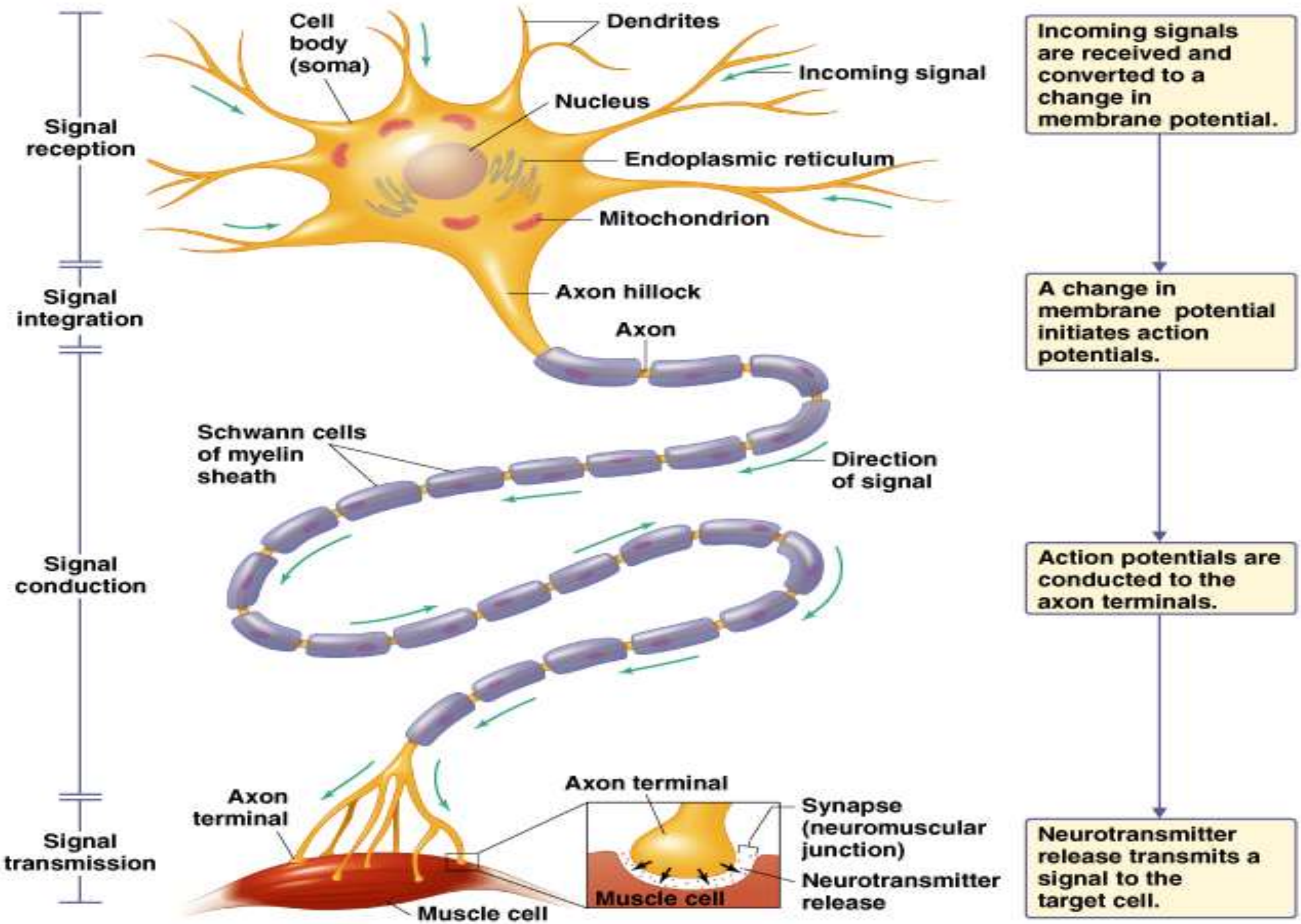
Nerve & Cardiac Impulse

Neural zone



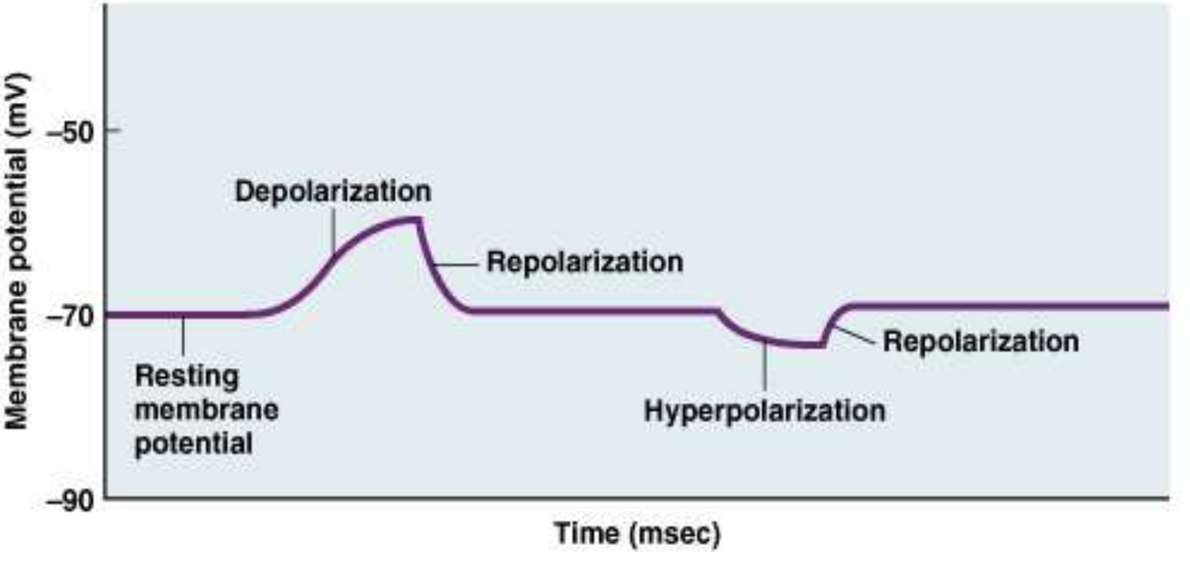
Signal reception
Signal integration
Signal conduction
Signal transmission
Cell body (soma)
Dendrites
Incoming signal
Nucleus
Endoplasmic reticulum
Mitochondrion
Axon hillock
Axon
Schwann cells of myelin sheath
Direction of signal
Axon terminal
Axon terminal
Synapse (neuromuscular junction)
Neurotransmitter release
Muscle cell
Muscle cell
Incoming signals are received and converted to a change in membrane potential.
A change in membrane potential initiates action potentials.
Action potentials are conducted to the axon terminals.
Neurotransmitter release transmits a signal to the target cell.

Electrical Signals in Neurons

Neurons have a resting membrane potential (like all cells)

Neurons are *excitable*; can rapidly change their membrane potential

Changes in membrane potential act as electrical signals



Membrane Potential

Three factors contribute to the membrane potential
The distribution of ions across the plasma membrane

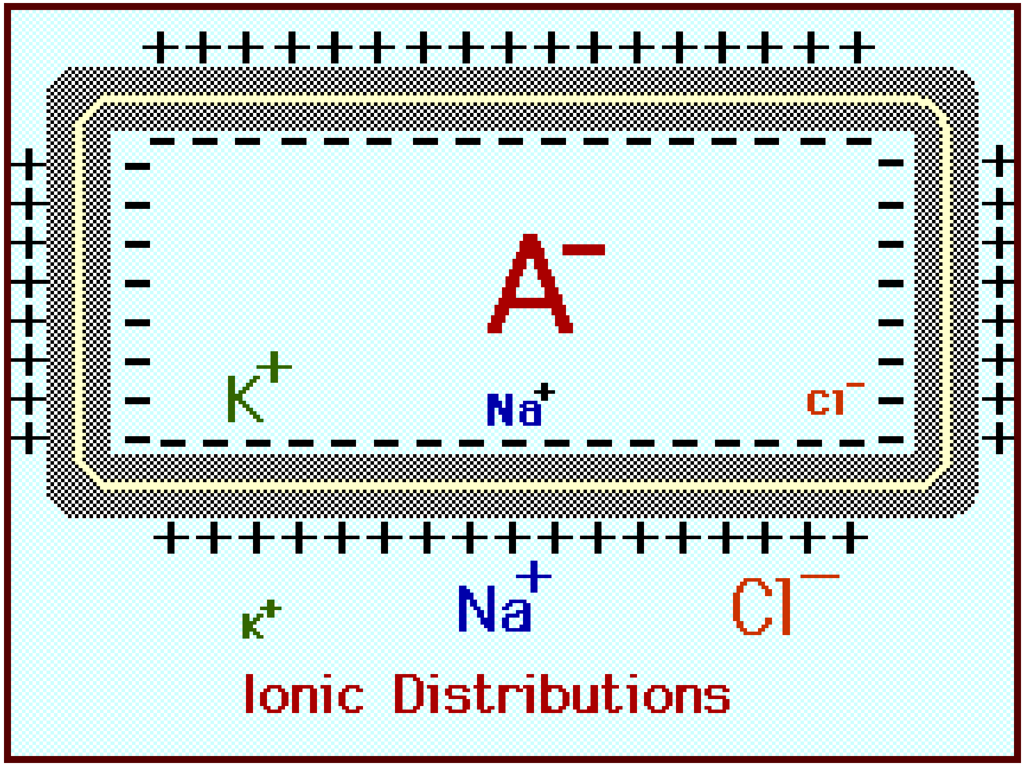
The relative permeability of the membrane to these ions

The charges of the ions

Nernst equation predicts membrane potential for a single ion

<u>Goldman equation</u> for the membrane potential : predicts the membrane potential using multiple ions

Resting potential



Action Potentials (AP)

Occurs only when the membrane potential at the axon hillock <u>reaches threshold</u>

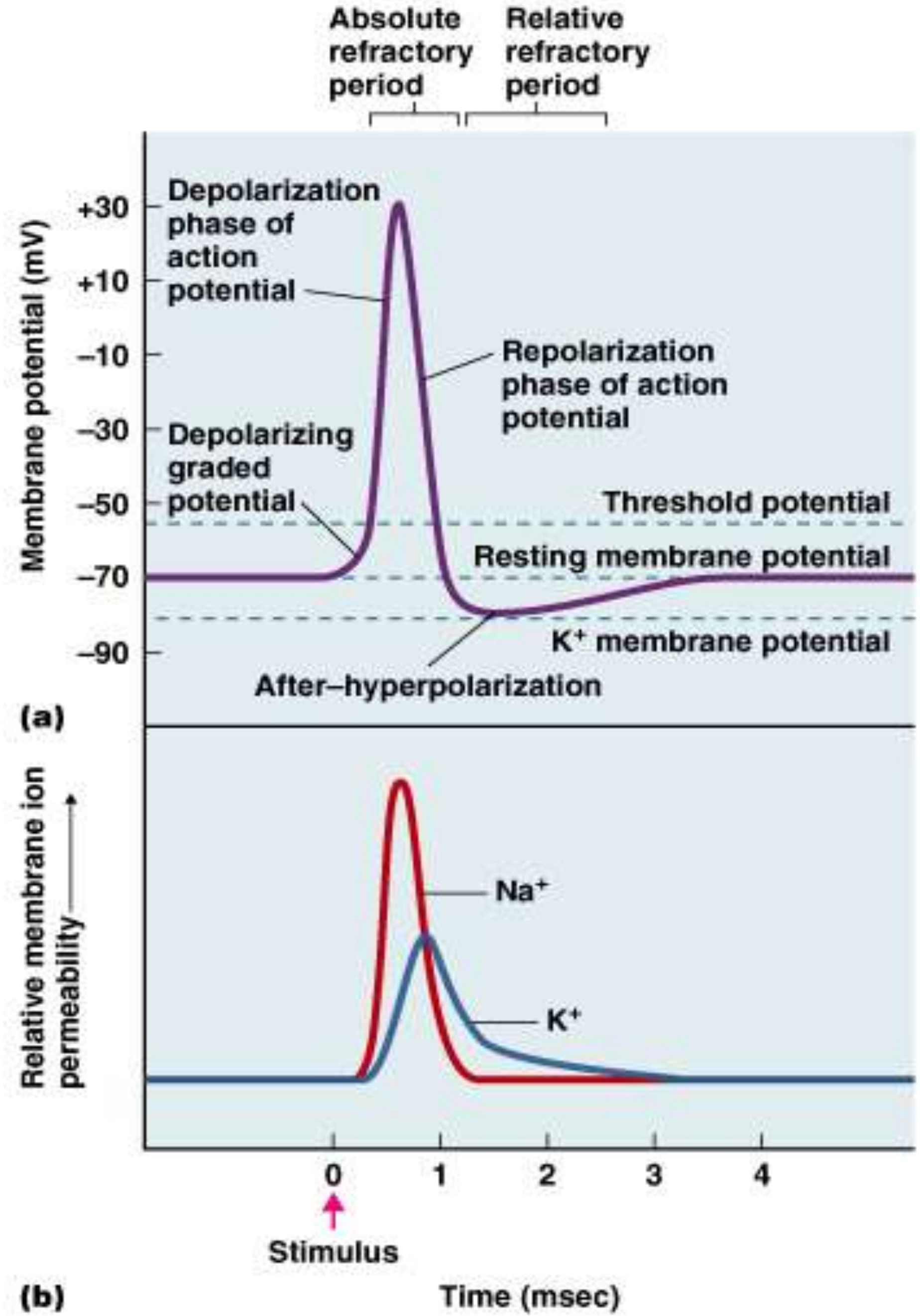
Three phases
Depolarization

Repolarization

Hyperpolarization

Absolute refractory period – incapable of generating a new AP

Relative refractory period – more difficult to generate a new AP



Positive feedback, e.g., influx of Na^+ → ↑ local depolarization → ↑ number of open Na^+ channels

Na^+ channels open first (depolarization)

K^+ channels open more slowly (repolarization)

Na^+ channels close

K^+ channels close slowly (relative refractory period)

EEG(Electroencephalogram)

The electroencephalogram (EEG) is a recording of the electrical activity of the brain (superficial layer i.e. the dendrites of pyramidal cells) by placing the electrodes on the scalp.

The first recordings were made by Hans Berger in 1929

EEG Waves

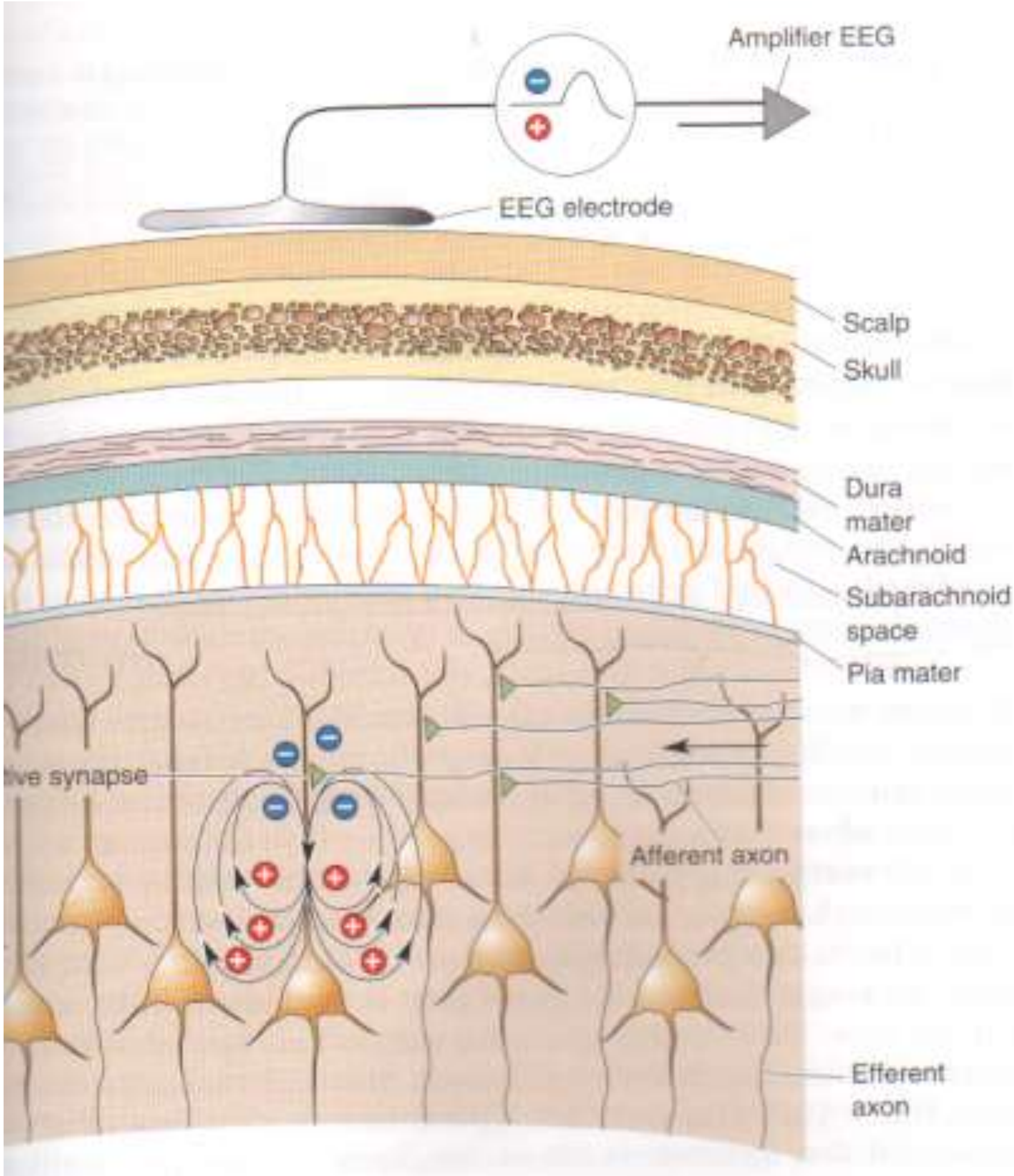
Alpha wave -- 8 – 13 Hz.

Beta wave -- >13 Hz. (14 – 30 Hz.)

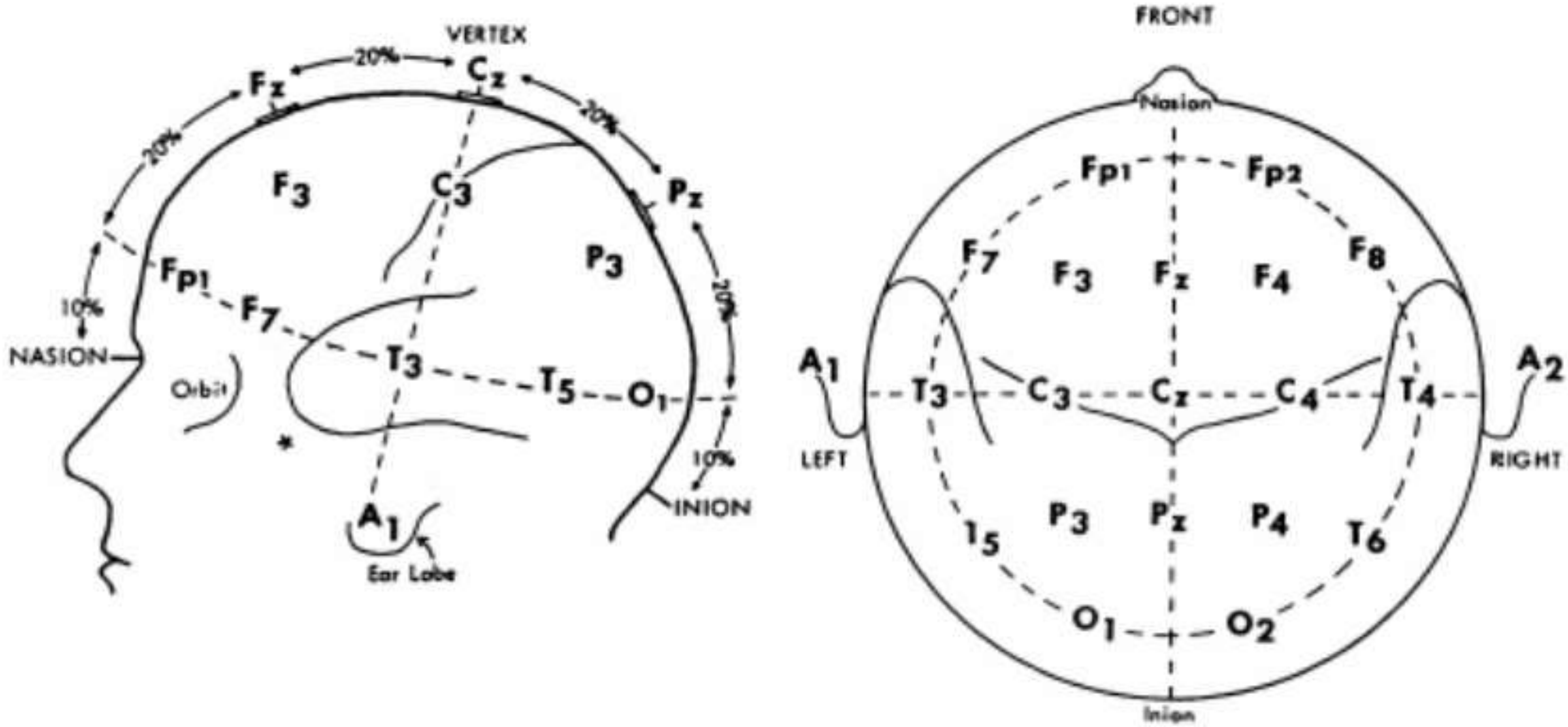
Theta wave -- 4 – 7.5 Hz.

Delta waves – 1 – 3.5 Hz.

Origin of EEG waves



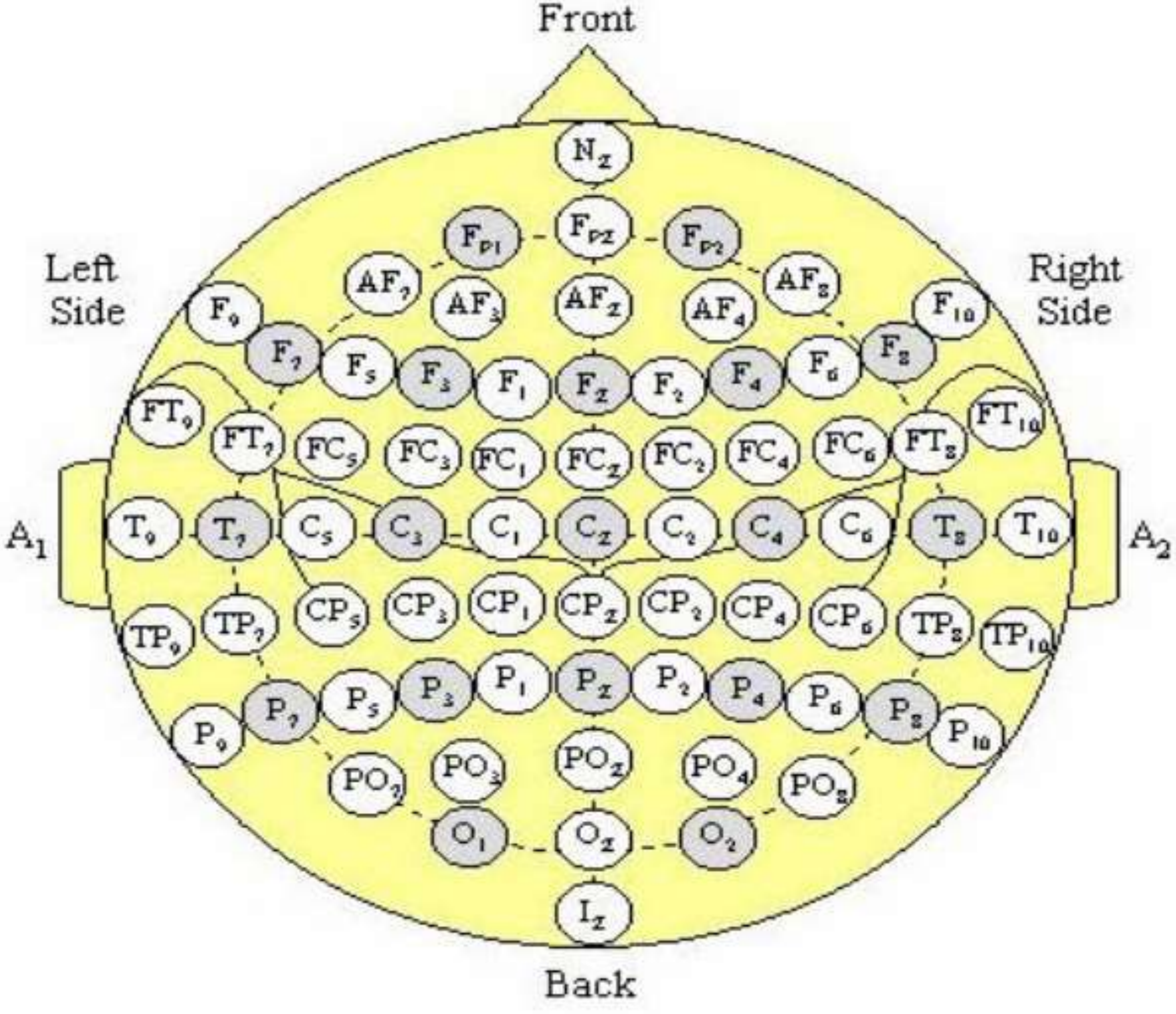
10-20 international system of electrode placement



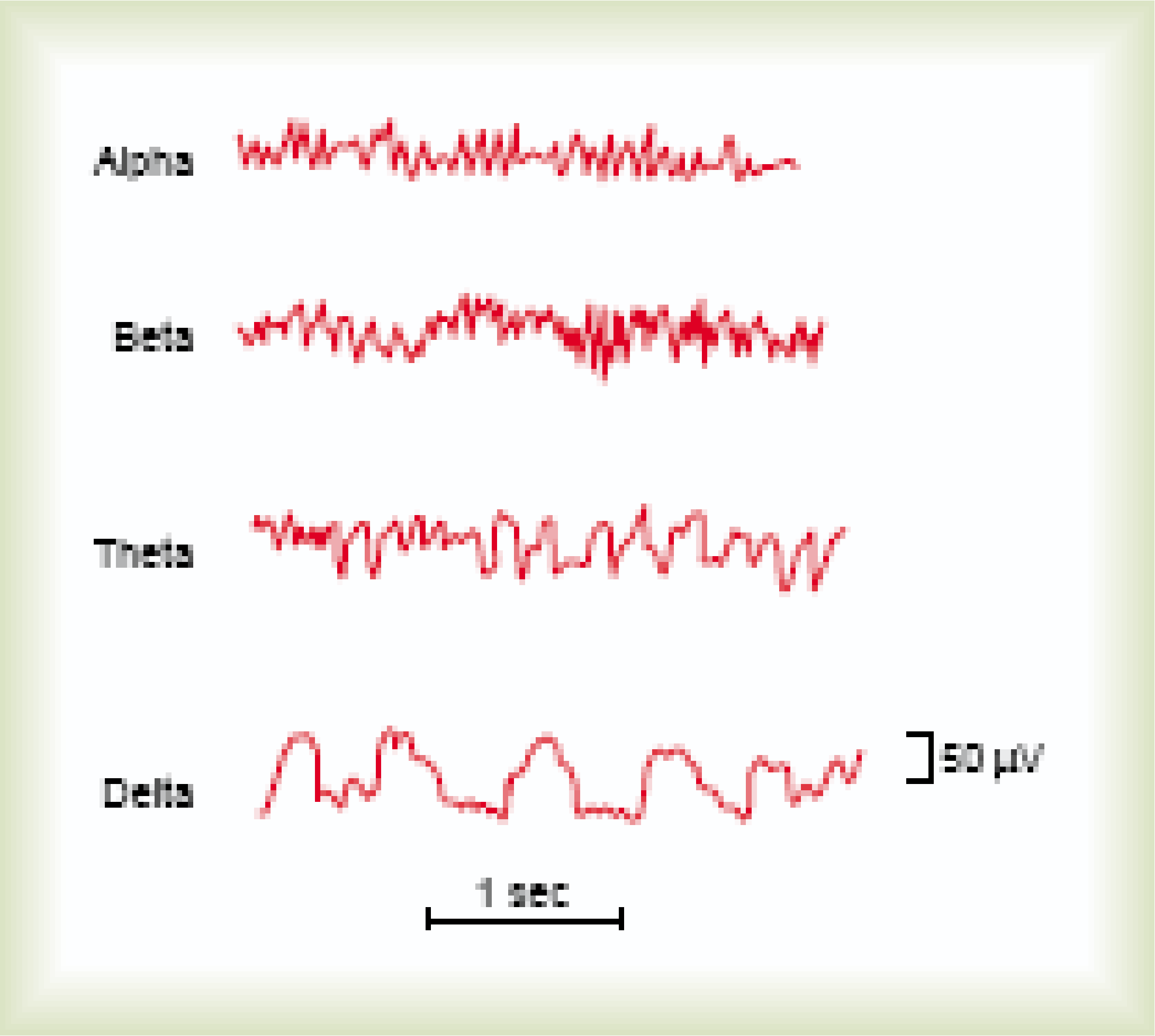
LEFT SIDE TOP

electrode placement system, where Fp is Prefrontal, F is Frontal, C is Central, T is Temporal, P is Parietal, O is Occipital, A is Ear.

10-10 international system of electrode placement



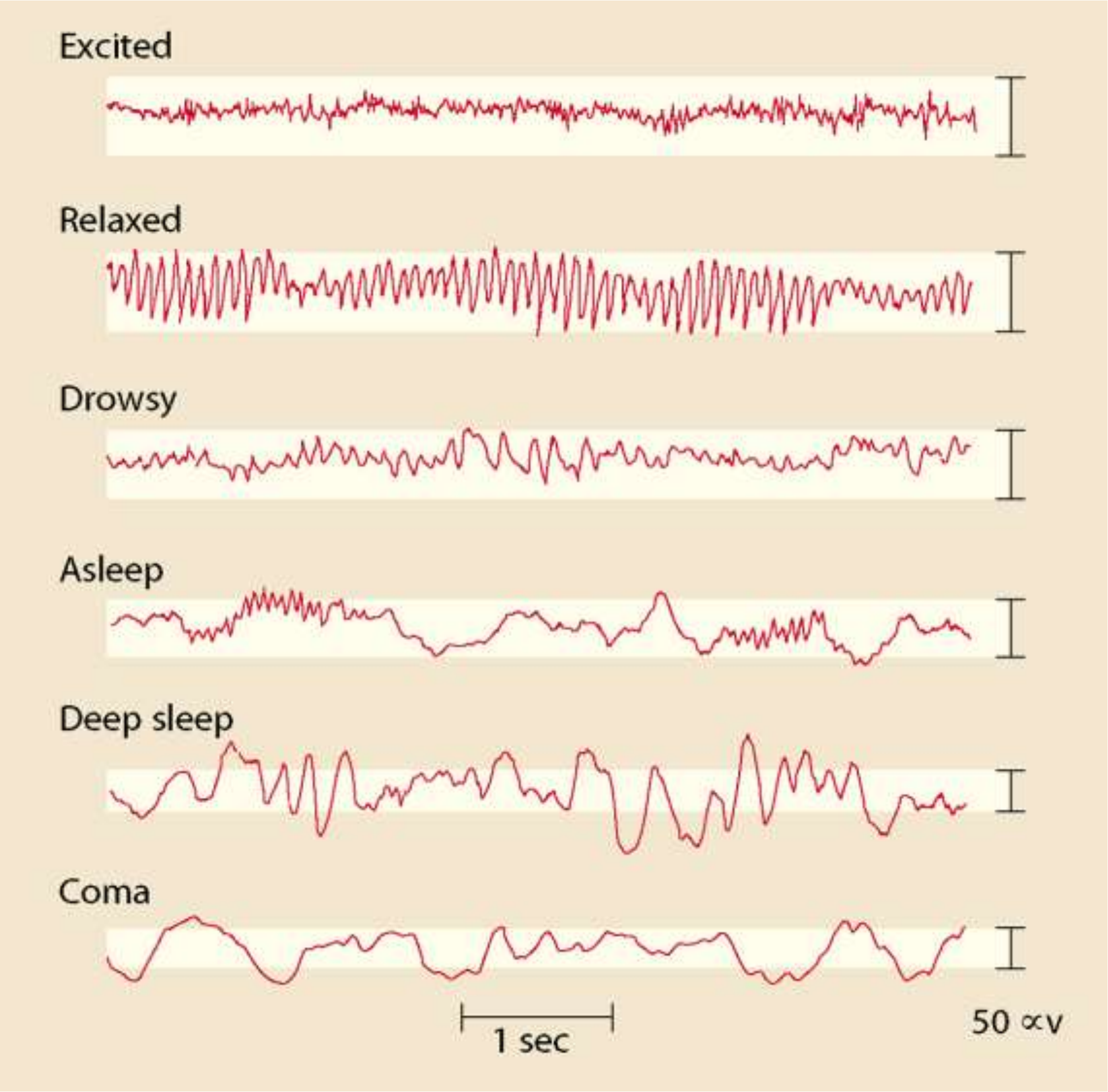
Different types of brain waves in normal EEG

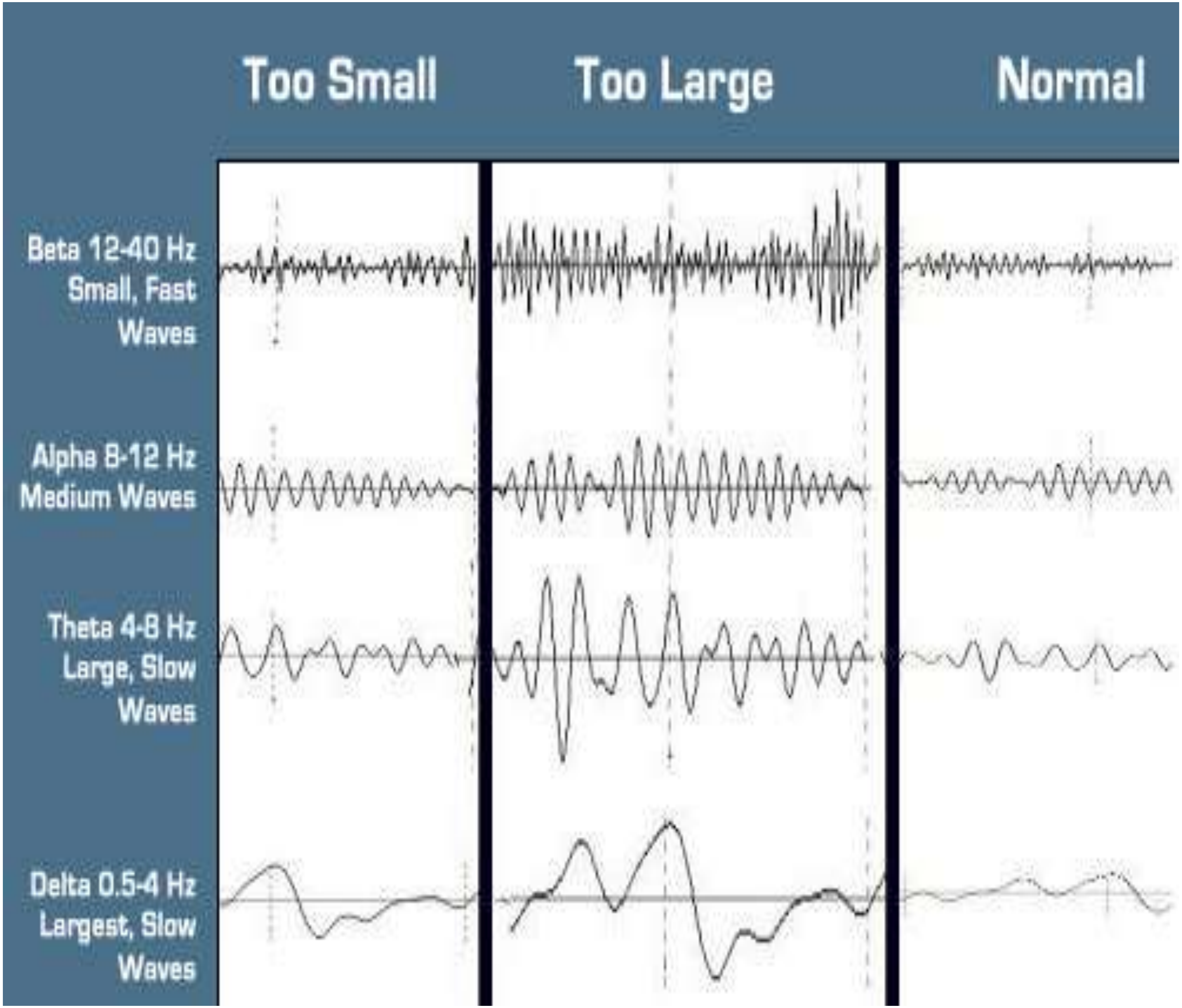


Different types of brain waves in normal EEG

Rhythm	**Frequency (Hz)**	**Amplitude (uV)**	**Recording & Location**
Alpha(α)	8 – 13	50 – 100	Adults, rest, eyes closed. Occipital region
Beta(β)	14 - 30	20	Adult, mental activity Frontal region
Theta(θ)	5 – 7	Above 50	Children, drowsy adult, emotional distress Occipital
Delta(δ)	2 – 4	Above 50	Children in sleep

EEG potentials are good indicators of global brain state. They often display rhythmic patterns at characteristic frequencies

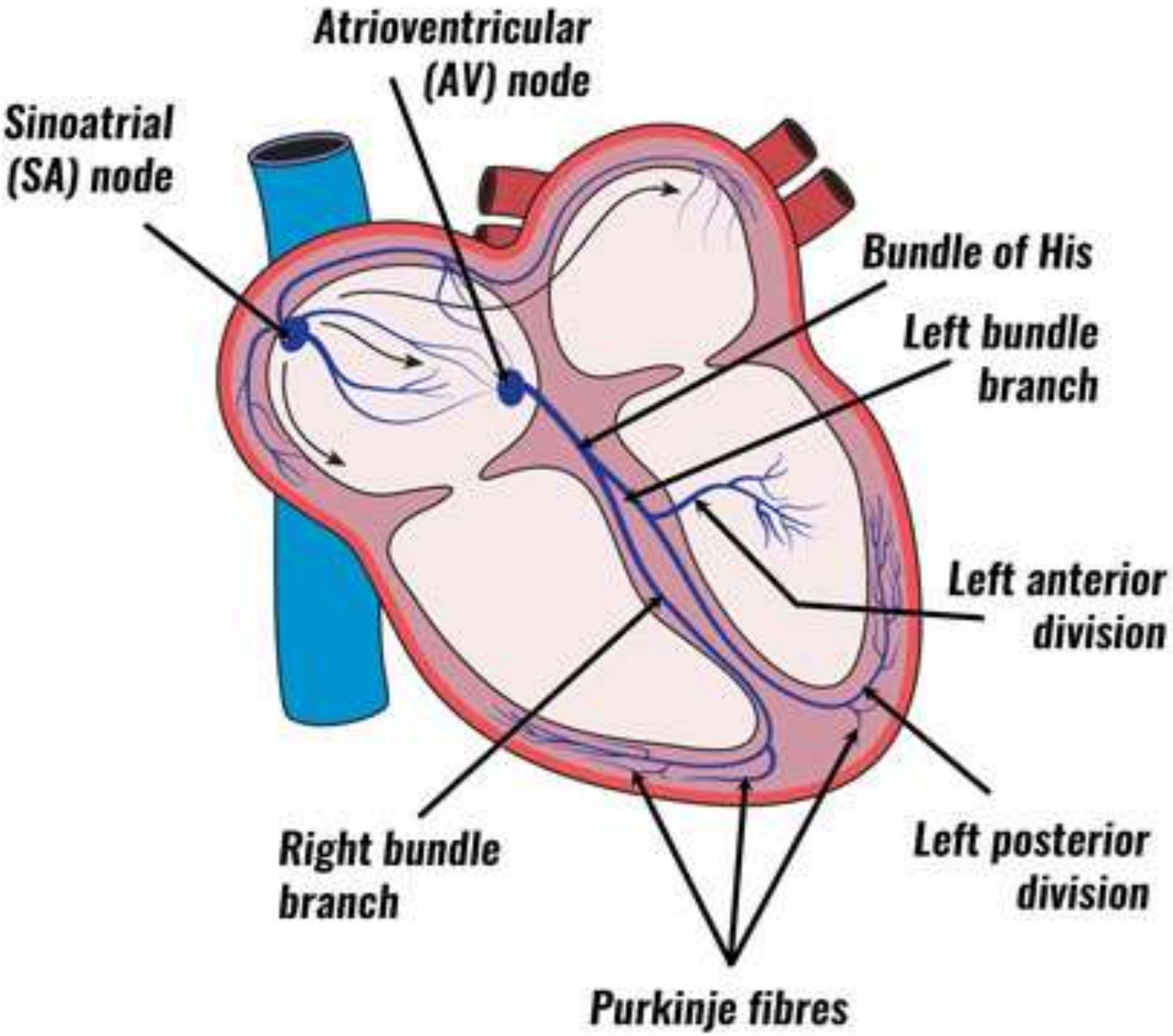



Too Small
Too Large
Normal
Beta 12-40 Hz
Small, Fast
Waves
Alpha 8-12 Hz
Medium Waves
Theta 4-8 Hz
Large, Slow
Waves
Delta 0.5-4 Hz
Largest, Slow
Waves

Normal EEG Awake

Benign Occipital

Conductive System of the Heart



Conduction system

The specialized heart cells of the cardiac conduction system generate and coordinate the transmission of electrical impulses to myocardial cells

The result is sequential atrioventricular contraction which provides for the most effective flow of blood , thereby optimizing cardiac out put

Characteristics of Cardiac Conduction Cells

Automaticity: ability to initiate an electrical impulse

Excitability: ability to respond to an electrical impulse

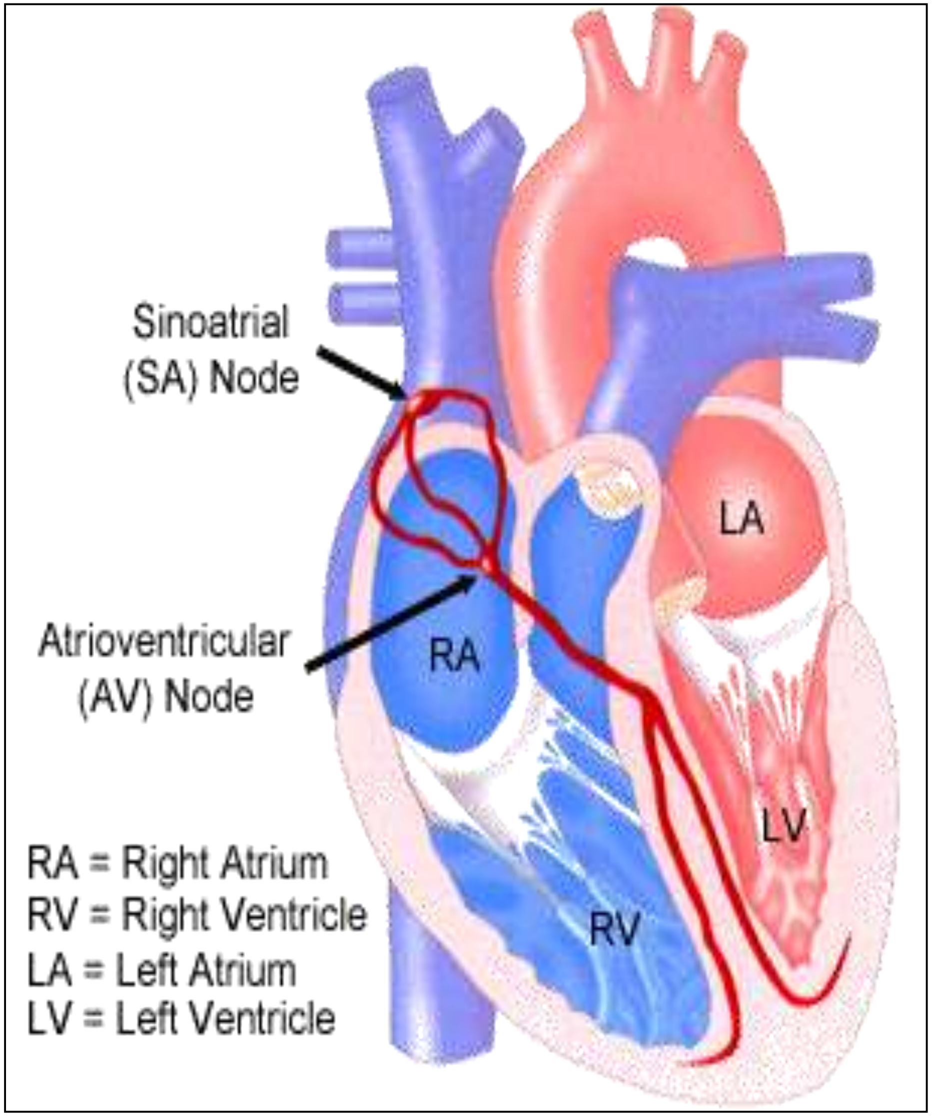
Conductivity: ability to transmit an electrical impulse from one cell to another

Conduction system

The sinoatrial (SA) node: a primary pacemaker of the heart

The electrical impulses initiated by the SA node are conducted along the myocardial cells of the atria via specialized tracts

The impulses cause electrical stimulation and subsequent contraction of the atria



Conduction System

The impulses are then conducted to atrioventricular(AV) node

The AV node consist of specialized muscle cells

The AV node coordinate the incoming electrical impulses from atria and after a slight delay (allowing the atria time to contract and complete ventricular filling) relays the impulses to the ventricles

The impulse is then conducted through a bundle of specialized conduction cells (bundle- His) that travel in the septum separating the left and right ventricles

The bundle of His divides into the right bundle branch (conducting impulses to the right ventricle)

The left bundle branch (conducting impulses to the left ventricle)

Impulses travel through bundle branches to reach terminal point in the conduction system called the **purkinjie fiber** this is the point at which myocardial cell at stimulated causing ventricular contraction

Physiology of cardiac conduction

- Cardiac electrical activity is result of the movement of ions (charged particles such as sodium, potassium and calcium) across to cell membrane

- In the resting state cardiac muscle cells are polarized, which means an electrical difference exists between the negatively charged inside and the positively charged outside of the cell membrane

- As soon as an electrical impulses is initiated,cell membrane permeability changes and sodium move rapidly into the cell while potassium exits the cell

- This ionic exchange begins depolarization (electrical activation of the cell) converting the internal charge of the cell to a positive one

- The repolarization is return of the cell to its resting state occurs as the cell returns to its baseline. This corresponds to relaxation of myocardial muscle

After the rapid influx of sodium into the cell during depolarization the permeability of cell membrane to calcium is changed calcium enters the cell and is released from intracellular calcium stores

There are two phases of refractory period refered to as the:

absolute refractory period

relative refractory period

The absolute refractory period is the time during which the heart can not be restimulated to contract regardless of strength of electrical stimulus. This period corresponds with depolarization and the early part of repolarization

During the later part of repolarization , if the electrical stimulus is stronger than normal the myocardium can be stimulated to contract

This short period at the end of repolarization is called **the relative refractory period**

Refractoriness protects the heart from sustained contraction **(tetany)** which would result in sudden cardiac death

change in serum calcium contraction may alter the contraction of the heart muscle fibers

change in serum potassium concentration is also important because potassium affects the normal electrical voltage of the cell

ECG(Electrocardiogram)

Electrical activity of the heart

Picked up by electrodes on the skin

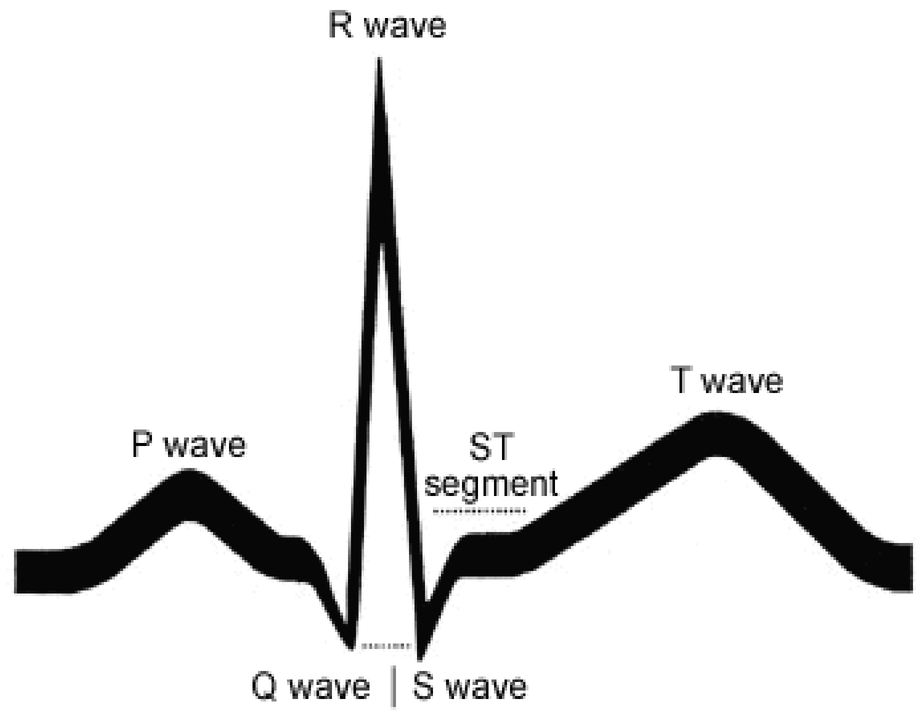
Amplified

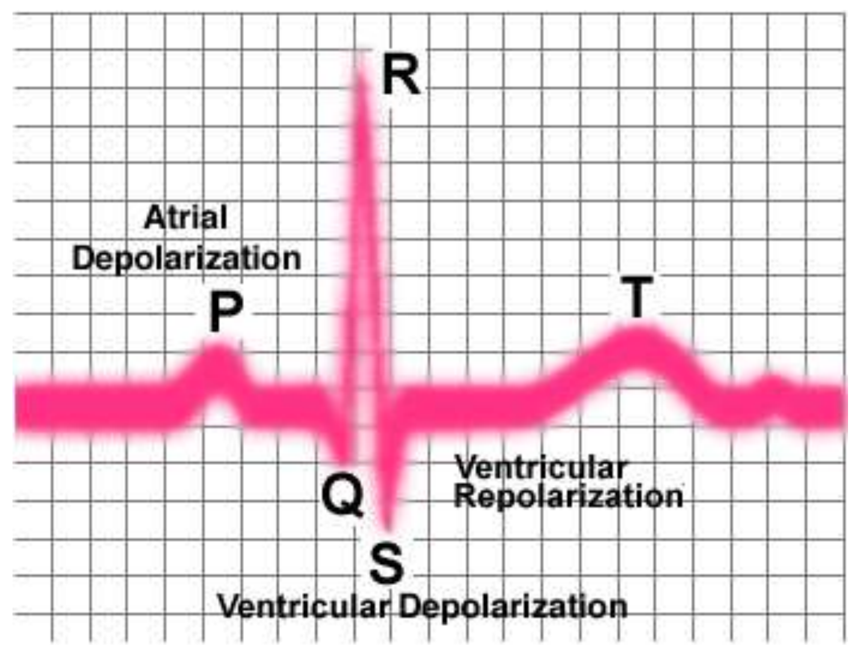
Displayed on oscilloscope screen

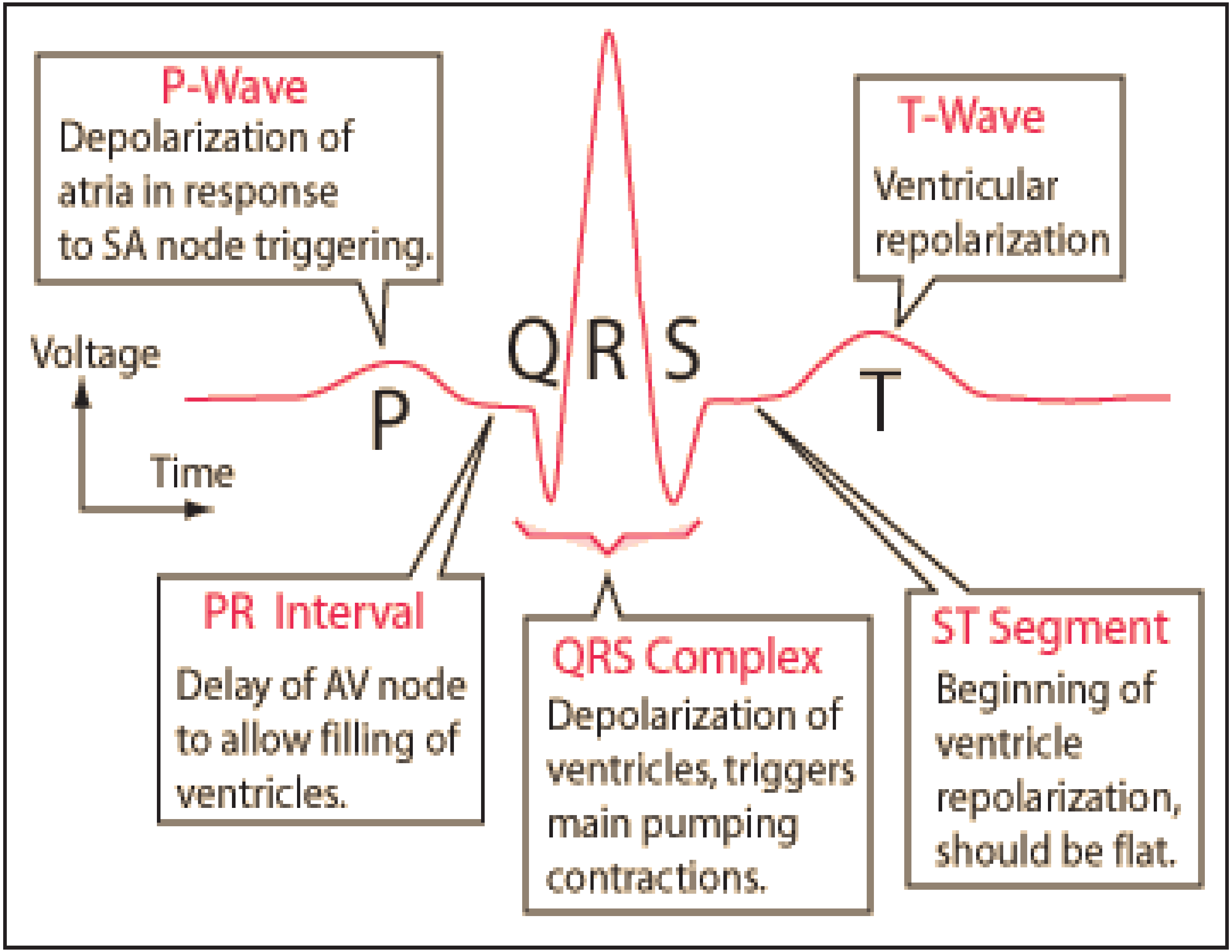
P wave = electrical impulses spreading from SAN over the atria

QRS complex = impulses passing through the ventricles

T wave = Electrical recovery of ventricles towards the end of ventricular systole






P-Wave
Depolarization of atria in response to SA node triggering.
T-Wave
Ventricular repolarization
Voltage
Time
P
Q
R
S
T
PR Interval
Delay of AV node to allow filling of ventricles.
QRS Complex
Depolarization of ventricles, triggers main pumping contractions.
ST Segment
Beginning of ventricle repolarization, should be flat.

Abnormal ECG Deflection Wave Patterns