

# **Other Biopotentials**

**EMG**

**EEG**

**Visually Evoked Potentials**

**Auditorily Evoked Potentials**



## Voltage and Frequency Ranges for Some Important Parameters That Are Measured in the Human Body

<b>Parameter sensor location</b>	<b>Voltage range</b>	<b>Frequency range (Hz)</b>
Electrocardiography (ECG) Skin electrodes	0.5–4 mV	0.01–250
Electroencephalography (EEG) Scalp electrodes	5–200 $\mu$ V	DC–150
Electrogastrography (EGG) Skin–surface electrodes	10–1000 $\mu$ V	DC–1
Stomach–surface electrodes	0.5–80 mV	DC–1
Electromyography (EMG) Needle electrodes	0.1–5 mV	DC–10,000
Electrooculography (EOG) Contact electrodes	50–3500 $\mu$ V	DC–50
Electroretinography (ERG) Contact electrodes	0–900 $\mu$ V	DC–50
Nerve potentials Surface or needle electrodes	0.01–3 mV	DC–10,000



# ElectroMyoGram

## **What** is an electromyogram(EMG) ?

- A test that is used to record the electrical activity of muscles.
- EMGs can be used to detect abnormal muscle electrical activity that can occur in many diseases and conditions, such as amyotrophic lateral sclerosis (ALS) (also known as Lou Gehrig disease).

## **Why** is an EMG test done?

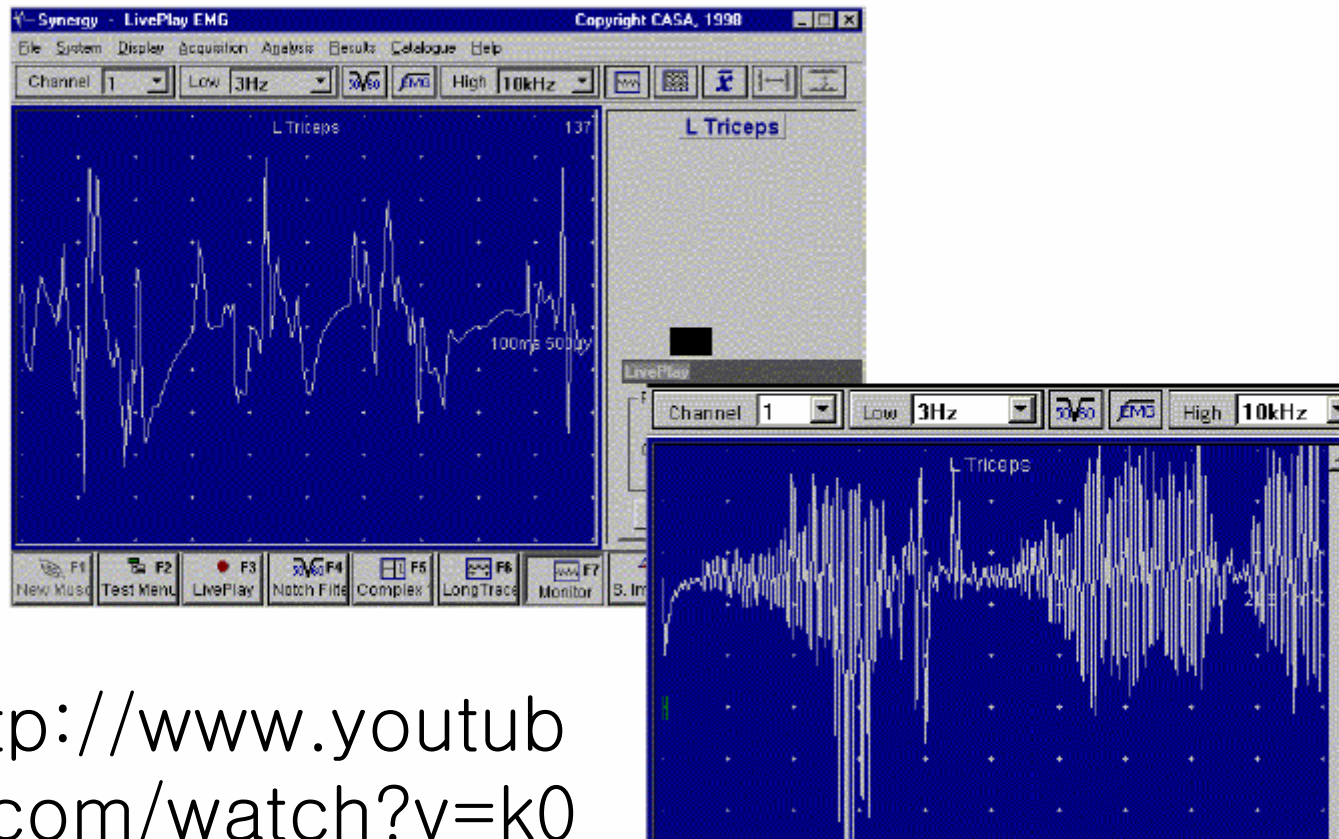
- For patients with unexplained muscle weakness.

## **What kinds** of EMG are there?

- *Intramuscular EMG* (the most commonly used type) involves inserting a needle electrode through the skin into the muscle whose electrical activity is to be measured.
- *Surface EMG* (SEMG) involves placing the electrodes on (not into) the skin overlying the muscle to detect the electrical activity of the muscle.



# EMG Waveform



[http://www.youtube.com/watch?v=k0uSpYd\\_Ics](http://www.youtube.com/watch?v=k0uSpYd_Ics)



# Electroencephalogram

1. A graphic recording of electrical activity of the brain, usually of the cerebral cortex, but sometimes of lower areas, recorded from electrodes placed on the surface of the scalp.
2. A graphic (voltage vs. time) depiction of the brain's electrical potentials (brain waves) recorded by scalp electrodes. It is used for diagnosis in neurologic and neuropsychiatric disorders and in neurophysiological research. Sometimes used interchangeably with electrocorticogram and depth record, in which the electrodes are in direct contact with brain tissue.



<http://www.youtube.com/watch?v=3eZTAAIt3QU>

<http://www.youtube.com/watch?v=M9XVm-ks1ME>

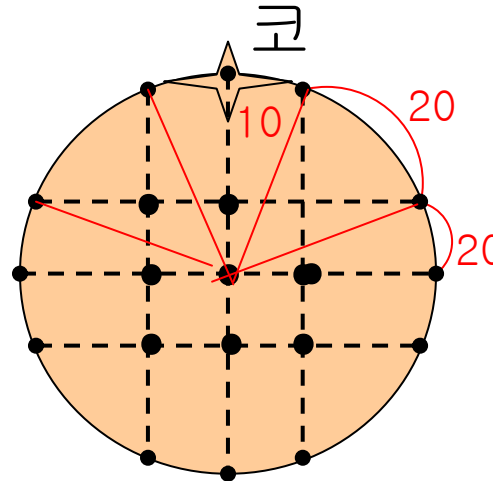
<http://www.youtube.com/watch?v=C4H-0eLVZAk>



# EEG

- EEG configuration  
21 electrodes,  $z \sim 10k\Omega$  max

Top view



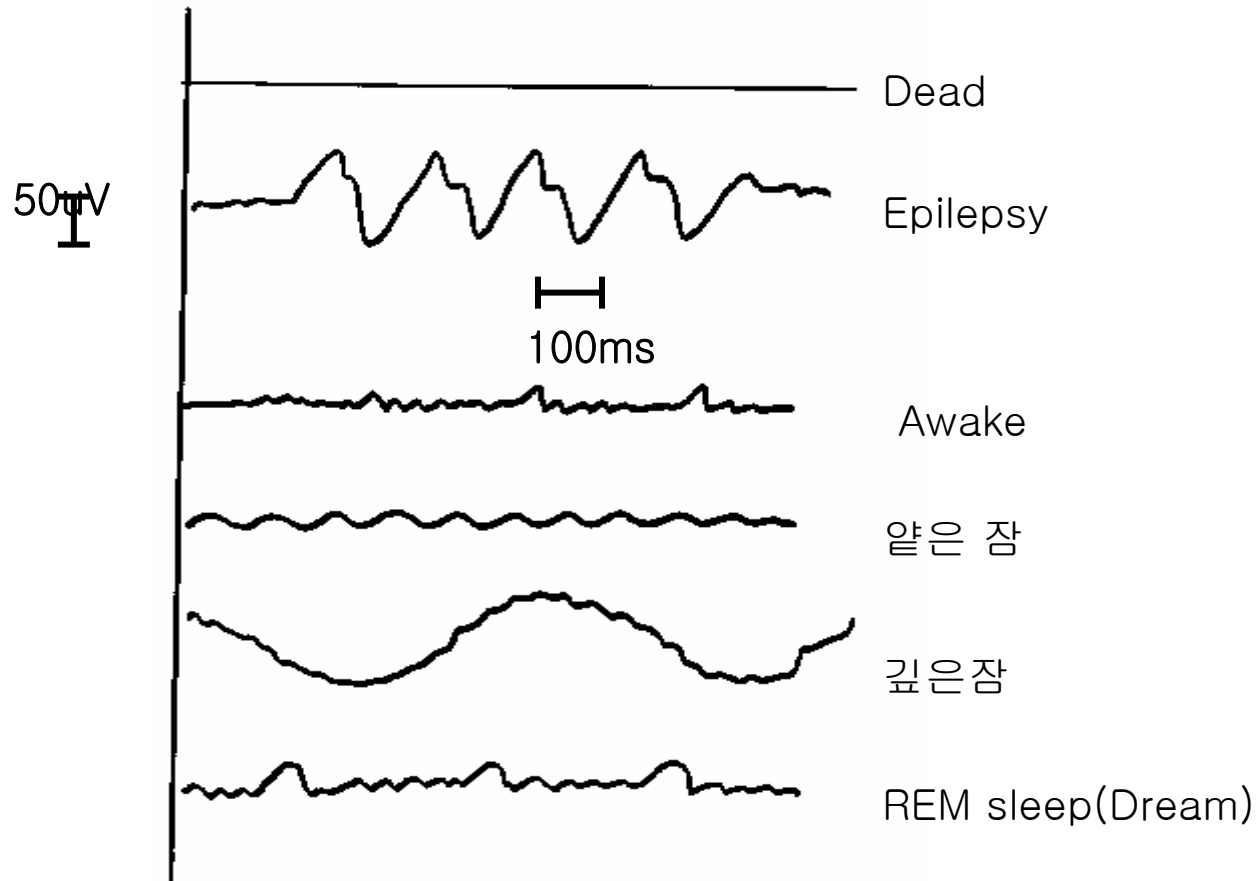
32 channel  
EEG

각 전극은 1cm 직경 정도의 면적을 봄.  
신호강도  $\alpha \propto 1/r^2$



# EEG

Wave	$\delta$	$\theta$	$\alpha$	$\beta$	$\gamma$
	0 ~ 4	~ 8	~ 13	~ 22	~ 30





# EEG source

Scalp EEG measures summated activity of post-synaptic currents. While it is post-synaptic potentials that generate the EEG signal, it is not possible to determine the activity within a single dendrite or neuron from the scalp EEG. Rather, surface EEG is the summation of the synchronous activity of thousands of neurons that have similar spatial orientation, radial to the scalp. Currents that are tangential to the scalp are not picked up by the EEG. The EEG therefore benefits from the parallel, radial arrangement of apical dendrites in the cortex. Because voltage fields fall off with the fourth power of the radius, activity from deep sources is more difficult to detect than currents near the skull.

Scalp EEG activity is composed of multiple oscillations. These have different characteristic frequencies, spatial distributions and associations with different states of brain functioning (such as awake vs. asleep). These oscillations represent synchronized activity over a network of neurons. The neuronal network underlying some of these oscillations are understood (such as the thalamocortical resonance underlying sleep spindles), while many others are not (e.g., the system that generates the posterior basic rhythm still defies understanding).



# EEG and MEG

Electroencephalography (EEG) and magnetoencephalography (MEG) are non-invasive techniques for detecting and localizing electrical activities of the central nervous system. EEG systems measure the electric potentials induced on the surface of the scalp using electrodes (see Fig. 1). MEG systems measure the magnetic fields emanating from the brain with SQUID biomagnetometers (SQUID is a Superconducting QUantum Interference Device.) (see Fig. 2). Both EEG and MEG are non-invasive, have good temporal resolution, and directly yield information about neurologic functions. Compared with EEG, MEG is more robust to modeling inaccuracy, more comfortable, has a smaller procedural cost (shorter preparation time), but is also more expensive. EEG and MEG can be used in clinical applications such as seizure source localization in epilepsy, fetal medicine, psychiatry, or in neuroscience to analyze sensorimotor or cognitive functions of the brain.





Fig. 1: 128 channel EEG system (courtesy of Electrical Geodesics).

Fig. 2: (a) 143 channel MEG system. (b) Illustration of the MEG sensor array. The contours correspond to the magnitude of the field induced by the source. (courtesy of VSM MedTech Ltd.)



**Intro. BME**

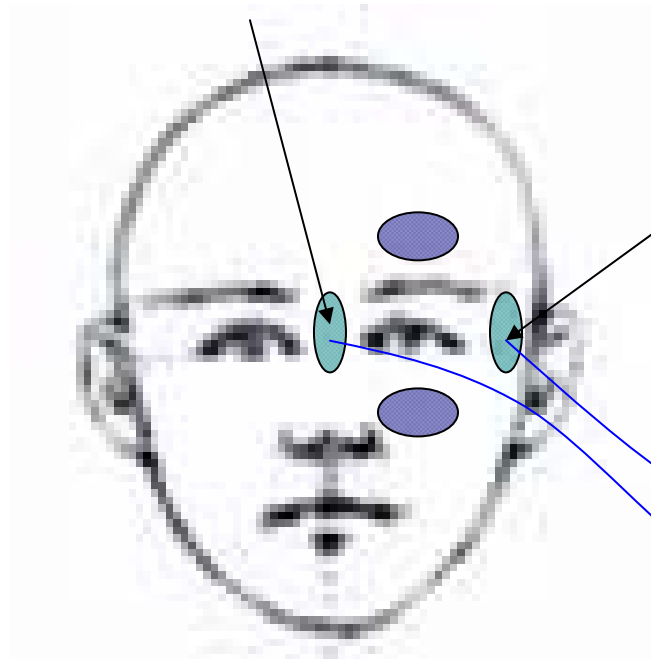
# Biopotentials related with Vision

- EOG : 안전도, eye battery 측정  
일정한 거리의 두 점을 교대로 보게 하면서 뇌파 기록
- ERG : 망막전계, 광자극에 의한 망막의 전기적 반응 계측
- Visually Evoked Potential (VEP) and EEP (from retina prosthesis)



# Electro-Oculogram

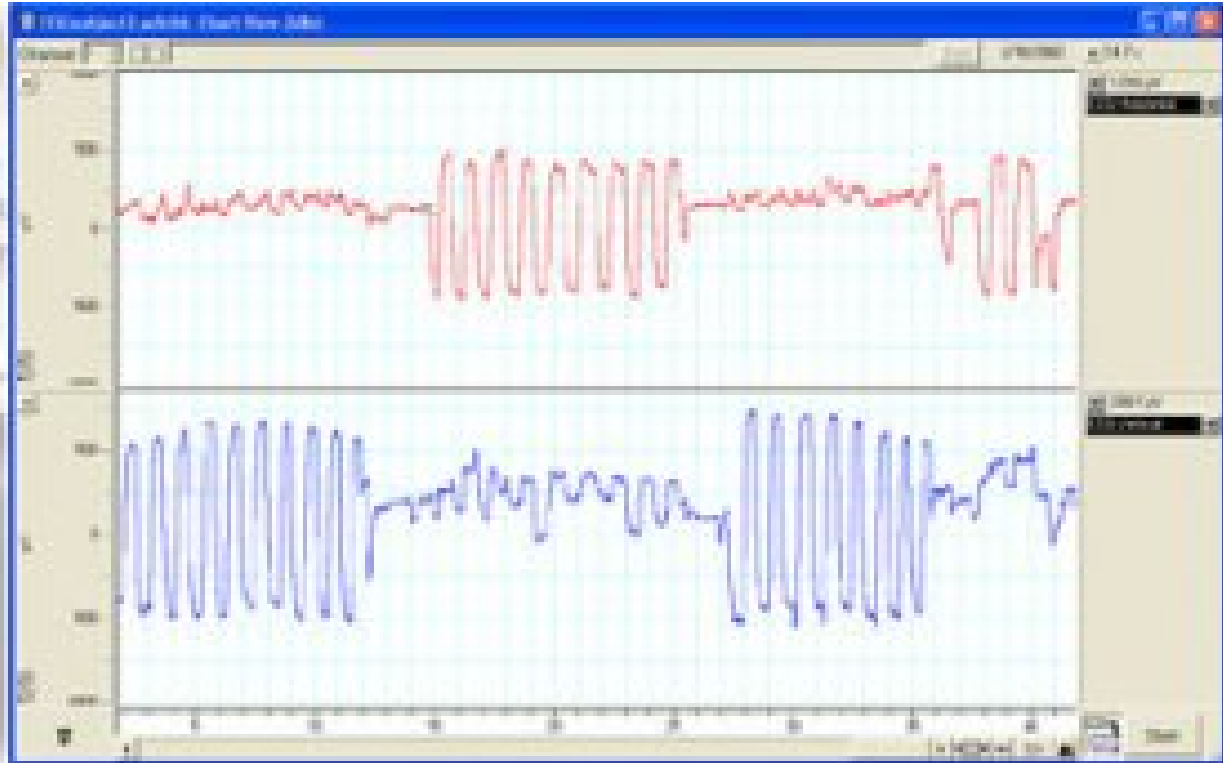
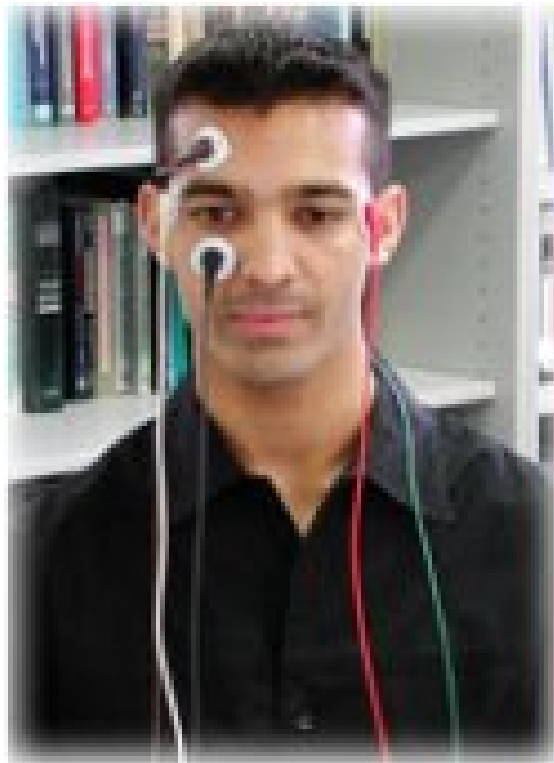
Surface electrode  
on the nose



Surface electrode  
on the temple

EOG Amplifier+filter





<http://www.adinstruments.com/education/experiments/applications/Electrooculogram--EOG--Recordings/>

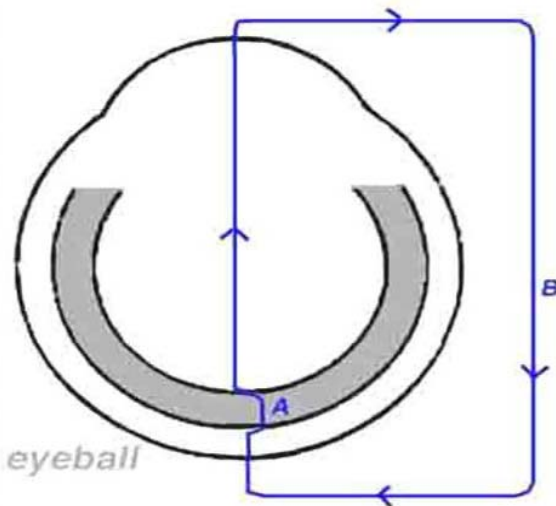
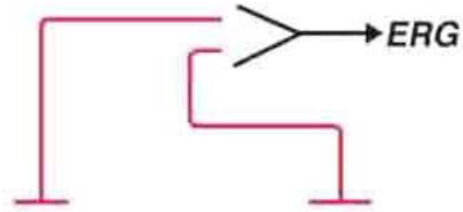


**Intro. BME**

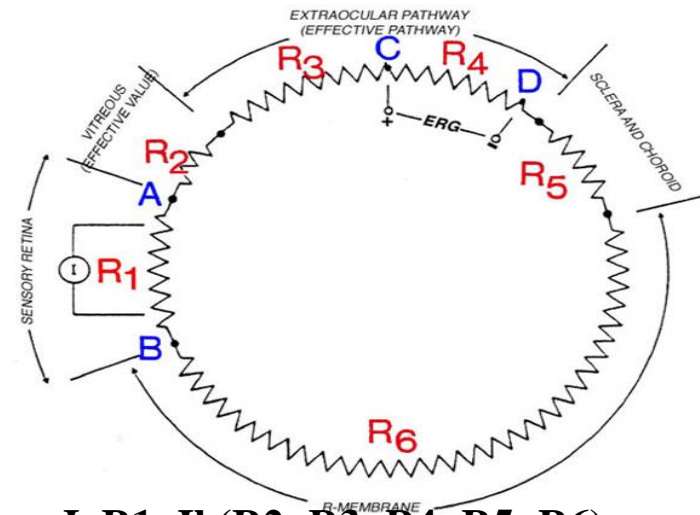
# Electroretinogram & Visual Evoked Potential



# The Electrical Basis of ERG Recordings



Current pathway following light stimulation



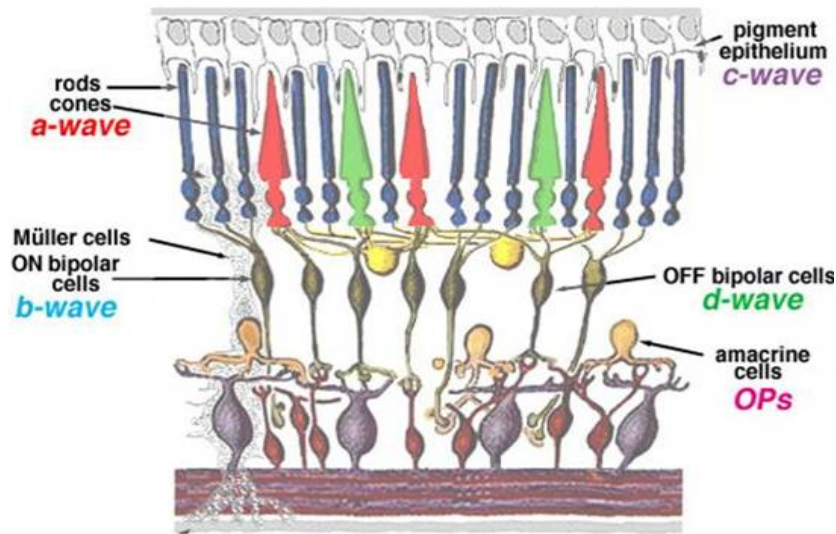
$$I_a R_1 = I_b (R_2 + R_3 + R_4 + R_5 + R_6)$$

An equivalent electrical circuit of the eye

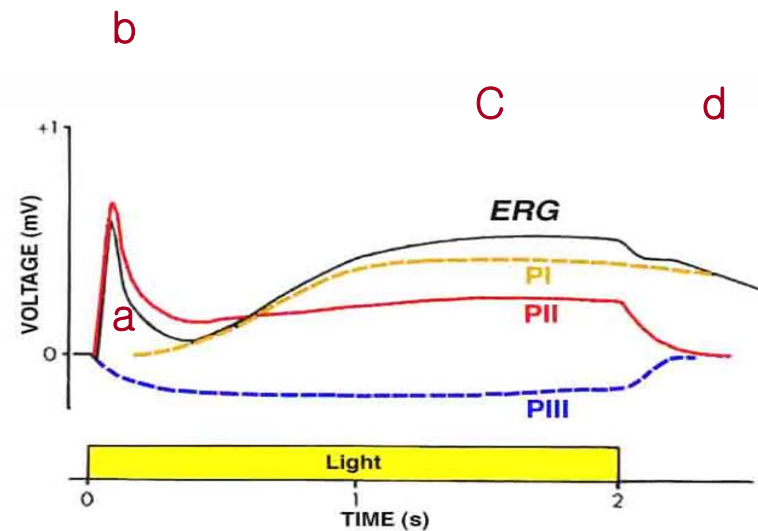




# ERG Parameters and Major Components



Retina layer



The ERG of a cat in response to a 2 sec light stimulus.

PI, PII, and PIII waveforms are isolated by depending the state of anesthesia.



# The ERG Parameters Measured in the Ophthalmic Clinic

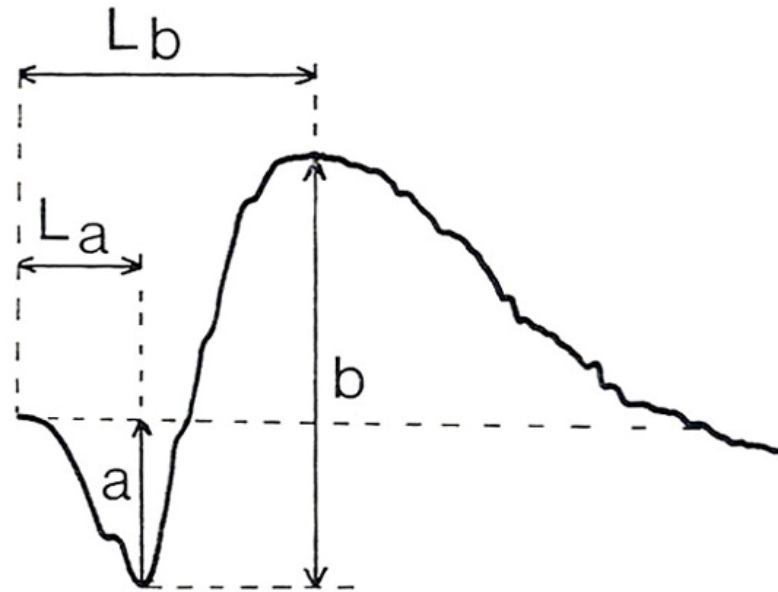
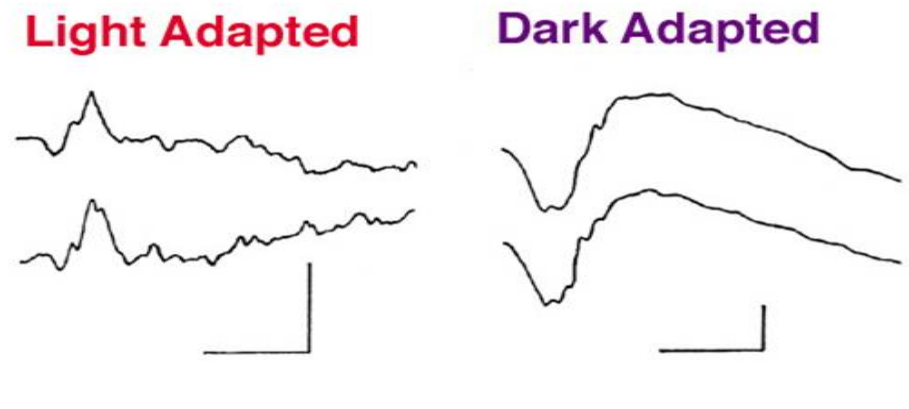


Fig. 21. The ERG parameters that are customarily measured in the ophthalmic clinic for electrodiagnosis. The size of the a-wave is measured from the baseline to the trough of the wave. The size of the b-wave is measured from the trough of the a-wave to the peak of the b-wave. The time-to-peak for both waves ( $L_a$  and  $L_b$ ) is determined from stimulus onset to the trough or peak of the waves.



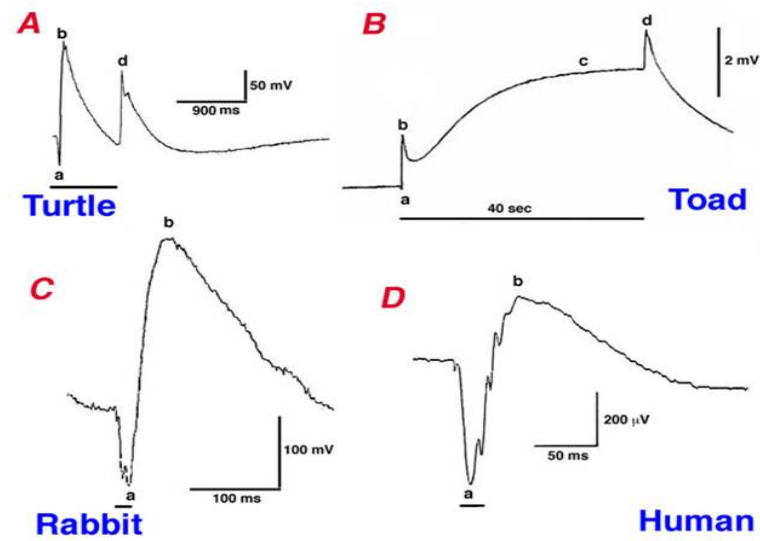
# ERG Responses from different light Adaptation



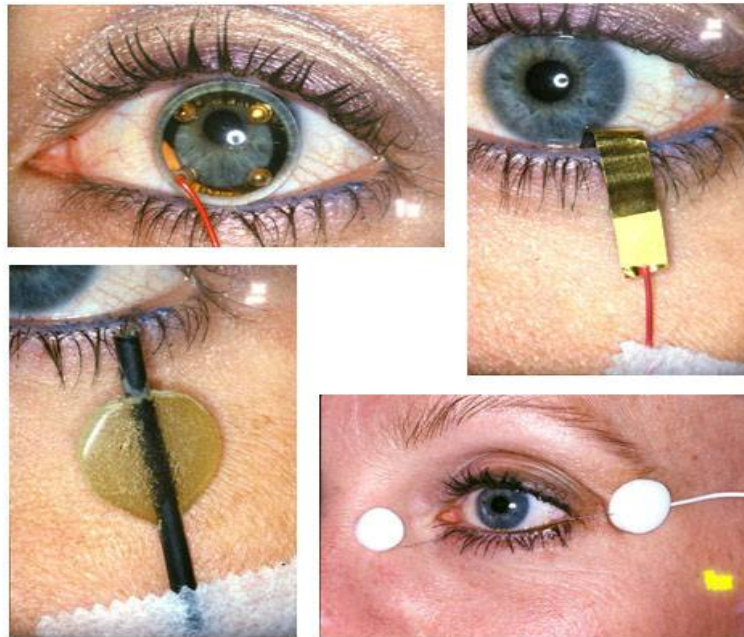
The same light stimulus was used.



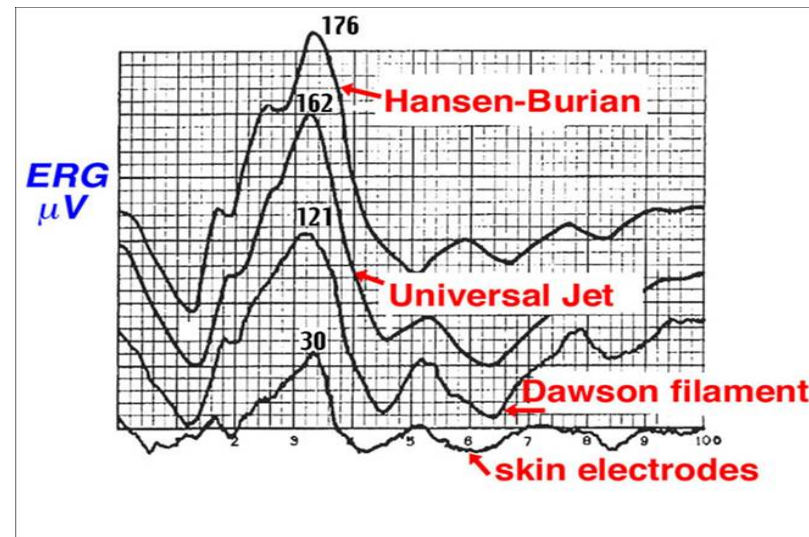
# ERG Responses from Different Species



# Typical ERGs as Recorded with Different Electrodes



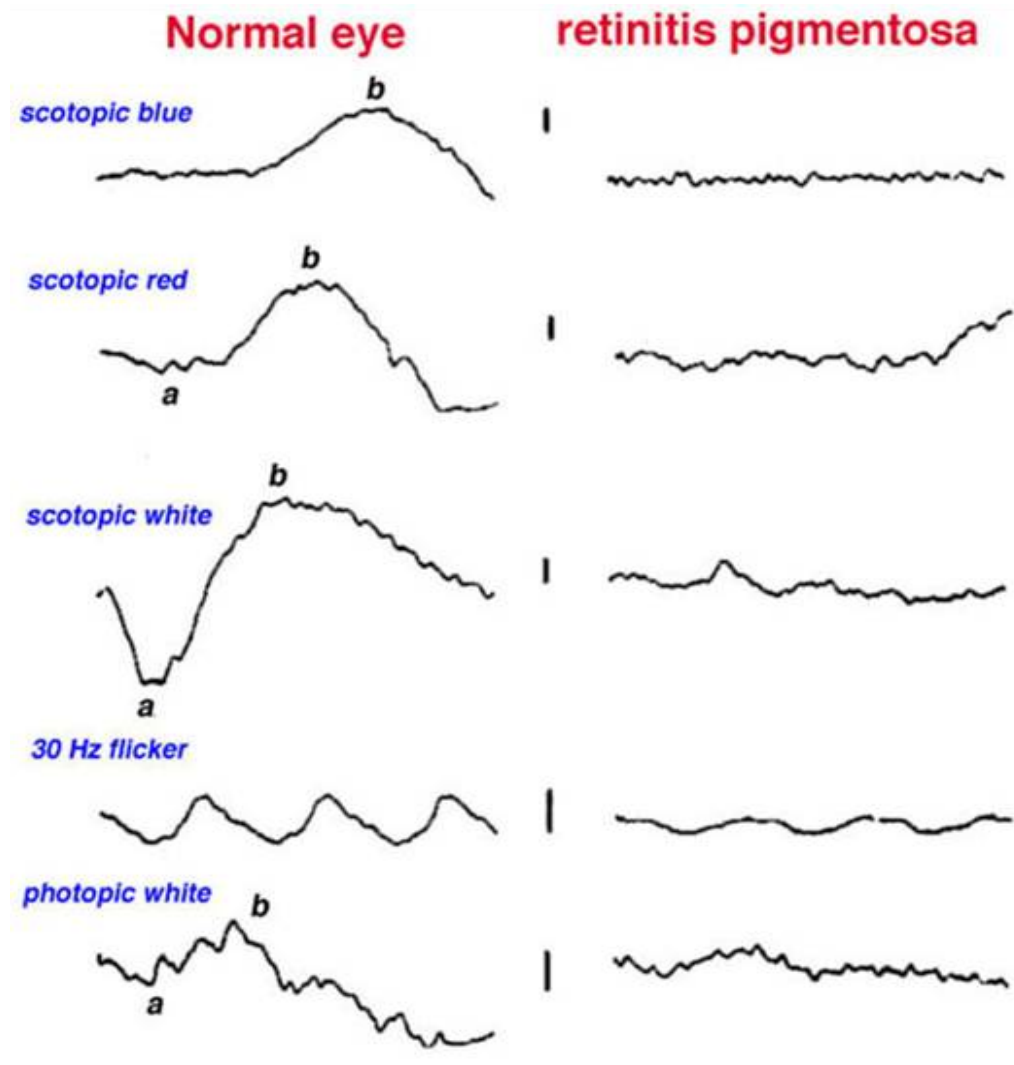
*some corneal ERG electrodes*



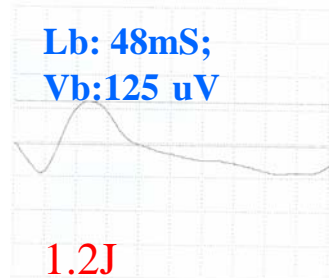
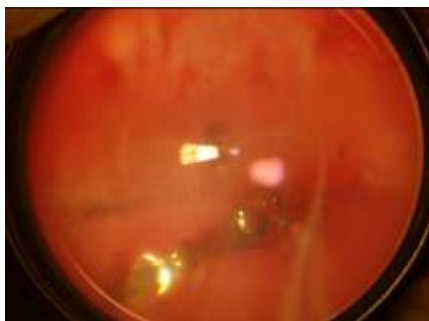
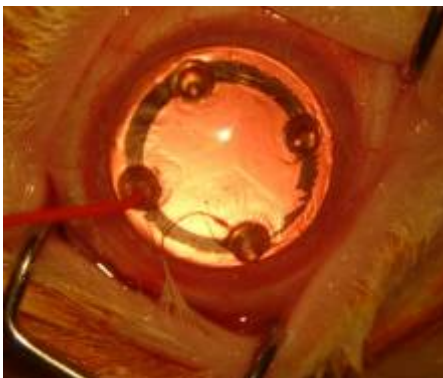
# Fundus Photo of Human Retina



# ERGs from Normal Subject and RP Patient



# ERG & EERG (Electrically Evoked ERG)



**Flash** (a)

20mS/DIV  
100uV/DIV  
High Cut: 30Hz  
Low Cut: 0.5Hz

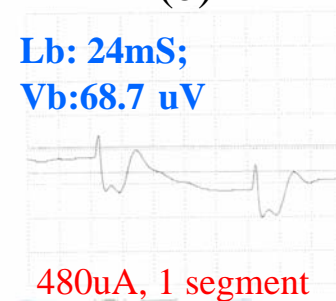
**Recording Condition**



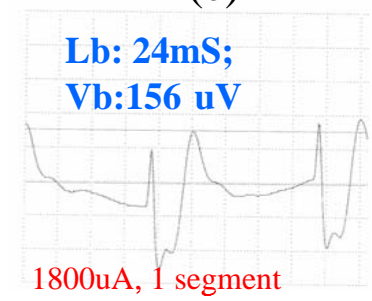
(b)



(c)



(d)



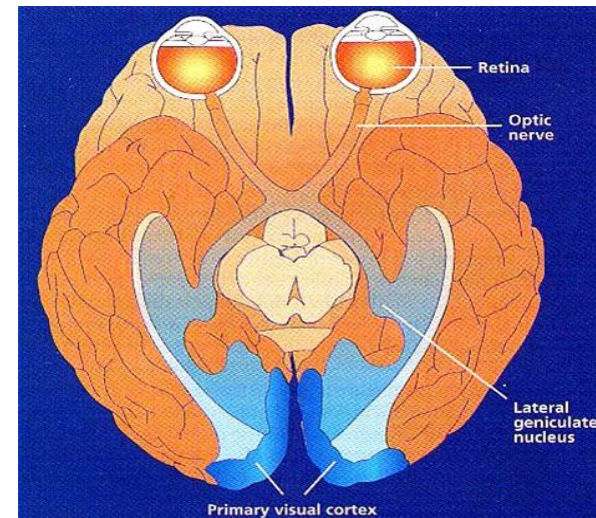
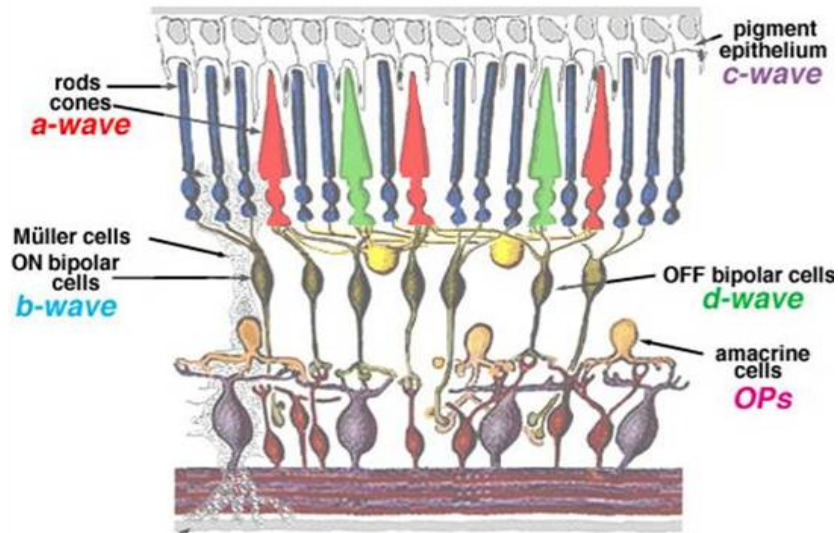
(e)

(b), (c): subretinal stimulation; (d), (e): epiretinal stimulation

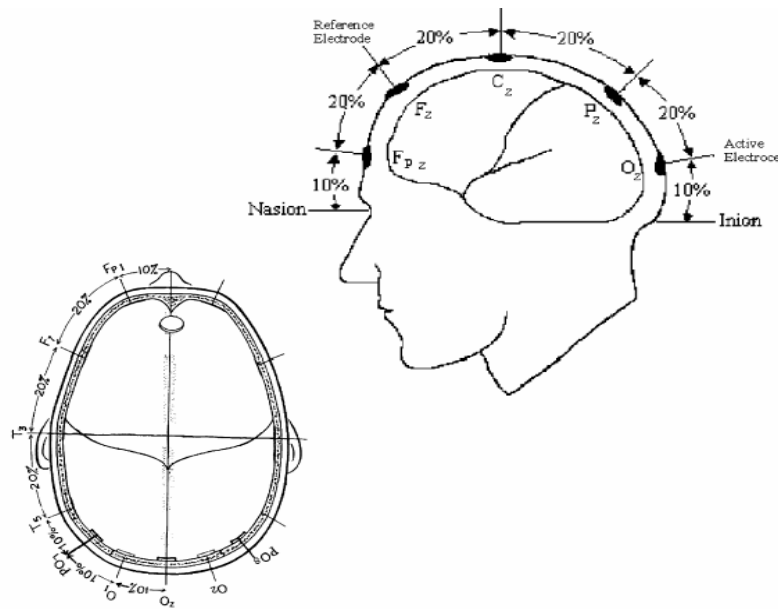




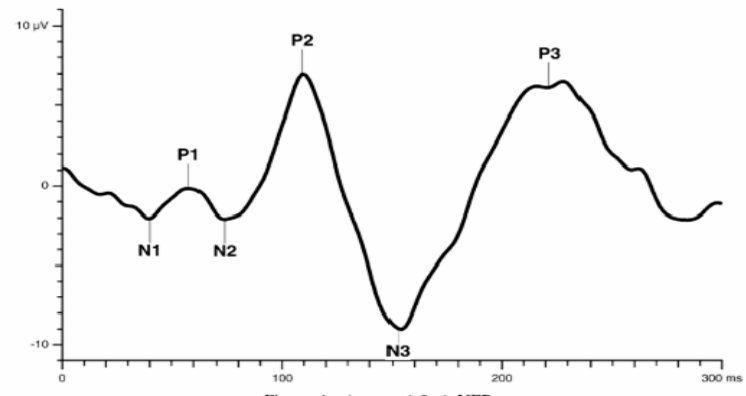
# The Retina and Visual System



# VEP Recording



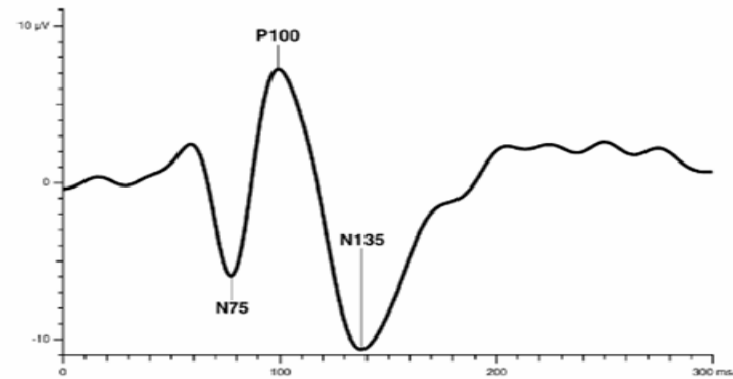
**Electrode Location**



**A normal flash VEP**

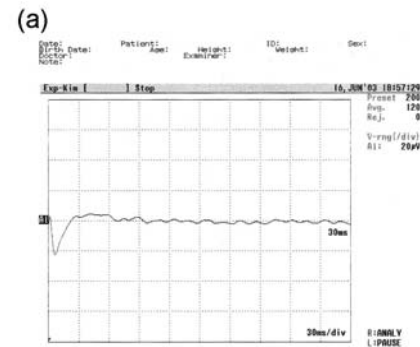


# A Pattern Reversal VEP

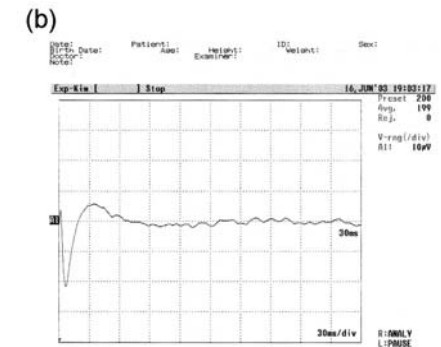


Intro. BME

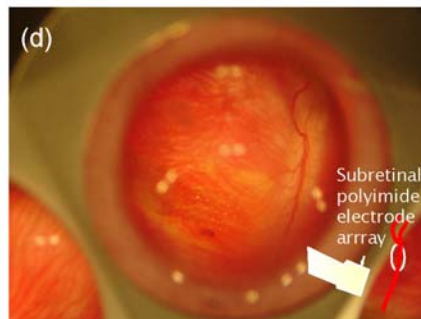
# Electrically Evoked Potentials



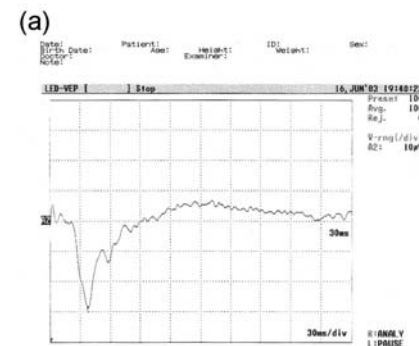
EEP, 1 mA



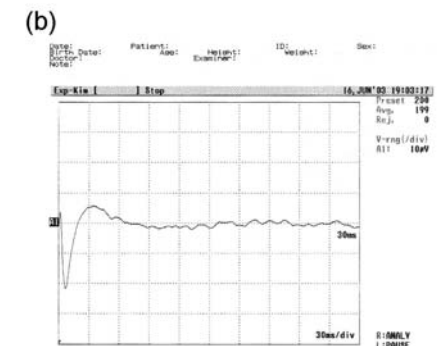
EEP, 2.5mA



## Subretinal Electrical Stimulation



VEP



EEP, 2.5mA

