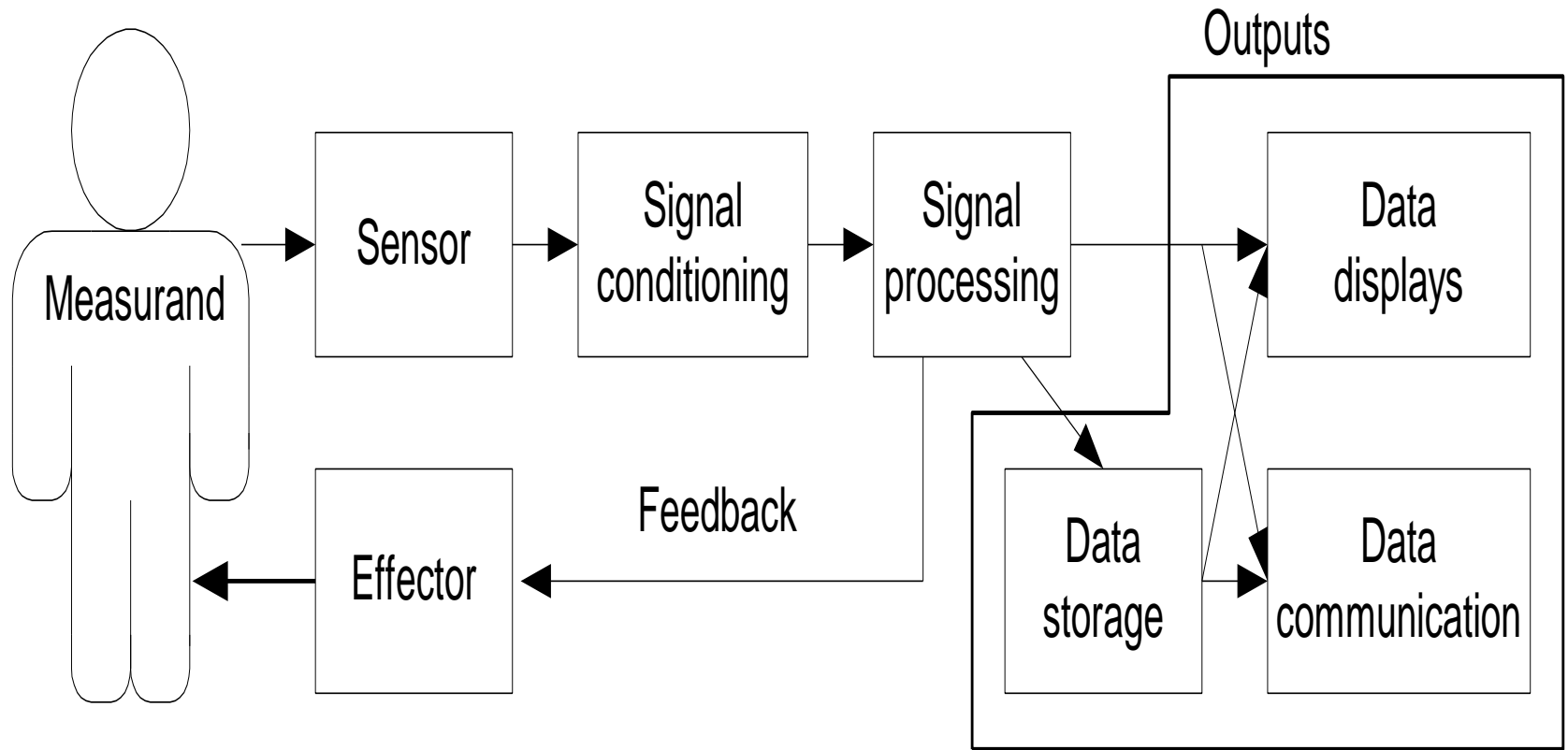


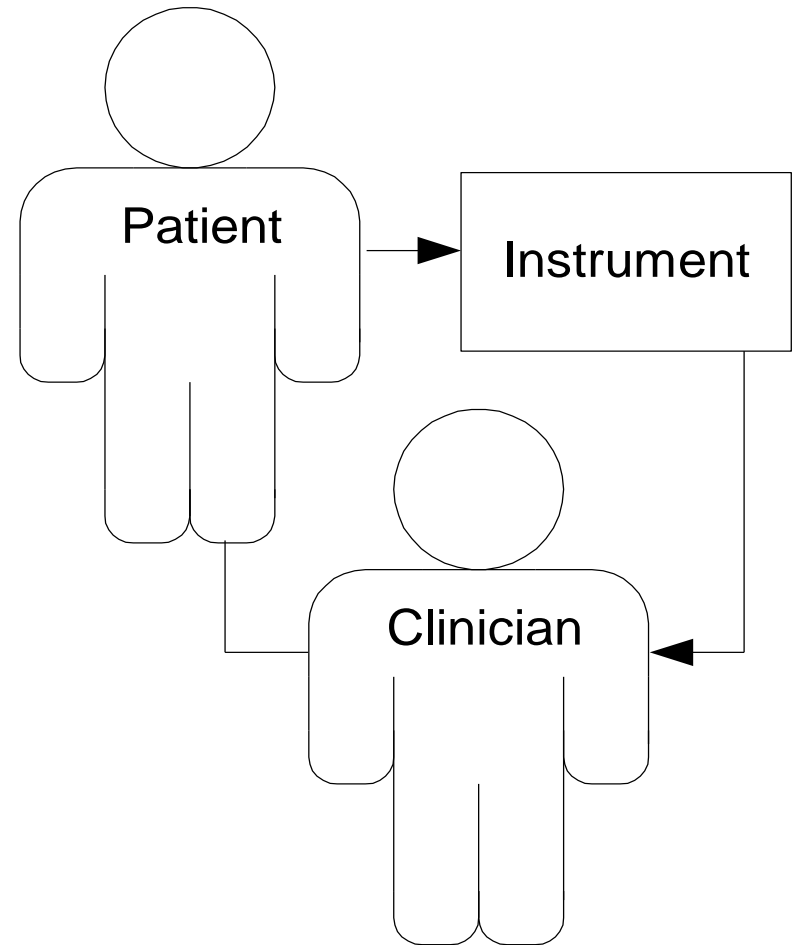
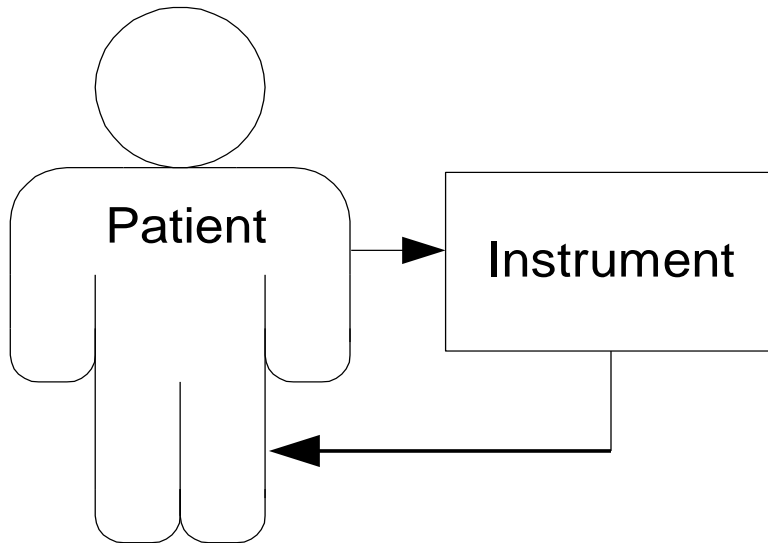
ELECTRO – PHYSIOLOGICAL MEASUREMENTS

Electrodes –Limb electrodes –floating electrodes –
pregelled disposable electrodes - Micro, needle and
surface electrodes – Amplifiers: Preamplifiers, differential
amplifiers, chopper amplifiers – Isolation amplifier.
ECG – EEG – EMG – ERG – Lead systems and recording
methods – Typical waveforms.
Electrical safety in medical environment: shock
hazards – leakage current- Instruments for checking
safety parameters of biomedical equipments

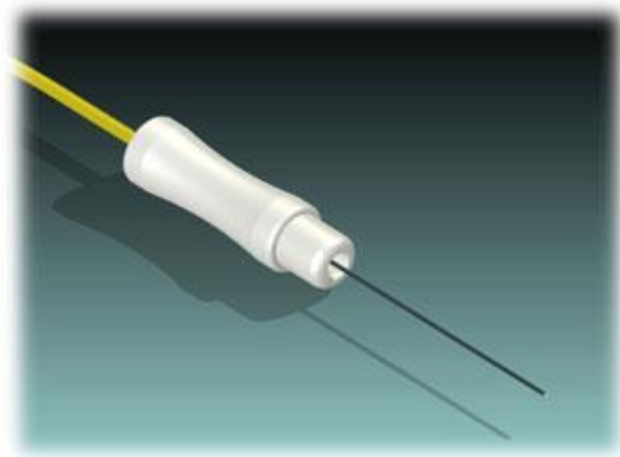
Basic Components of a Biomedical System



Biomedical System



Electrodes :Micro,needle



Electrodes :Micro,needle

DISPOSABLE DETACHABLE EMG MONOPOLAR NEEDLE ELECTRODES

PTFE coated stainless steel needle

Color coded caps

Pre-sterilized

Includes 2 reusable super-flexible 24" wire leads with touch proof connector

Individually packaged and sold in packs of 25 or 50 electrodes

DISPOSABLE CONCENTRIC NEEDLE ELECTRODES



DISPOSABLE CONCENTRIC NEEDLE ELECTRODES

One time use

Pre-sterilized

No assembly required

Platinum alloy core

.07 sq mm recording area

Color coded caps

Super flexible red/black twisted lead

Standard touch proof connectors

Individually packaged and sold in packs of 20 electrodes

DISPOSABLE INJECTABLE MONOPOLAR NEEDLE ELECTRODE



DISPOSABLE INJECTABLE MONOPOLAR NEEDLE ELECTRODE

One time use

Pre-sterilized

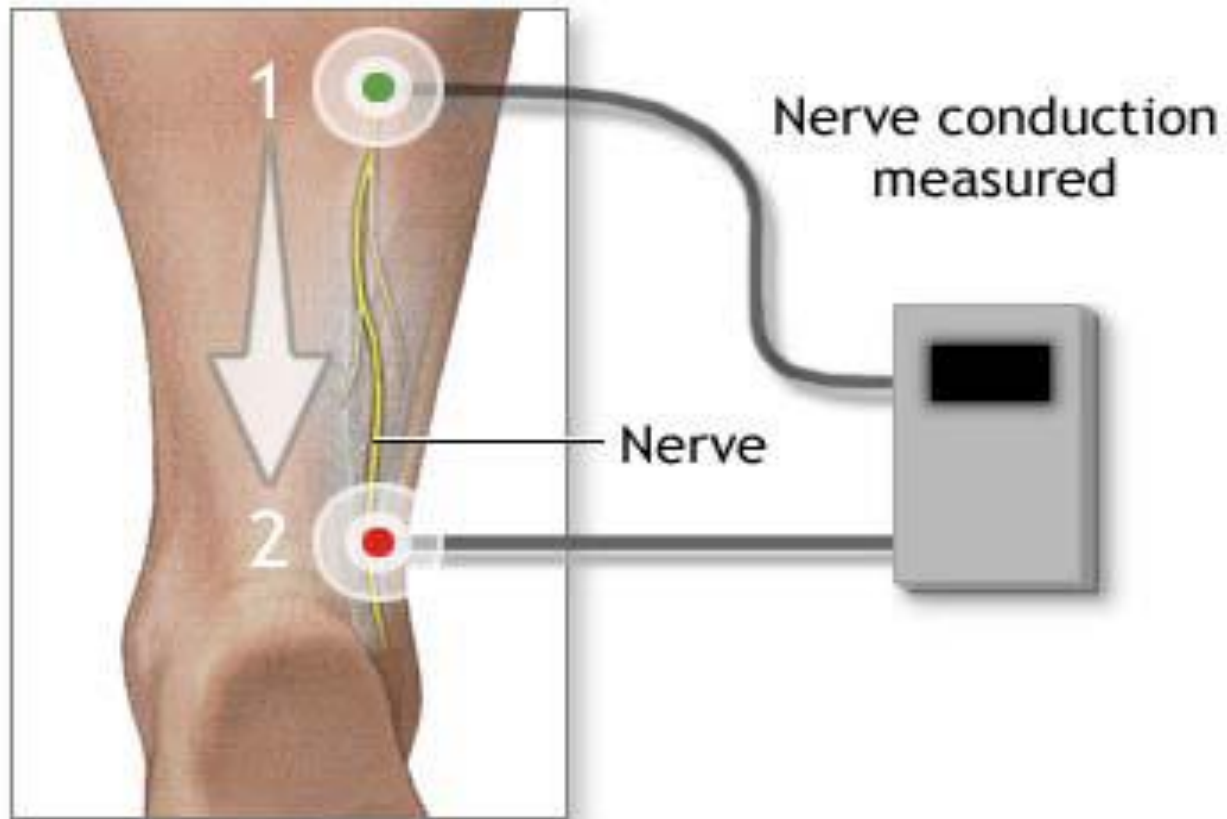
Teflon coated, stainless steel hollow cannula

24" Detachable cable

Standard touch proof connectors

Individually packaged and sold in packs of 10
needles

Surface Electrodes



(Cont...)

measures the rate at which an electrical impulse moves along a nerve.

It is used to diagnose disorders of the peripheral nerves and muscle

The nerve is stimulated, usually with surface electrodes, which are patch-like electrodes (similar to those used for ECG) placed on the skin over the nerve at various locations.

(Cont...)

One electrode stimulates the nerve with a very mild electrical impulse

The resulting electrical activity is recorded by the other electrodes. The distance between electrodes and the time it takes for electrical impulses to travel between electrodes are used to calculate the nerve conduction velocity.

Normal body temperature must be maintained (low body temperature slows nerve conduction)

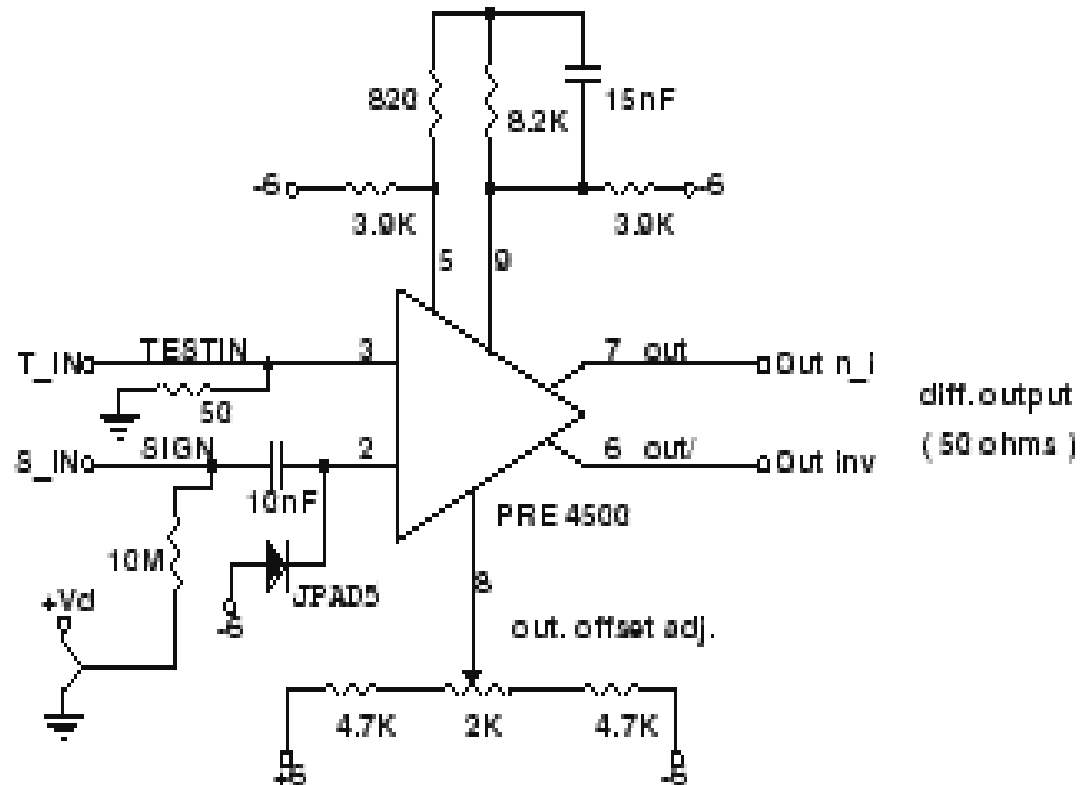
Amplifier

an **amplifier** or simply **amp**, is any device that changes, usually increases, the amplitude of a signal. The "signal" is usually voltage or current. The relationship of the input to the output of an amplifier — usually expressed as a function of the input frequency — is called the transfer function of the amplifier, and the magnitude of the transfer function is termed the gain.

Preamplifiers

To pos. voltage for cathodes
(sectors and common sides
of quad. det.)

To GND for anodes
(rings and quadrants)



(Cont...)

A **preamplifier** (preamp), or **control amp** in some parts of the world, is an electronic amplifier which precedes another amplifier to prepare an electronic signal for further amplification or processing. The preamplifier circuitry may or may not be housed as a separate component.

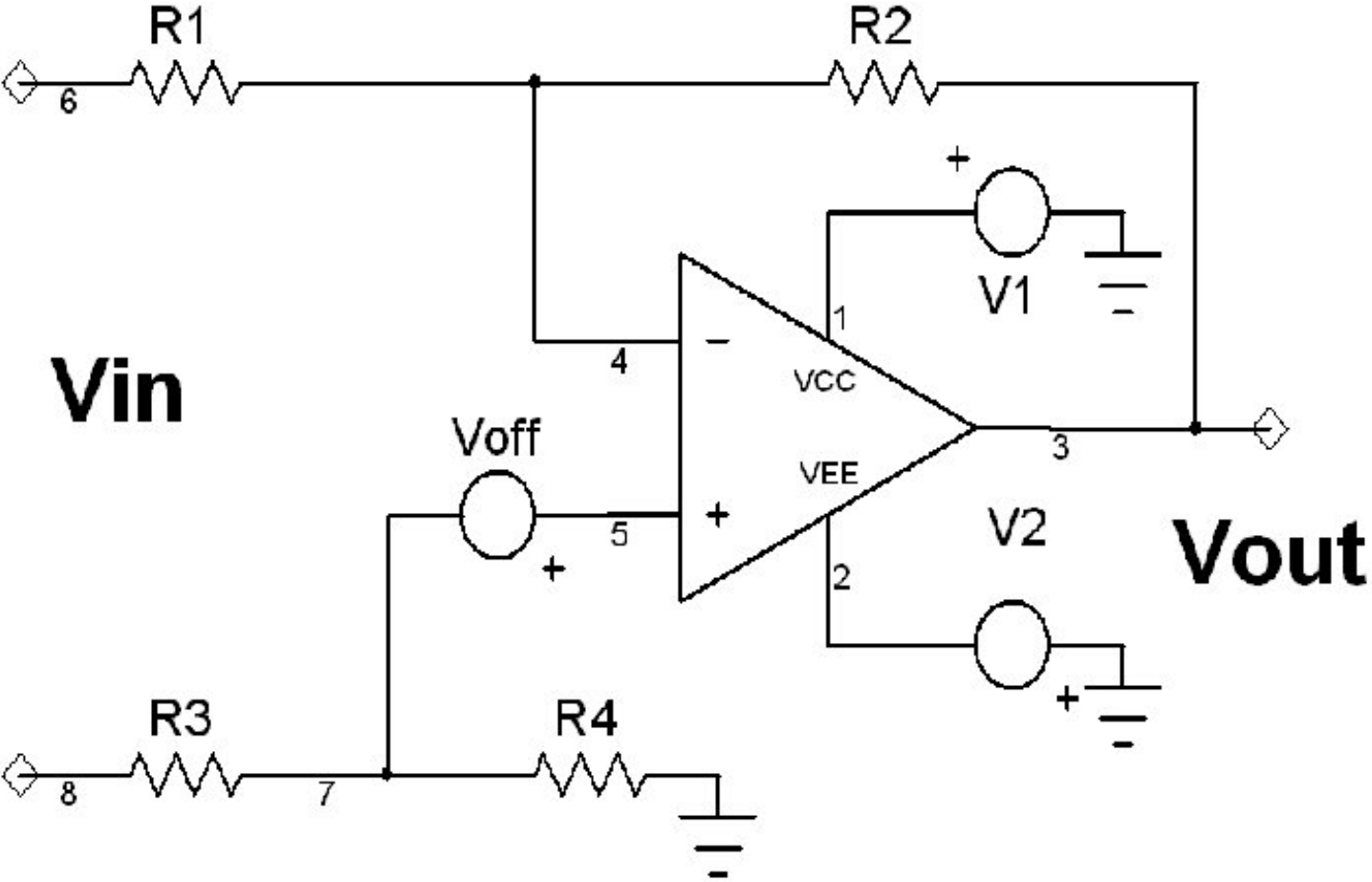
In general, the function of a preamp is to amplify a low-level signal to line-level

(Cont...)

Preamplifiers may be:

incorporated into the housing or chassis of the amplifier they feed
in a separate housing
mounted within or near the signal source, such as a turntable, microphone or musical instrument.

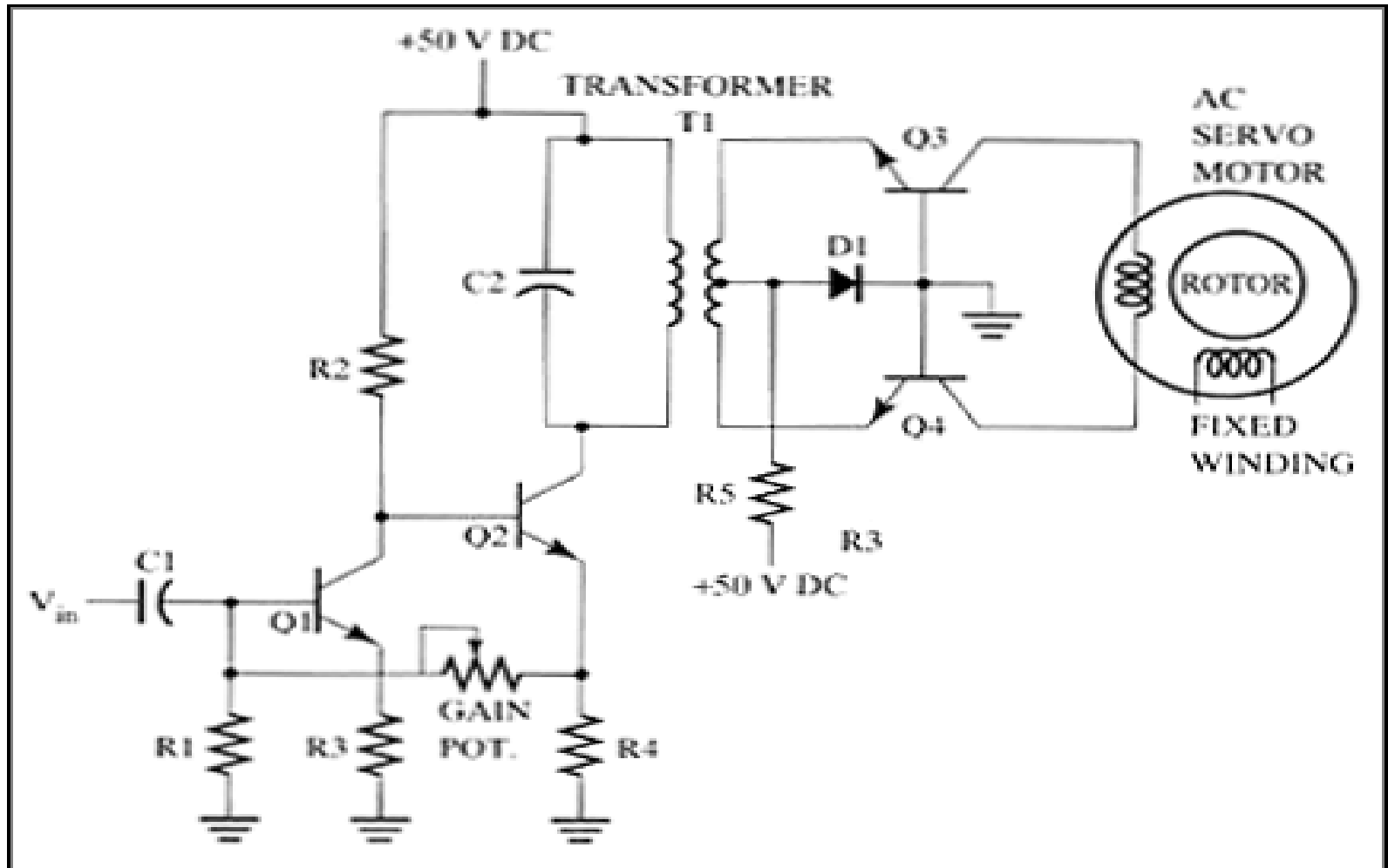
Differential Amplifiers



(Cont...)

Differential amplifier is a type of electronic amplifier that multiplies the difference between two inputs by some constant factor (the differential gain). Many electronic devices use differential amplifiers internally. Given two inputs and , a practical differential amplifier gives an output V_{out} :

Chopper Amplifiers



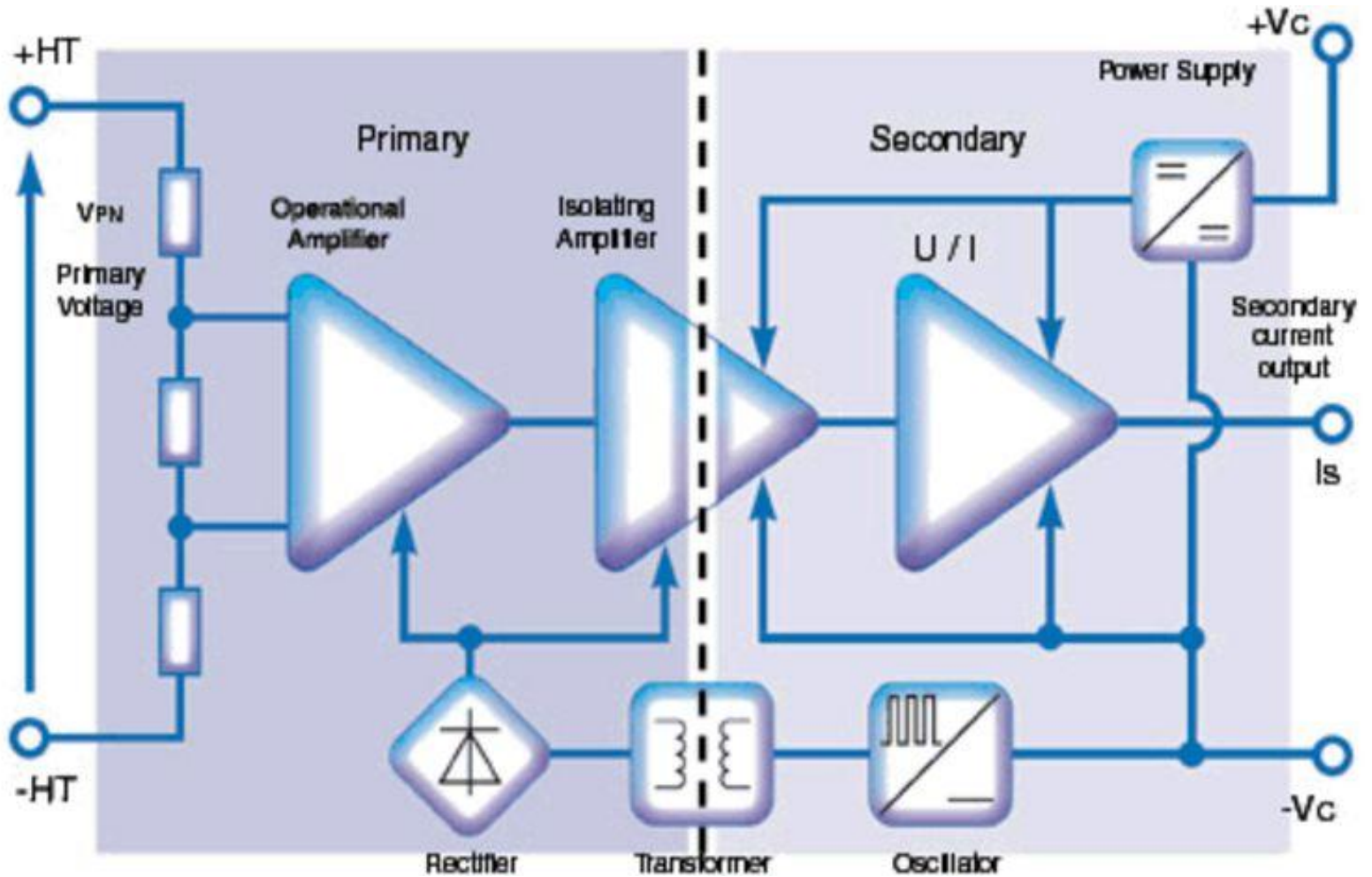
(Cont...)

In this type of amplifier the positive rectangular DC pulses arrive at the input of the amplifier circuit at capacitor C_1 . These pulses arrive at the base of Q_1 as narrow spikes, which momentarily turn Q_1 on. This in turn momentarily turns Q_2 on, which allows current to flow through the primary of transformer T_1 . Now the primary of transformer T_1 is really an L - C tank circuit. (Remember that the primary winding of the transformer is actually a big inductor.) When this tank circuit is hit by a pulse, it will produce a cycle or two of pure sine wave. When hit, in other words, the tank circuit will ring like a bell.

(Cont...)

The amplifier circuit is the clapper that rings the bell. Notice the secondary of T_1 is center tapped to $-60 V_p$. The secondary of T_1 sees a pure AC sine wave, and to this AC signal, the $-60 V_p$ appears as a ground. This means that for the positive half-cycle of the sine wave, Q_3 would see a positive pulse, and Q_4 would see a negative pulse. Both power transistors are NPN transistors, so a positive bias is needed at the base to cause them to conduct. As both bases are grounded, Q_4 would go into conduction because its emitter is lower than its base, giving it a forward base-emitter bias. The output of the tapped control winding would then be a sine wave. It should be noticed that the tapped control winding has $+60 V_p$ on it, and the secondary of T_1 has $-60 V_p$ on it. This means that the output of the tapped control winding is going to be a $120\text{-}V_p$ sine wave.

Isolation Amplifier



(Cont...)

Isolation amplifiers provide electrical isolation and an electrical safety barrier. They protect [data acquisition](#) components from common mode voltages, which are potential differences between instrument ground and signal ground. Instruments without an isolation barrier that are applied in the presence of a common mode voltage allow ground currents to circulate, leading in the best case to a noisy representation of the signal under investigation. In the worst case, assuming that the magnitude of common mode voltage and/or current is sufficient, instrument destruction is likely.

(Cont...)

This action serves to protect the amplifier and the instrument connected to it, while still allowing a reasonably accurate measurement.

These amplifiers are also useful when you need to amplify low-level signals in multi-channel applications. They can also eliminate measurement errors caused by ground loops. Amplifiers with internal transformers reduce circuit costs by eliminating the need for additional isolated power supply. We usually use them as analogue interfaces between systems with separated grounds.

Electrocardiogram (ECG)

The electrocardiogram (ECG) is a technique of recording bioelectric currents generated by the heart. Clinicians can evaluate the conditions of a patient's heart from the ECG and perform further diagnosis. ECG records are obtained by sampling the bioelectric currents sensed by several electrodes, known as leads

Electrocardiography (ECG or EKG) is the recording of the electrical activity of the heart over time via skin electrodes. It is a noninvasive recording produced by an electrocardiographic device. The etymology of the word is derived from *electro*, because it is related to electrical activity, *cardio*, Greek for heart, *graph*, a Greek root meaning "to write".

Electrical impulses in the heart originate in the [sinoatrial node](#) and travel through the intrinsic conducting system to the [heart muscle](#). The impulses stimulate the myocardial muscle fibres to contract and thus induce [systole](#). The electrical waves can be measured at selectively placed [electrodes](#) (electrical contacts) on the skin. Electrodes on different sides of the heart measure the activity of different parts of the heart muscle. An ECG displays the voltage between pairs of these electrodes, and the muscle activity that they measure, from different directions, also understood as vectors. This display indicates the overall rhythm of the heart and weaknesses in different parts of the heart muscle.

It is the best way to measure and diagnose abnormal rhythms of the heart, particularly abnormal rhythms caused by damage to the conductive tissue that carries electrical signals, or abnormal rhythms caused by levels of dissolved salts (electrolytes), such as potassium, that are too high or low

In [myocardial infarction](#) (MI), the ECG can identify damaged heart muscle. But it can only identify damage to muscle in certain areas, so it can't rule out damage in other areas. The ECG cannot reliably measure the pumping ability of the heart; for which ultrasound-based ([echocardiography](#)) or [nuclear medicine](#) tests are used.

Leads

Graphic showing the relationship between positive electrodes, depolarization wavefronts (or mean electrical vectors), and complexes displayed on the ECG.

In electrocardiography, the word, "lead" (rhymes with 'speed') refers to the signal that goes between two [electrodes](#). These electrodes are attached to the patient's body, usually with very sticky circles of thick tape-like material (the electrode is embedded in the center of this circle).

Placement of electrodes

Ten electrodes are used for a 12-lead ECG. They are labeled and placed on the patient's body as follows:

ELECTRODE LABEL	ELECTRODE PLACEMENT
RA	On the right arm, avoiding bony prominences.
LA	In the same location that RA was placed, but on the left arm this time.
LL	On the left leg, avoiding bony prominences.
RL	In the same place that LL was positioned, but on the right leg.
V1	In the <i>fourth</i> intercostal space (between ribs 4 & 5) to the <i>right</i> of the sternum (breastbone).
V2	In the <i>fourth</i> intercostal space (between ribs 4 & 5) to the <i>left</i> of the sternum.
V3	Between leads V2 and V4.

V4	In the fifth intercostal space (between ribs 5 & 6) in the midclavicular line (the imaginary line that extends down from the midpoint of the clavicle (collarbone)).
V5	Horizontally even with V4, but in the anterior axillary line. (The anterior axillary line is the imaginary line that runs down from the point midway between the middle of the clavicle and the lateral end of the clavicle; the lateral end of the collarbone
V6	Horizontally even with V4 and V5 in the midaxillary line. (The midaxillary line is the imaginary line that extends down from the middle of the patient's armpit.)

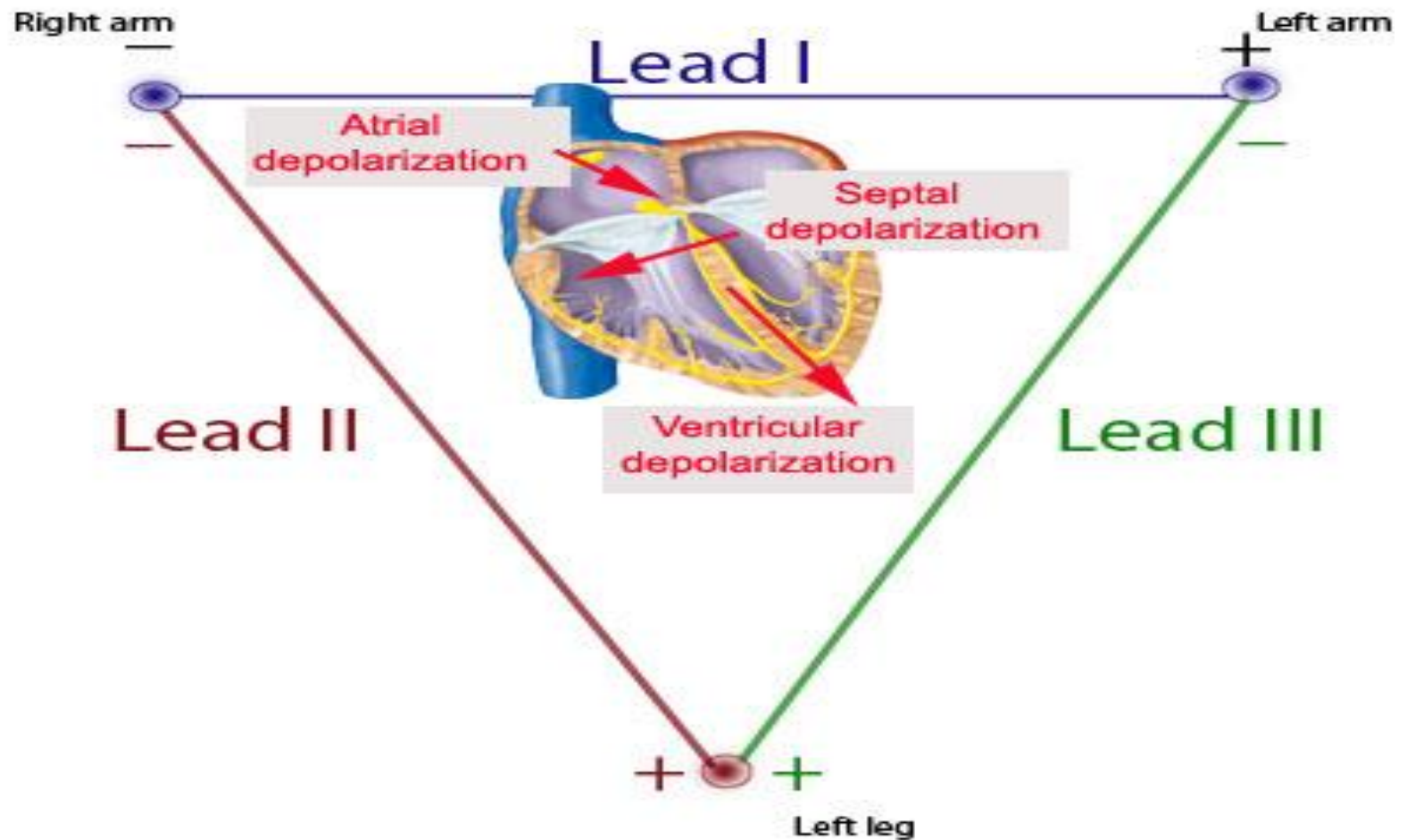
Unipolar vs. bipolar leads

There are two types of leads—*unipolar* and *bipolar*. Bipolar leads have one positive and one negative pole. In a 12-lead ECG, the limb leads (I, II and III) are bipolar leads.

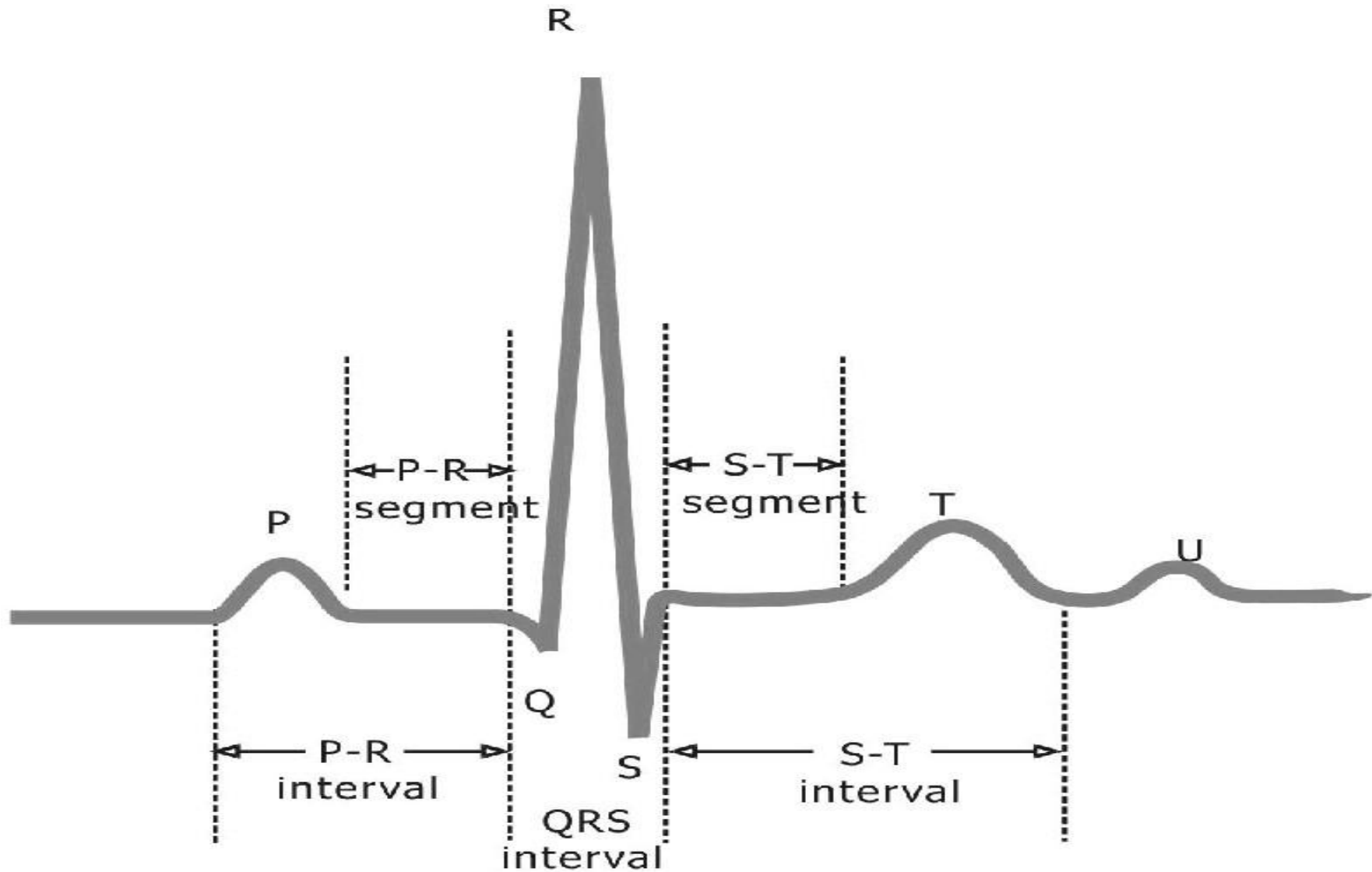
Unipolar leads have only one true pole (the positive pole). The negative pole is a "composite" pole made up of signals from lots of other electrodes. In a 12-lead ECG, all leads besides the limb leads are unipolar (aVR, aVL, aVF, V1, V2, V3, V4, V5, and V6).

In both the 5- and 12-lead configuration, leads I, II and III are called **limb leads**. The electrodes that form these signals are located on the limbs—one on each arm and one on the left leg. The limb leads form the points of what is known as **Einthoven's triangle**.

Einthoven's triangle.



A typical one-cycle ECG tracing



P wave

During normal atrial depolarization, the main electrical vector is directed from the SA node towards the AV node, and spreads from the right atrium to the left atrium. This turns into the P wave on the ECG, which is upright in II, III, and aVF (since the general electrical activity is going toward the positive electrode in those leads), and inverted in aVR (since it is going away from the positive electrode for that lead). A P wave must be upright in leads II and aVF and inverted in lead aVR to designate a cardiac rhythm as **Sinus Rhythm**.

The relationship between P waves and QRS complexes helps distinguish various cardiac arrhythmias.

The shape and duration of the P waves may indicate atrial enlargement.

Absence of the P wave may indicate atrial fibrillation.

A saw tooth formed P wave may indicate atrial flutter.

The QRS complex is a structure on the ECG that corresponds to the depolarization of the ventricles. Because the ventricles contain more muscle mass than the atria, the QRS complex is larger than the P wave. In addition, because the **His/Purkinje system** coordinates the depolarization of the ventricles, the QRS complex tends to look "spiked" rather than rounded due to the increase in conduction velocity. A normal QRS complex is 0.08 to 0.12 sec (80 to 120 ms) in duration represented by three small squares or less, but any abnormality of conduction takes longer, and causes widened QRS complexes.

PR/PQ interval

The PR interval is measured from the beginning of the P wave to the beginning of the QRS complex. It is usually 120 to 200 ms long. On an ECG tracing, this corresponds to 3 to 5 small boxes. In case a Q wave was measured with a ECG the PR interval is also commonly named PQ interval instead.

ST segment

The ST segment connects the QRS complex and the T wave and has a duration of 0.08 to 0.12 sec (80 to 120 ms). It starts at the J point (junction between the QRS complex and ST segment) and ends at the beginning of the T wave. However, since it is usually difficult to determine exactly where the ST segment ends and the T wave begins, the relationship between the ST segment and T wave should be examined together. The typical ST segment duration is usually around 0.08 sec (80 ms). It should be essentially level with the PR and TP segment.

T wave

The T wave represents the repolarization (or recovery) of the ventricles. The interval from the beginning of the QRS complex to the apex of the T wave is referred to as the **absolute refractory period**. The last half of the T wave is referred to as the **relative refractory period** (or vulnerable period).

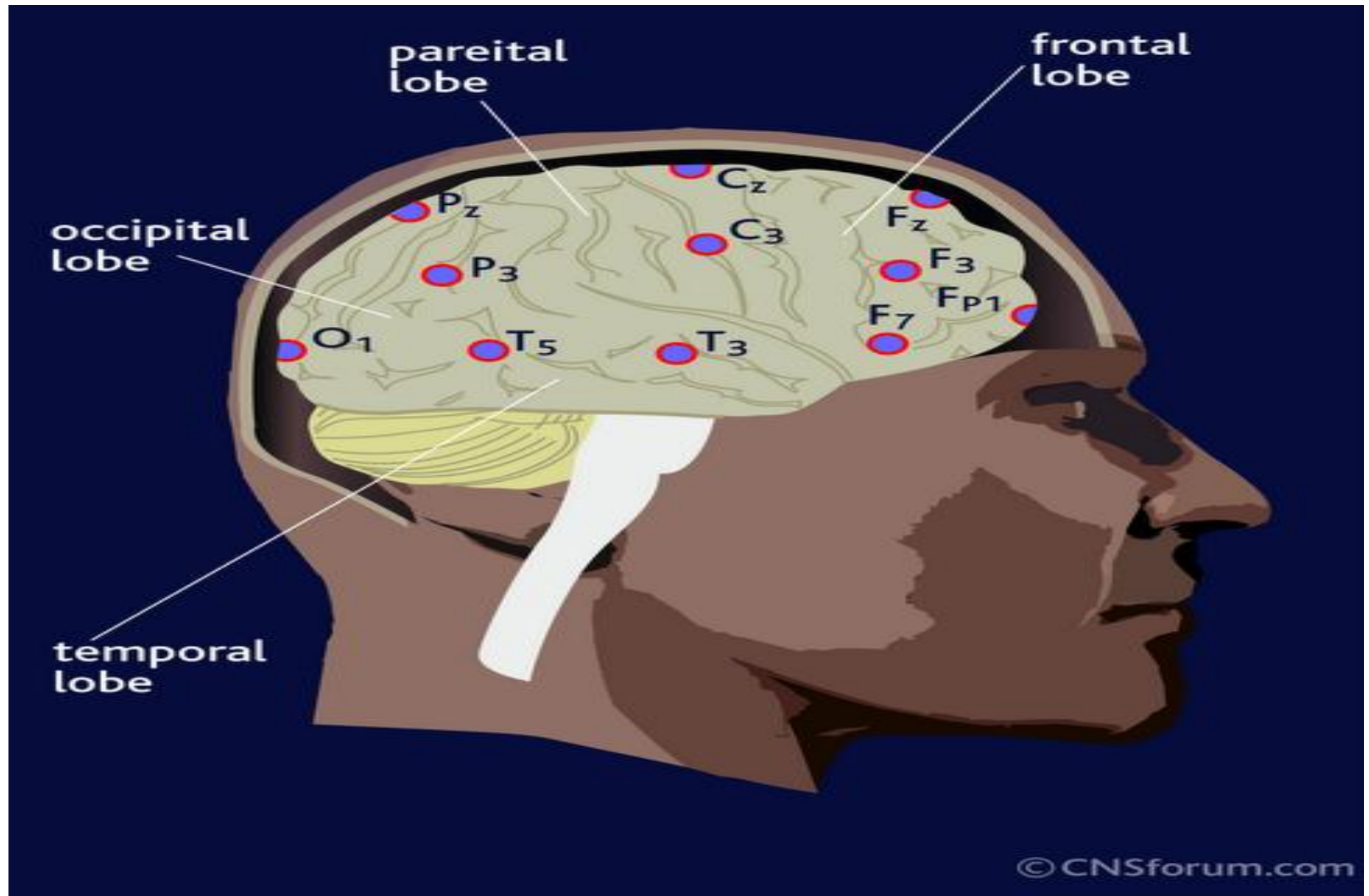
QT interval

The QT interval is measured from the beginning of the QRS complex to the end of the T wave. Normal values for the QT interval are between 0.30 and 0.44 seconds. The QT interval as well as the corrected QT interval are important in the diagnosis of long QT syndrome and short QT syndrome. Long QT intervals may also be induced by antiarrhythmic agents that block potassium channels in the cardiac myocyte. The QT interval varies based on the heart rate, and various correction factors have been developed to correct the QT interval for the heart rate. The QT interval represents on an ECG the total time needed for the ventricles to depolarize and repolarize.

U wave

The U wave is not always seen. It is typically small, and, by definition, follows the T wave. U waves are thought to represent repolarization of the papillary muscles or Purkinje fibers. Prominent U waves are most often seen in hypokalemia, but may be present in hypercalcemia, thyrotoxicosis, or exposure to digitalis, epinephrine, and Class 1A and 3 antiarrhythmics, as well as in congenital long QT syndrome and in the setting of intracranial hemorrhage. An inverted U wave may represent myocardial ischemia or left ventricular volume overload.

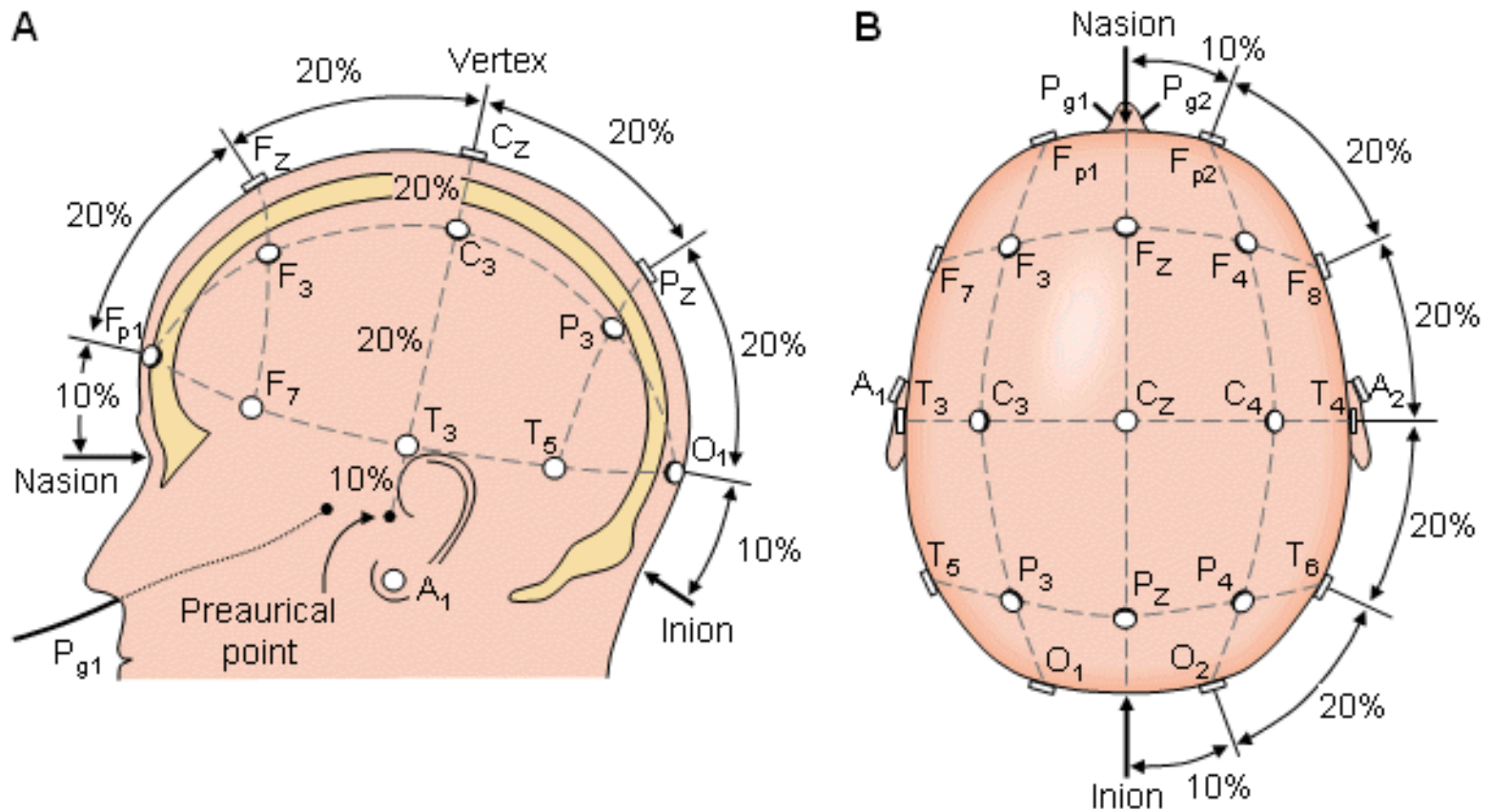
Electroencephalography



Electroencephalography

Electroencephalography (EEG) is the recording of [electrical](#) activity along the scalp produced by the firing of [neurons](#) within the [brain](#). In clinical contexts, EEG refers to the recording of the brain's spontaneous electrical activity over a short period of time, usually 20–40 minutes, as recorded from multiple [electrodes](#) placed on the [scalp](#). In [neurology](#), the main [diagnostic](#) application of EEG is in the case of [epilepsy](#), as epileptic activity can create clear abnormalities on a standard EEG study. A secondary clinical use of EEG is in the diagnosis of [coma](#) and [encephalopathies](#). EEG used to be a first-line method for the diagnosis of [tumors](#), [stroke](#) and other focal brain disorders, but this use has decreased with the advent of anatomical imaging techniques such as [MRI](#) and [CT](#).

PLACEMENT OF EEG LEAD



(Cont...)

In this system 21 electrodes are located on the surface of the scalp, as shown . The positions are determined as follows: Reference points are *nasion*, which is the delve at the top of the nose, level with the eyes; and *inion*, which is the bony lump at the base of the skull on the midline at the back of the head. From these points, the skull perimeters are measured in the transverse and median planes. Electrode locations are determined by dividing these perimeters into 10% and 20% intervals. Three other electrodes are placed on each side equidistant from the neighboring points,

EEG

One second of EEG signal

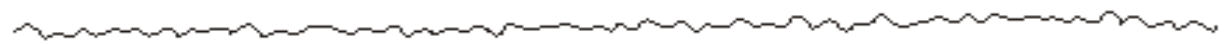
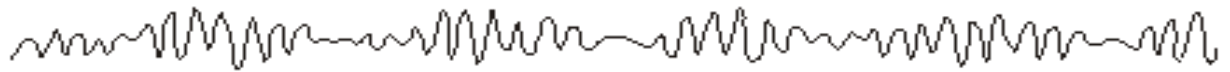
The EEG is typically described in terms of (1) rhythmic activity and (2) transients. The rhythmic activity is divided into bands by frequency. To some degree, these frequency bands are a matter of nomenclature (i.e., any rhythmic activity between 8–12 Hz can be described as "alpha"), but these designations arose because rhythmic activity within a certain frequency range was noted to have a certain distribution over the scalp or a certain biological significance.

Most of the cerebral signal observed in the scalp EEG falls in the range of 1–20 Hz (activity below or above this range is likely to be artifactual, under standard clinical recording techniques).

Beta (β) 13-30 Hz
Parietally and frontally



Alpha (α) 8-13 Hz
Occipitally



Theta (θ) 4-8 Hz
Children, sleeping adults

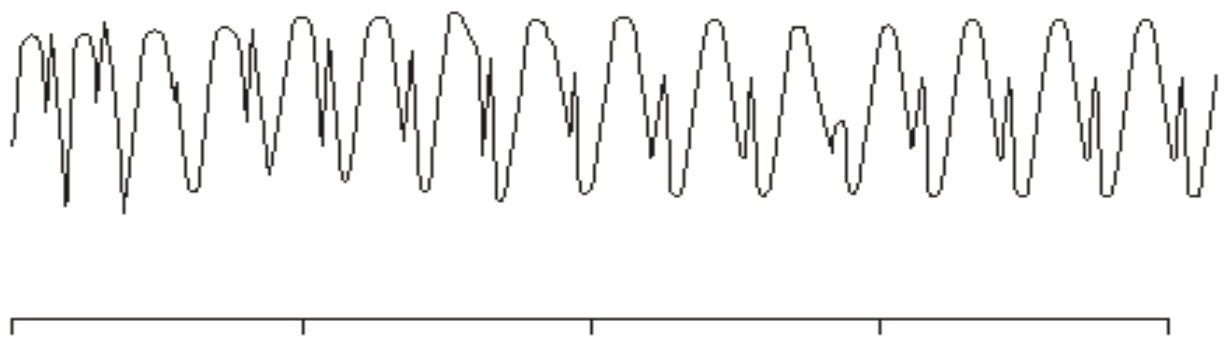


Delta (δ) 0.5-4 Hz
Infants, sleeping adults



Spikes
Epilepsy - petit mal

3 Hz
200
100
0
V [μ V]



0 1 2 3 4
Time [s]

Beta waves

Beta is the frequency range from 12 Hz to about 30 Hz. It is seen usually on both sides in symmetrical distribution and is most evident frontally. Low amplitude beta with multiple and varying frequencies is often associated with active, busy or anxious thinking and active concentration. Rhythmic beta with a dominant set of frequencies is associated with various pathologies and drug effects, especially [benzodiazepines](#). Activity over about 25 Hz seen in the scalp EEG is rarely cerebral (i.e., it is most often artifactual). It may be absent or reduced in areas of cortical damage. It is the dominant rhythm in patients who are alert or anxious or who have their eyes open.

Alpha waves

- Alpha is the frequency range from 8 Hz to 12 Hz. Hans Berger named the first rhythmic EEG activity he saw, the "alpha wave." This is activity in the 8–12 Hz range seen in the posterior regions of the head on both sides, being higher in amplitude on the dominant side. It is brought out by closing the eyes and by relaxation. It was noted to attenuate with eye opening or mental exertion. This activity is now referred to as "posterior basic rhythm," the "posterior dominant rhythm" or the "posterior alpha rhythm." The posterior basic rhythm is actually slower than 8 Hz in young children (therefore technically in the theta range). In addition to the posterior basic rhythm, there are two other normal alpha rhythms that are typically discussed: the mu rhythm and a temporal "third rhythm". Alpha can be abnormal; for example, an EEG that has diffuse alpha occurring in coma and is not responsive to external stimuli is referred to as "alpha coma".

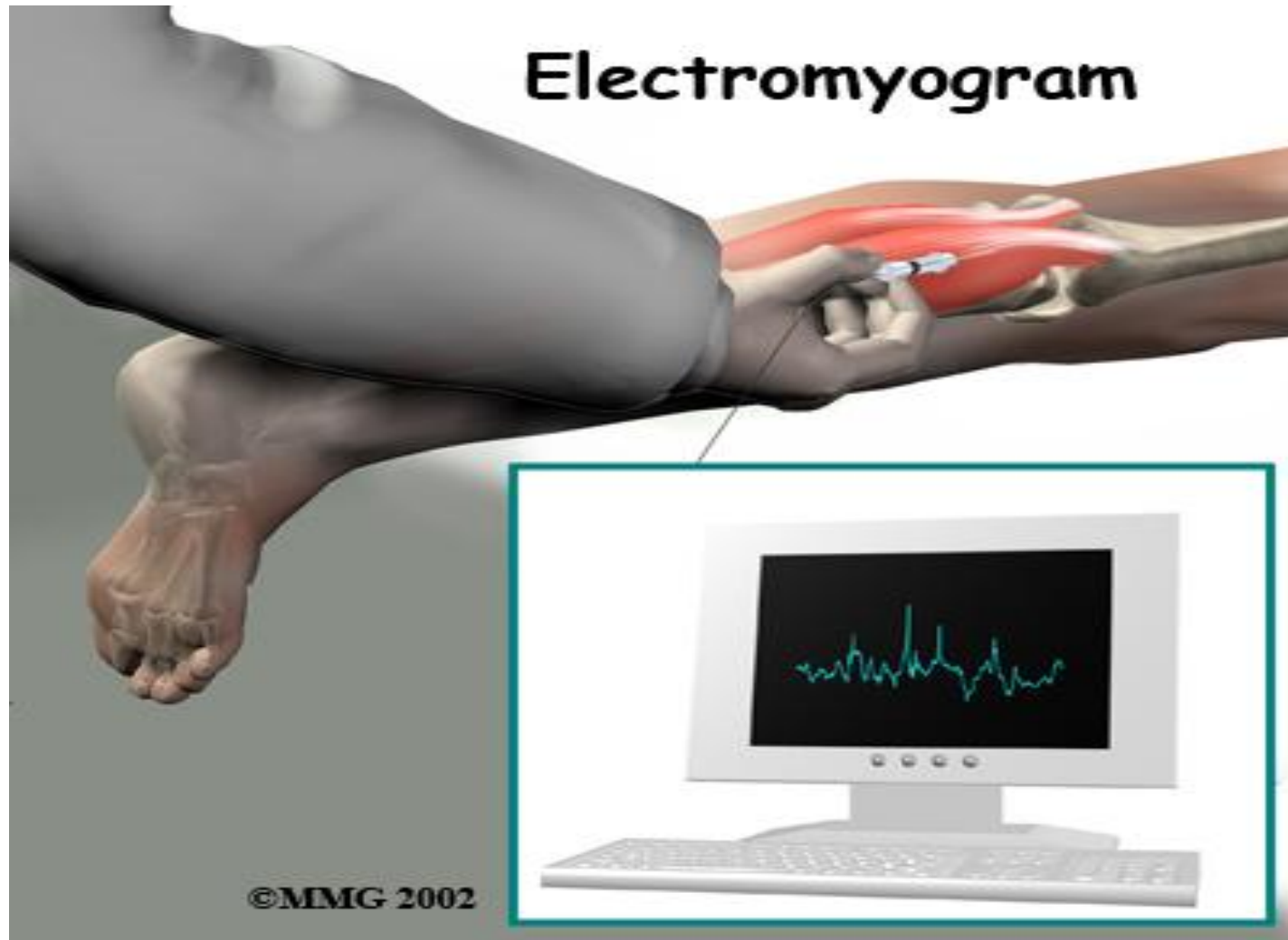
Theta waves.

Theta is the frequency range from 4 Hz to 7 Hz. Theta is seen normally in young children. It may be seen in drowsiness or arousal in older children and adults; it can also be seen in [meditation](#). Excess theta for age represents abnormal activity. It can be seen as a focal disturbance in focal subcortical lesions; it can be seen in generalized distribution in diffuse disorder or metabolic encephalopathy or deep midline disorders or some instances of hydrocephalus. On the contrary this range has been associated with reports of relaxed, meditative, and creative states.

Delta waves

Delta is the frequency range up to 3 Hz. It tends to be the highest in amplitude and the slowest waves. It is seen normally in adults in slow wave sleep. It is also seen normally in babies. It may occur focally with subcortical lesions and in general distribution with diffuse lesions, metabolic encephalopathy hydrocephalus or deep midline lesions. It is usually most prominent frontally in adults (e.g. FIRDA - Frontal Intermittent Rhythmic Delta) and posteriorly in children (e.g. OIRDA - Occipital Intermittent Rhythmic Delta).

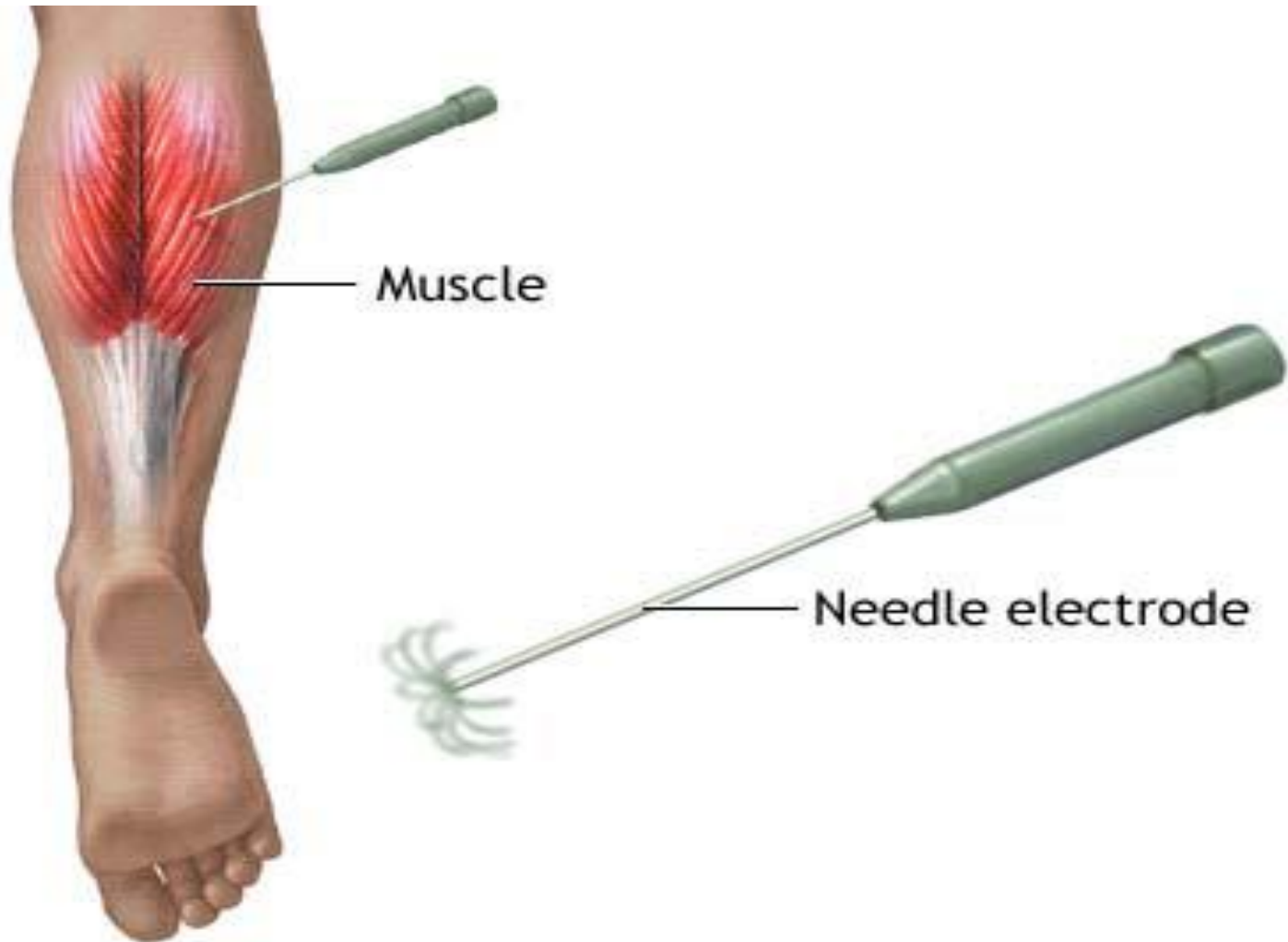
Electromyogram (EMG)



An EMG, used in conjunction with a neurological examination, helps establish a diagnosis and the extent of a problem by measuring the electrical activity of a muscle in response to stimulation.

An *electromyogram* (EMG) is a special test used to determine if there are problems with any of the nerves going to the upper limbs. EMGs are usually done to see if one or more nerve roots have been pinched by a herniated disc. During the test, small needles are placed into certain muscles that are supplied by each nerve root. If there has been a change in the function of the nerve, the muscle will send off different types of electrical signals. The EMG test reads these signals and can help determine which nerve root is involved.

(Cont...)



(Cont...)

A needle electrode is inserted through the skin into the muscle.

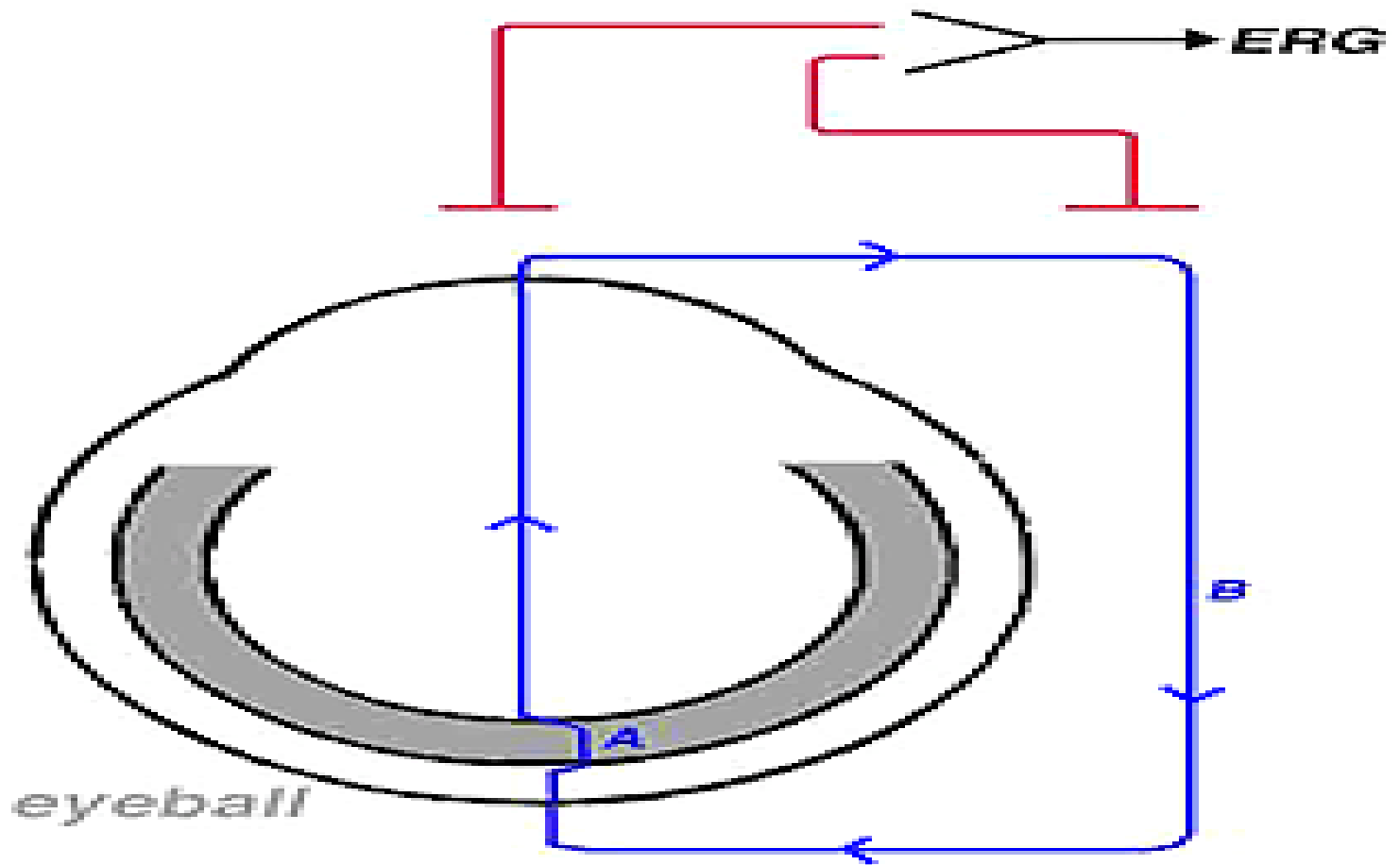
The electrical activity detected by this electrode is displayed on an oscilloscope.

You may be asked to contract the muscle

ERG

ERG responses are recorded with an active extracellular electrode positioned either on the cornea, in the vitreous or at different levels inside the retina. Extracellular recording of electrical activity of living tissue is rendered possible when electrical currents spread along an extracellular matrix with electrical resistance. An example of extracellular electrical current in the vertebrate retina is the 'dark' current spreading from the inner segments to the outer segments of the photoreceptors

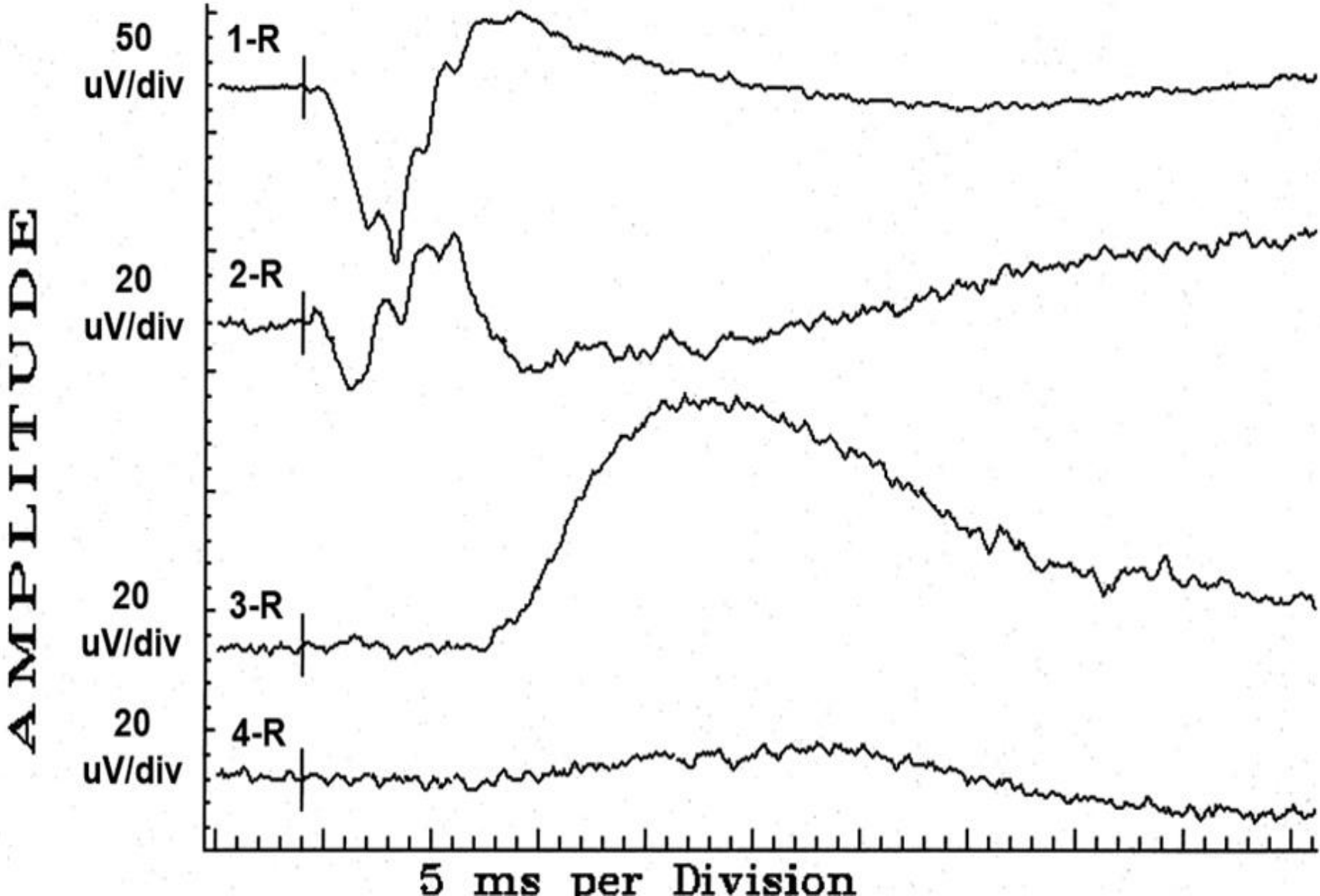
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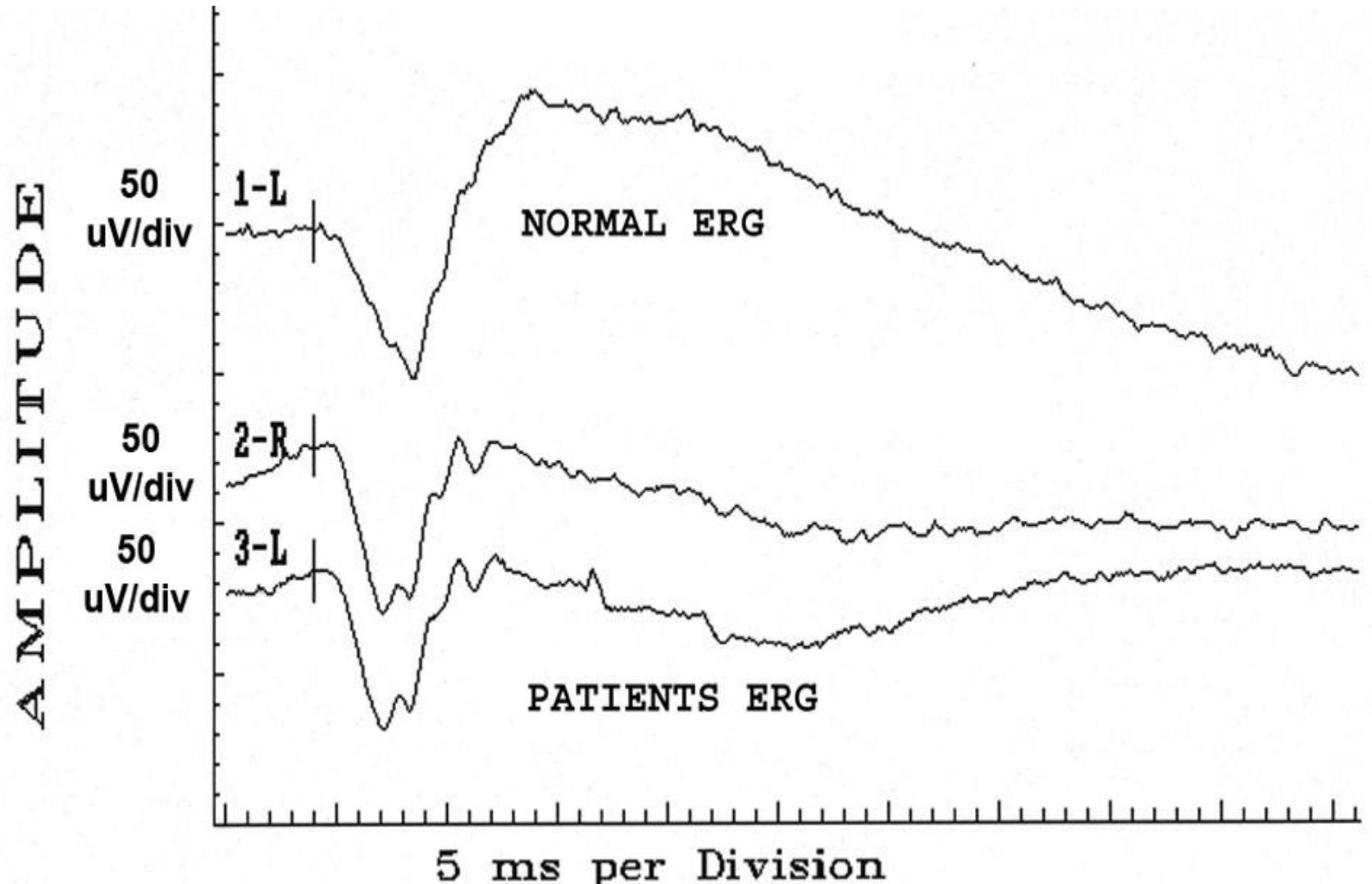
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A schematic representation of the extra cellular currents that are formed following light stimulation. Pathway A represents local currents within the retina, while pathway B shows the currents leaving the retina through the vitreous and the cornea and returning to the retina through the choroid and the pigment epithelium. ERG recording in human is done along the B path.

ERG NORMAL



ERG ABNORMAL



THANK YOU