PD233: Design of Biomedical Devices and Systems

(Lecture-7 Biopotentials- 2)

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Course Website:
http://cpdm.iisc.ac.in/utsaah/courses/

Electromyogram (EMG)

Skeletal muscles are organized functionally on basis of ***motor unit***

Motor unit is smallest unit that can be by activated by volitional effort and all muscle fibers in that unit are activated synchronously.

In a single firing of motor unit extracellular field 20-2000µV for duration of 3-15ms.

Frequency of discharge varies from 6-30 per second.

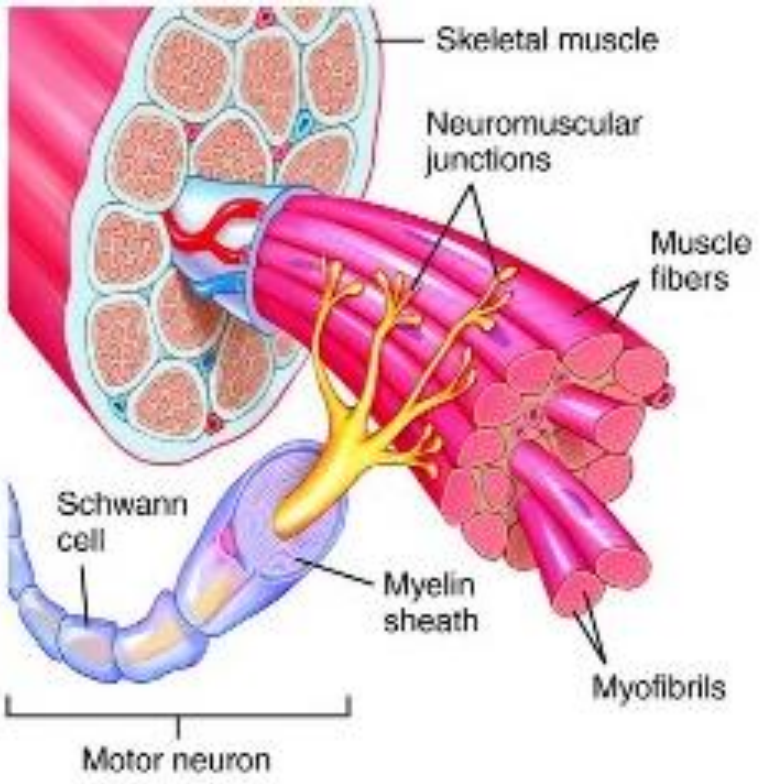
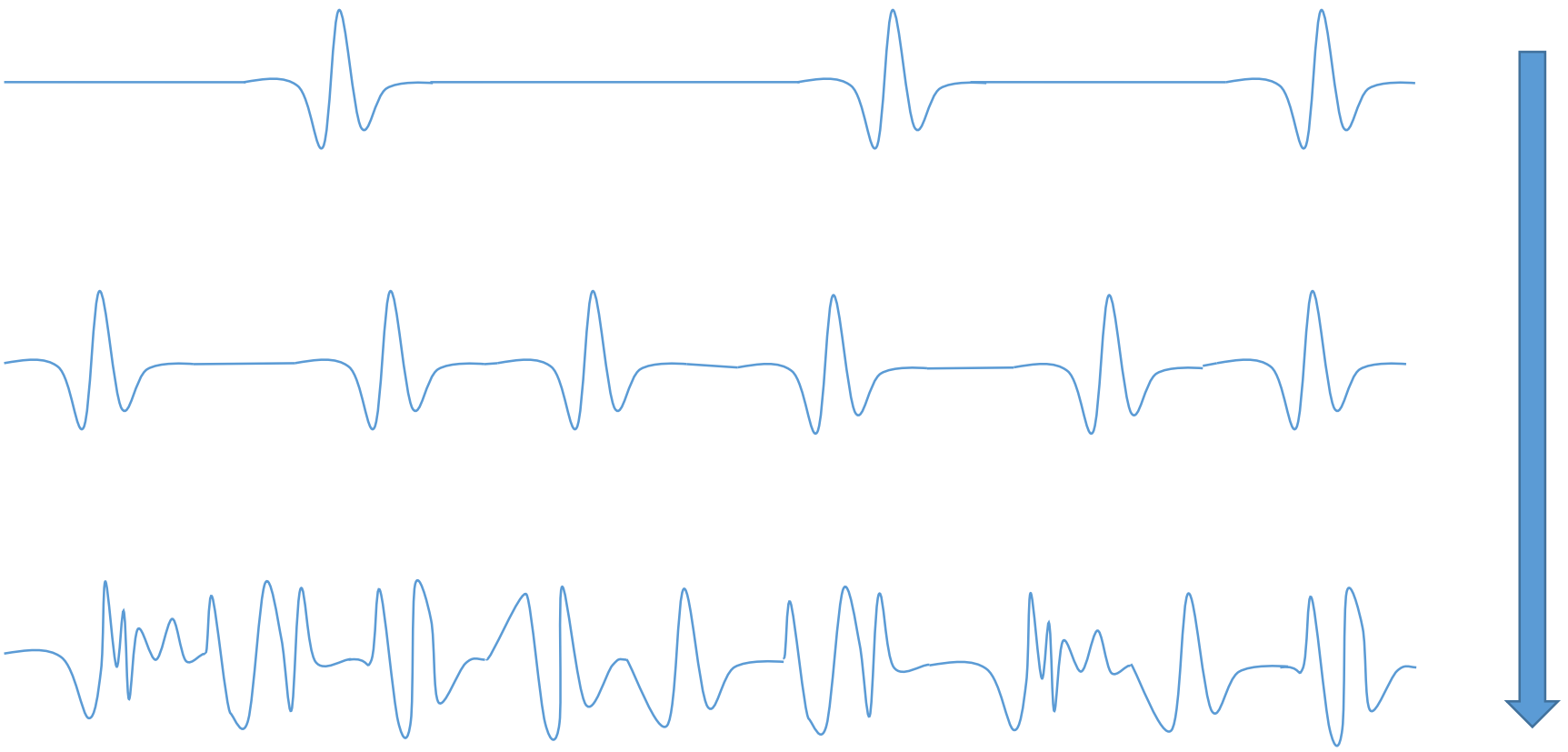
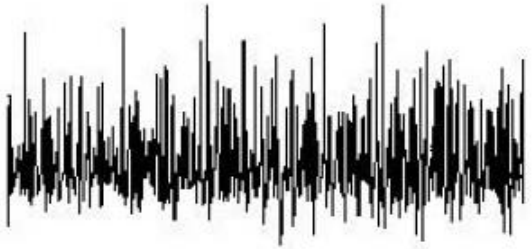


Image source: Mosby's Medical Dictionary, 8th edition

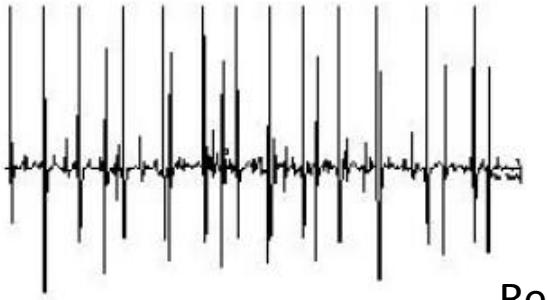
Normal EMG with increasing effort



Clinical use of EMG

A. 

Normal trace

B. 

Neuropathic trace

Recruitment, incorporation of additional MU in muscle action, is reduced in primary neuropathies

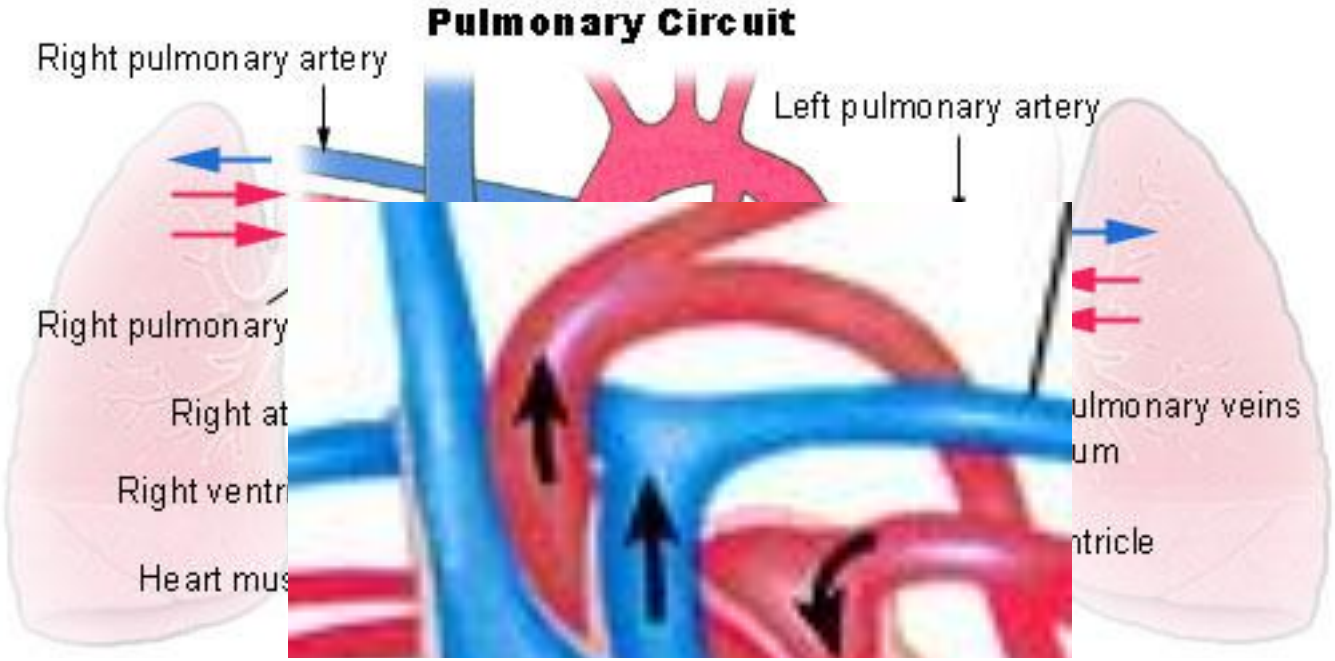
C. 

Myopathic trace

Reduced Motor Unit Action Potential (MUAP) is usual finding in some myopathies

Wu *et al., Overview of the Application of EMG Recording in the Diagnosis and Approach of Neurological Disorders,2013,* http://dx.doi.org/10.5772/56030

Anatomy and Function of Heart



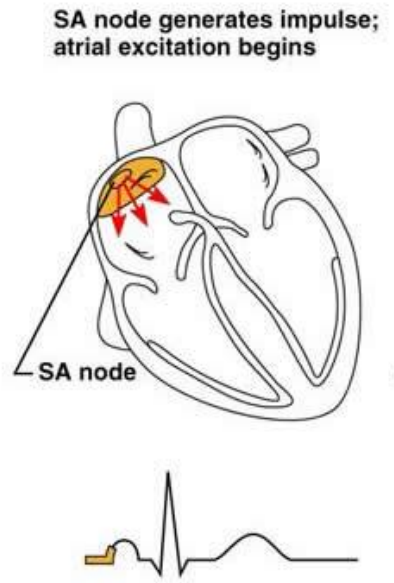
Heart in humans is four chambered pump of circulatory system.

Filling phase : ***Diastole***
Active/contractile phase: ***Systole***

Well coordinated electrical activity leads smooth rhythmic contractions of atria and ventricles

Image Source: Wikimedia.org

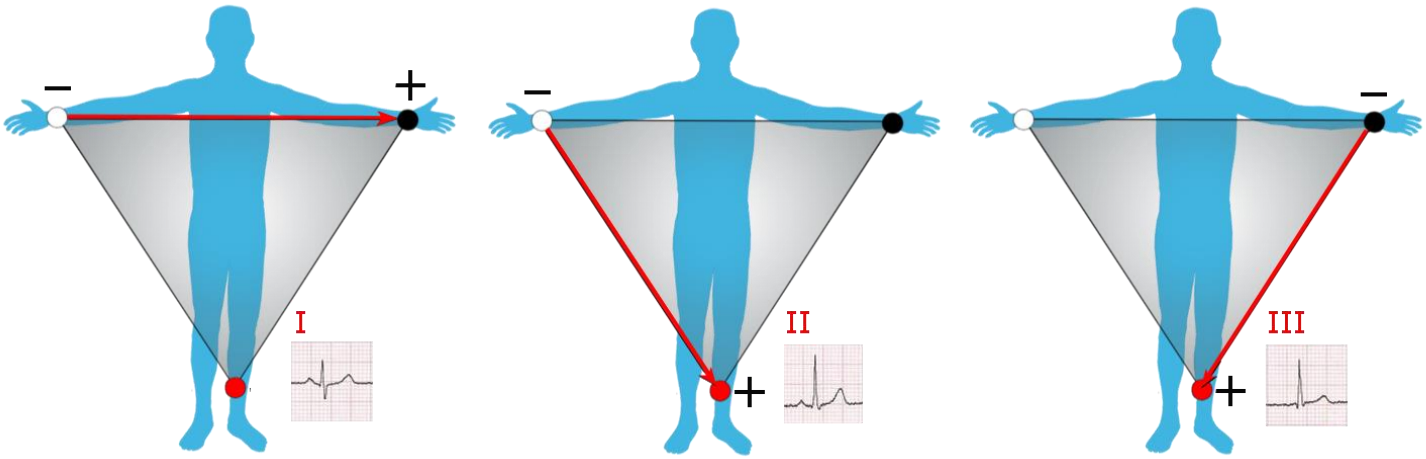
Electrical activity of heart



Heart muscles have resting potential of about -90mV
During electrical systole heart muscles ***first rapidly depolarized*** (at 150V/s) originating at **Sinoartrial (SA)** node and then ***gradually repolarize*** over 200-300ms
This depolarization and repolarization happens in spatially co-ordinated manner

Image credit: http://classes.midlandstech.edu/carterp Dr. Perry Carter

ECG measurements (3 lead system)



I = LA - RA

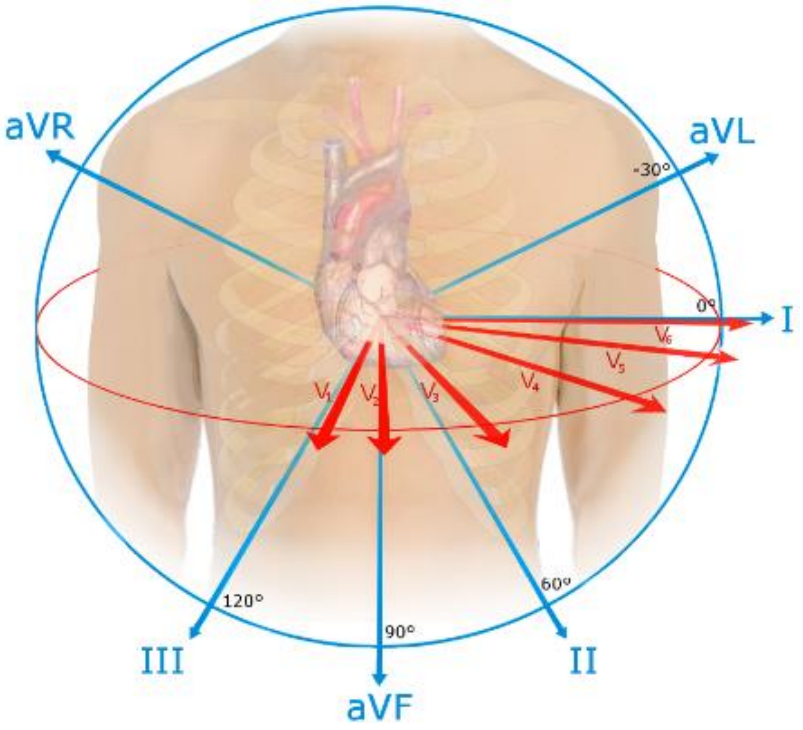
II = LL - RA

III = LL - LA

Three lead configuration uses three surface electrodes:
Note: Leads do not mean electrodes, Lead refers voltage difference between two electrodes

Three lead configuration gives component of ***polarization vector*** in the vertical (coronal plane)

ECG measurements (other leads)



Wilsons terminal: V_w= (RA+LA+LL)/3

Augmented limb leads

aV_R= 2/3(RA- V_w)

aV_L= 2/3(LA- V_w)

aV_F= 2/3(LL- V_w)

V_1-V_6 are precordial lead which give projection polarization vector in ***horizontal plane***

Wilsons terminal is used as negative electrodes for precordial leads.

Normal and Abnormal Heart Rhythms

Bradycardia : slow down on heart rate (e.g. during sleep)

Tachycardia : faster than normal heart rate (e.g. due to exercise, emotions or fever)

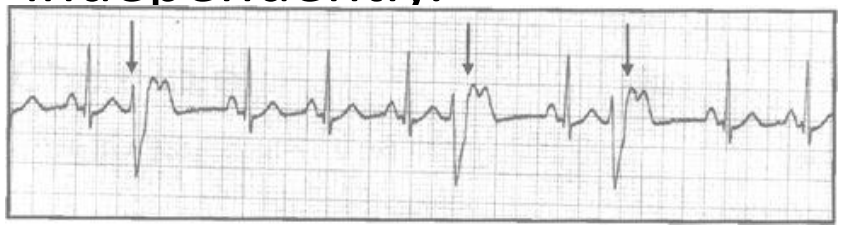
Complete Heart Block: electrical activity does not pass to ventricles (Problem with bundle of His)

First degree Heart Block: longer transmission time to ventricles, P-R interval in prolonged

Second Degree Heart Block: not all atrial pulse are conducted

Normal and Abnormal Heart Rhythms

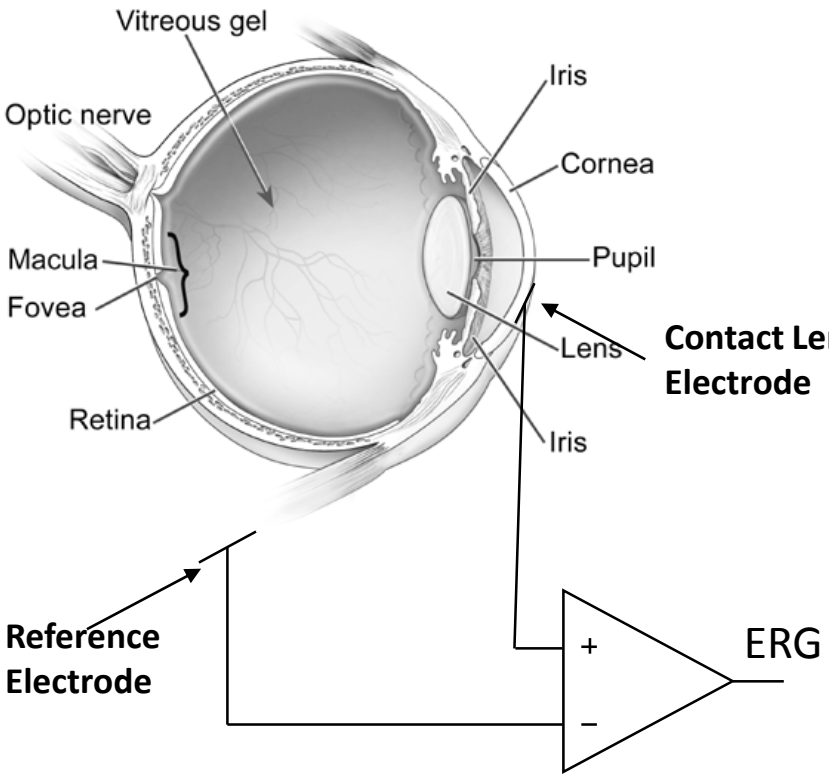
Ectopic focus: A portion of myocardium node is irritable and can 'fire' independently.



Paroxymal Tachycardia
Atrial Flutter
Atrial fibrillation
Ventricular Fibrillation

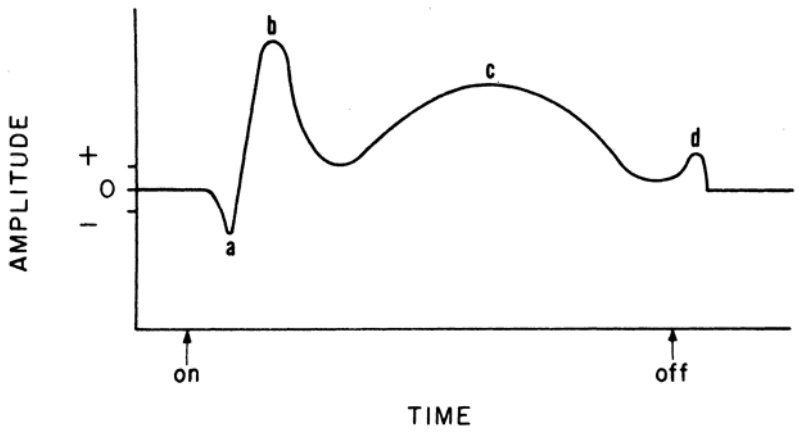
Myocardial Infarction (MI): Blood flow stops to part of the cardiac muscle.

Electro-retinogram (ERG)



Rod and ***Cone*** are specialized (photosensitive) nerve cells present in the ***Retina***

Temporal changes in potential between retina and reference location in response to exposure to light.



Electro-oclulogram (EOG)

- Steady potential between retina and cornea (i.e. DC measurement)
- Can be used for eye gaze tracking – horizontal and vertical
- Linear relationship between angle of gaze and EOG

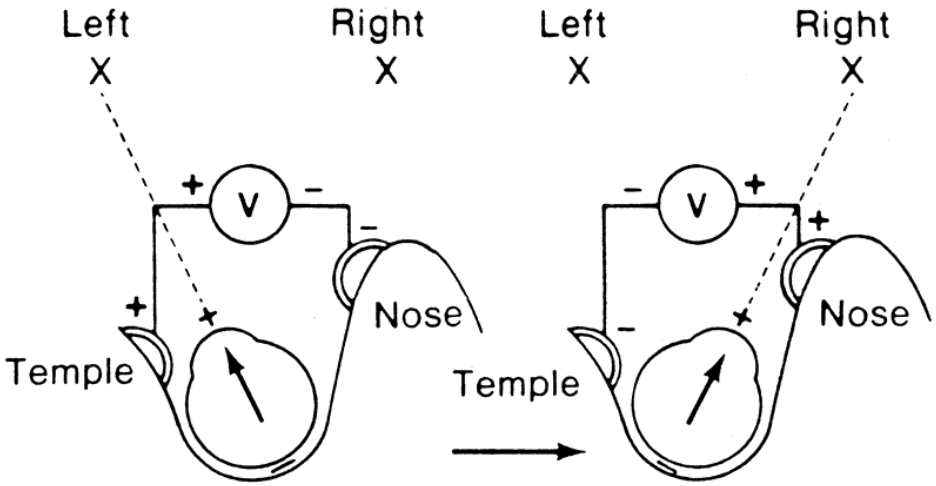


Image credit : http://www.oculist.net

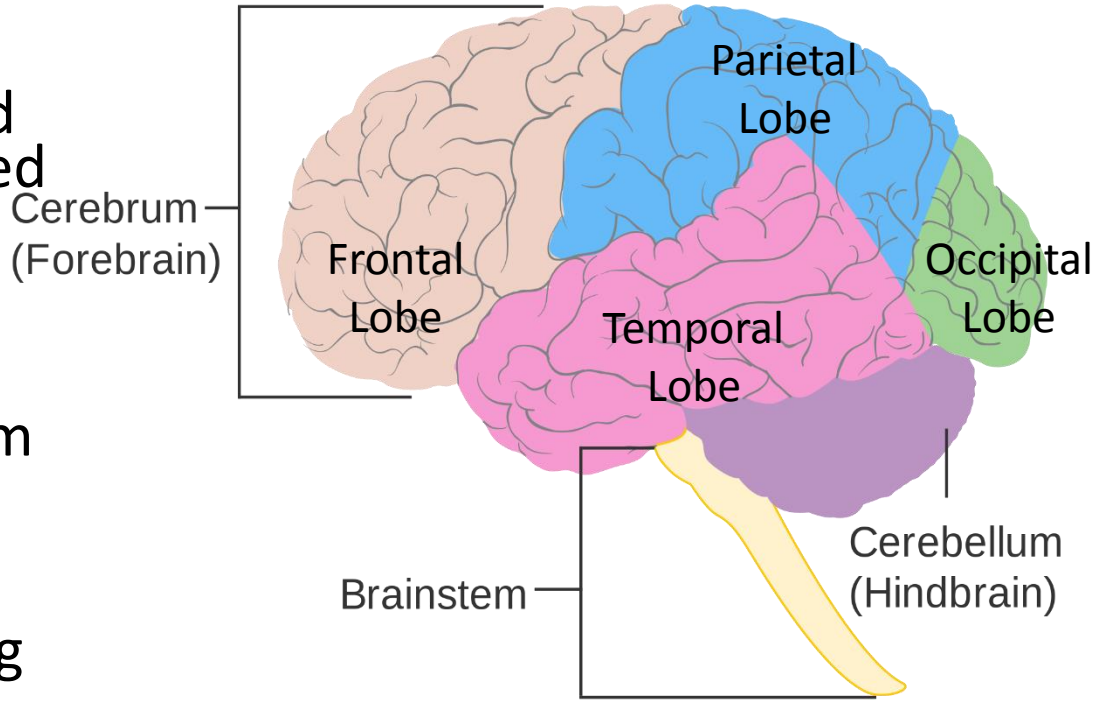
Electroencephalogram (EEG)

In the nervous system information is transmitted using frequency modulated impulse.

EEG measures potential fluctuations recorded from the brain.

EEG can be recorded using

- scalp electrodes
- cortical electrodes
- depth electrodes



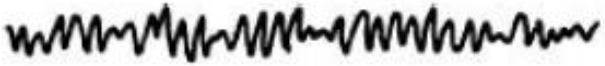
Main parts of the brain
Image credit: CRUK

Resting EEG

Cortical or depth EEG recording can be as large as 10mV but scalp EEG recoding are order 100µV, and are result of **synchronous** action of a region in the brain.

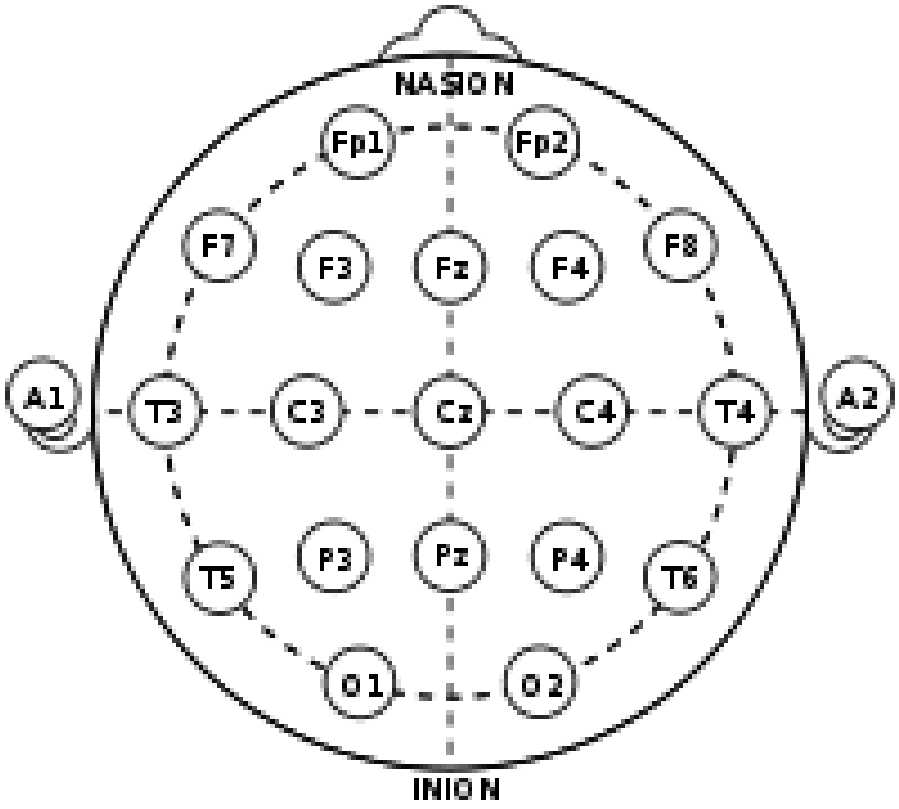
Resting stage EEG is divided into:

Alpha 8-13 Hz



(Relaxation)

10-20 electrode system



Standardized system for EEG Electrode placement.

Epilepsy

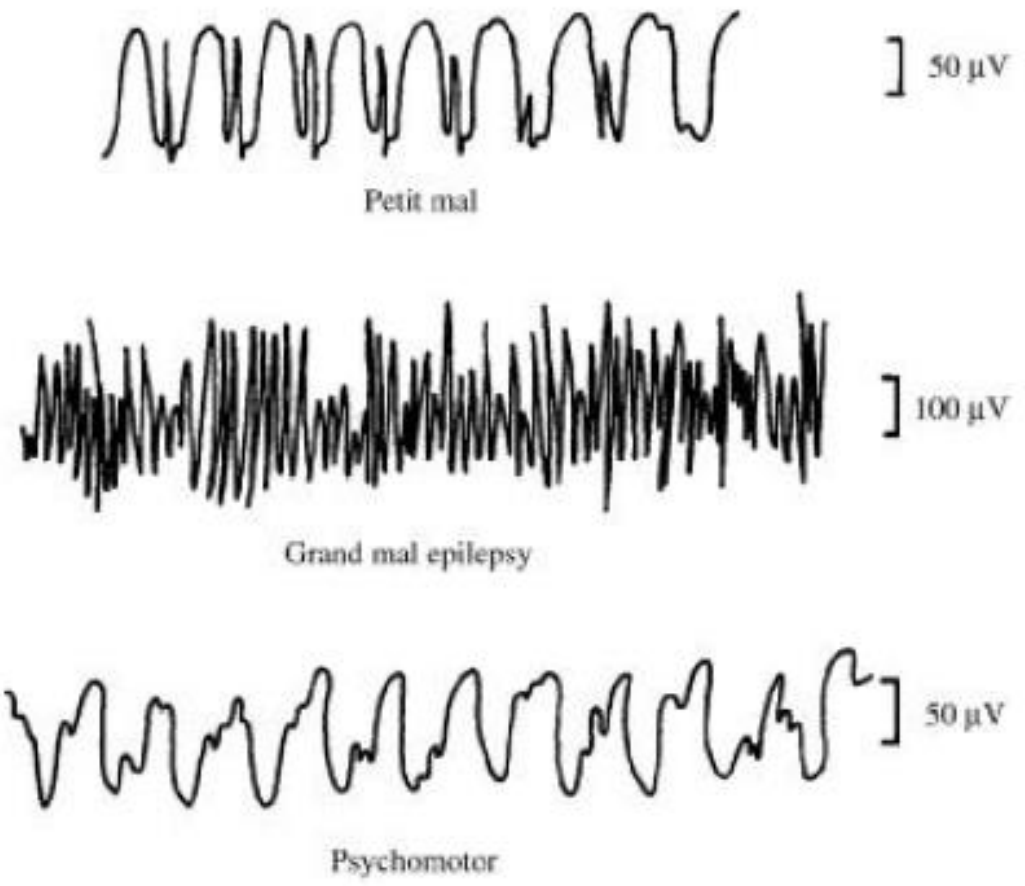
Neurological disease characterized by seizures

EEG is used as tool to characterized Epilepsy

Convulsive seizures occur in 60% of the cases, but 40% cases may not have show convulsion.

Abnormal EEG patters in Epilepsy

- Generalized
- Partial
- Focal



Evoked Reponses Potentials (ERP)

EEG response can be gathered in response to certain stimuli, e.g.

Auditory evoked response (AER)

-Response to clicks (100µs) and tones (100ms pulses) can be used to check auditory circuit of the brain.

Visual evoked response (VER)

-Reponses to visual stimuli

Cognition potentials

-Response to cognitive function (recognising known object, odd sound etc.)

Electrode-electrolyte interface

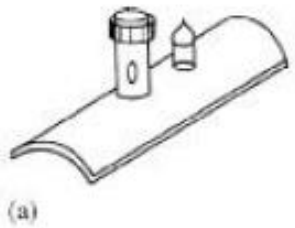
Biopotenatial electrodes are also transducers

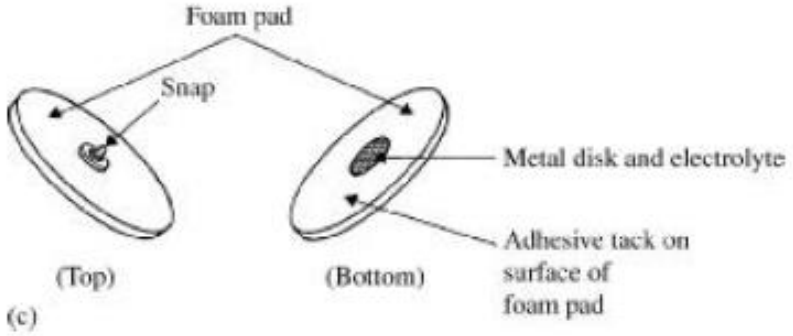
- they convert ionic currents to electron flow in the lead wires.

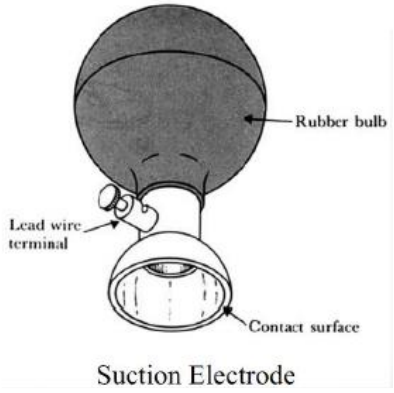
The electrochemistry of electrode materials governs their characteristics

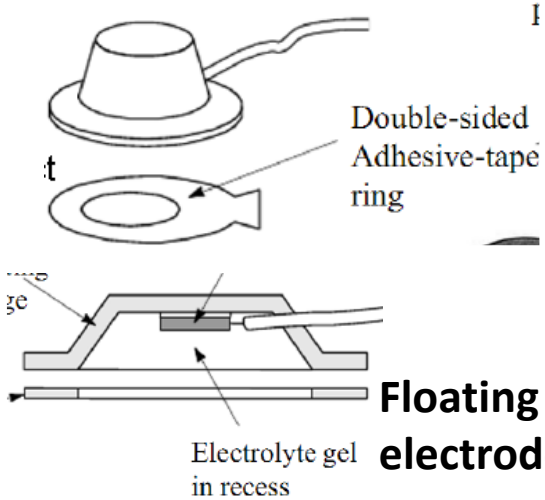
Types of electrodes:

- Polarizable electrodes (noble metals, Au, Pt)
- Non-polarizable electrode (Ag/AgCl)









Floating electrodes

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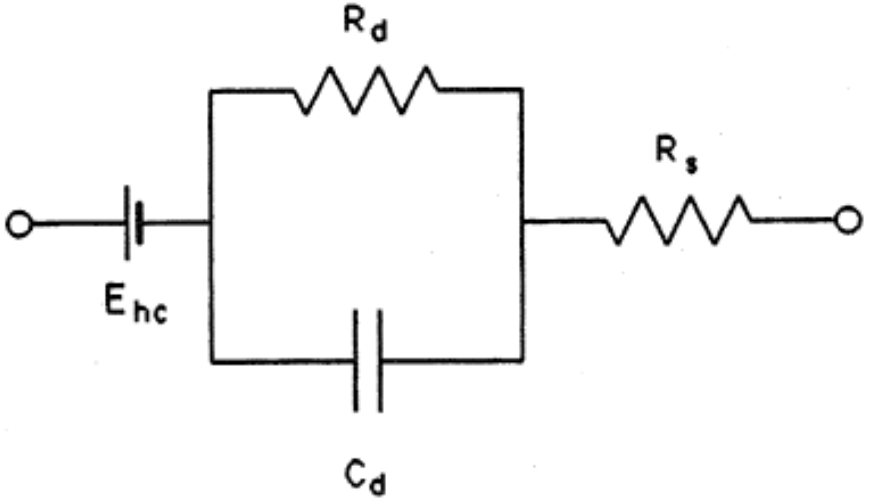
Equivalent circuit of electrode

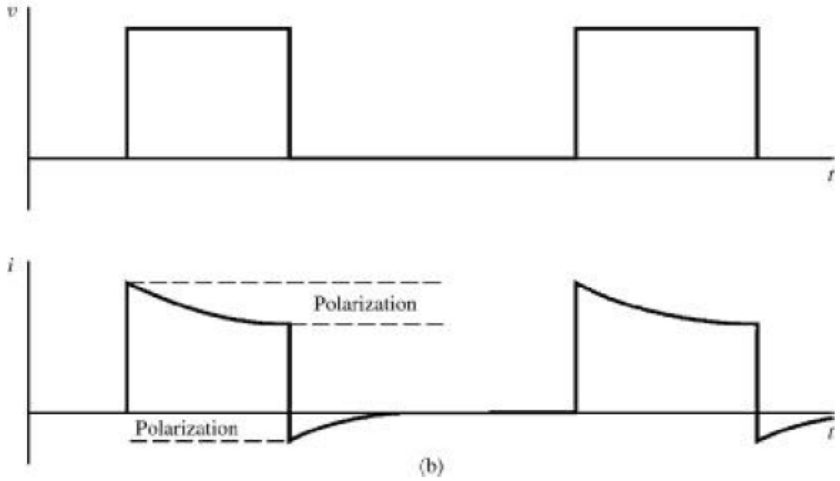


E_{hc} = Half cell potential

R_d , C_d = impedances associated with electrode-electrolyte systems

R_s = Series resistance

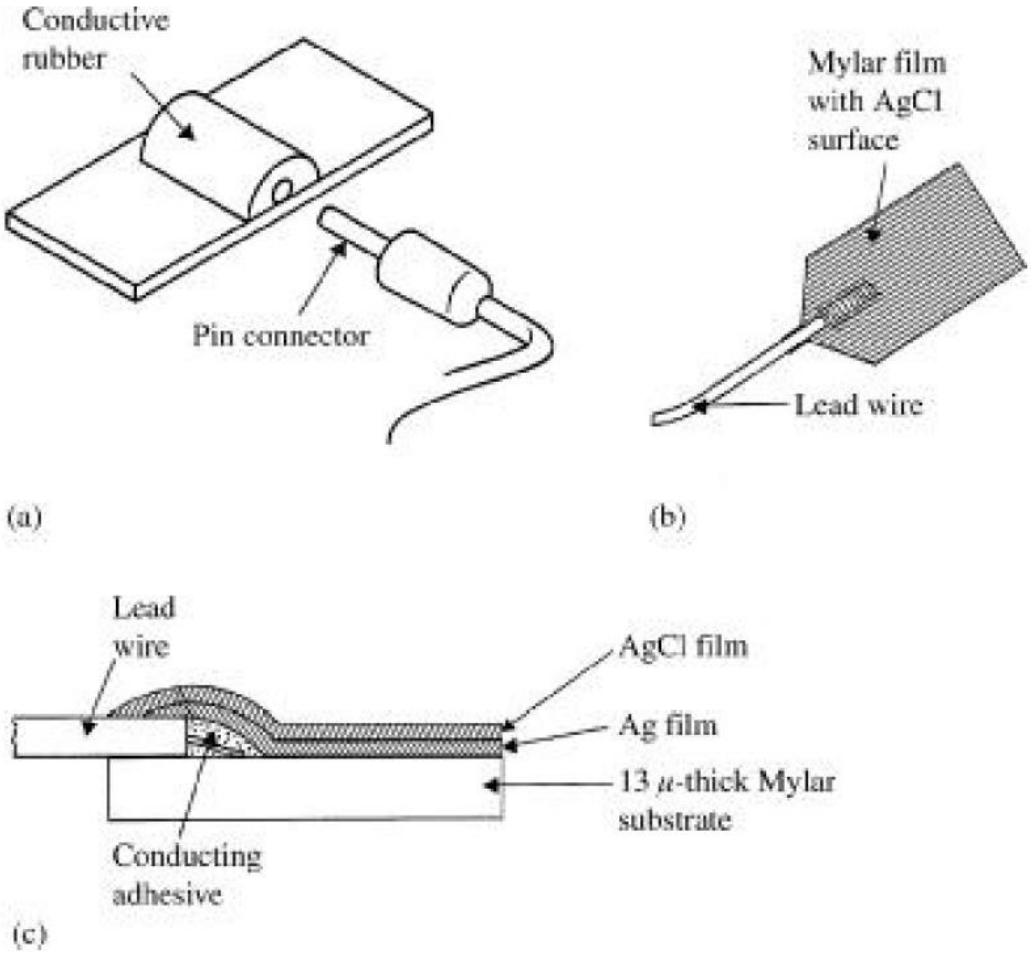
Effect of Polarization on Electrical Stimulation



Constant Voltage Stimulation

Constant Current Stimulation

Flexible electrodes



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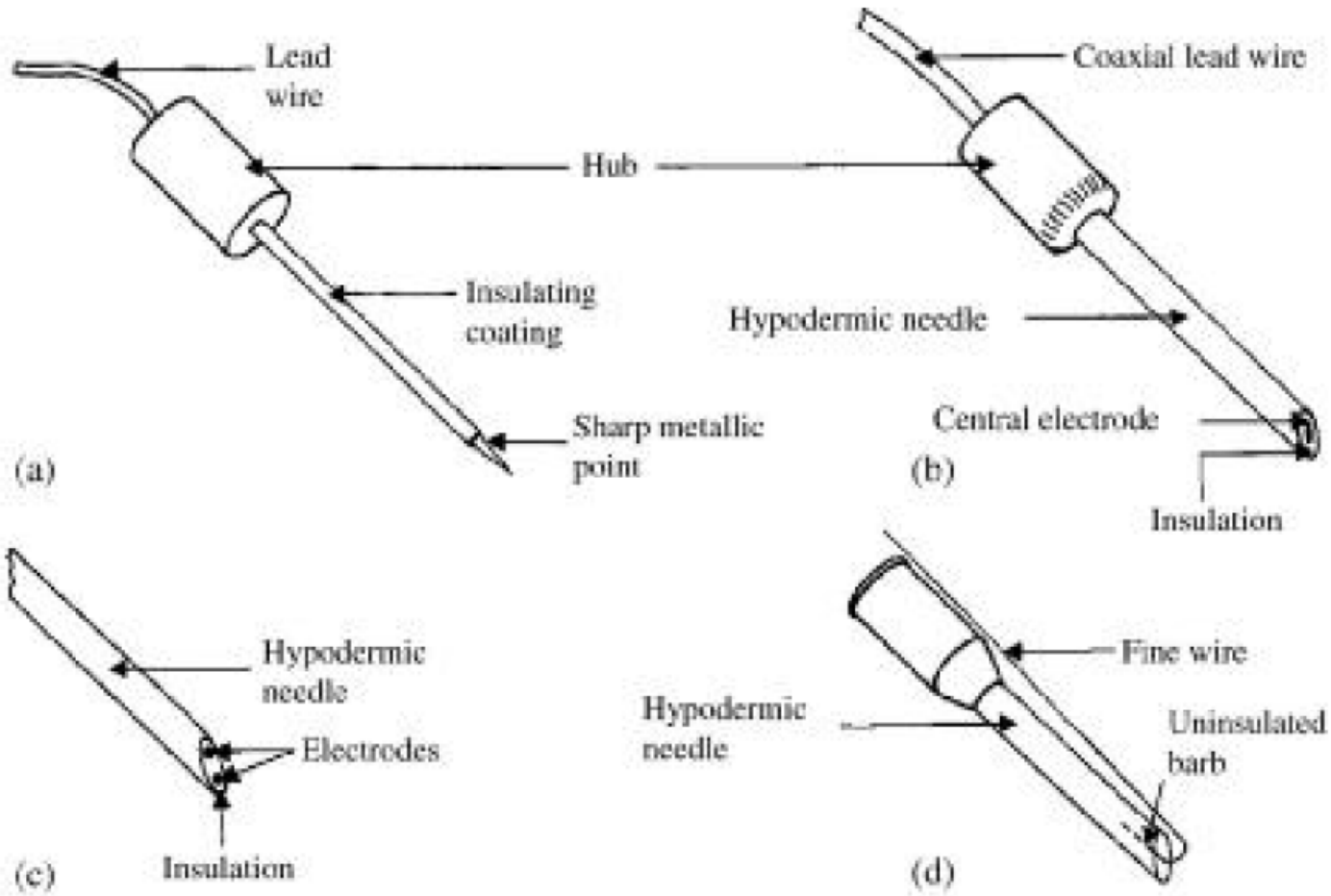
Needle electrodes



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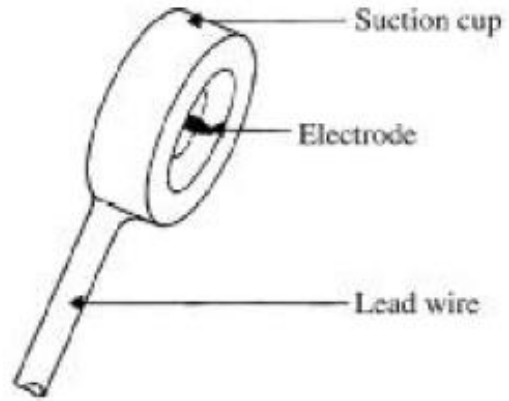
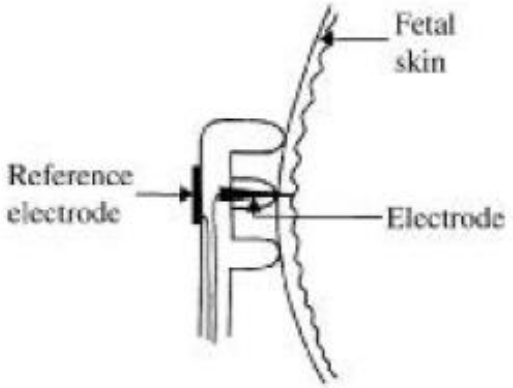
Foetal Electrode



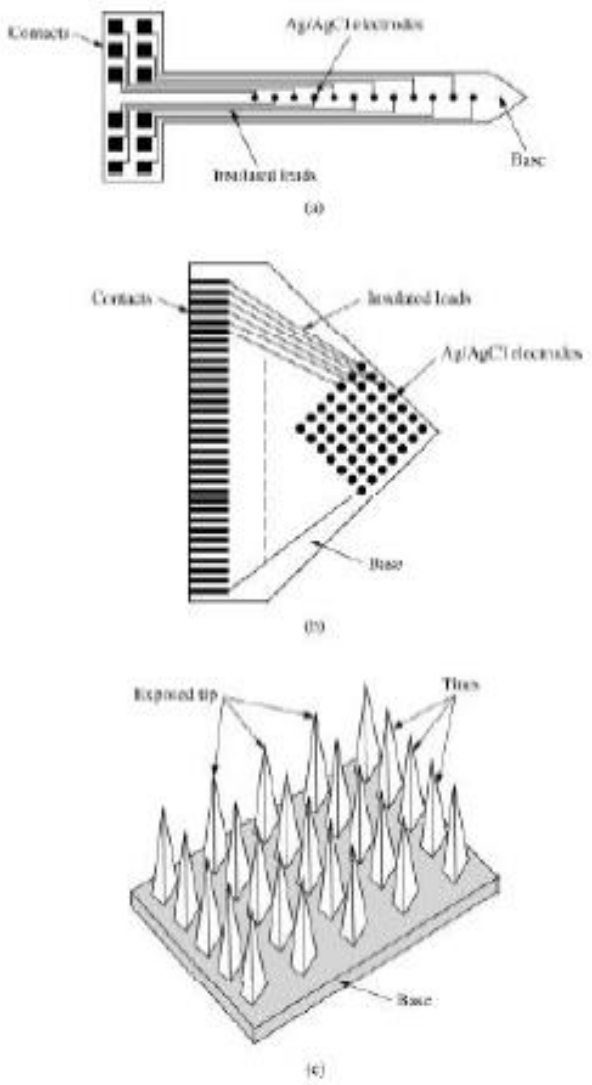
(a)

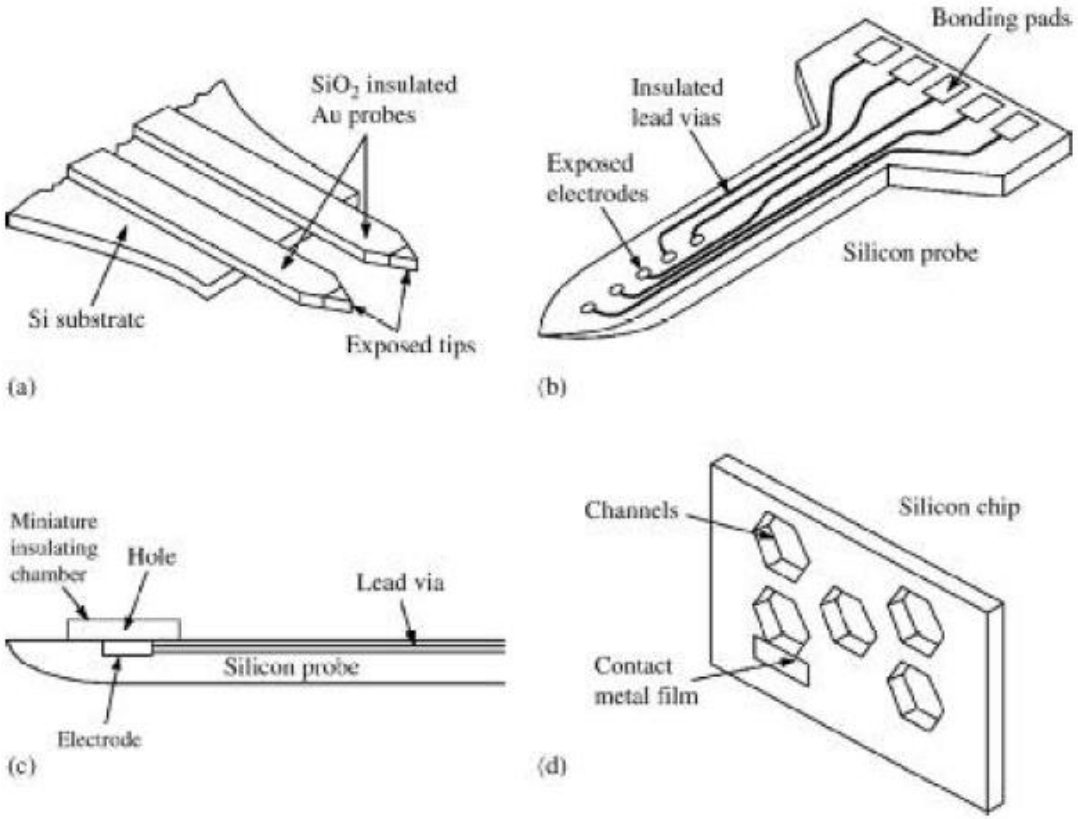
(c)



(b)

Microelectrode Arrays



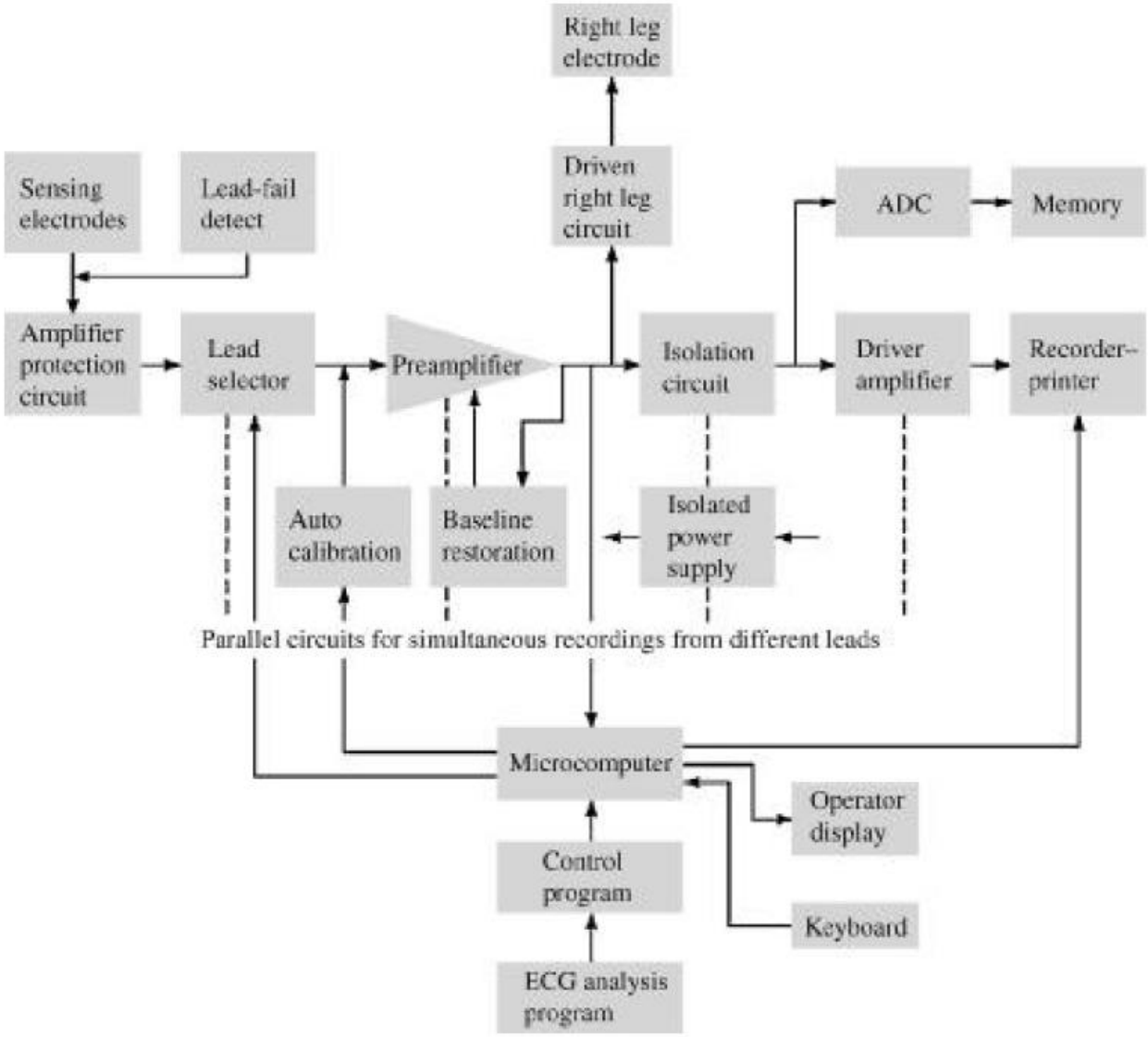


Microfabricated electrode array

Biopotential Amplifiers Requirements

- High input impedance
- Input protection
- High Gain
- Differential Input
- High Common Mode Rejection
- Calibration possibility

Electrocardiogram (ECG)



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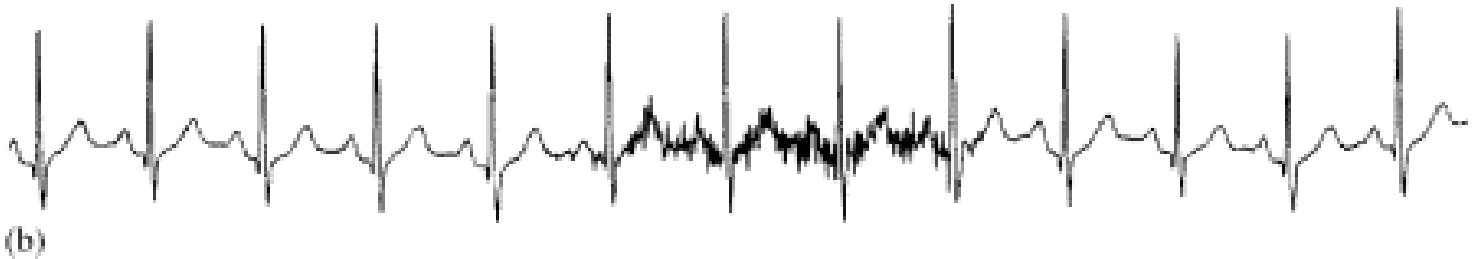
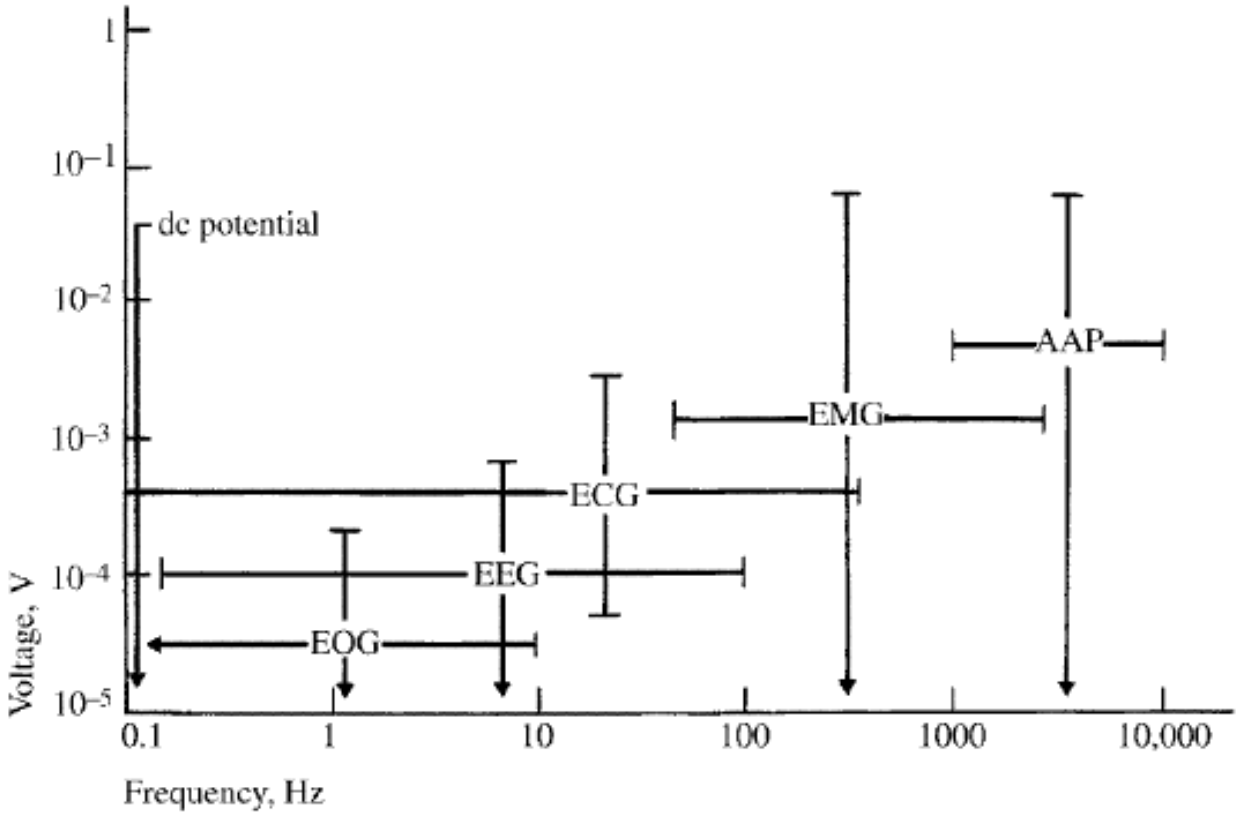
Electrical Interference

Power Line Pickup



Myogenic interference

Other Biopotential Amplifier



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