls at the end of rapid filling phase of the ventricles.
- S3 is commonly heard in children and young adults and occasionally in person over 30 years old and extremely rare in person over 40 years old.
- It occurs between 0.12s to 0.18s after the onset of S2 and it last for 0.04s to 0.08s.
- Fourth heart sound, S4 is produced by an accelerated flow of blood into the ventricles as results of atria contraction.
- S4 last for 0.03s to 0.06s (Wartak, 1972).

Characteristics of Murmurs

- Turbulence of blood flow produces series of vibration is the main cause of heart sounds murmurs.
- Four main causes of murmurs (Tilkian and Conover, 1993)
  - high rates of blood flow through normal or abnormal valves,
  - forward flow through a constricted or irregular valve or dilated vessels,
  - backward flow through an incompetence valve or septal defect
  - decrease viscosity which caused turbulence to increase

Characteristics of Murmurs

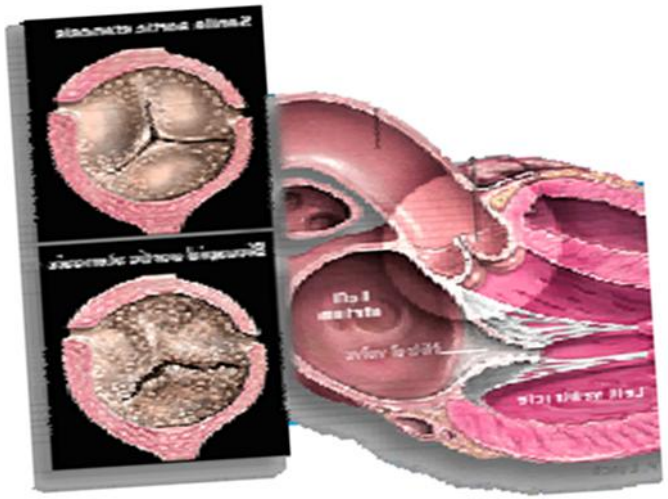
- Murmurs can be divided into three groups: systolic murmurs, diastolic murmurs and continuous murmurs.
- Location of murmurs in cardiac cycle is shown.



Structural Heart Diseases

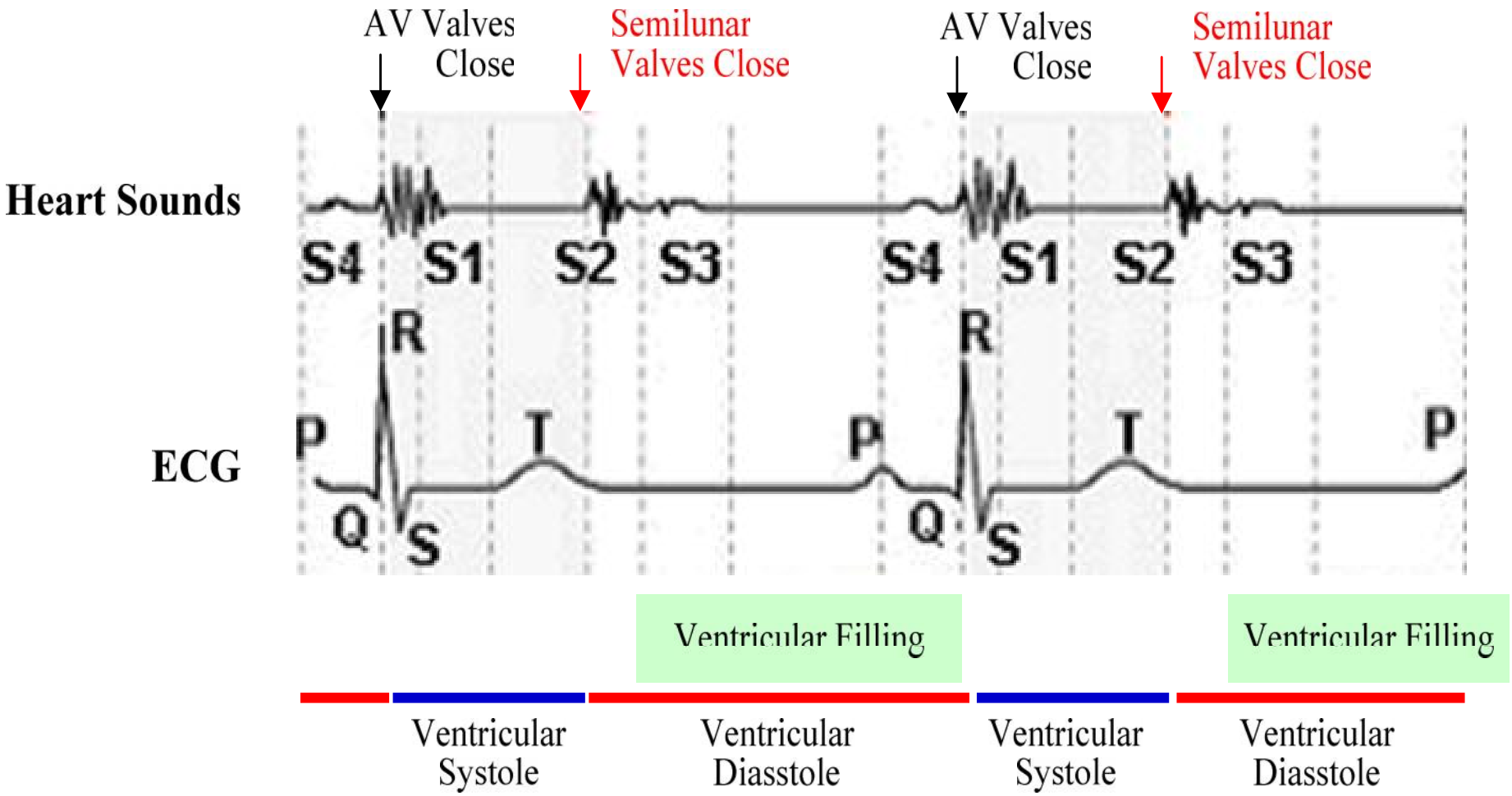
- Structural refers to the heart diseases related to the valves.
  - Regurgitation: Valves does not close completely or tightly.

  - Stenosis: Valves does not open completely.



- It doesn't cause any changes in the ECG.

Characteristics of Heart Sound & Relationship with ECG



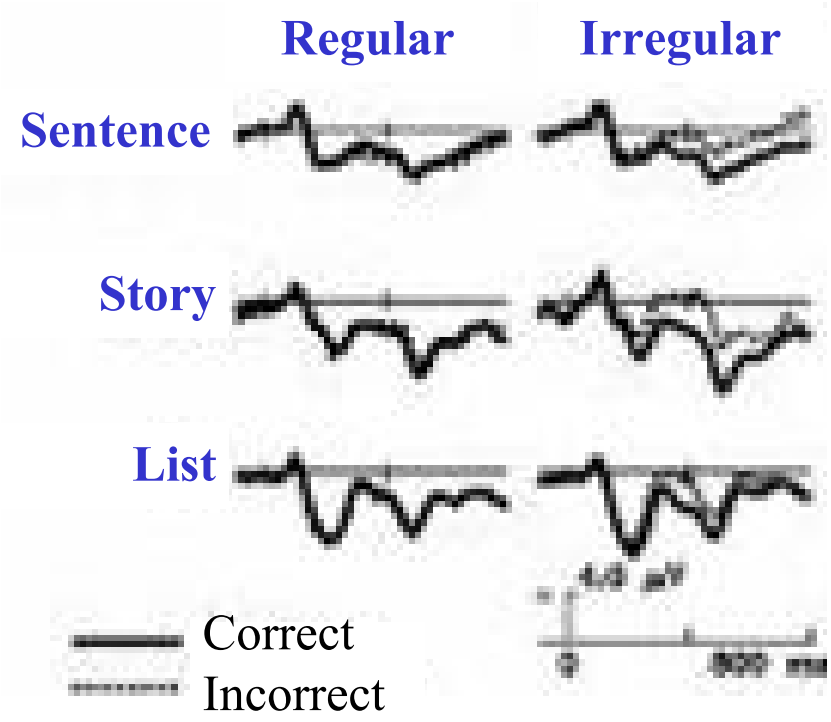
The Event Related Potentials

- ERPs are EEGs obtained under a specific protocol that requires the patient to response to certain stimuli/task – hence event related potentials.

- Also called **evoked potentials** these signals can be used to diagnose certain neurological disorders such as dementia, and they can also be used as a lie detector

The Event Related Potentials

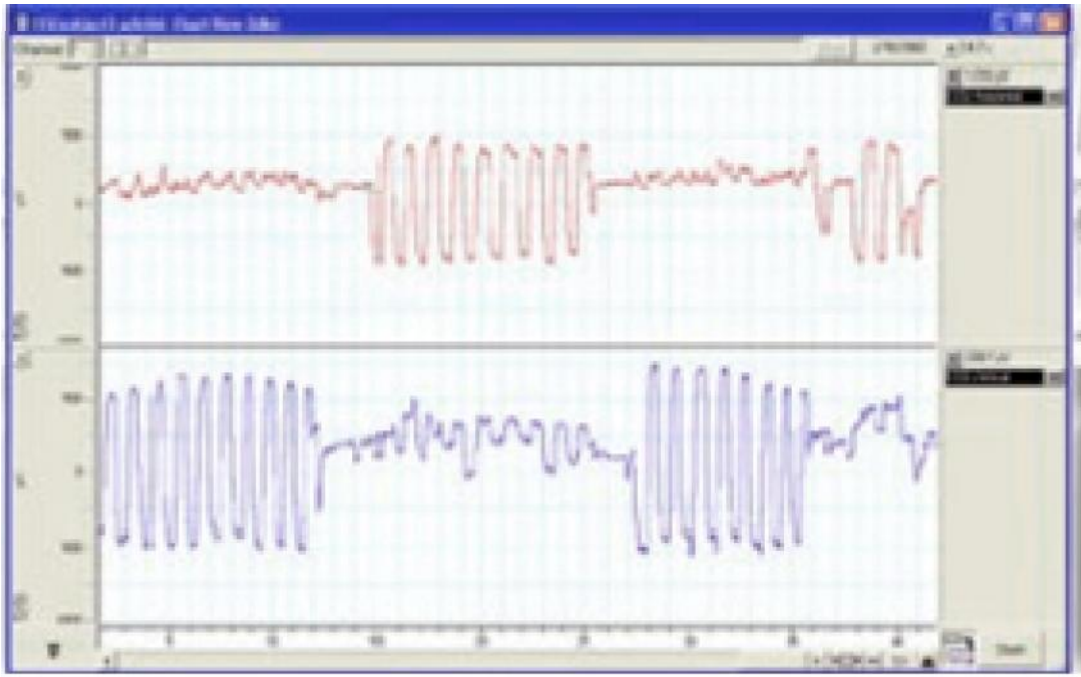
- Comparison of regular and irregular participles according to ending (-t versus -n) presented in three experimental versions, as part of a simple sentence, in a word list, and embedded in a story.

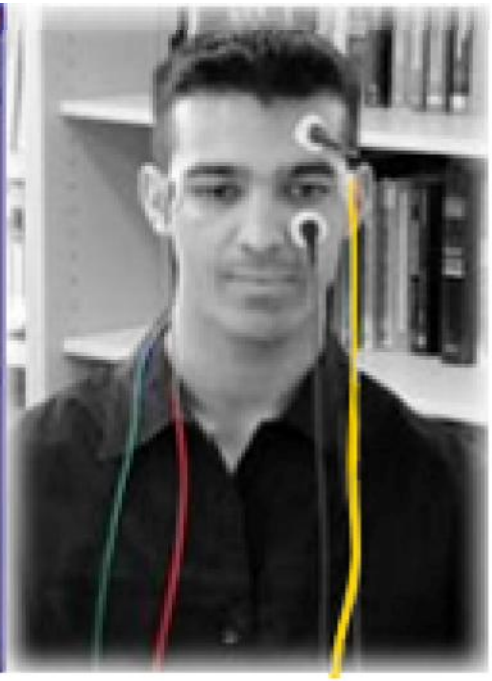


Electrooculography (EOG)

- The EOG is the electrical manifestation of the eye movements.

- EOG is a technique for measuring the resting potential of retina





Recording of EOG

- Pairs of electrodes are placed either above and below the eye or to the left and right of the eye.
- If the eye is moved from the center position towards one electrode, this electrode "sees" the positive side of the retina and the opposite electrode "sees" the negative side of the retina.
- Consequently, a potential difference occurs between the electrodes.
- The recorded potential is a measure for the movement of eye.

Moving to new area: Newborn Hearing Screening

- A joint research between Centre for Biomedical Engineering and Computational Diagnostic and Biocybernetic Unit, Saarland University, Germany

- To establish a Newborn Hearing Screening Program in Malaysia started with the state of Johor

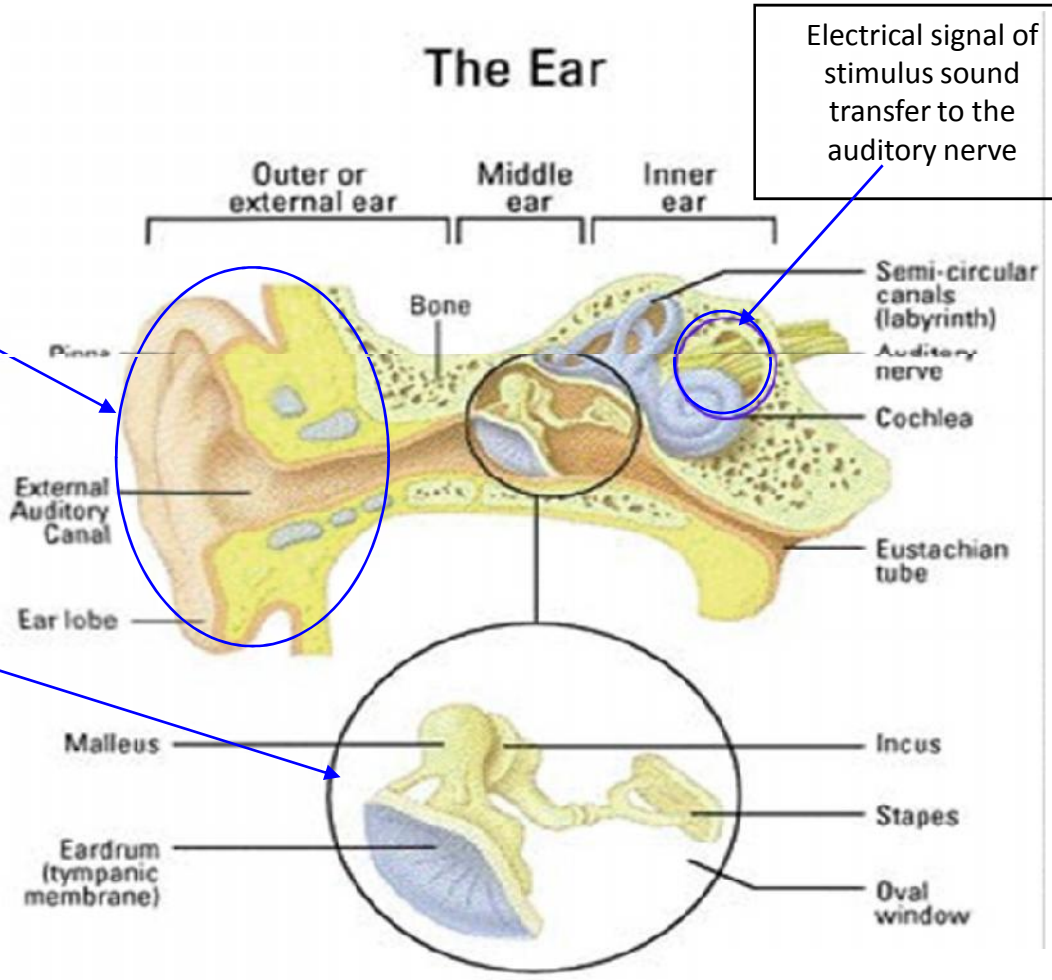
- Based on Fast ABR

Hearing Screening : Physiology of Hearing

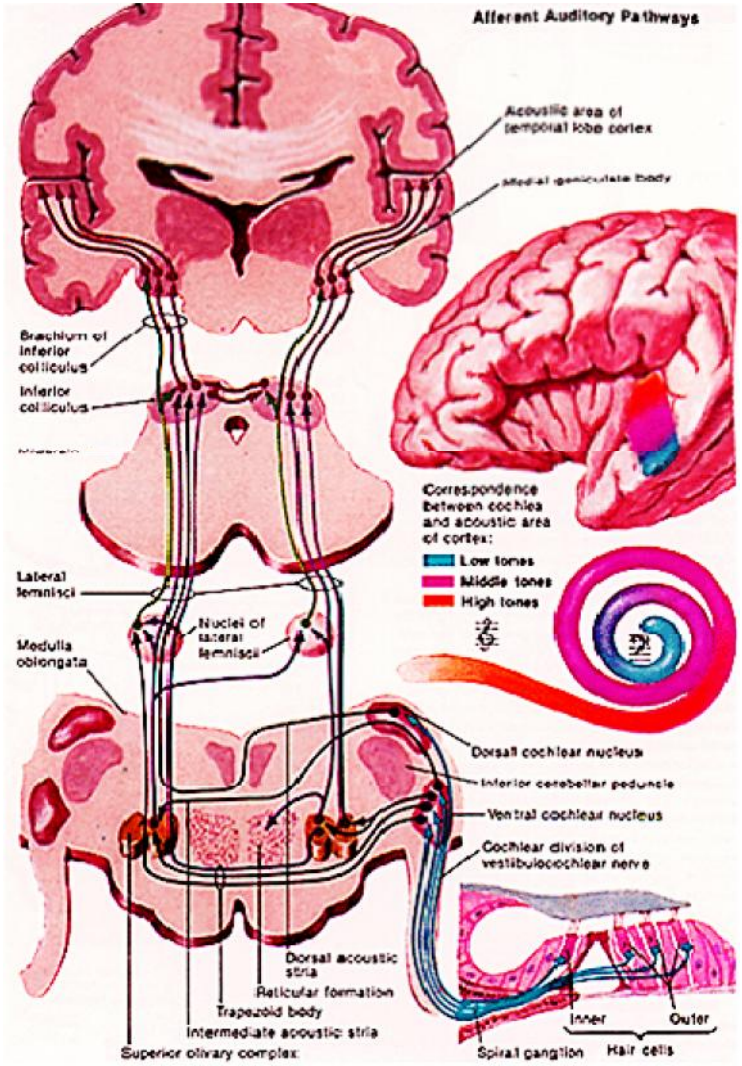
Outer ear collect sound from outside

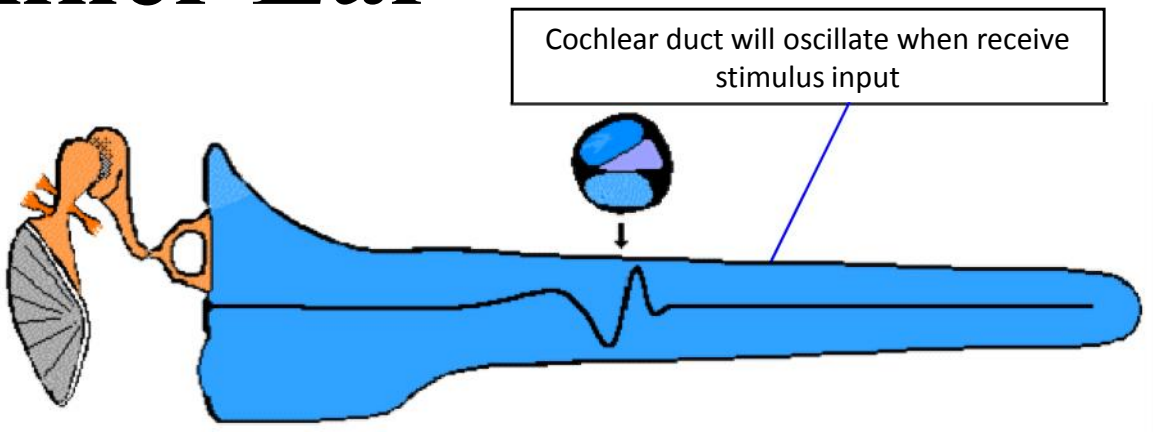
Middle ear convert sound into electrical signal

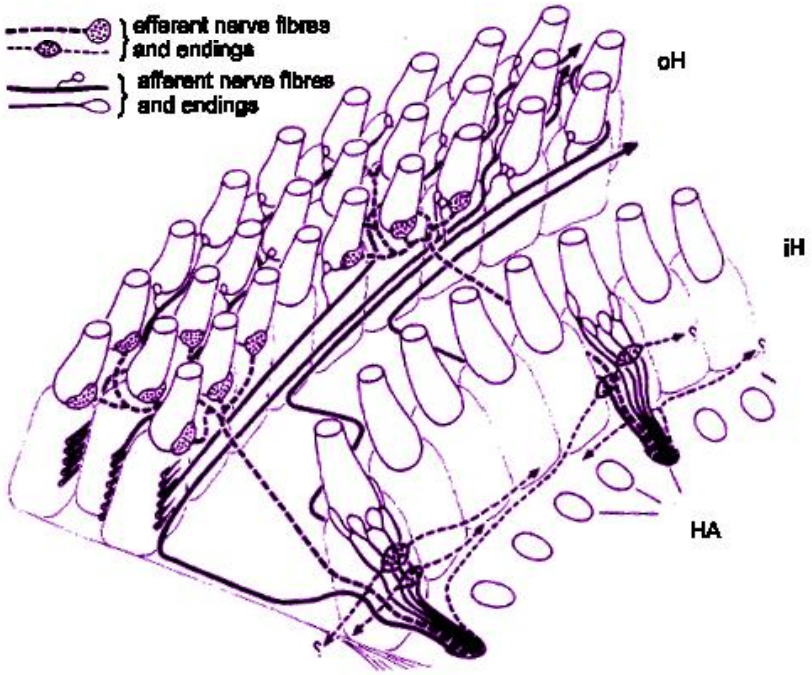
Electrical signal of stimulus sound transfer to the auditory nerve



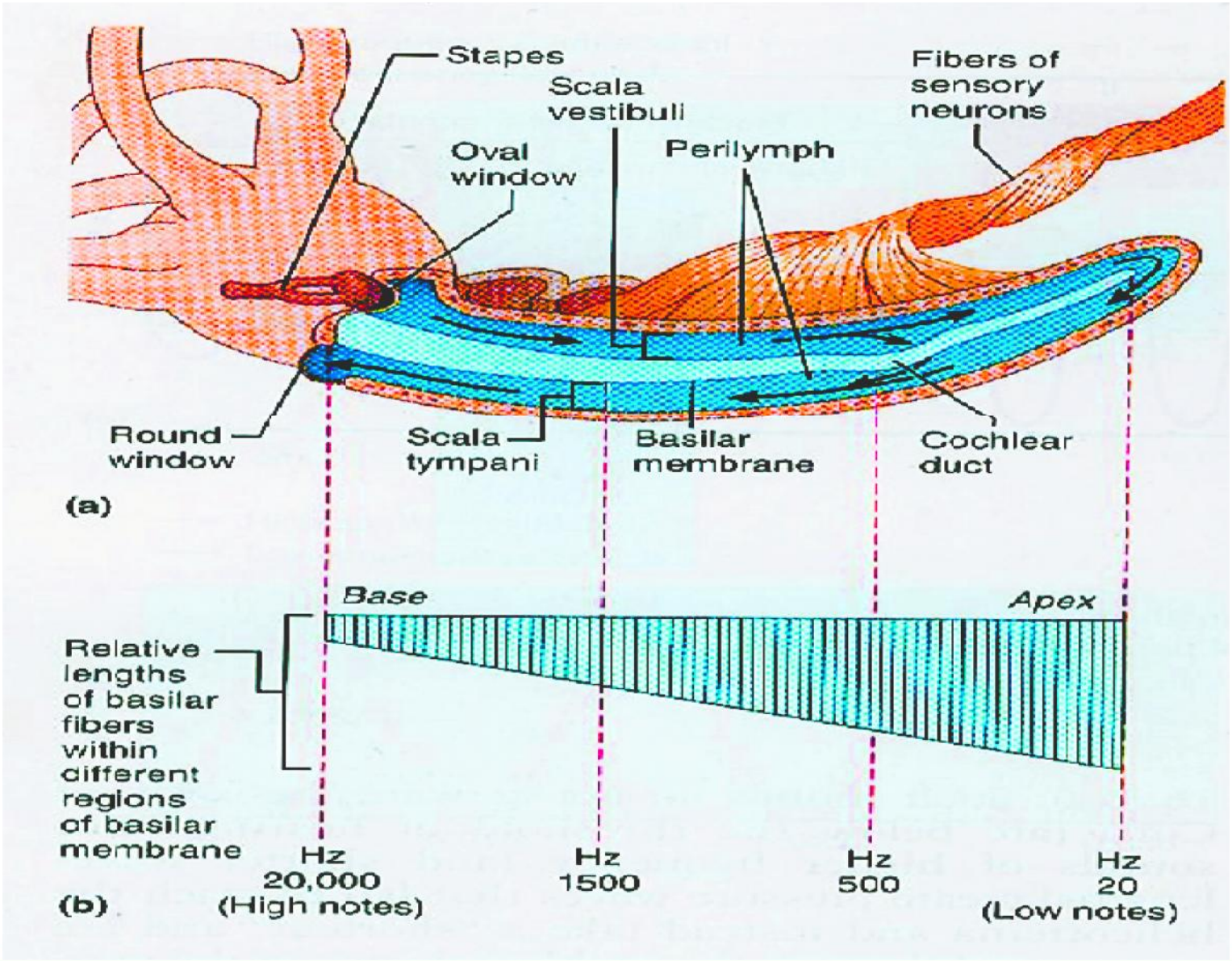
Inner Ear


Afferent Auditory Pathways
Acoustic area of temporal lobe cortex
Medial geniculate body
Brachium of inferior colliculus
Inferior colliculus
Correspondence between cochlea and acoustic area of cortex:
Low tones
Middle tones
High tones
Lateral lemnisci
Nuclei of lateral lemnisci
Medulla oblongata
Dorsal cochlear nucleus
Inferior cerebellar peduncle
Ventral cochlear nucleus
Cochlear division of vestibulocochlear nerve
Dorsal acoustic stria
Reticular formation
Trapezoid body
Intermediate acoustic stria
Superior olivary complex
Inner
Outer
Spiral ganglion
Hair cells

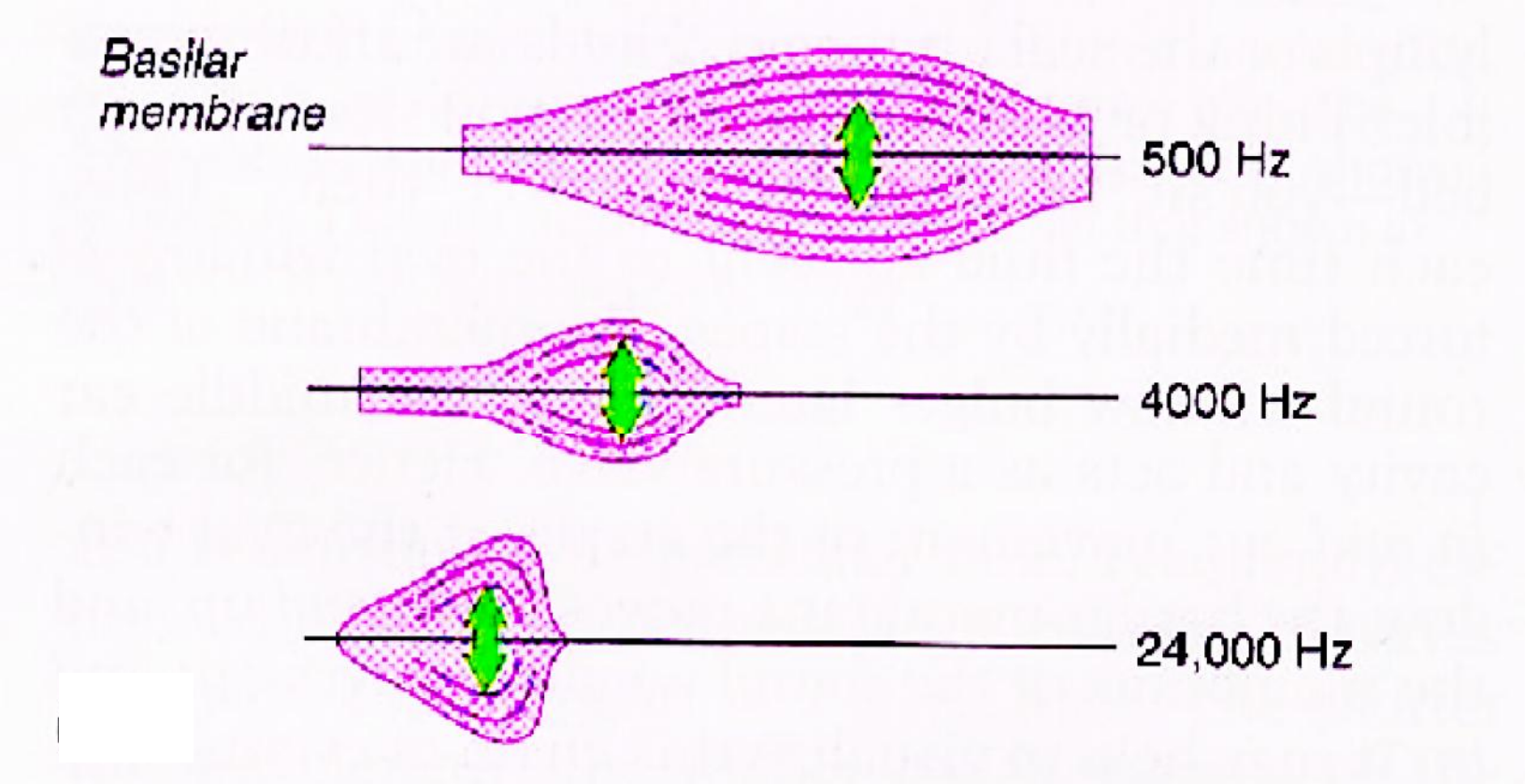

Cochlear duct will oscillate when receive stimulus input


efferent nerve fibres and endings
afferent nerve fibres and endings
oH
iH
HA

Inner Ear


Stapes
Scala vestibuli
Fibers of sensory neurons
Oval window
Perilymph
Round window
Scala tympani
Basilar membrane
Cochlear duct
(a)
Base
Apex
Relative lengths of basilar fibers within different regions of basilar membrane
Hz 20,000 (High notes)
Hz 1500
Hz 500
Hz 20 (Low notes)
(b)

Basilar Membrane

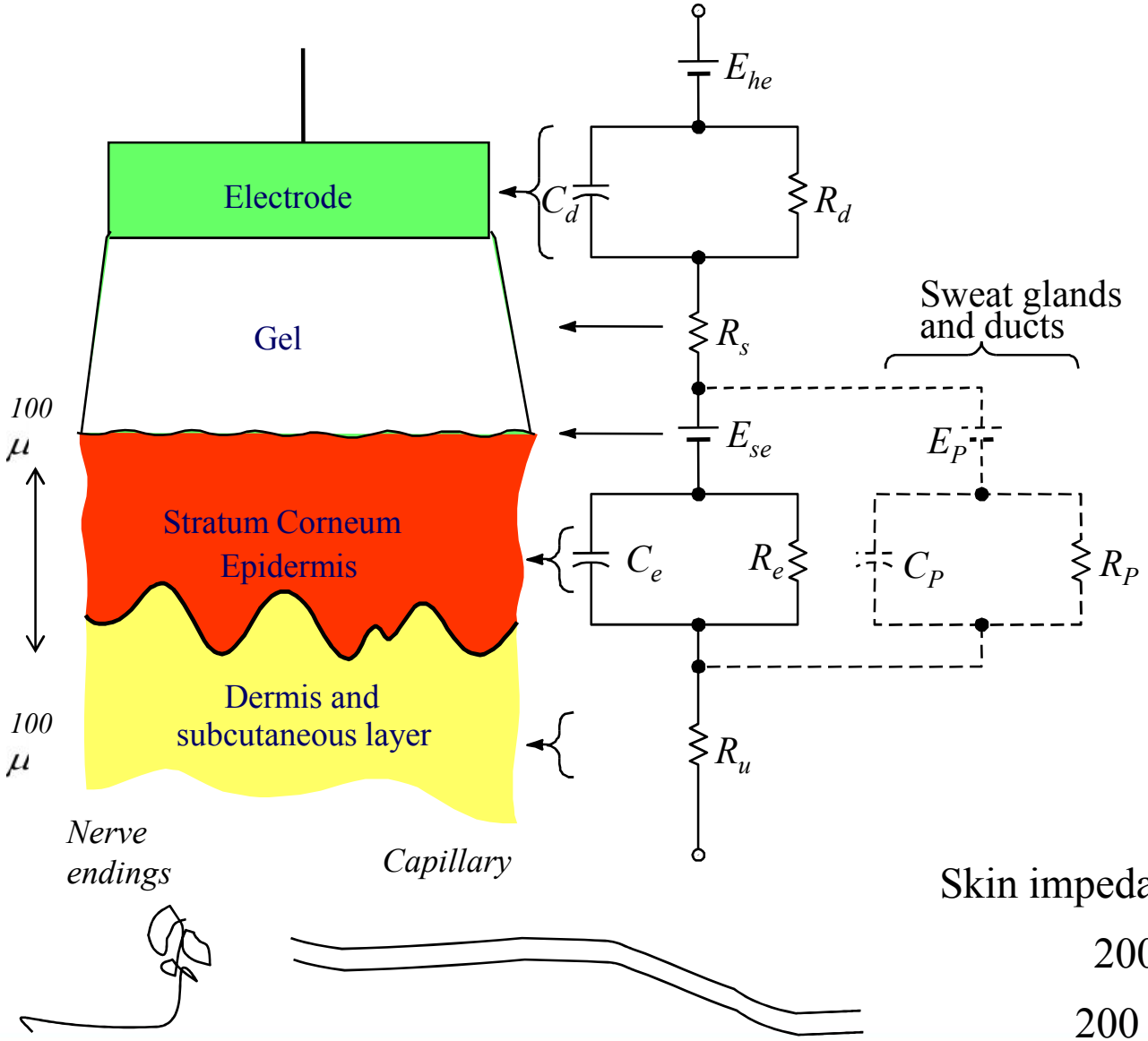


- Figure: Resonance of the basilar membrane and activation of the cochlear hair cells (c) Different frequencies of pressures waves in the cochlea

ABR Machine


XeCT SYSTEM 1
Diversified Diagnostic Products, Inc.
Houston, Tx

Electrode Skin Interface



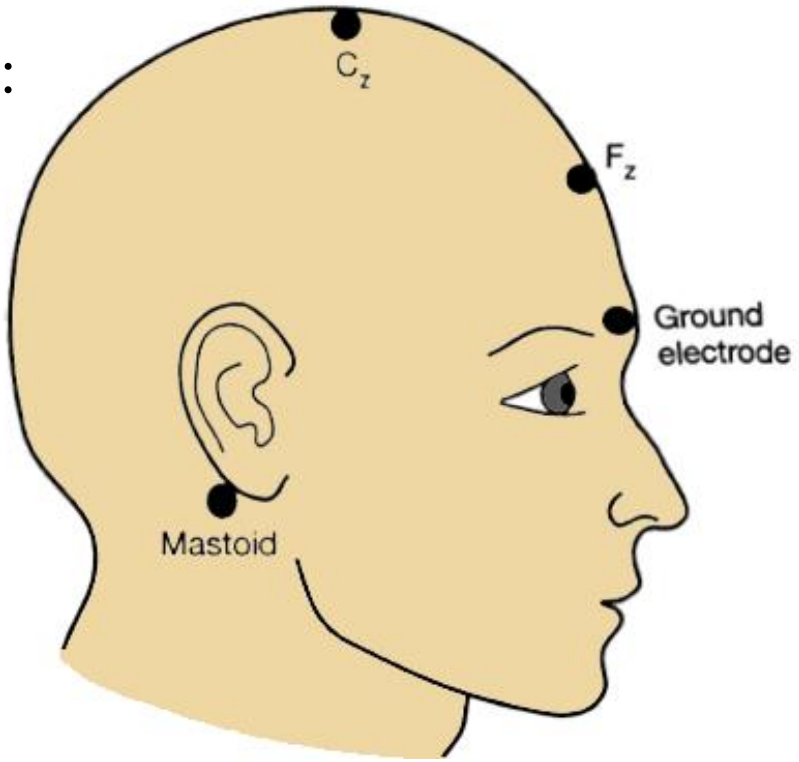
Skin impedance for 1cm^2 patch:

200kΩ @1Hz

200 Ω @ 1MHz

ABR Electrode Placement

- Electrodes placed at three location:
  - Mastoid left - reference
  - Upper Forehead - channel 1
  - Mastoid right - ground
  - Stimulus – right ear



ABR Signal

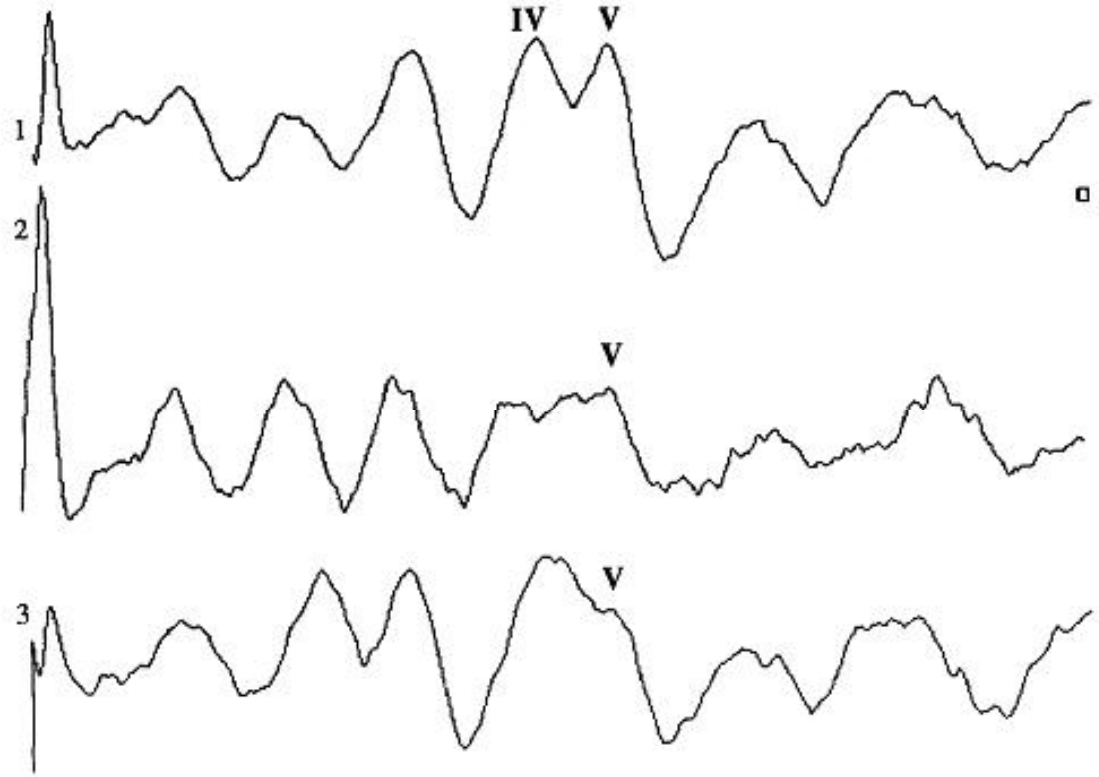


Figure : Intersubject variations in the normal ABR.
(1) the classic IV-V couples;
(2) noisy recording with large stimulation artefact;
(3) peak V is riding on the down-shoulder of peak IV

ABR Signal

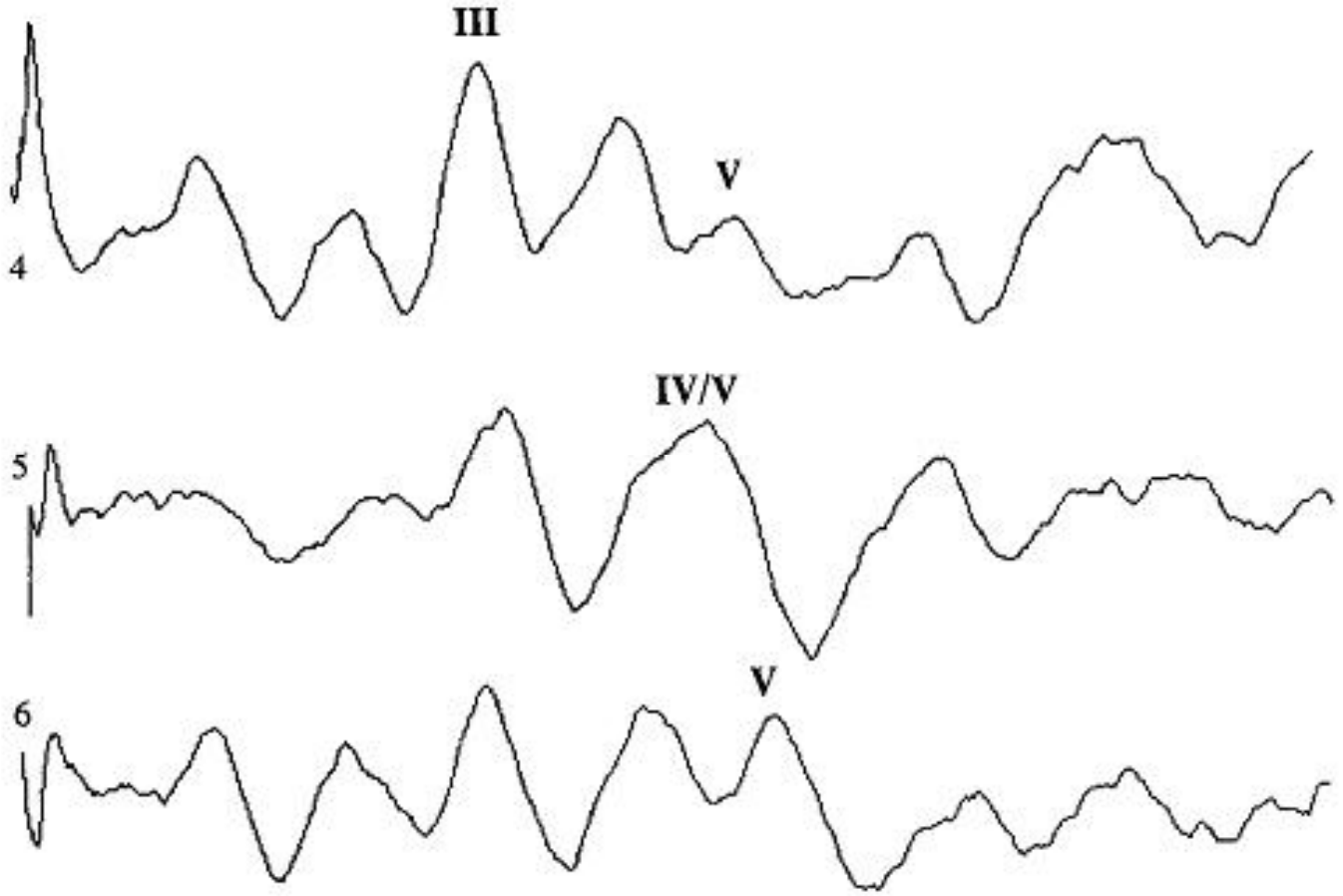


Figure : Intersubject variations in the normal ABR. (4)peak V amplitude is greatly reduced from peak IV; (5) fused IV-V; (6) so-called ‘M’ configuration

ABR Signal

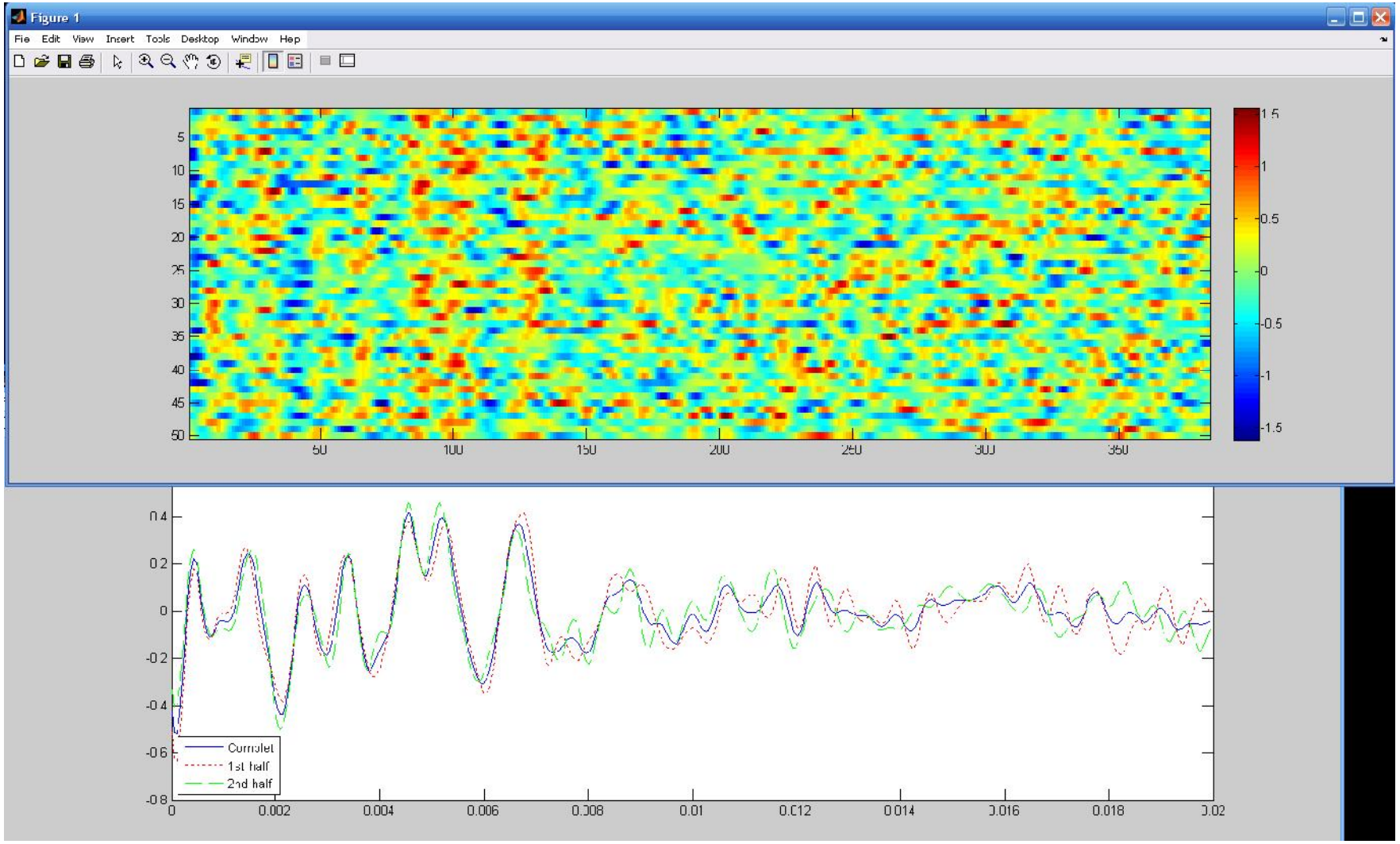


Figure 1
File Edit View Insert Tools Desktop Window Help
Curvelet
1st half
2nd half

Amplitudes of ABR Waves

Amplitudes in microvolts for Wave I, III, and V with the noninverting electrode at the vertex or upper forehead and the inverting and common electrodes positioned at the seventh cervical vertebra, the lower forehead, the side of the neck, or mastoid. Standard deviations are shown in parentheses. Also presented for each wave are amplitudes combined across rows and columns, as well as the mean of all measurements.

Noninverting Electrode Placement	Inverting/Common Electrode Placements					
	Seventh/Forehead	Neck/Forehead	Neck/Neck	Mastoid/Mastoid	Mastoid/Forehead	Combined
Wave I						
Vertex	0.184 (0.068)	0.210 (0.103)	0.215 (0.093)	0.233 (0.110)	0.234 (0.131)	0.215 (0.102)
Upper forehead	0.168 (0.059)	0.184 (0.072)	0.154 (0.062)	0.183 (0.091)	0.203 (0.108)	0.178 (0.080)
Combined	0.176 (0.063)	0.197 (0.088)	0.185 (0.083)	0.208 (0.102)	0.218 (0.119)	0.197 (0.093)
Wave III						
Vertex	0.253 (0.101)	0.270 (0.093)	0.273 (0.110)	0.267 (0.104)	0.269 (0.094)	0.267 (0.098)
Upper forehead	0.267 (0.085)	0.270 (0.101)	0.254 (0.104)	0.231 (0.108)	0.239 (0.074)	0.252 (0.094)
Combined	0.260 (0.092)	0.270 (0.095)	0.264 (0.106)	0.249 (0.106)	0.254 (0.084)	0.259 (0.096)
Wave V						
Vertex	0.604 (0.133)	0.540 (0.130)	0.539 (0.135)	0.475 (0.117)	0.479 (0.113)	0.527 (0.132)
Upper forehead	0.447 (0.156)	0.420 (0.139)	0.426 (0.147)	0.312 (0.100)	0.324 (0.098)	0.385 (0.139)
Combined	0.525 (0.163)	0.480 (0.147)	0.483 (0.150)	0.393 (0.136)	0.401 (0.130)	0.456 (0.152)

Why Signals Are Processed

- There are numerous reasons why signal are processed and can be group into three categories:
  - To remove unwanted signal components that is corrupting the signal of interest.
  - To extract information by rendering it in a more obvious or more useful form.
  - To predict future values of the signal in order to anticipate the behavior of this source.