

Bioelectric Signals

- Bioelectrical potential is a result of electrochemical activity across the membrane of the cell.
- Bioelectrical signals are generated by excitable cells such as nervous muscular, and glandular cells.
- The resting potential of the cell is -40 to -90 mV relative to the outside and $+60$ mV during action potential.
- Volume conductor electric field is an electric field generated by many excitable cells of the specific organ such as the heart.

Typical types of bioelectric signals

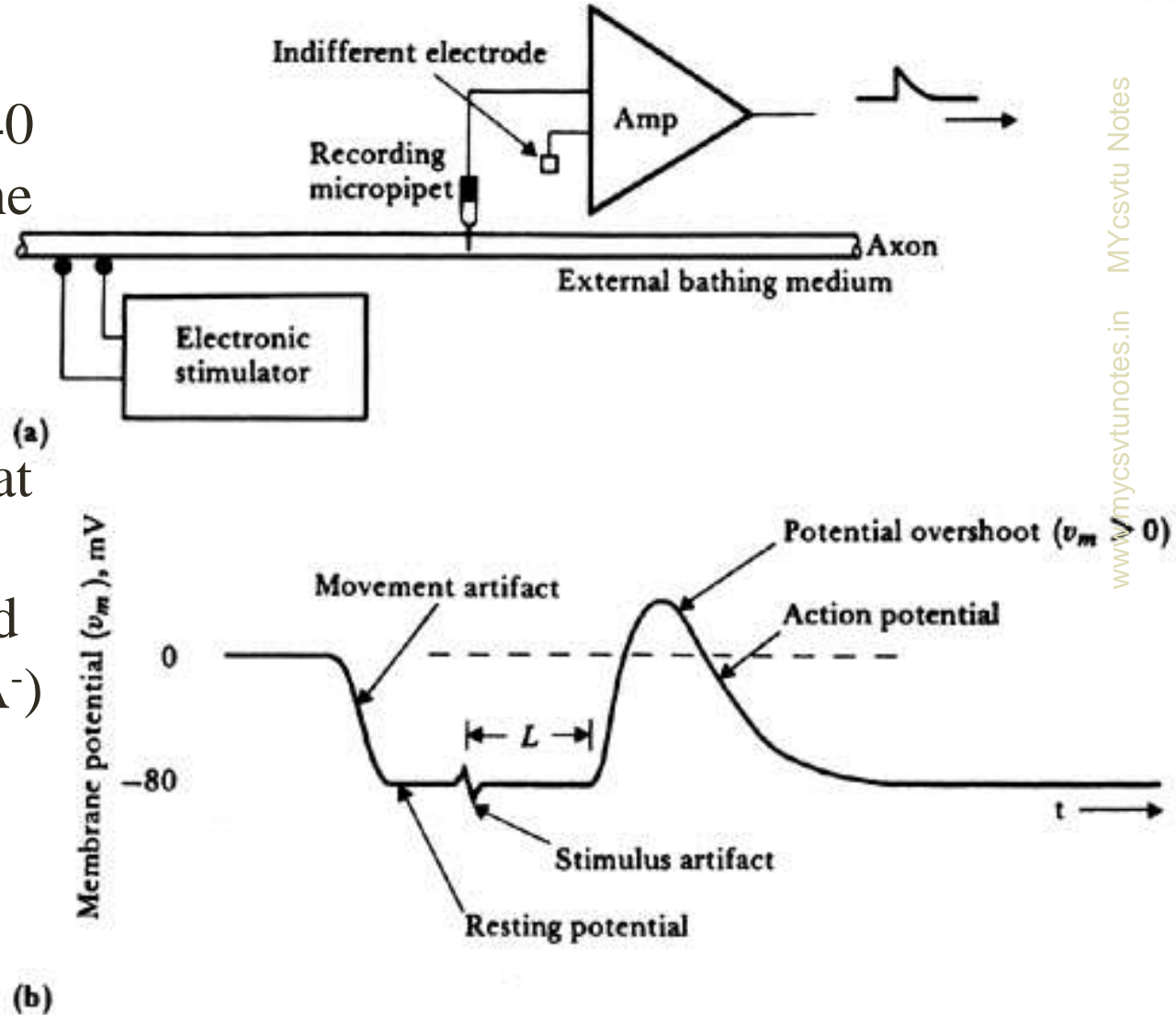
- Electrocardiogram (ECG, EKG)
- Electroencephalogram (EEG)
- Electromyogram (EMG)
- Electroretinogram (ERG)

Bioelectric Signals

L: latent period= transmission time from stimulus to recording site.

Potential inside cells -40 to -90 mV relative to the outside.

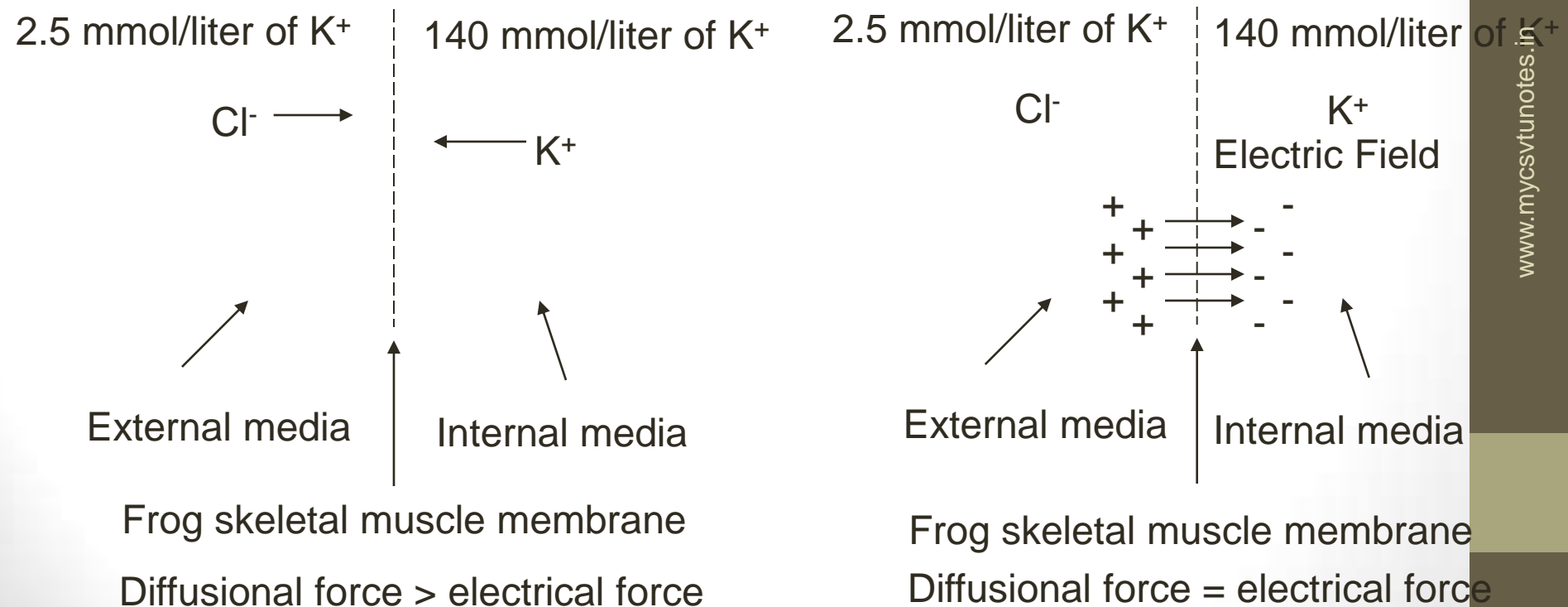
Cell membrane is lipoprotein complex that is impermeable to intracellular protein and other organic anions (A^-)



The Resting State

Membrane at resting state is

- slightly permeable to Na^+ and freely permeable to K^+ and Cl^-
- permeability of potassium P_{K} is 50 to 100 times larger than the permeability to sodium ion P_{Na} .

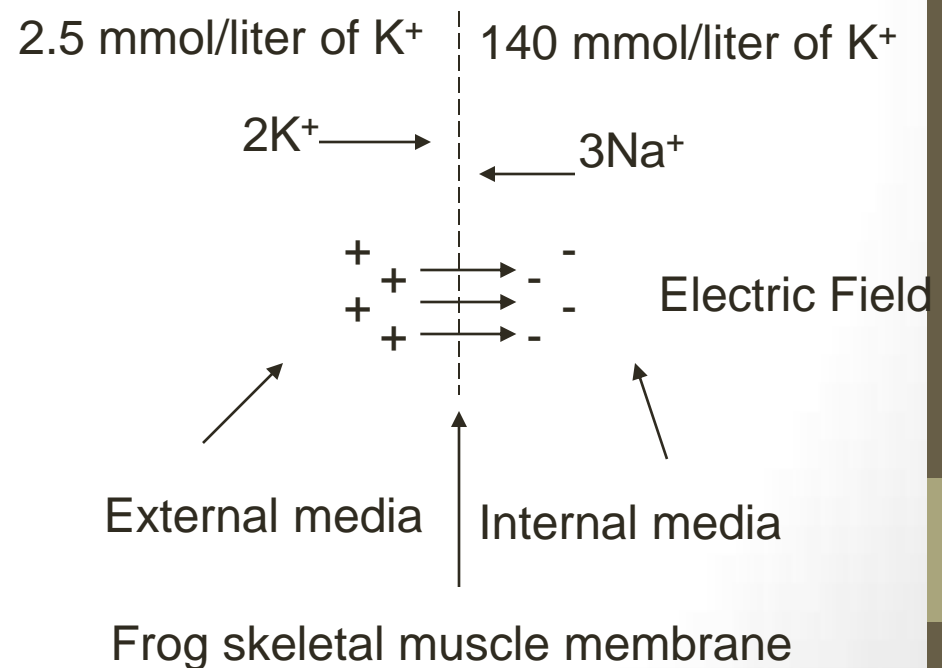


Sodium-Potassium Pump

Keeping the cell at resting state requires active transport of ionic species against their normal electrochemical gradients.

Sodium-potassium pump is an active transport that transports Na^+ out of the cell and K^+ into the cell in ratio $3\text{Na}^+ : 2\text{K}^+$

Energy for the pump is provided by a cellular energy adenosine triphosphate (ATP)



Equilibrium Potential- Nernst Equation

$$E_k = \frac{RT}{nF} \ln \frac{[K]_o}{[K]_i} = 0.0615 \log_{10} \frac{[K]_o}{[K]_i} \quad \text{At } 37 \text{ }^\circ\text{C}$$

Where n is the valence of K^+ .

$$E = \frac{RT}{F} \ln \left\{ \frac{P_K [K]_o + P_{Na} [Na]_o + P_{Cl} [Cl]_i}{P_K [K]_i + P_{Na} [Na]_i + P_{Cl} [Cl]_o} \right\}$$

E: Equilibrium transmembrane resting potential, net current is zero

P_M : permeability coefficient of the membrane for ionic species M

$[M]_i$ and $[M]_o$: the intracellular and extracellular concentrations of M

in moles/ liter

R: Universal gas constant (8.31 j/mol.k)

T: Absolute temperature in K

F: Faraday constant (96500 c/equivalent)

Example 4.1

For the frog skeletal muscle, typical values for the intracellular and extracellular concentrations for the major ion species (in millimoles per liter) are as follows.

Species	Intracellular	Extracellular
Na ⁺	12	145
K ⁺	155	4
Cl ⁻	4	120

Assuming room temperature (20 °C) and typical values of permeability coefficient for the frog skeletal muscle ($P_{Na} = 2 \cdot 10^{-8}$ cm/s, $P_K = 2 \cdot 10^{-6}$ cm/s, and $P_{Cl} = 4 \cdot 10^{-6}$ cm/s), calculate the equilibrium resting potential for this membrane, using the Goldman equation.

The Active State

Membrane at resting state is polarized (more negative inside the cell)

Depolarization : lessening the magnitude of cell polarization by making inside the cell less negative.

Hyperpolarization : increasing the magnitude of cell polarization by making inside the cell more negative.

A stimulus that depolarize the cell to a potential higher than the threshold potential causes the cell to generate an action potential.

Action Potential:

- Rate: 1000 action potential per second for nerve
- All-or-none
- $\Delta v = 120 \text{ mV}$ for nerve

Action Potential

If stimulus depolarize the cell such that $V_{\text{cell}} > V_{\text{threshold}}$ an action potential is generated.

External media Internal media

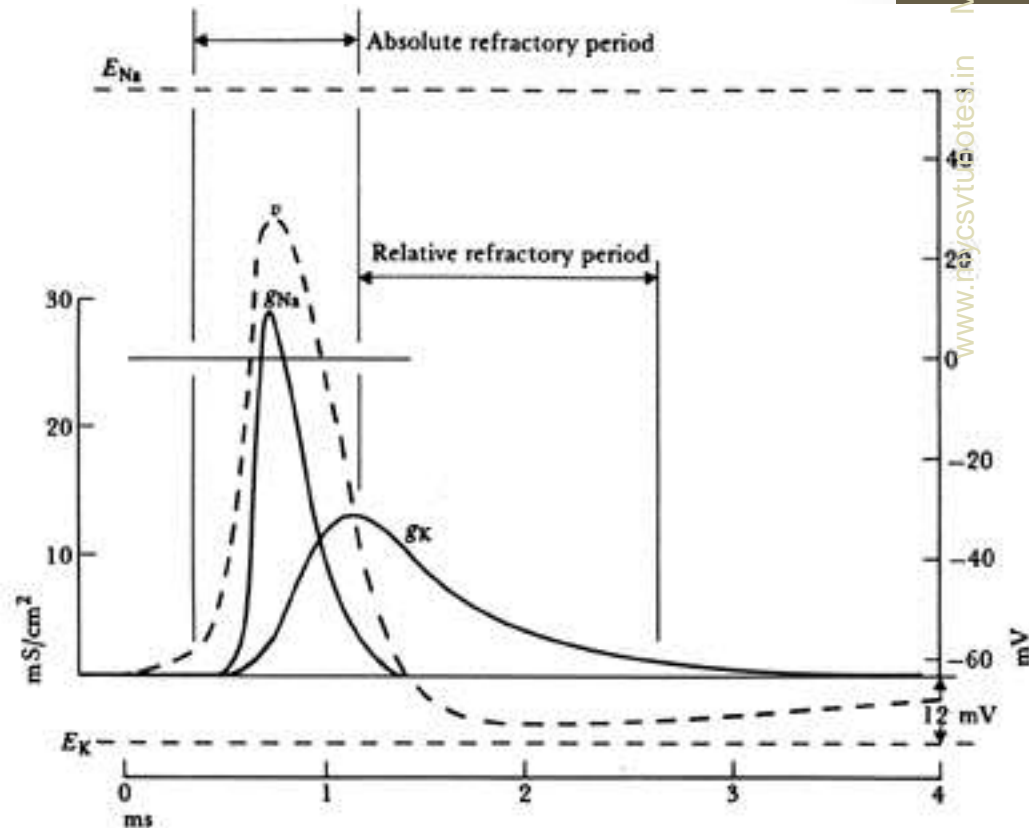
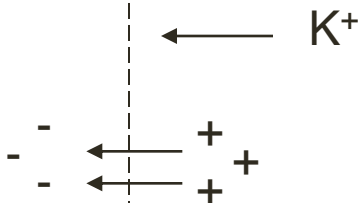
2.5 mmol/liter of K^+ 140 mmol/liter of K^+

Na^+ →

Electric Field



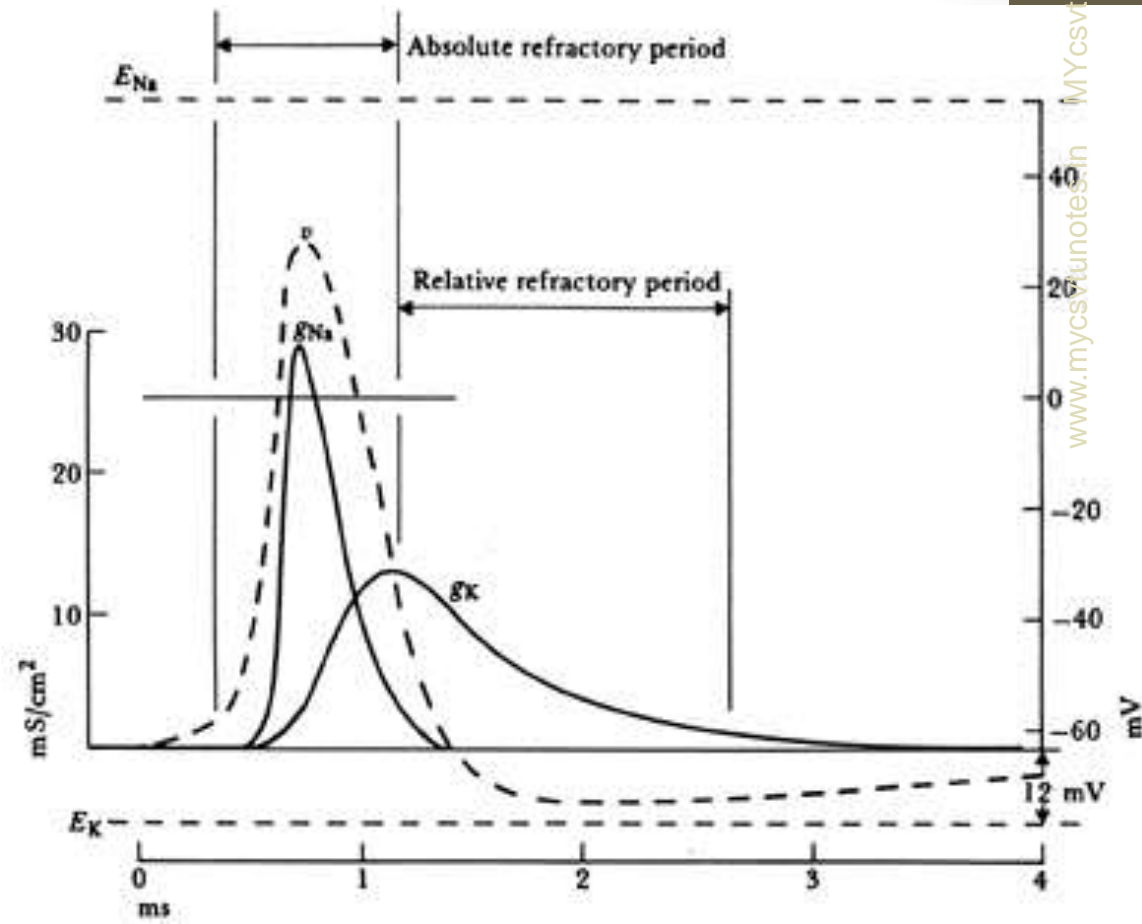
Electric Field



Action Potential

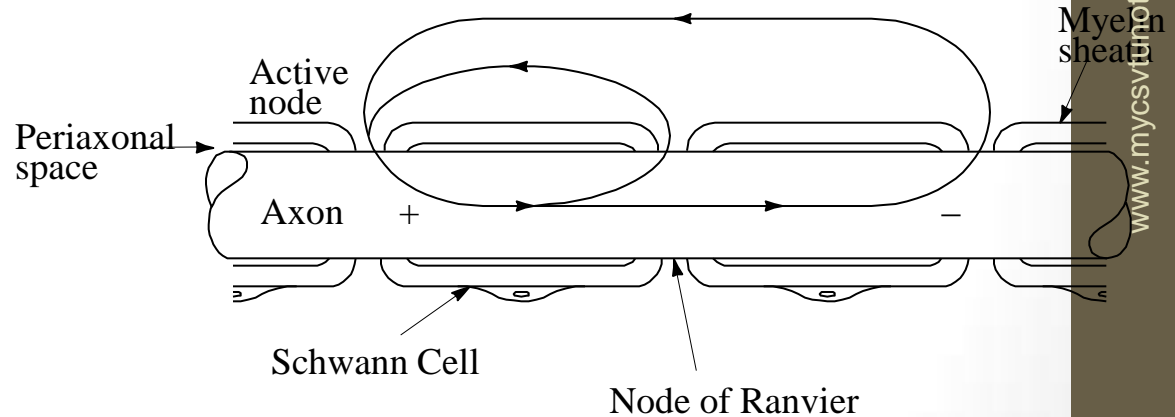
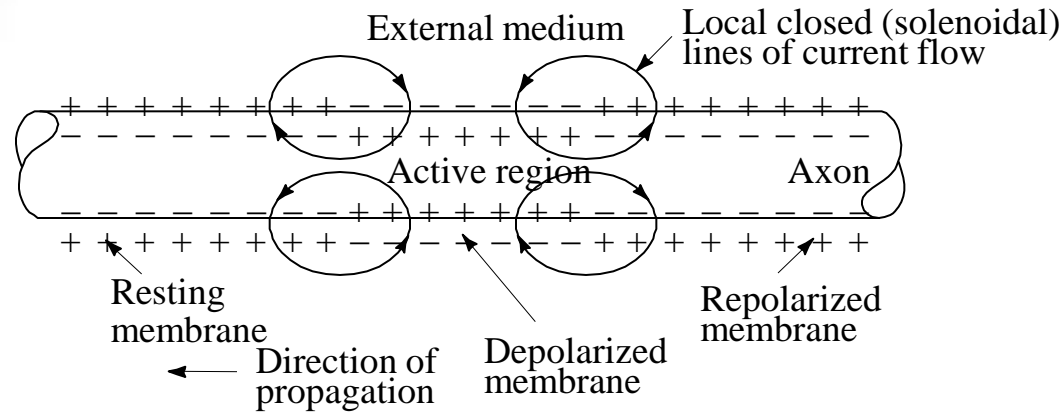
Absolute refractory period: membrane can not respond to any stimulus.

Relative refractory period: membrane can respond to intense stimulus.



Action Potential

Action potential travel at one direction.



Myelination reduces leakage currents and improve transmission rate by a factor of approximately 20.

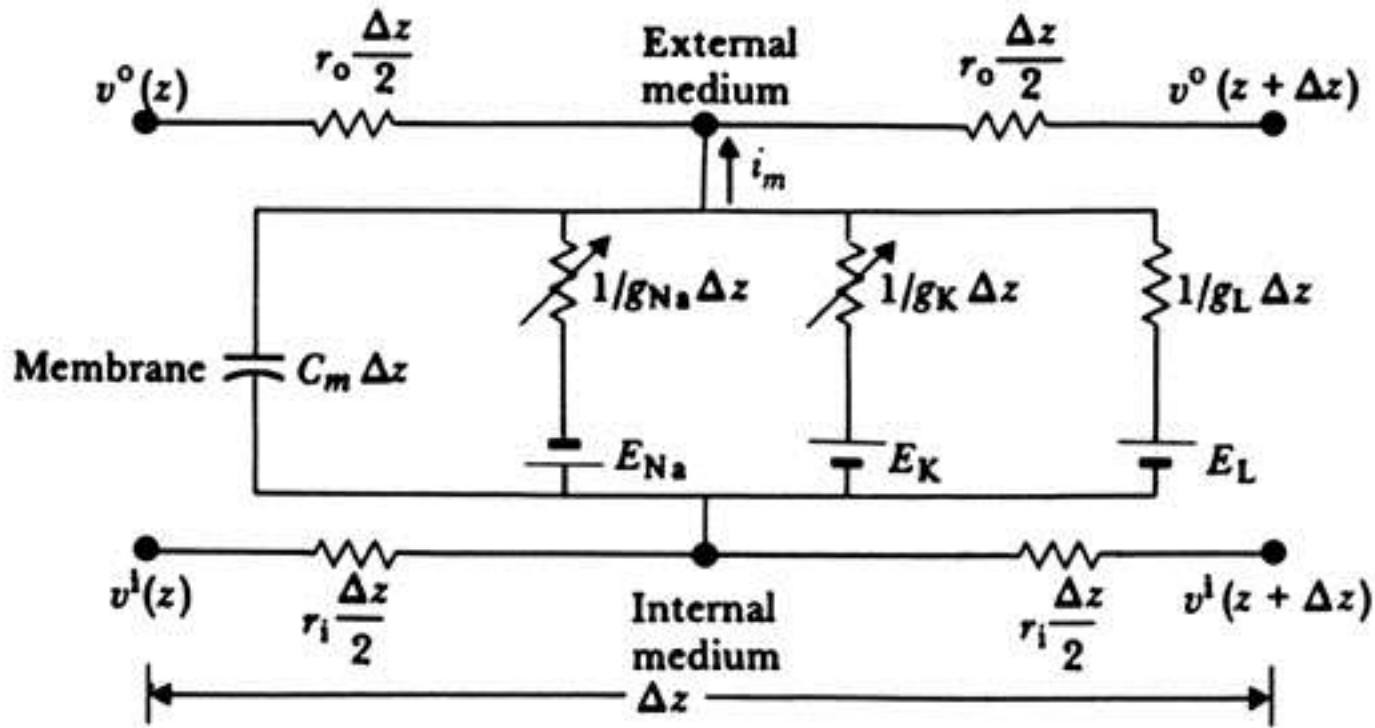


Diagram of network equivalent circuit of a small length (Δz) of an unmyelinated nerve fiber or a skeletal muscle fiber The membrane proper is characterized by specific membrane capacitance C_m ($\mu\text{F}/\text{cm}^2$) and specific membrane conductance g_{Na} , g_{K} , and g_{Cl} in mS/cm^2 (millisiemens/ cm^2). Here an average specific leakage conductance is included that corresponds to ionic current from sources other than Na^+ and K^+ (for example, Cl^-). This term is usually neglected. The cell cytoplasm is considered simply resistive, as is the external bathing medium; these media may thus be characterized by the resistance per unit length r_i and r_o (Ω/cm), respectively. Here i_m is the transmembrane current per unit length (A/cm), and v^i and v^o are the internal and external potentials v at point z , respectively.

Volume Conductor Fields

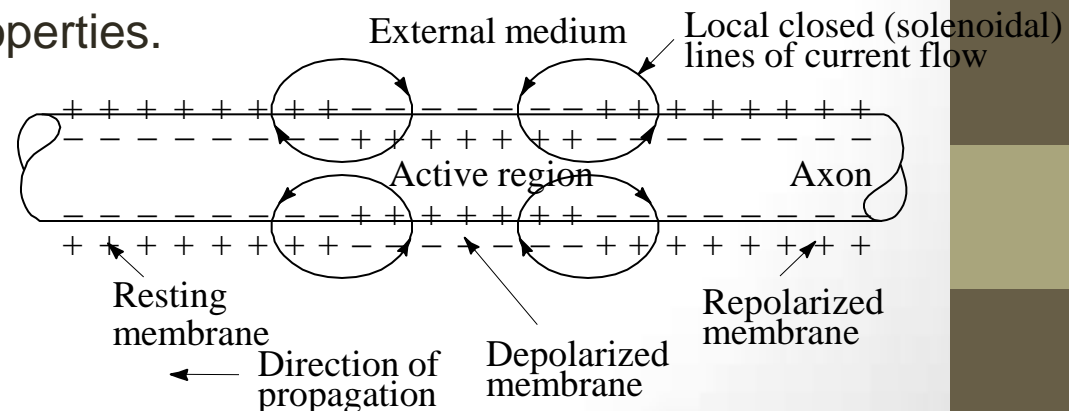
Volume conductor fields is an electric field generated by active cell (current source) or cells immersed in a volume conductor medium of resistivity ρ such as the body fluids.

Potential Waveform at the outer surface of membrane for monophasic action potential:

- 1- triphasic in nature
- 2- greater spatial extent than the action potential
- 3- much smaller in peak to peak magnitude
- 4- relatively constant in propagation along the excited cell.

- Potential in the extracellular medium of a single fiber fall off exponentially in magnitude with increasing radial distance from the fiber (potential zero within fifteen fiber radii)

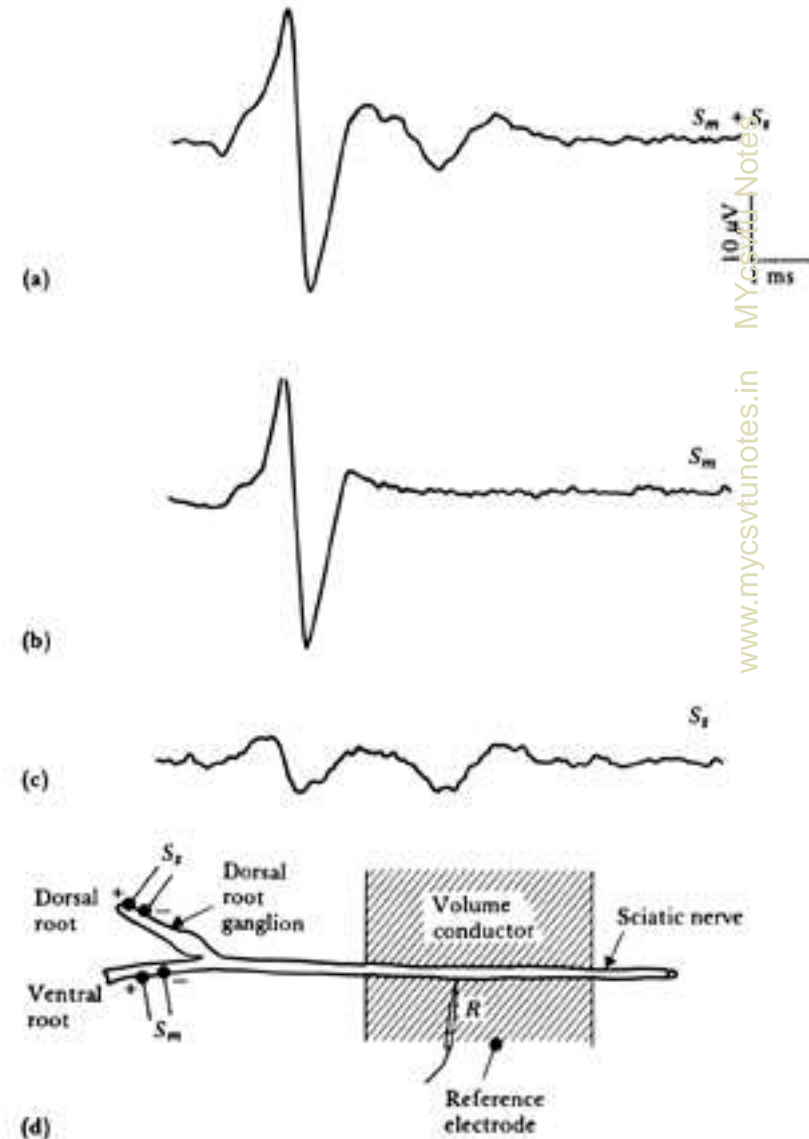
- Potential depends on medium Properties.

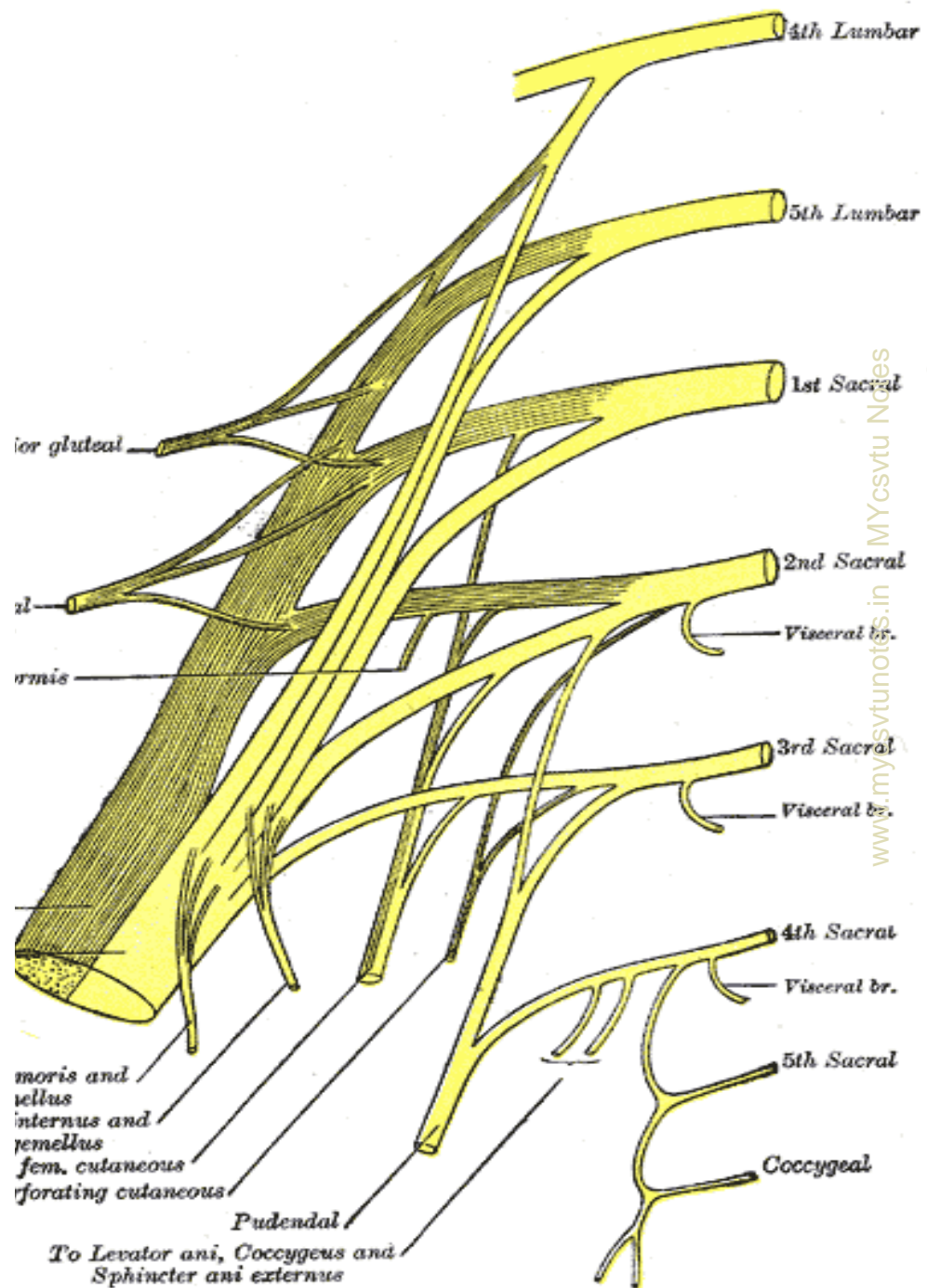
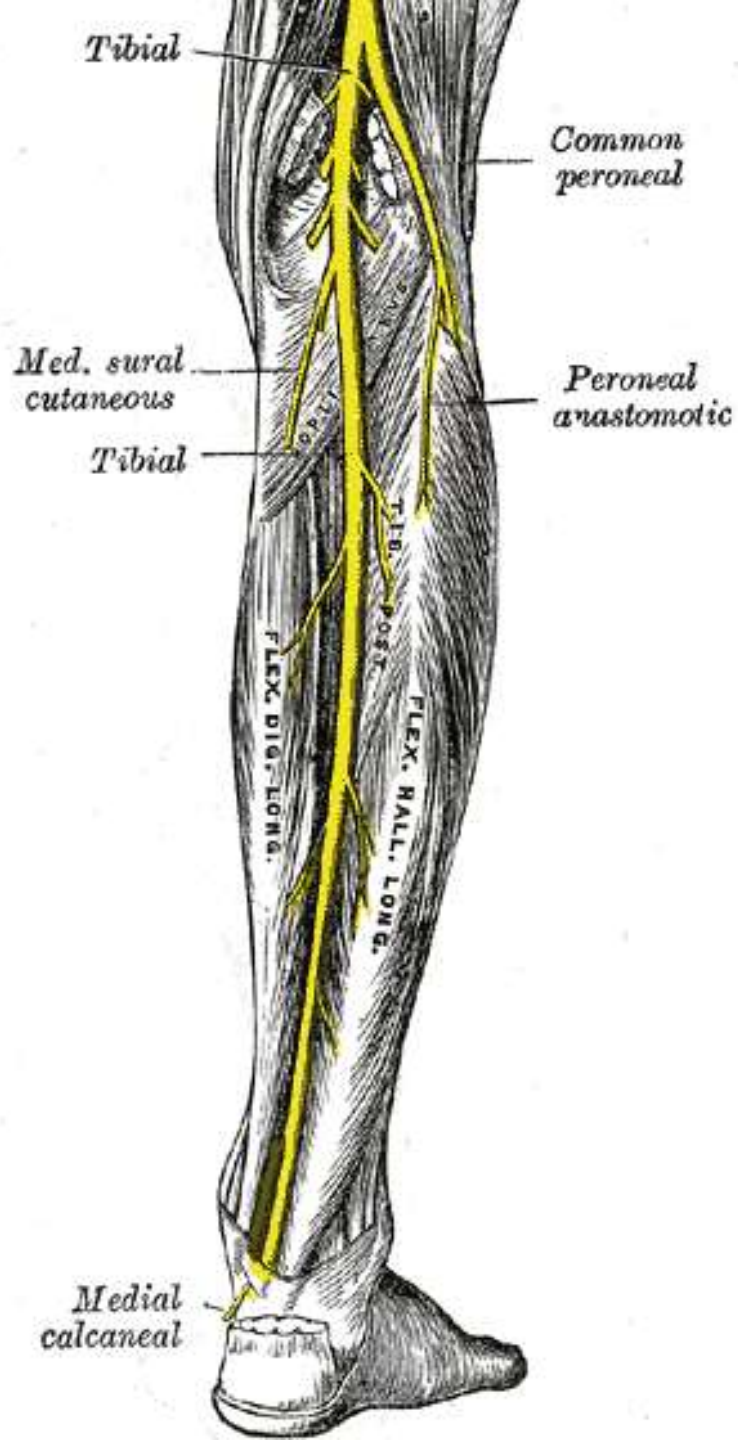


Volume Conductor Fields

The extracellular field of an active nerve trunk with its thousands of component nerve fibers simultaneously activated is similar to the field of a single fiber.

Figure 4.5 Extracellular field potentials (average of 128 responses) were recorded at the surface of an active (1-mm-diameter) frog sciatic nerve in an extensive volume conductor. The potential was recorded with (a) both motor and sensory components excited ($S_m + S_s$), (b) only motor nerve components excited (S_m), and (c) only sensory nerve components excited (S_s).





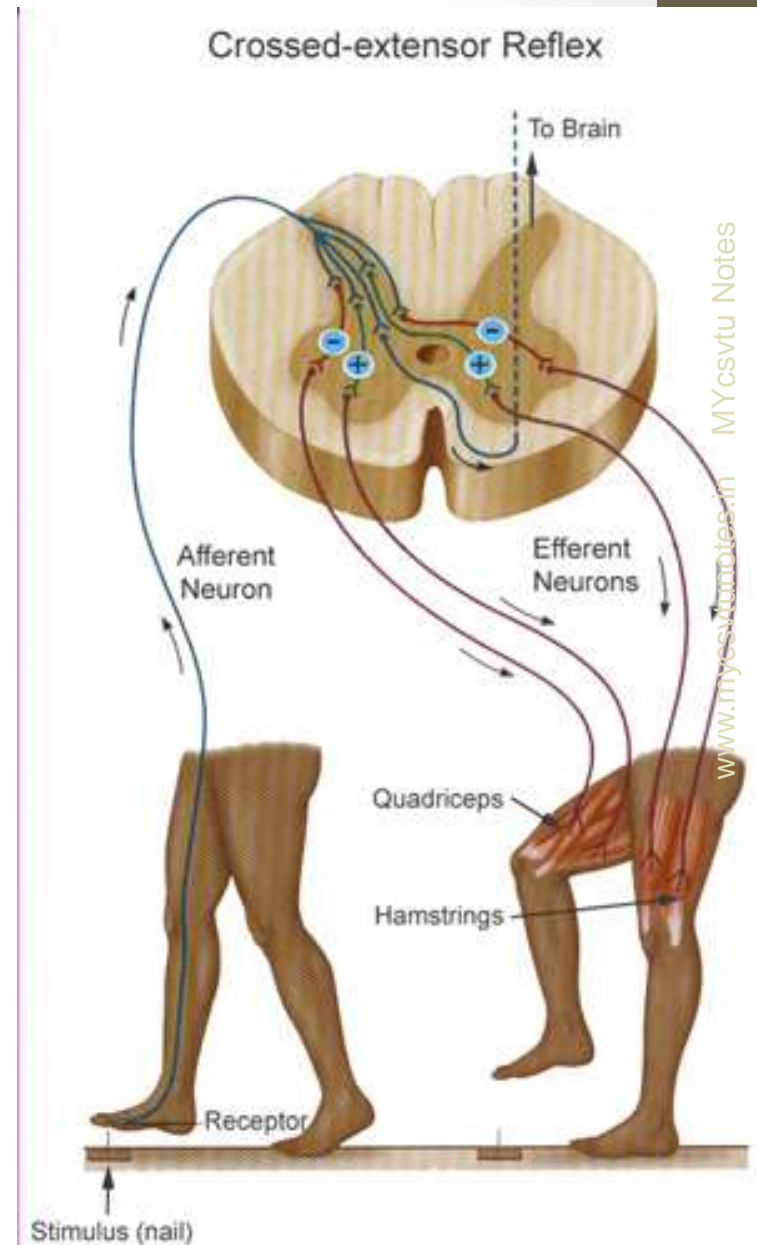
Peripheral Nervous System

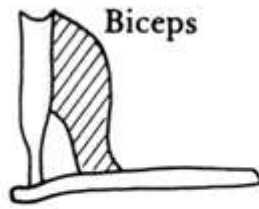
Spinal nervous system is functionally organized on the basis of what is called the reflex arc:

1. A sense organ: (ear-sound, eye-light, skin-temperature)
2. A sensory nerve: (transmit information to the CNS)
3. The CNS: serves as a central integrating station
4. Motor nerve: communication link between CNS and peripheral muscle
5. Effector organ: skeletal muscle fibers

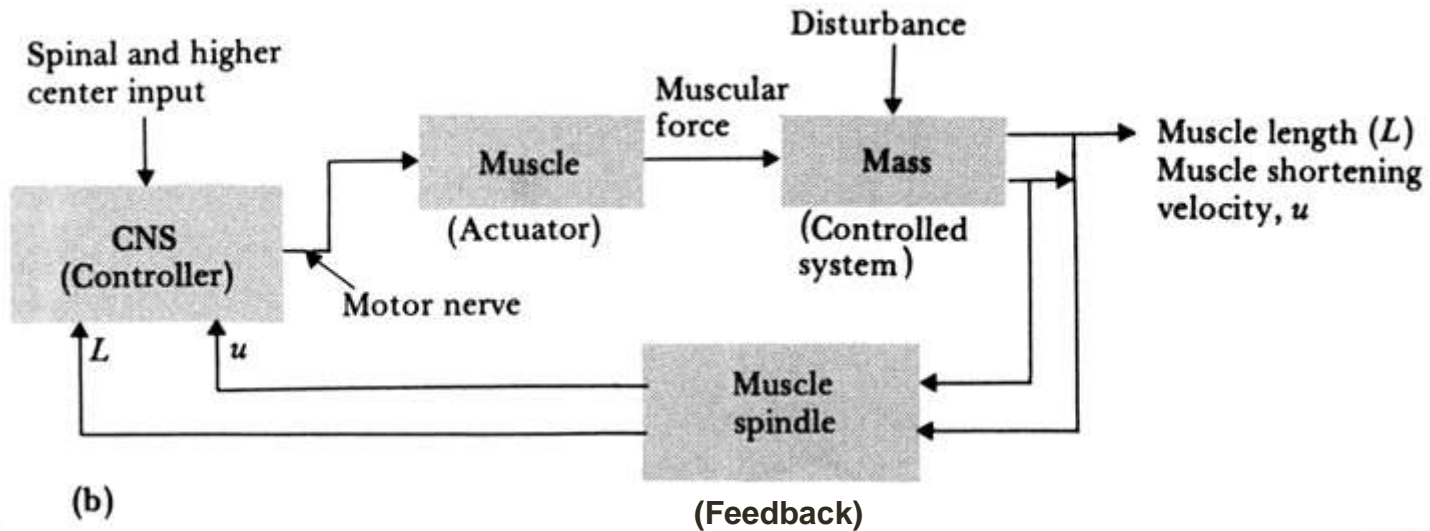
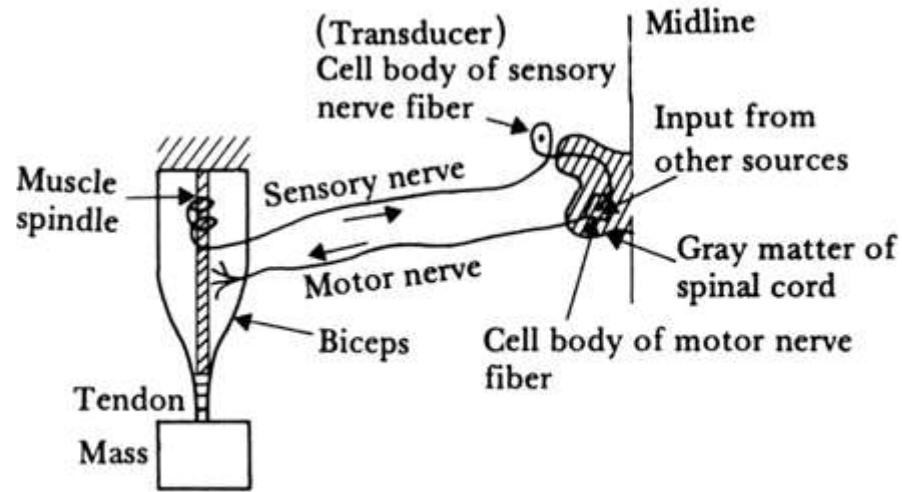
Example of reflex arc

Example of reflex arc





(a)



(b)

Schematic diagram of a muscle-length control system for a peripheral muscle (biceps) (a) Anatomical diagram of limb system showing interconnections. (b) Block diagram of control system.

Junctional Transmission

Synapses: intercommunicating links between neurons

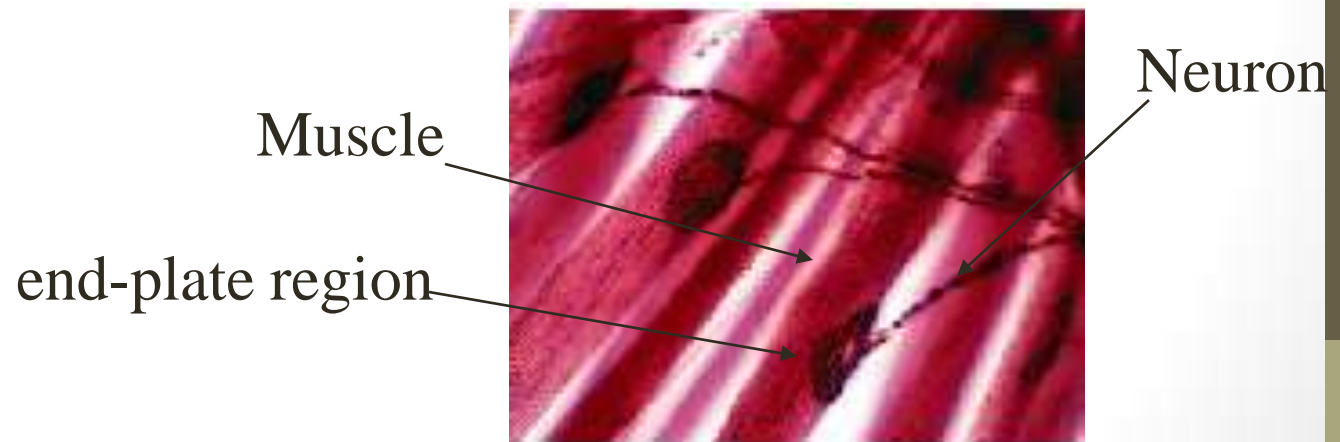
Neuromuscular junctions: communicating links between neurons and muscle fibers at *end-plate region*.

Neuromuscular junction (20nm thickness)

release neurotransmitter substance Acetylcholine (Ach)

Time delay due to junction is 0.5 to 1 msec

Excitation-contraction time delay due to muscle contraction



At high stimulation rates, the mechanical response fuse into one continuous contraction called a tetanus (mechanical response summates).

Field Potential of Sensory Nerves

Extracellular field response from the sensory nerves of the median or ulnar nerves

To excite the large, rapidly conducting sensory nerve fibers but not small pain fibers or surrounding muscle, apply brief, intense stimulus (square pulse with amplitude 100-V and duration 100-300 μ sec). To prevent artifact signal from muscle movement position the limb in a comfortable posture.

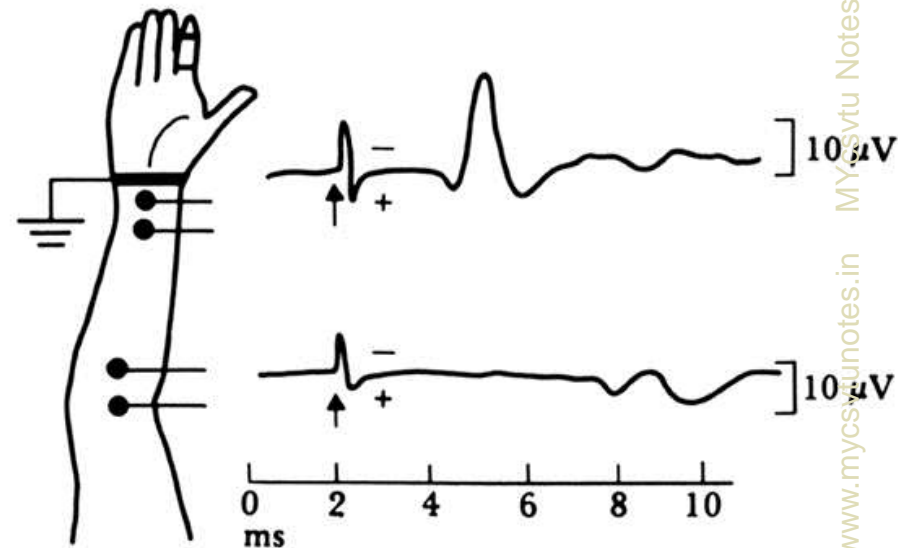
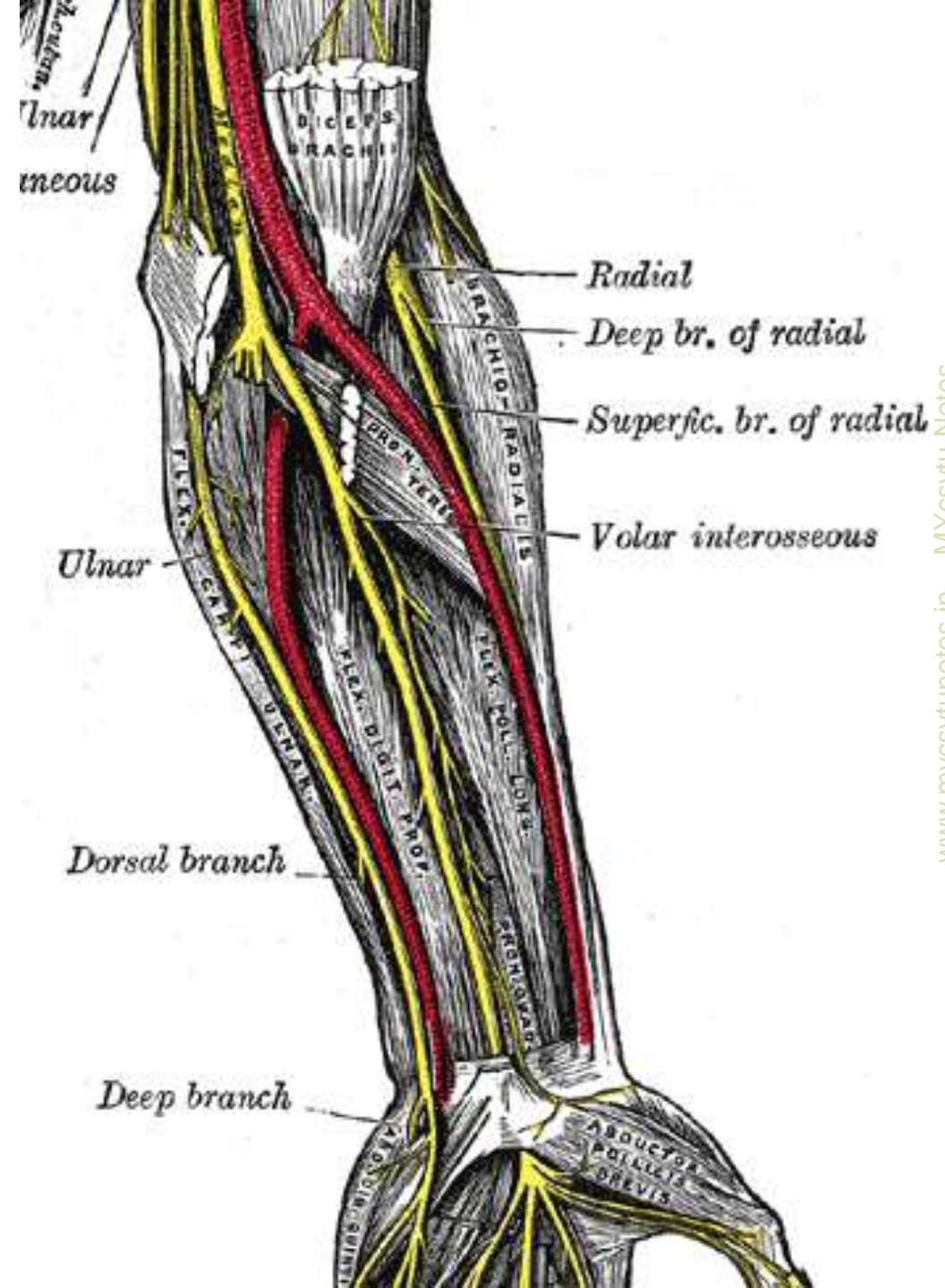
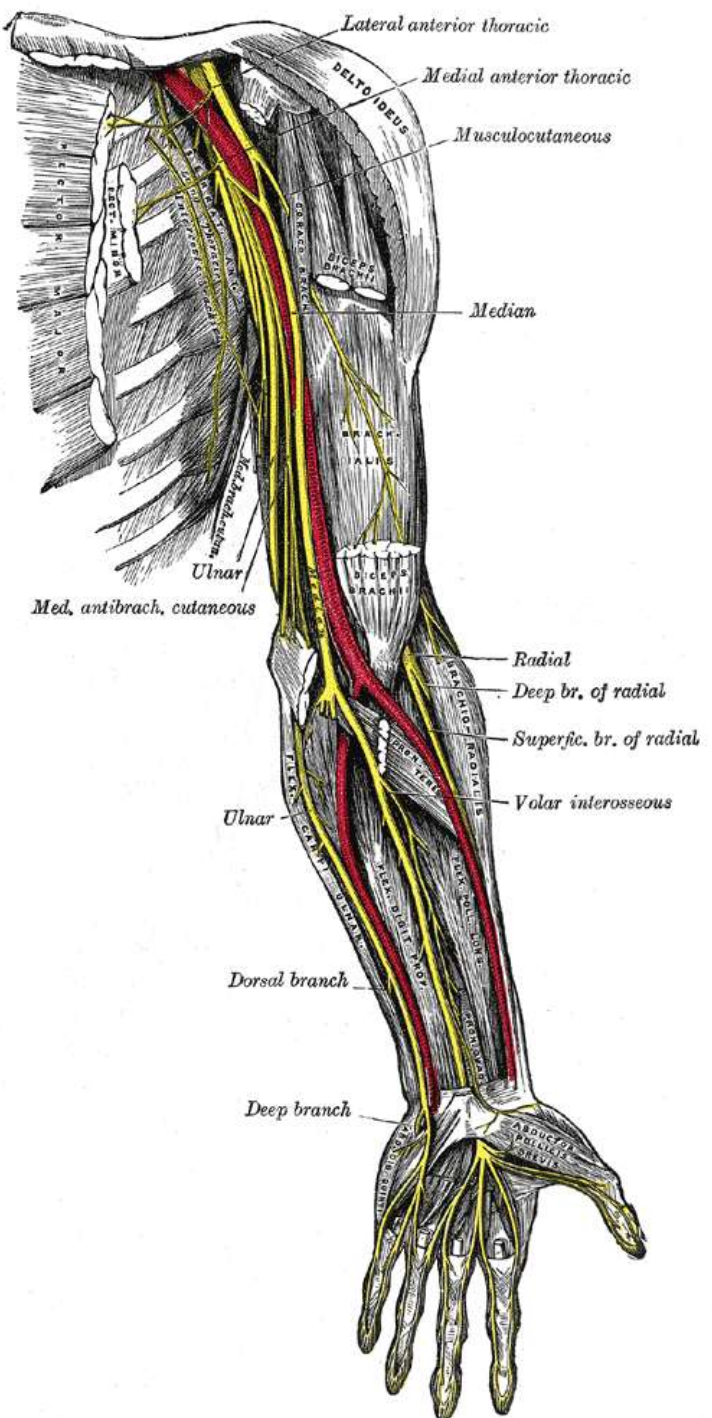
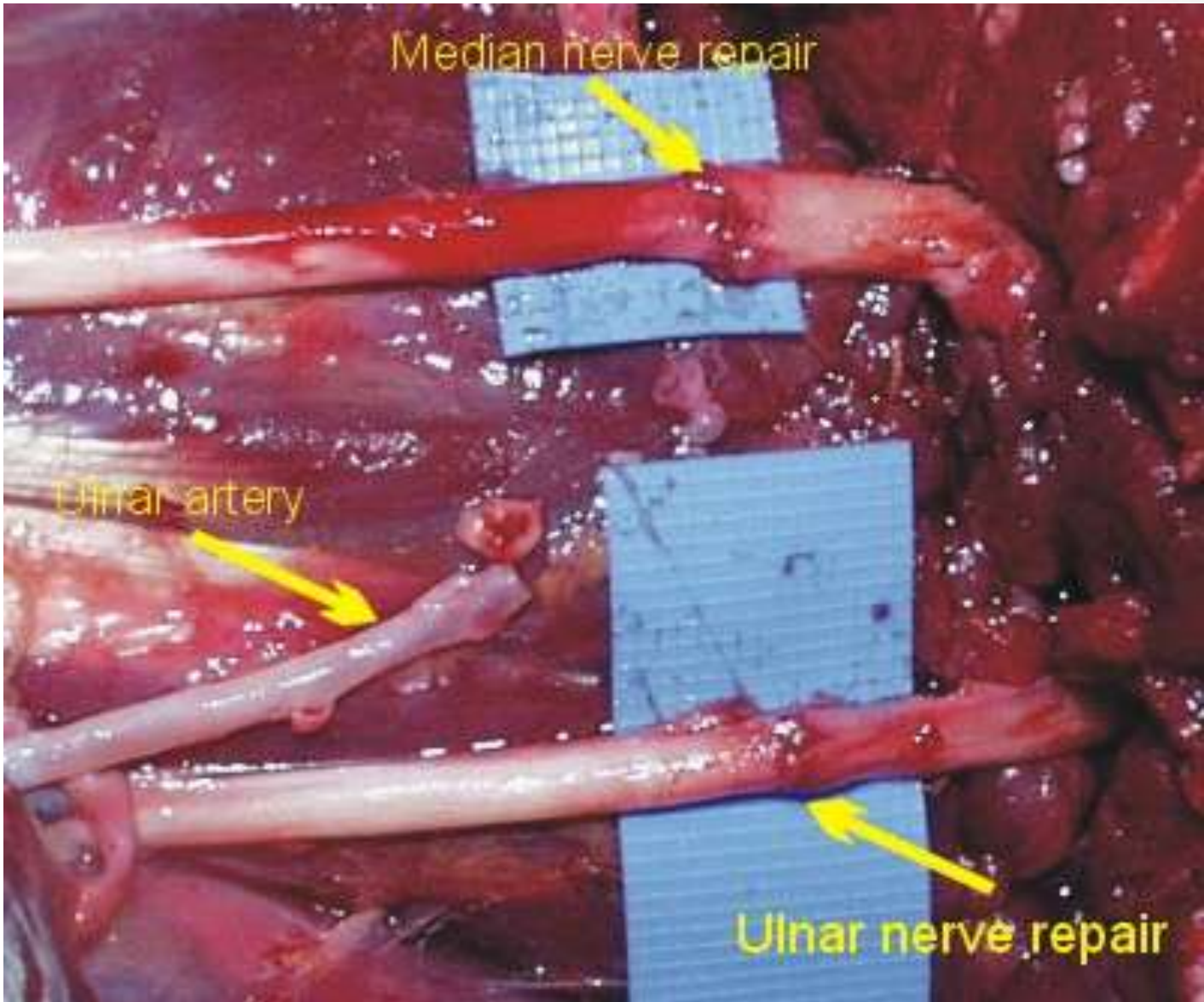


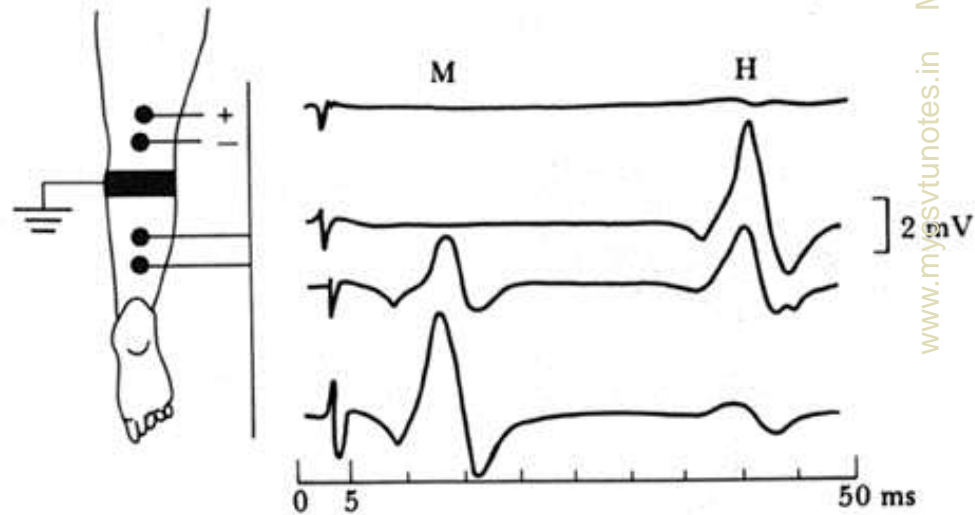
Figure 4.8 Sensory nerve action potentials evoked from median nerve of a healthy subject at the elbow and wrist after stimulation of index finger with ring electrodes. The potential at the wrist is triphasic and of much larger magnitude than the delayed potential recorded at the elbow. Considering the median nerve to be of the same size and shape at the elbow as at the wrist, we find that the difference in magnitude and waveshape of the potentials is due to the size of the volume conductor at each location and the radial distance of the measurement point from the neural source.



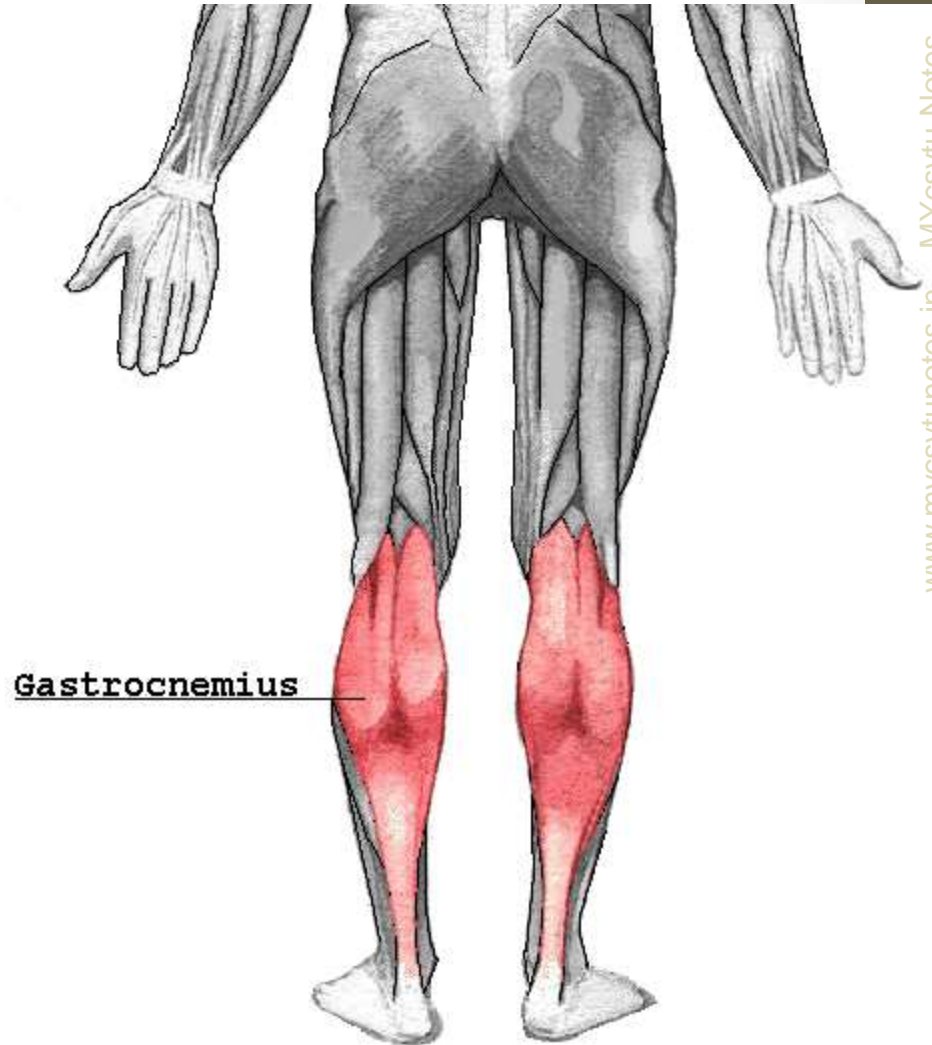
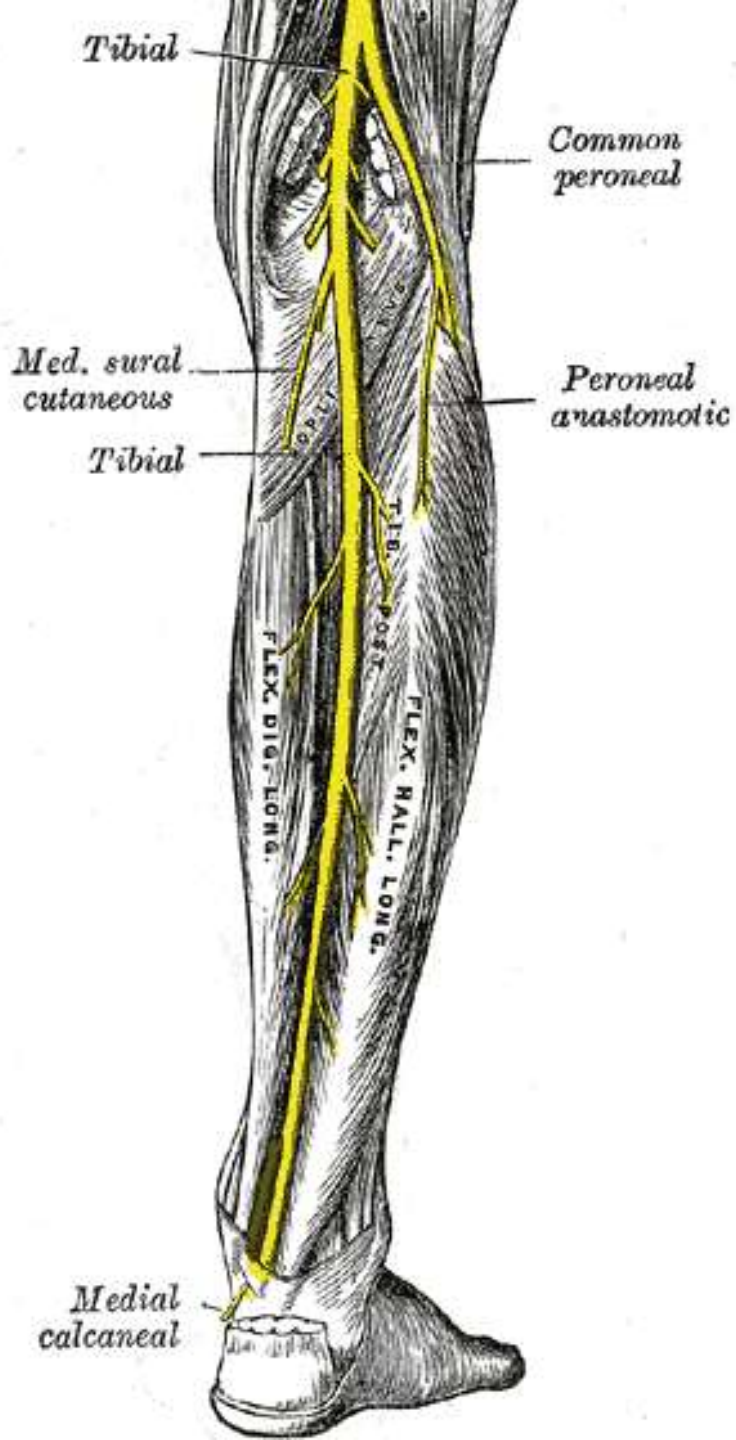


Reflexly Evoked Field Potentials

Some times when a peripheral nerve is stimulated, a two evoked potentials are recorded in the muscle the nerve supplies. The time difference between the two potentials determined by the distance between the stimulus and the muscle.



Stimulated nerve: posterior tibial nerve
Muscle: gastrocnemius



Reflexly Evoked Field Potentials

Medium intensity stimulus stimulate smaller motor fibers in addition to the large sensory fibers. Motor fibers produce a direct muscle response the M wave.

With strong stimuli, the excited motor fibers are in their refractory period so only the M wave is produced.

Low intensity stimulus stimulate only the large sensory fibers that conduct toward the CNS. No M wave

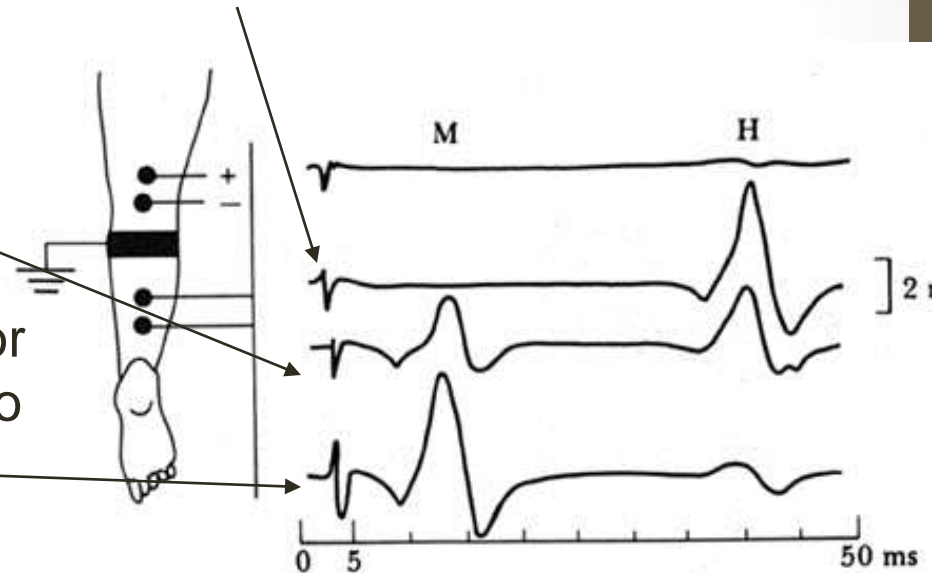


Figure 4.9 The H reflex The four traces show potentials evoked by stimulation of the medial popliteal nerve with pulses of increasing magnitude (the stimulus artifact increases with stimulus magnitude). The later potential or H wave is a low-threshold response, maximally evoked by a stimulus too weak to evoke the muscular response (M wave). As the M wave increases in magnitude, the H wave diminishes.

Electromyogram (EMG)

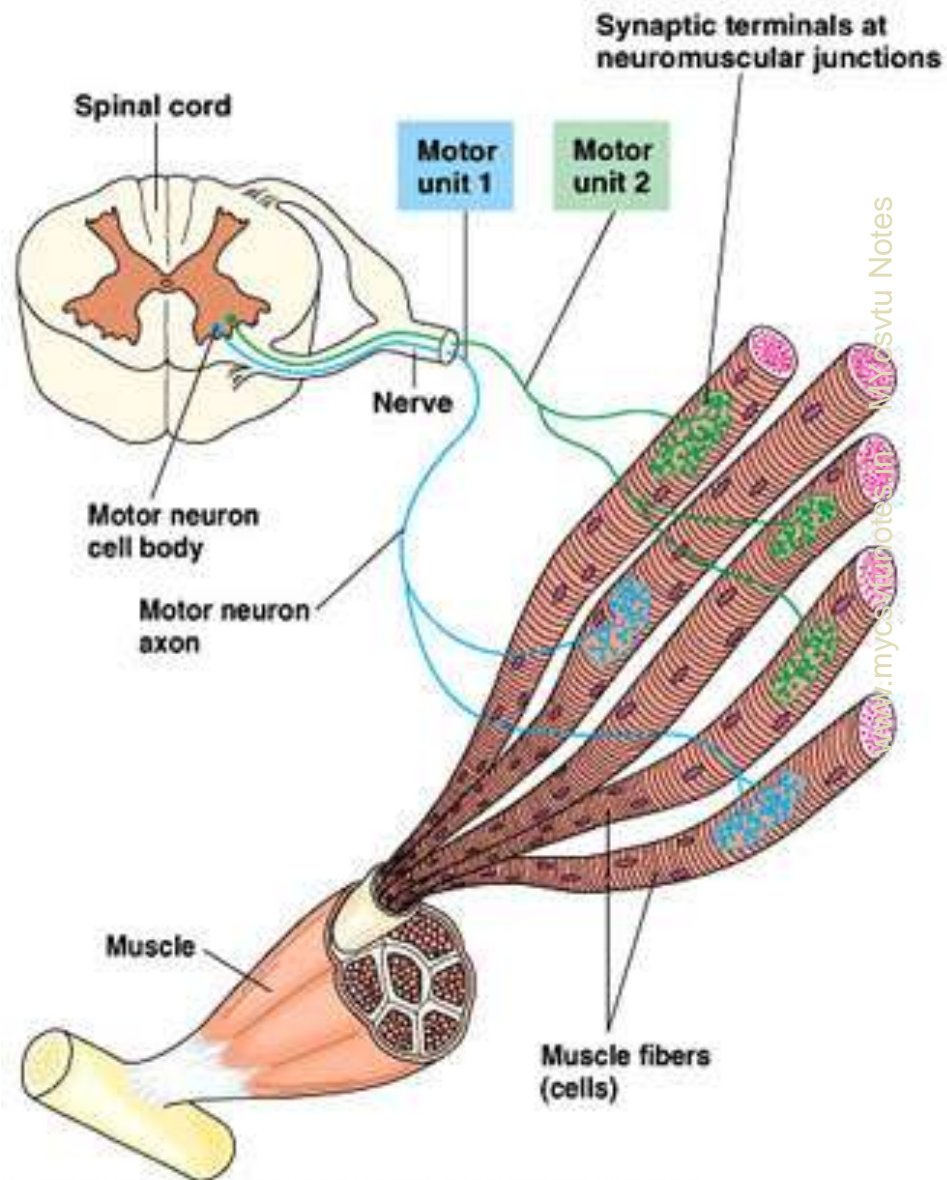
Skeletal muscle is organized functionally on the basis of the single motor unit (SMU).

SMU is the smallest unit that can be activated by a volitional effort where all muscle fibers are activated synchronously.

SMU may contain 10 to 2000 muscle fibers, depending on the location of the muscle.

Factors for muscle varying strength

1. Number of muscle fibers contracting within a muscle
2. Tension developed by each contracting fiber



Muscle Fiber (Cell)

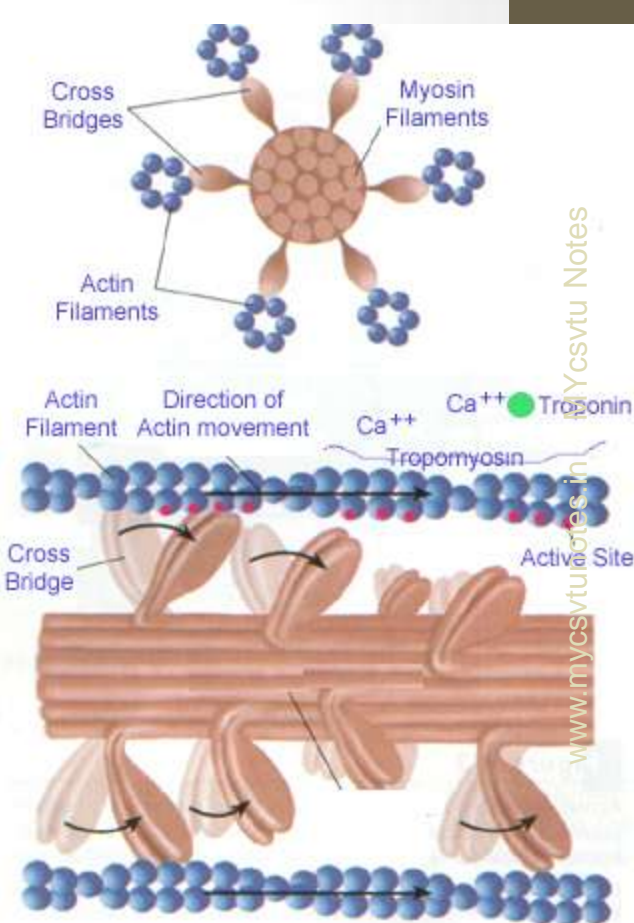
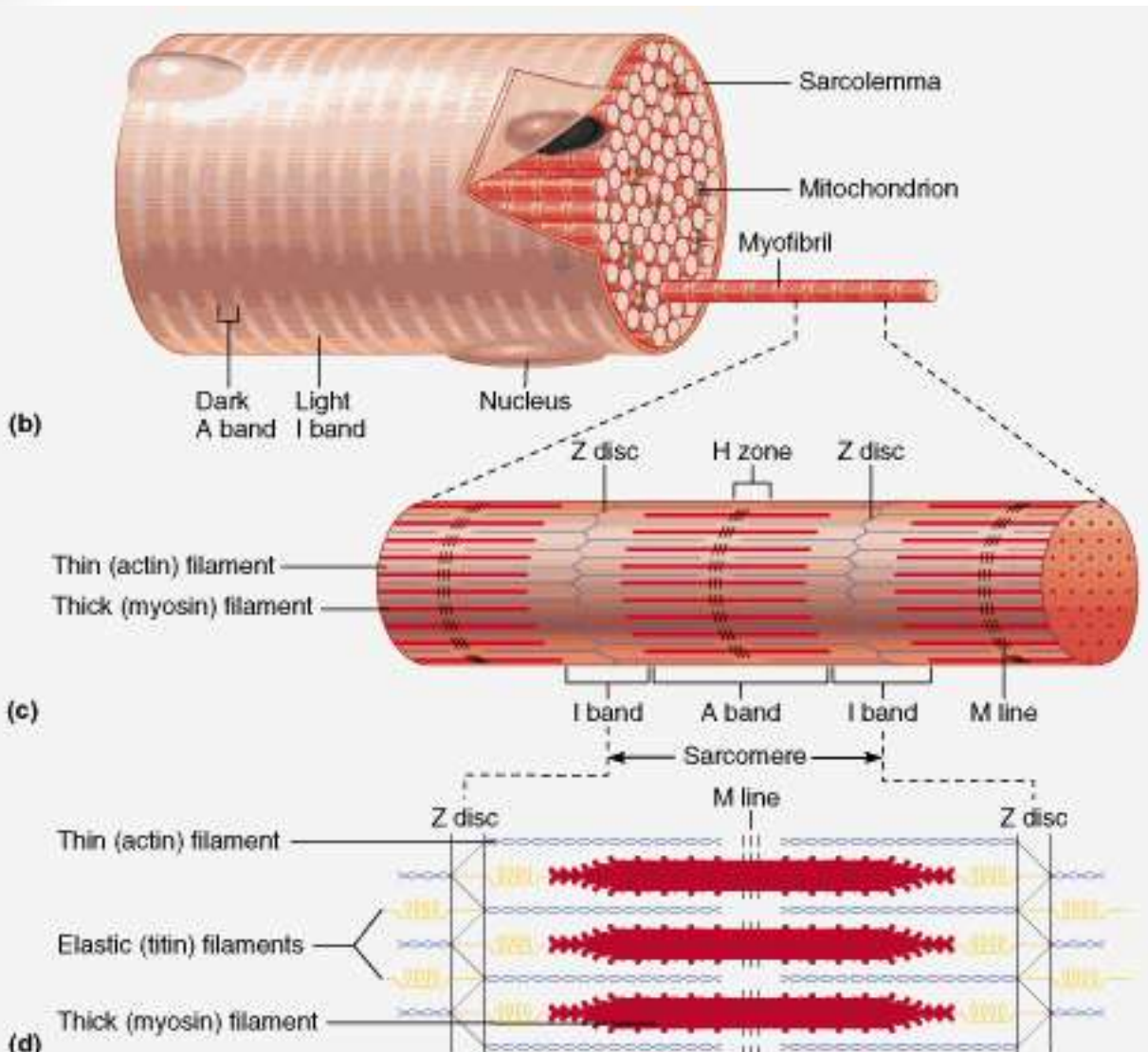
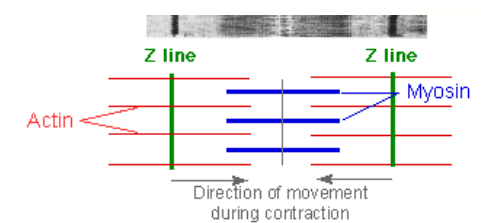


Figure 8-2



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<http://www.blackwellpublishing.com/matthews/myosin.html>

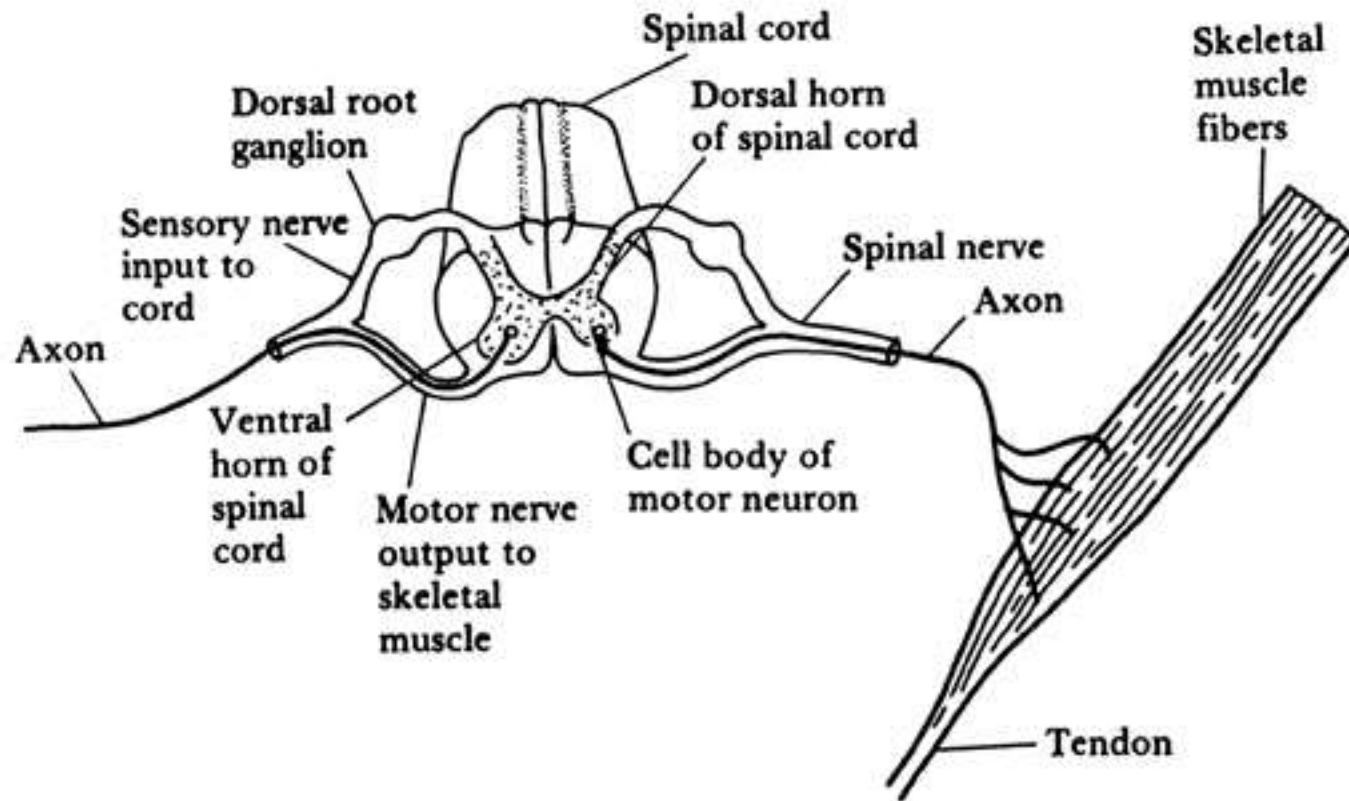


Figure 4.10 Diagram of a single motor unit (SMU), which consists of a single motoneuron and the group of skeletal muscle fibers that it innervates. Length transducers [muscle spindles, Figure 4.6(a)] in the muscle activate sensory nerve fibers whose cell bodies are located in the dorsal root ganglion. These bipolar neurons send axonal projections to the spinal cord that divide into a descending and an ascending branch. The descending branch enters into a simple reflex arc with the motor neuron, while the ascending branch conveys information regarding current muscle length to higher centers in the CNS via ascending nerve fiber tracts in the spinal cord and brain stem. These ascending pathways are discussed in Section 4

Electromyogram (EMG)

Field potential of the active fibers of an SMU

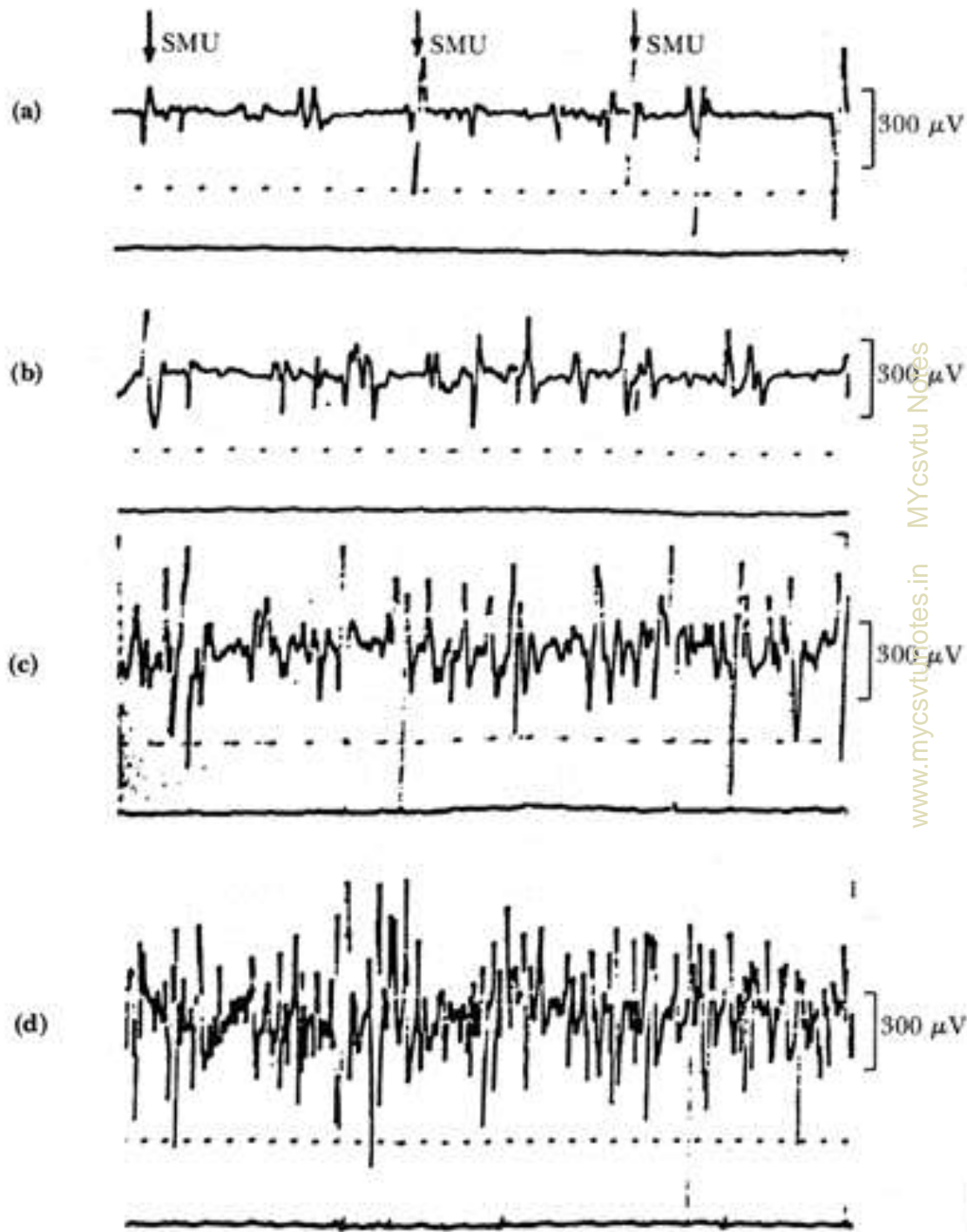
- 1- triphasic form
- 2- duration 3-15 msec
- 3- discharge rate varies from 6 to 30 per second
- 4- Amplitude range from 20 to 2000 μV

Surface electrode record field potential of surface muscles and over a wide area.

Monopolar and bipolar insertion-type needle electrode can be used to record SMU field potentials at different locations.

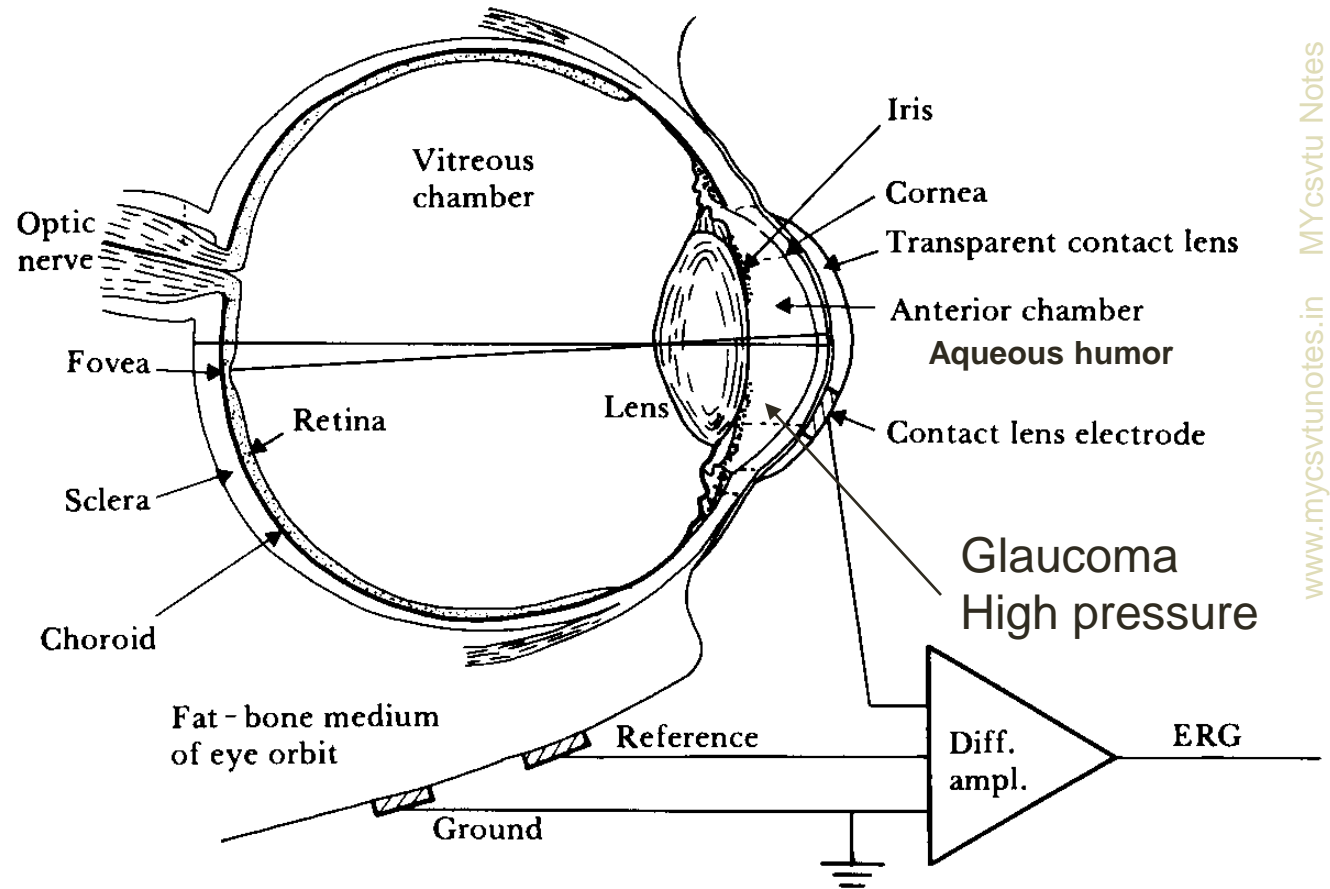
The shape of SMU potential is considerably modified by disease such as partial denervation.

Figure 4.11 Motor unit action potentials from normal dorsal interosseus muscle during progressively more powerful contractions. In the interference pattern (c), individual units can no longer be clearly distinguished. (d) Interference pattern during very strong muscular contraction. Time scale is 10 ms per dot.



Electroretinogram (ERG)

ERG is a recording of the temporal sequence of changes in potential in the retina when stimulated with a brief flash of light.



A transparent contact lens contains one electrode and the reference electrode can be placed on the right temple.

Electroretinogram (ERG)

Ag/AgCl electrode impeded in a special contact lens.

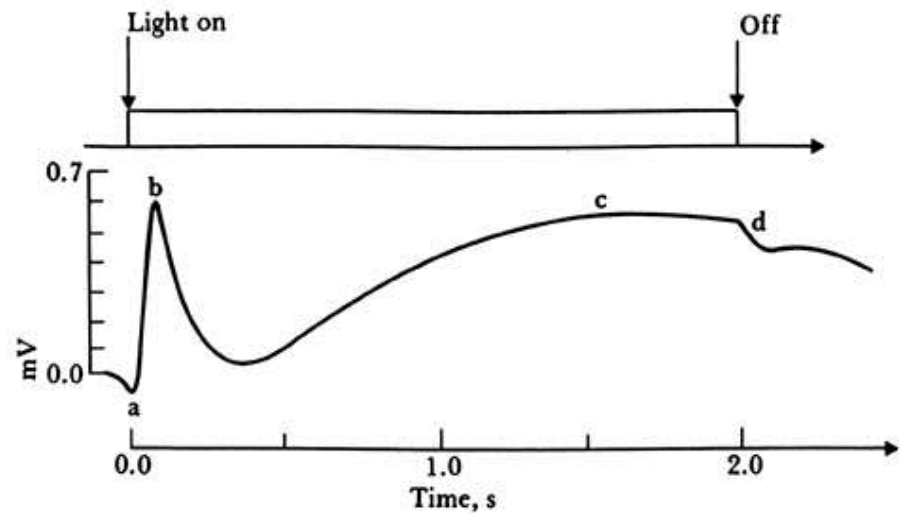


some corneal ERG electrodes

Burian speculum type electrodes



Cotton wick electrodes



Source of Retinal Potential

There are more photoreceptors than ganglion cells so there is a convergence pattern. Many photoreceptors terminate into one bipolar cell and many bipolar cells terminate into one ganglion cell. The convergence rate is greater at peripheral parts of the retina than at the fovea. Rod (10 million) is for vision in dim light and cone (3 million) is for color vision in brighter light.

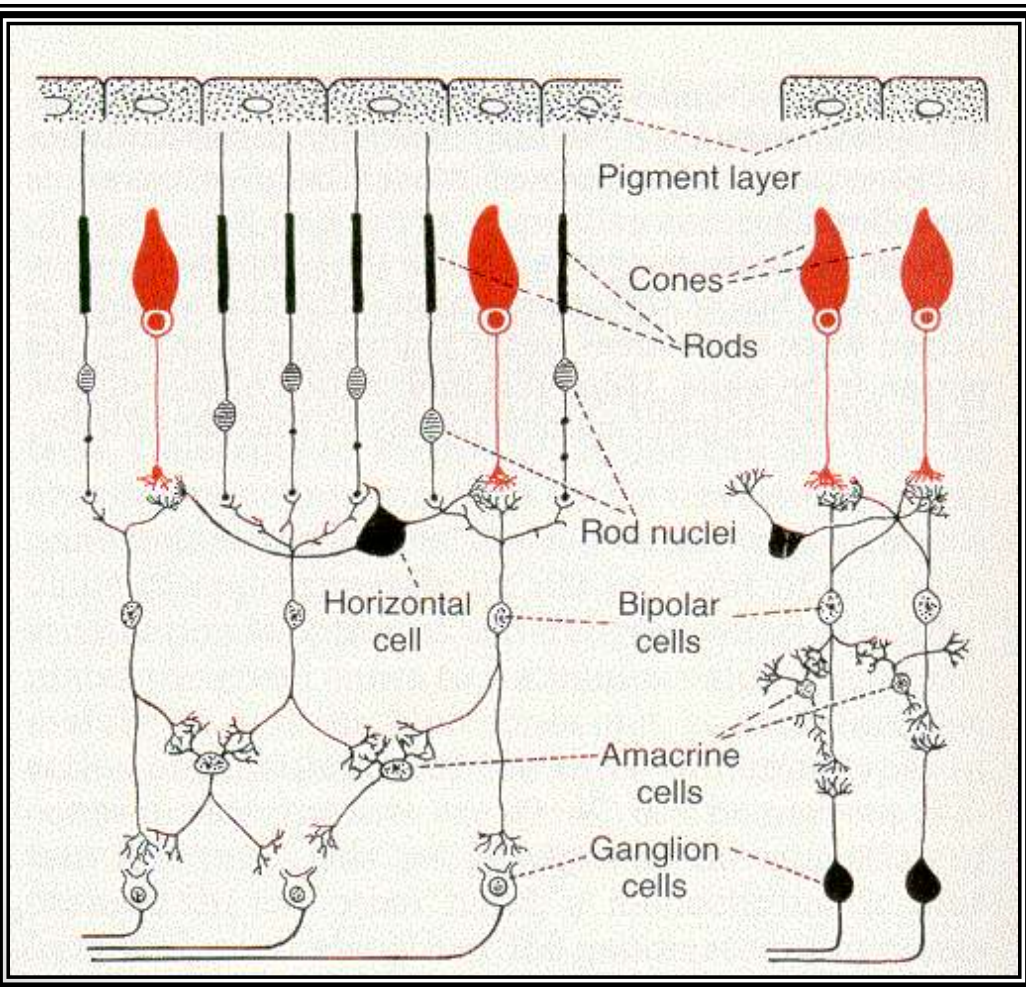
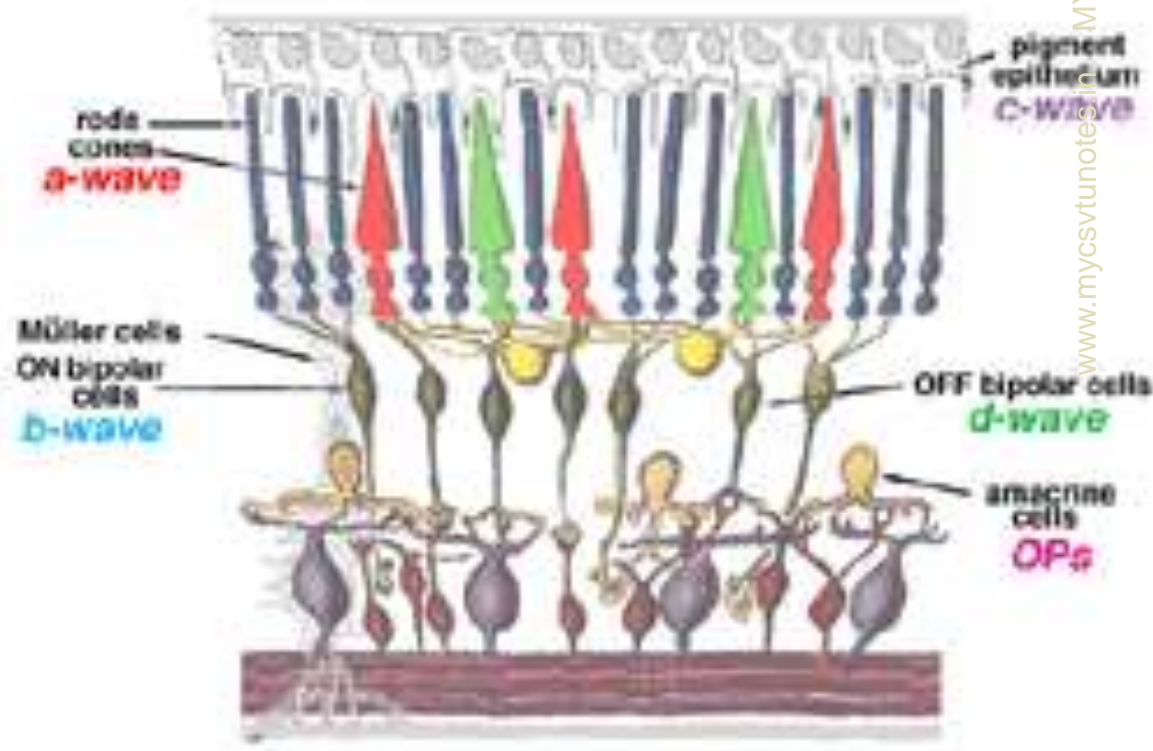
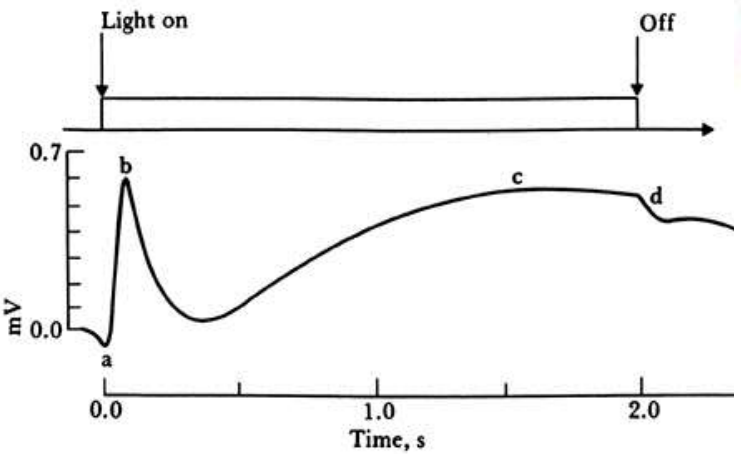


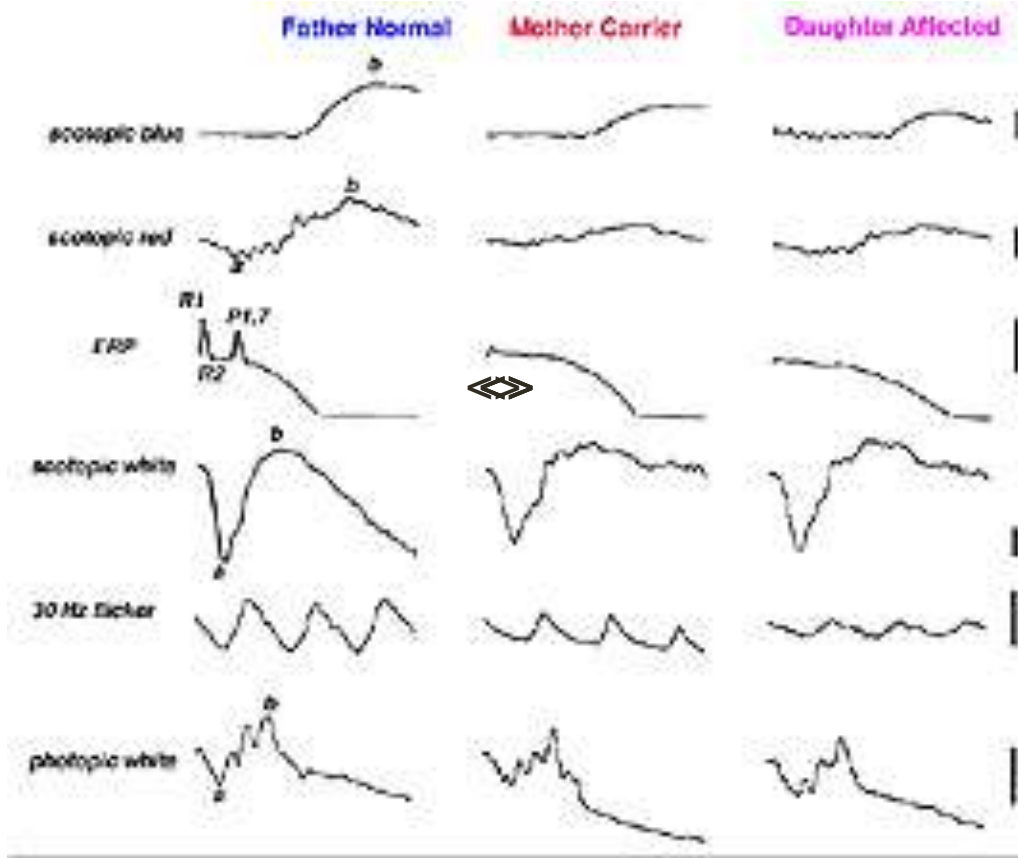
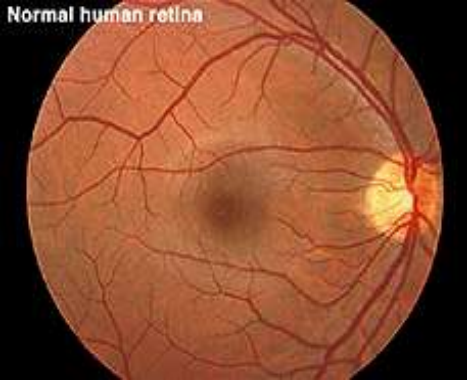
Figure 60. SEM photograph of the receptor layer of a retina from the toad, *Bufo marinus*. The retina was fixed and then cracked to expose the long axis of the receptors. Types of photoreceptors present include red rods, green rods, and single cones, all of which are readily identified by distinctive features described in the text. (From Brown and Flaming (1977a), reproduced by permission of Pergamon Press, Oxford, England)

Electroretinogram (ERG)

The **a-wave**, sometimes called the "late receptor potential," reflects the general physiological health of the photoreceptors in the outer retina. In contrast, the b-wave reflects the health of the inner layers of the retina, including the ON bipolar cells and the Müller cells (Miller and Dowling, 1970). Two other waveforms that are sometimes recorded in the clinic are the c-wave originating in the pigment epithelium (Marmor and Hock, 1982) and the d-wave indicating activity of the OFF bipolar cells (see Figure 3).

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<http://webvision.med.utah.edu/ClinicalERG.html>

Electro-Oculogram (EOG)

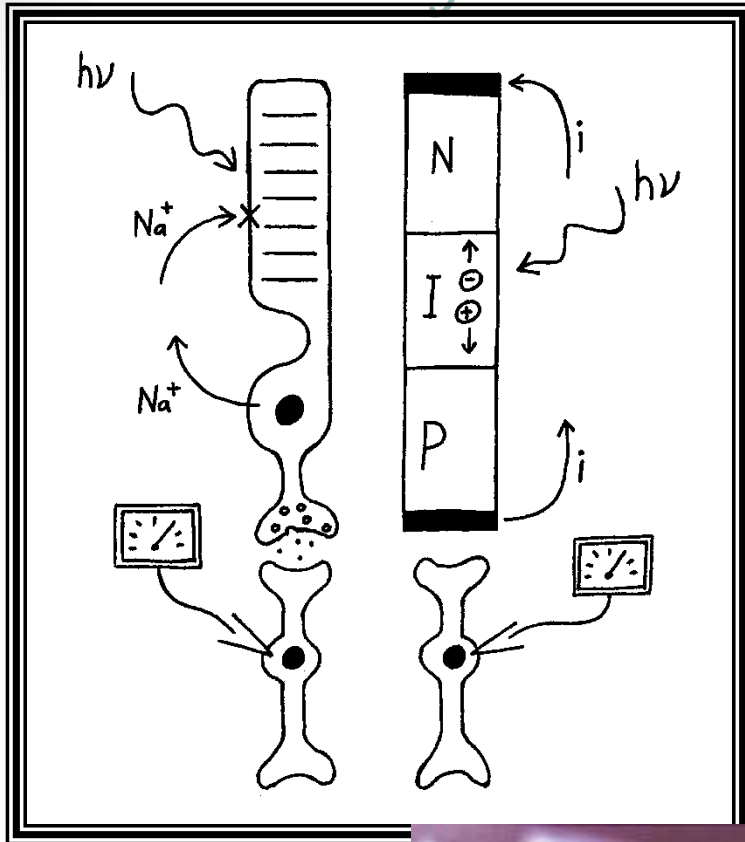
EOG is the recording of the corneal-retinal potential to determine the eye movement.

By placing two electrodes to the left and the right of the eye or above and below the eye one can measure the potential between the two electrode to determine the horizontal or vertical movement of the eye. The potential is zero when the gaze is straight ahead.

Applications

- 1- Sleep and dream research,
- 2- Evaluating reading ability and visual fatigue.

Bionic Eyes

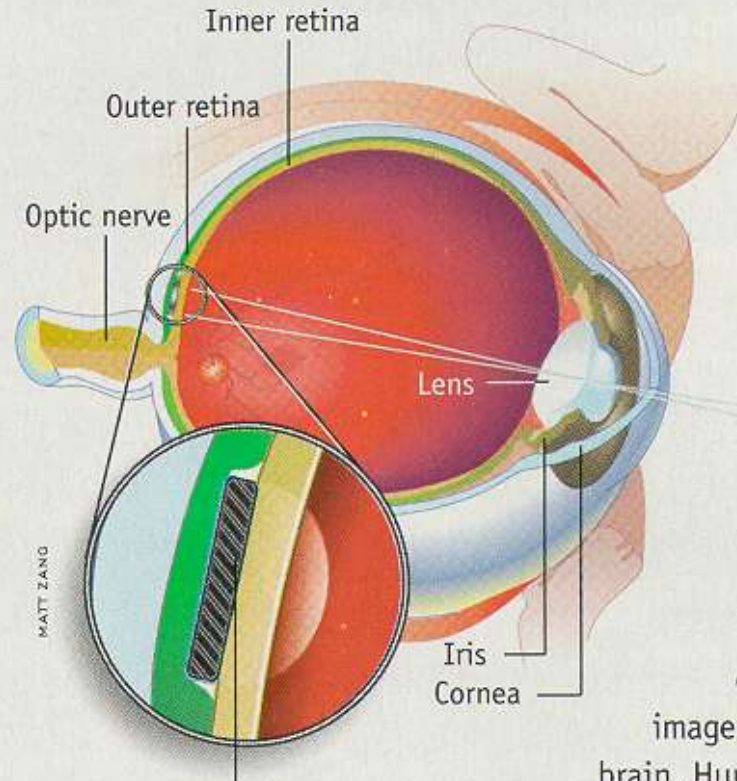


Bionic Eyes

SOMEDAY, artificial light receptors, or photoreceptors, may be inserted under damaged retinas to help patients regain sight. Normally, the brain creates images by interpreting signals relayed from

the retina via the optic nerve; the signals contain information about color and brightness. Now researchers at Optobionics of Wheaton, Illinois, have demonstrated in animals that their artificial receptors can transmit

image information to the brain. Human trials are expected within a few years.



Implant in subretinal space



Electrocardiogram (ECG)

Blood (poor with oxygen) flows from the body to the right atrium and then to the right ventricle. The right ventricle pump the blood to the lung.

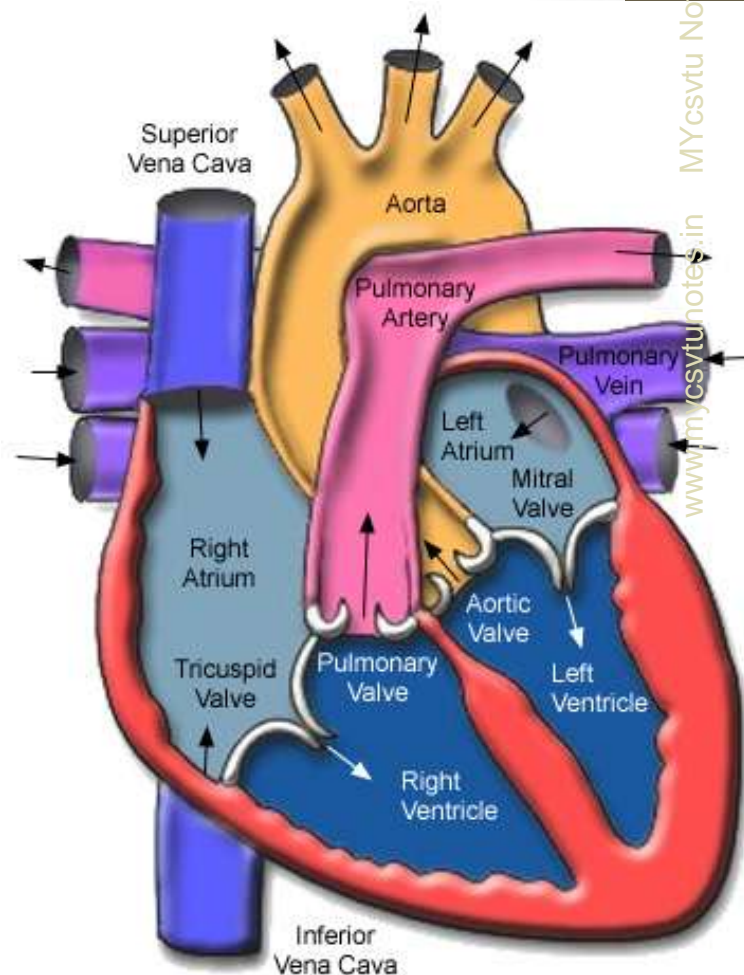
Blood (rich with oxygen) flows from the lung into the left atrium and then to the left ventricle. The left ventricle pump the blood to the rest of the body.

Diastole: is the resting or filling phase (atria chamber) of the heart cycle.

Systole: is the contractile or pumping phase (ventricle chamber) of the heart cycle.

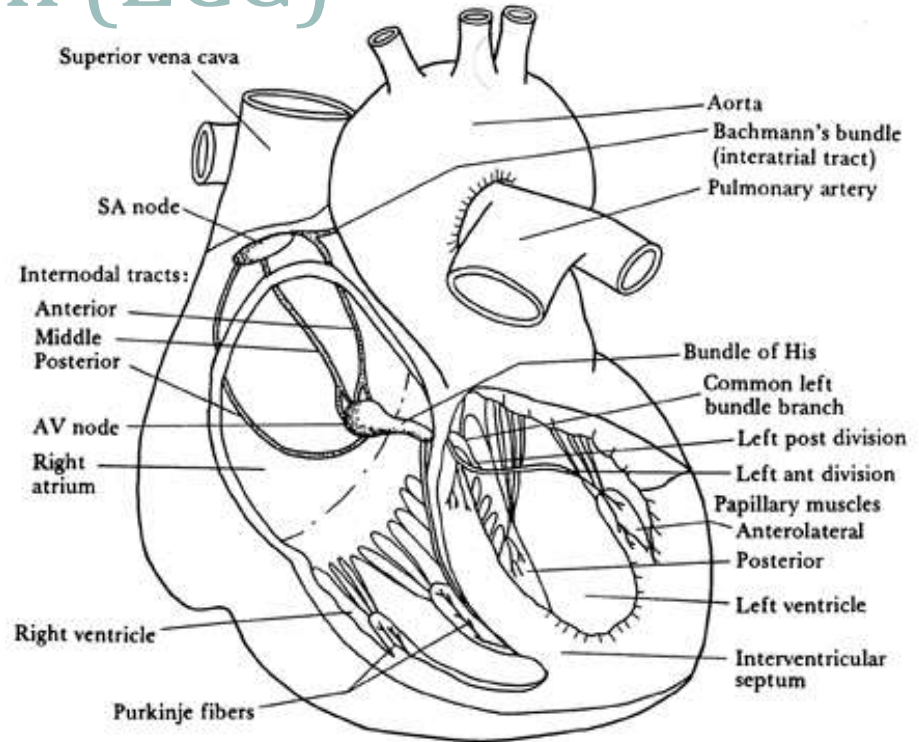
The electrical events is intrinsic to the heart itself. See website below for the animation of the heart.

<http://www.bostonscientific.com/templatedata/imports/HTML/CRM/heart/index.html>



Electrocardiogram (ECG)

Distribution of specialized conductive tissues in the atria and ventricles, showing the impulse-forming and conduction system of the heart. The rhythmic cardiac impulse originates in pacemaking cells in the sinoatrial (SA) node, located at the junction of the superior vena cava and the right atrium. Note the three specialized pathways (anterior, middle, and posterior internodal tracts) between the SA and atrioventricular (AV) nodes.



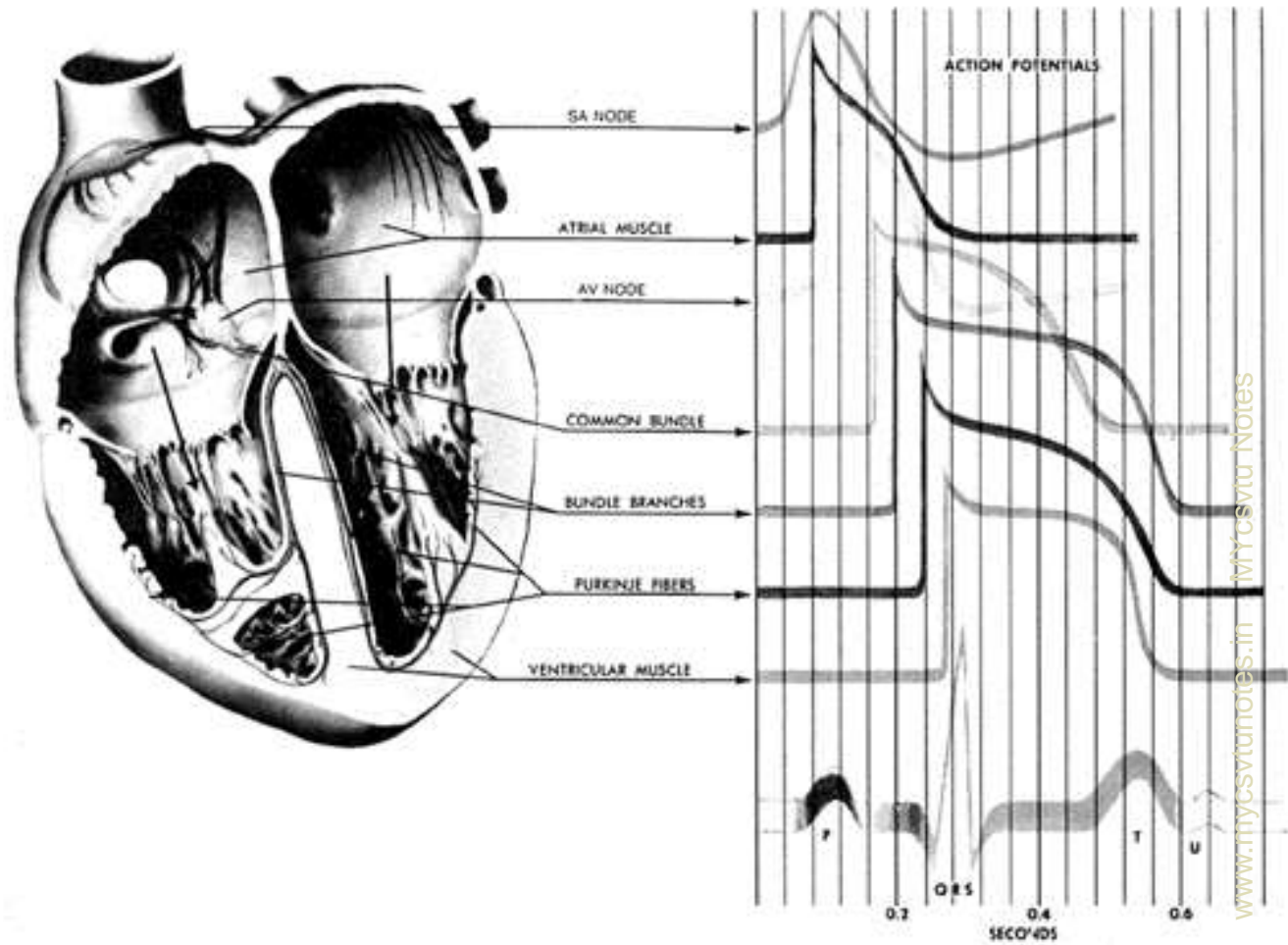
Bachmann's bundle (interatrial tract) comes off the anterior internodal tract leading to the left atrium. The impulse passes from the SA node in an organized manner through specialized conducting tracts in the atria to activate first the right and then the left atrium. Passage of the impulse is delayed at the AV node before it continues into the bundle of His, the right bundle branch, the common left bundle branch, the anterior and posterior divisions of the left bundle branch, and the Purkinje network. The right bundle branch runs along the right side of the interventricular septum to the apex of the right ventricle before it gives off significant branches. The left common bundle crosses to the left side of the septum and splits into the anterior division (which is thin and long and goes under the aortic valve in the outflow tract to the anterolateral papillary muscle) and the posterior division (which is wide and short and goes to the posterior papillary muscle lying in the inflow tract).

SA node activates first the right and then the left atrium.

AV node delays a signal coming from the SA node before it distribute it to the Bundle of His.

Bundle of His and Purkinie fibers activate the right and left ventricles

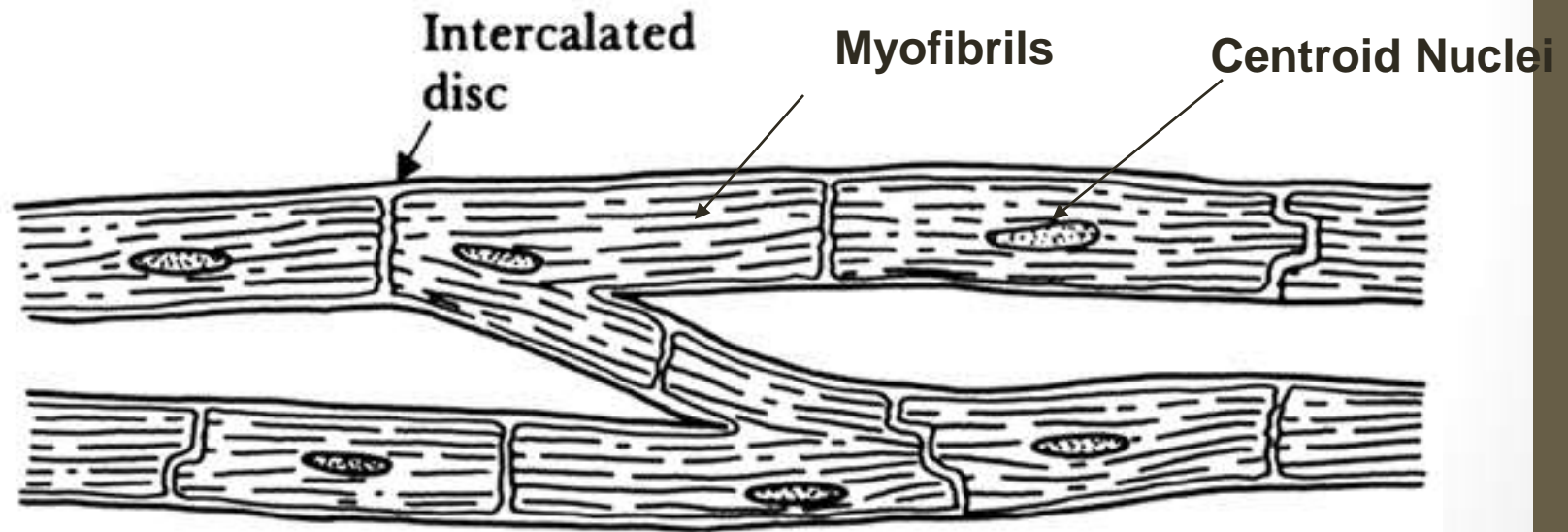
A typical QRS amplitude is 1-3 mV



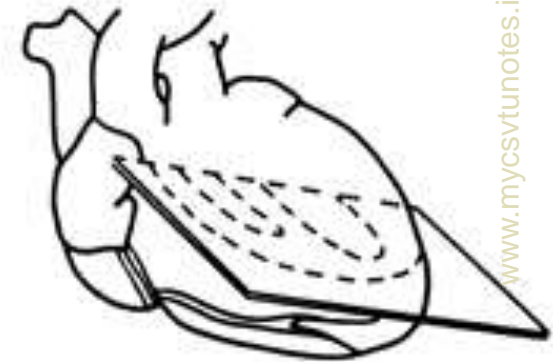
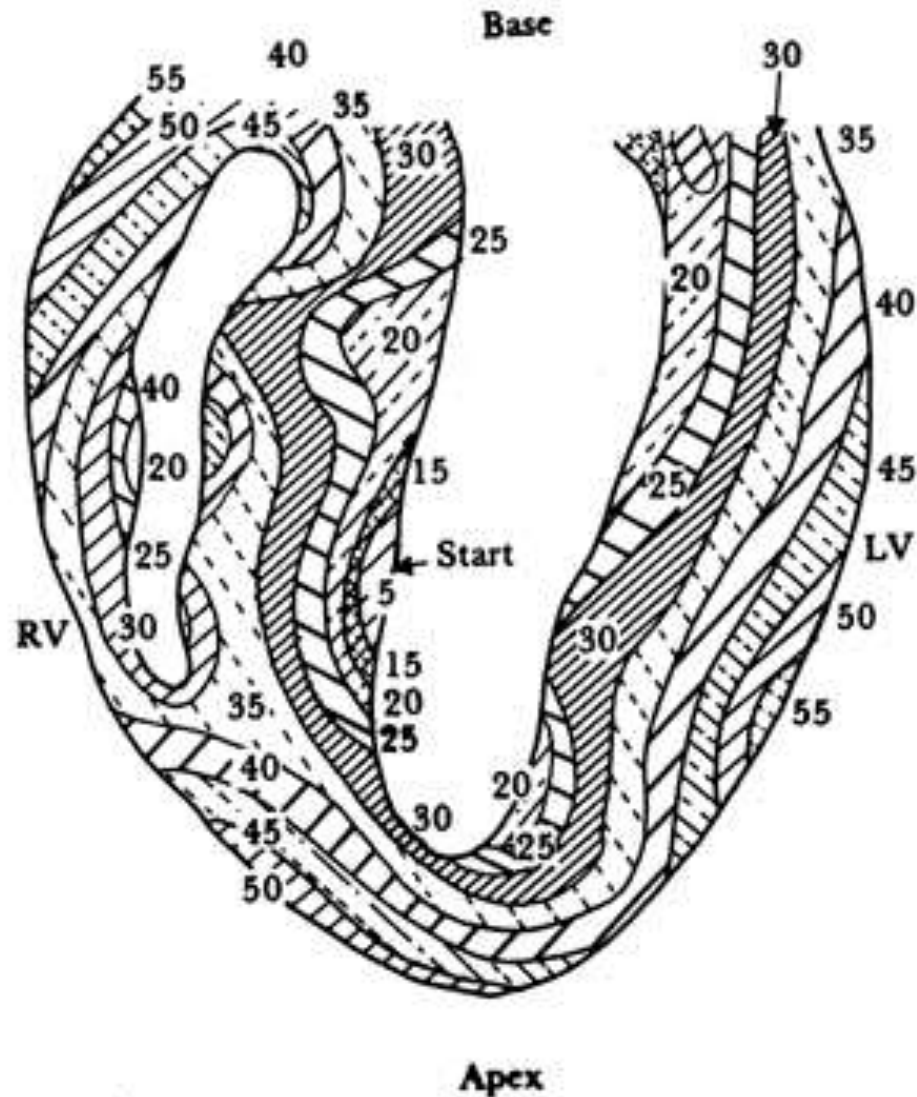
The **P-wave** shows the heart's upper chambers (atria) contracting (depol.)
The **QRS complex** shows the heart's lower chambers (ventricles) contracting
The **T-wave** shows the heart's lower chambers (ventricles) relaxing (repol.)
The **U-wave** believed to be due repolarization of ventricular papillary muscles.
P-R interval is caused by delay in the AV node
S-T segment is related to the average duration of the plateau regions of the individual ventricular cells.

Steps of action potential of the ventricular cell

- Prior to excitation the resting potential is -90 mV
- Rapid Depolarization at a rate 150 V/s
- Initial rapid repolarization that leads to a fixed depolarization level for 200 to 300 msec
- Final repolarization phase that restore membrane potential to the resting level for the remainder of the cardiac cycle



The cellular architecture of myocardial fibers.



Isochronous lines of ventricular activation of the human heart Note the nearly closed activation surface at 30 ms into the QRS complex.

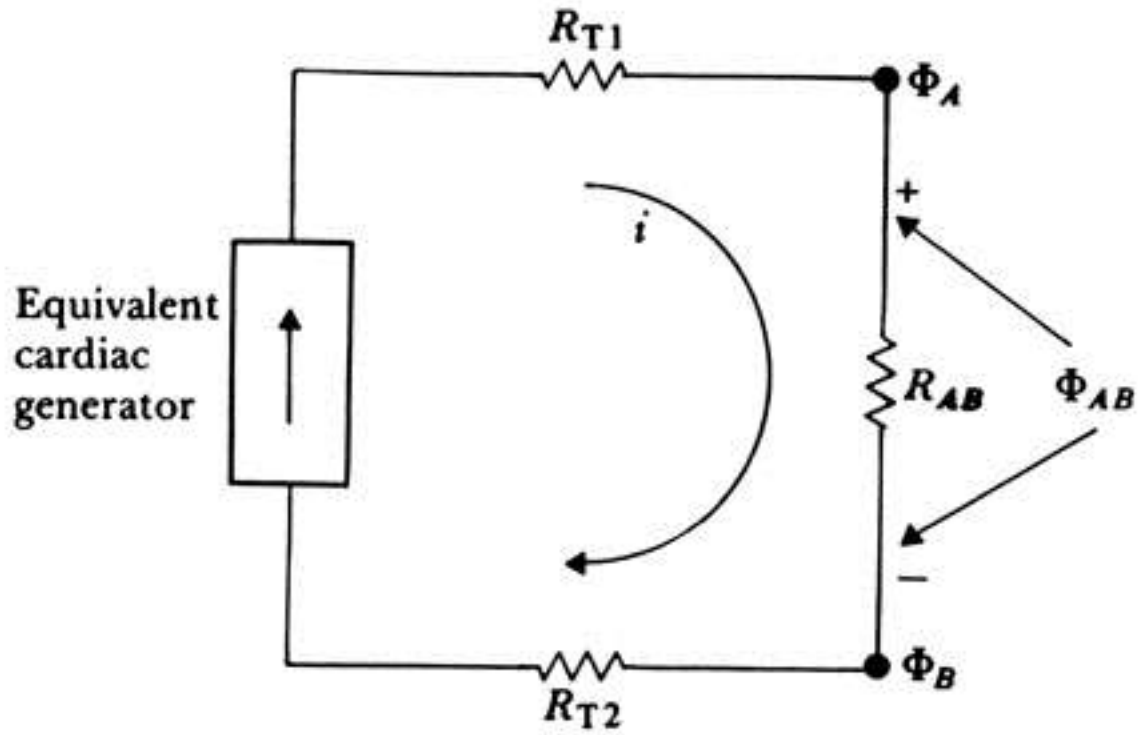
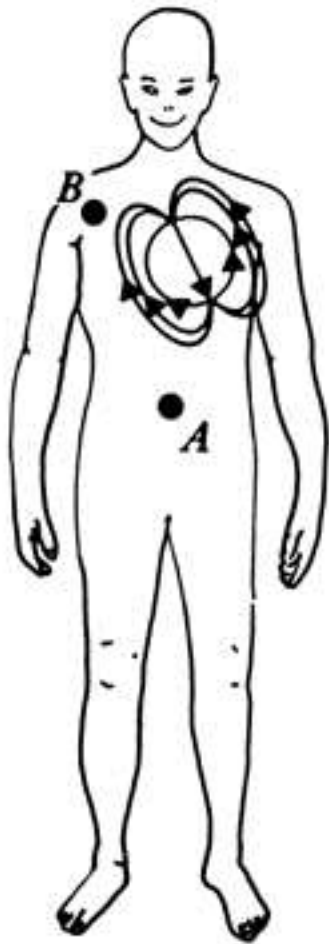
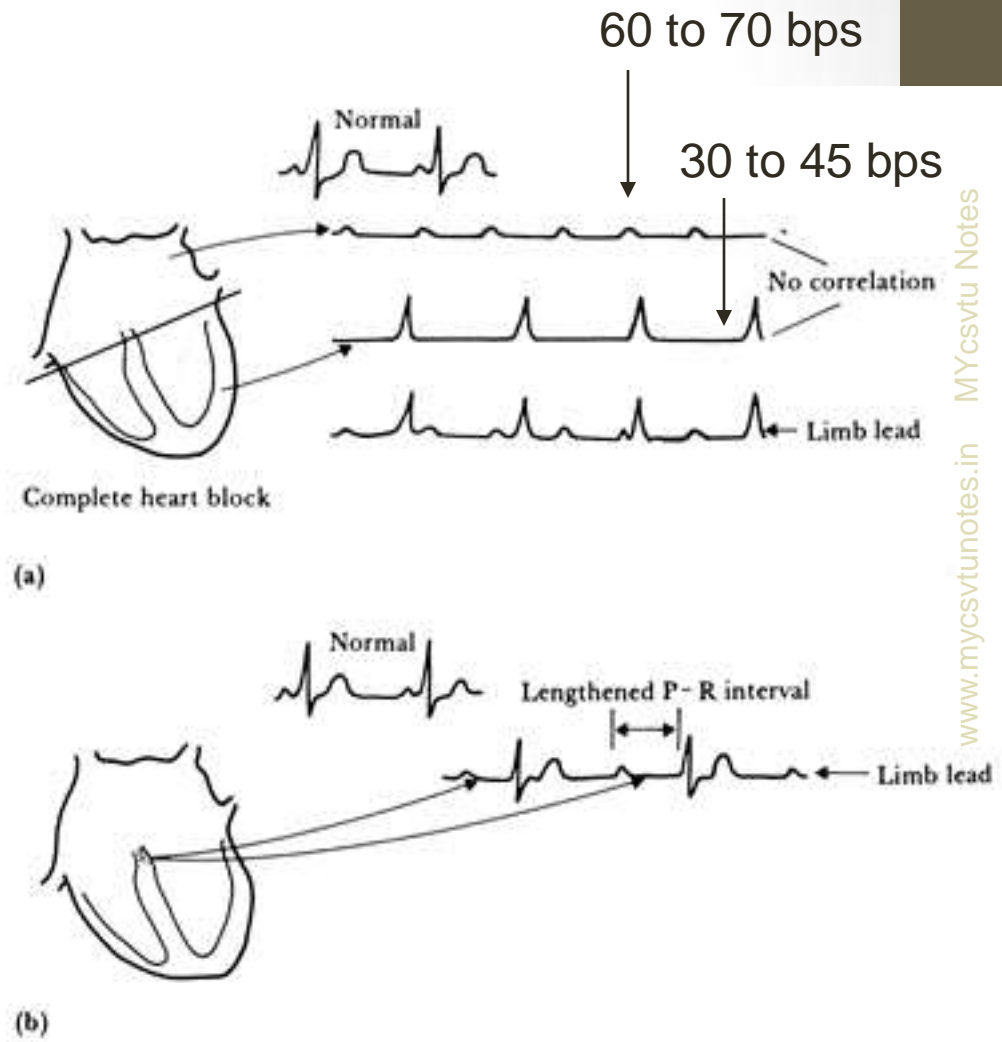


Figure 4.16 The electrocardiography problem Points A and B are arbitrary observation points on the torso, R_{AB} is the resistance between them, and R_{T1} , R_{T2} are lumped thoracic medium resistances. The bipolar ECG scalar lead voltage is $\phi_A - \phi_B$, where these voltages are both measured with respect to an indifferent reference potential.

Heart Block (dysfunctional His Bundle)

Figure 4.17 Atrioventricular block (a) Complete heart block. Cells in the AV node are dead and activity cannot pass from atria to ventricles. Atria and ventricles beat independently, ventricles being driven by an ectopic (other-than-normal) pacemaker. (B) AV block wherein the node is diseased (examples include rheumatic heart disease and viral infections of the heart). Although each wave from the atria reaches the ventricles, the AV nodal delay is greatly increased. This is first-degree heart block.



- When one branch of the bundle of His is interrupted, then the QRS complexes are prolonged while the heart rate is normal.

Arrhythmias

A portion of the myocardium sometimes becomes “irritable” and discharge independently.

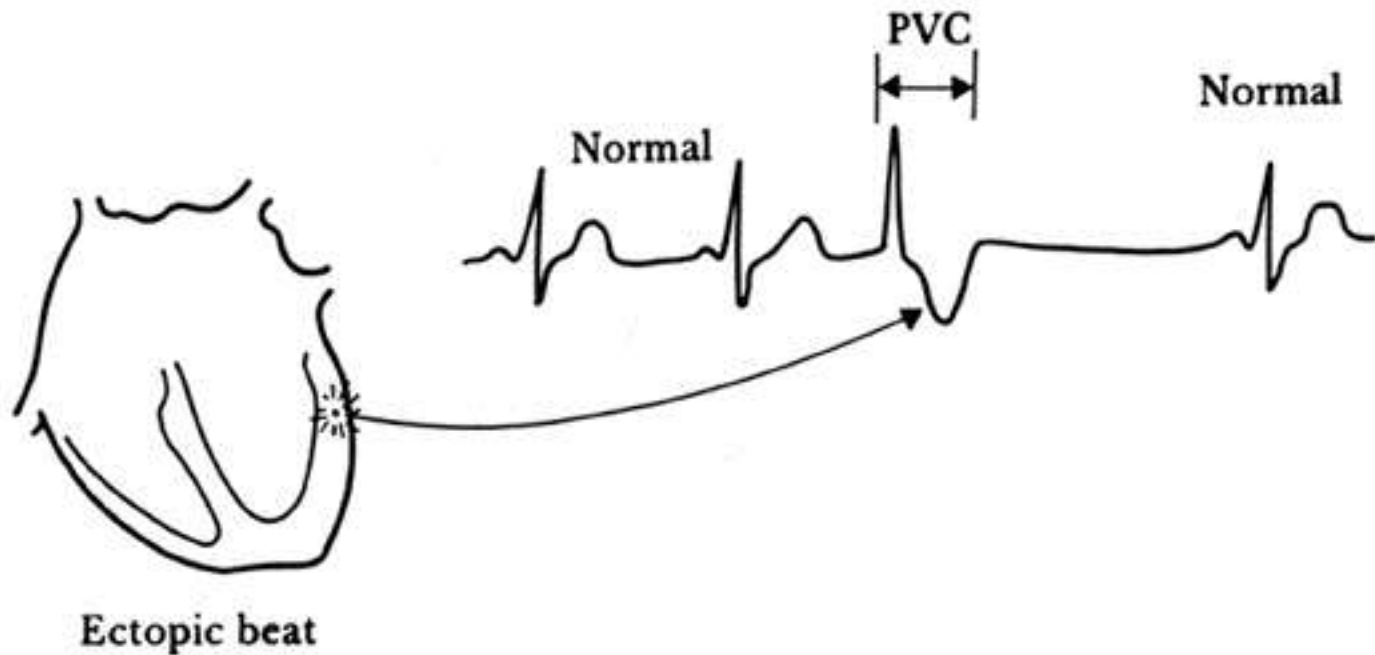
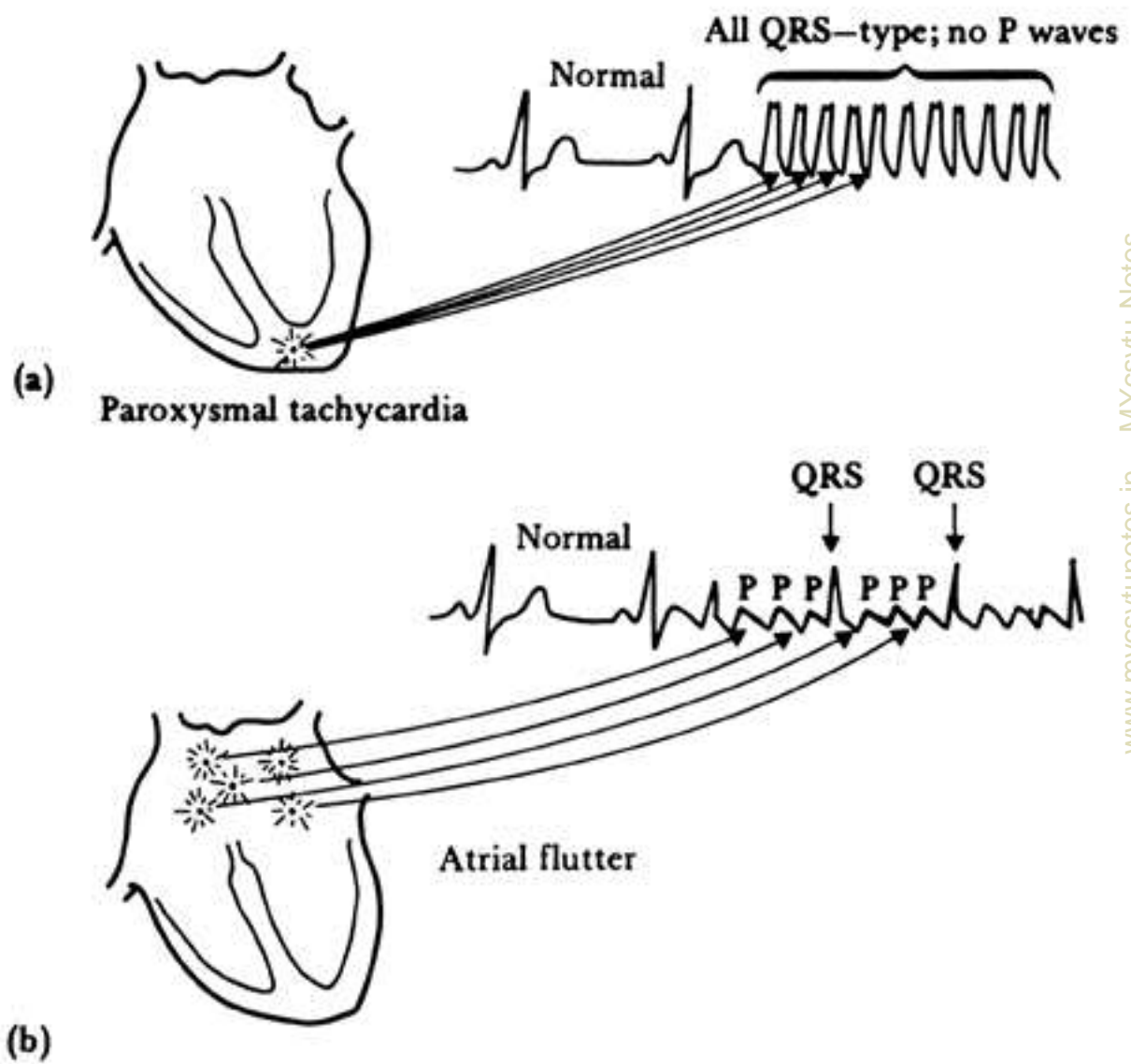


Figure 4.18 Normal ECG followed by an ectopic beat An irritable focus or *ectopic pacemaker*, within the ventricle or specialized conduction system may discharge, producing an extra beat, or *extrasystole*, that interrupts the normal rhythm. This extrasystole is also referred to as a premature ventricular contraction (PVC).

Figure 4.19 (a) Paroxysmal tachycardia. An ectopic focus may repetitively discharge at a rapid regular rate for minutes, hours, or even days. (B) Atrial flutter. The atria begin a very rapid, perfectly regular "flapping" movement, beating at rates of 200 to 300 beats/min.



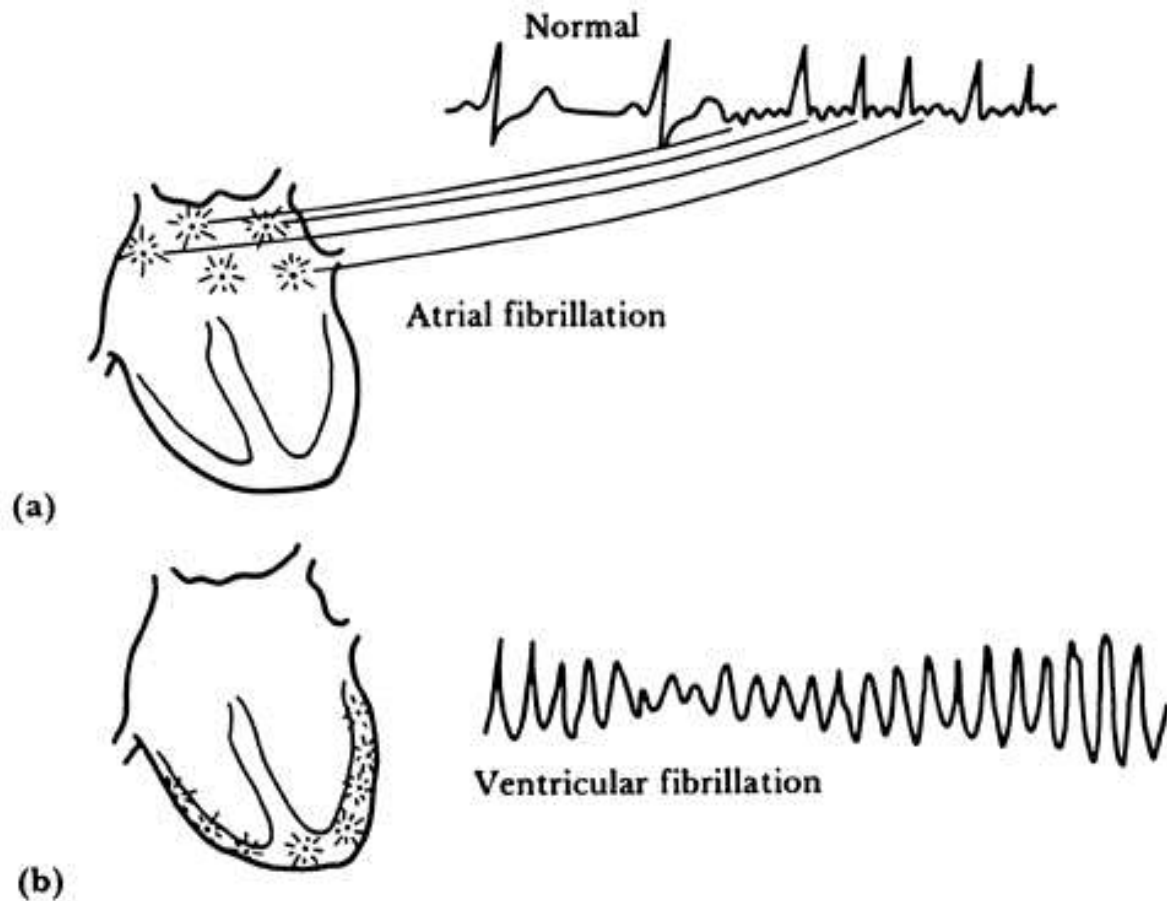


Figure 4.20 (a) Atrial fibrillation. The atria stop their regular beat and begin a feeble, uncoordinated twitching. Concomitantly, low-amplitude, irregular waves appear in the ECG, as shown. This type of recording can be clearly distinguished from the very regular ECG waveform containing atrial flutter. (b) Ventricular fibrillation. Mechanically the ventricles twitch in a feeble, uncoordinated fashion with no blood being pumped from the heart. The ECG is likewise very uncoordinated, as shown

Alteration of Potential Waveforms in Ischemia

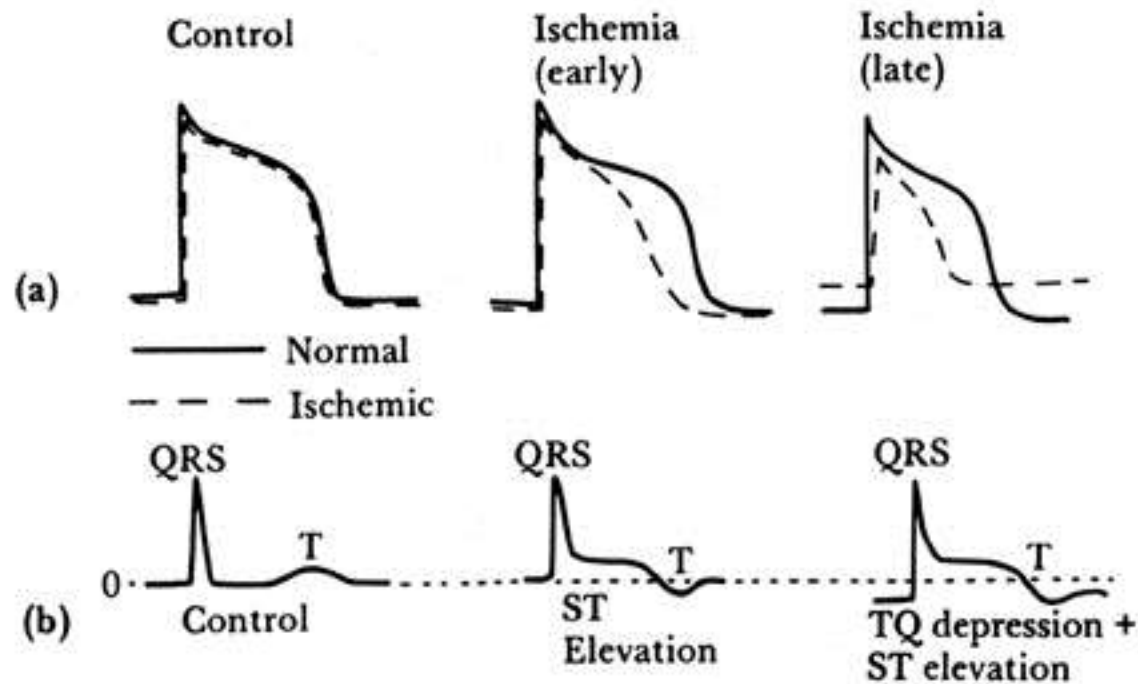


Figure 4.21 (a) Action potentials recorded from normal (solid lines) and ischemic (dashed lines) myocardium in a dog. Control is before coronary occlusion. (b) During the control period prior to coronary occlusion, there is no ECG S-T segment shift; after ischemia, there is such a shift.

Electroencephalogram (EEG)

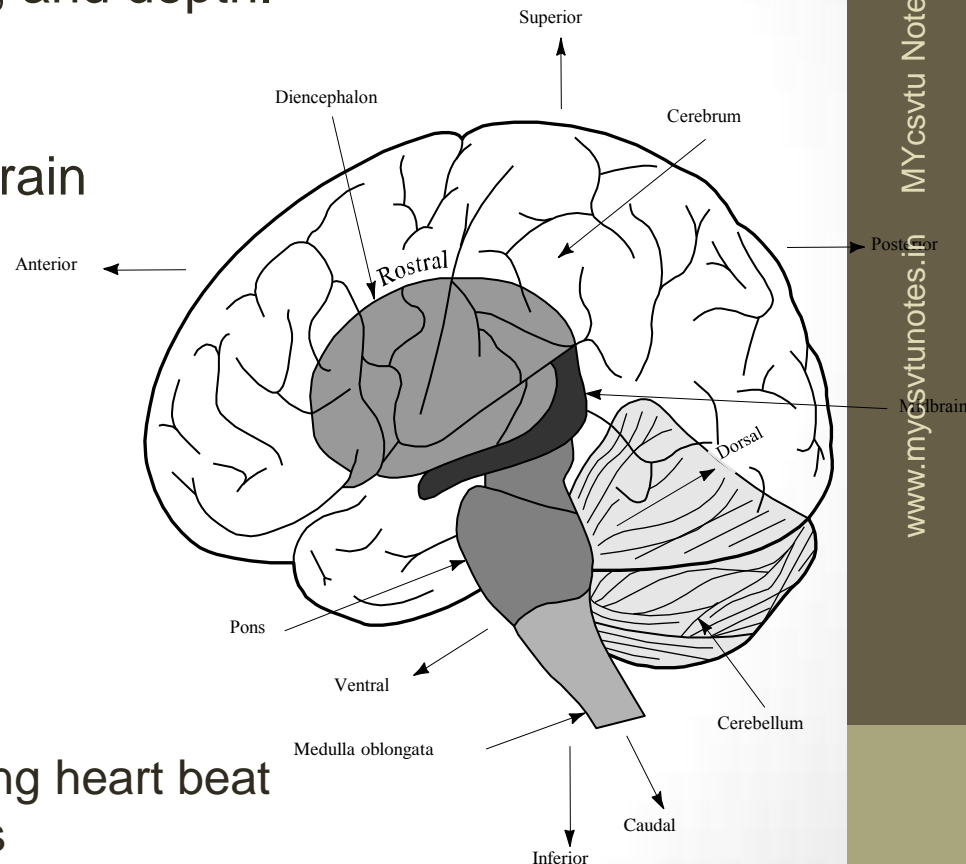
EEG is a superposition of the volume-conductor fields produced by a variety of active neuronal current generators. The three type of electrodes to make the measurements are scalp, cortical, and depth.

Topics in this section

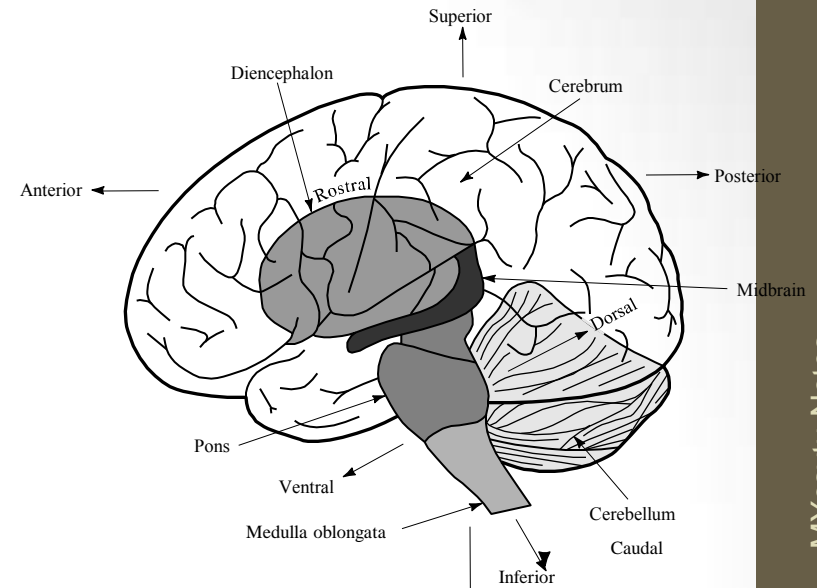
- Gross anatomy and function of the brain
- Ultrastructure of the cerebral cortex
- The potential fields of single neuron
- Typical clinical EEG waveform
- Abnormal EEG waveform

The three main parts of the brain:

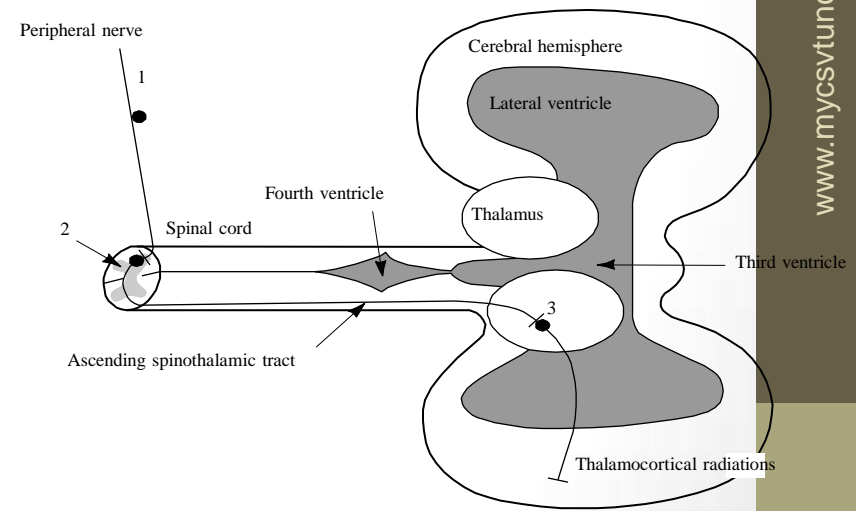
- Cerebrum
 - Conscious functions
- Brainstem
 - primitive functions such as controlling heart beat
 - Integration center for motor reflexes
 - Thalamus is integration center for sensory system
- Cerebellum (balance and voluntary muscle movement)



Anatomical relationship of brainstem structures (medulla oblongata, pons, midbrain, and diencephalons) to the cerebrum and cerebellum. General anatomic directions of orientation in the nervous system are superimposed on the diagram. Here the terms rostral (toward head), caudal (toward tail), dorsal (back), and ventral (front) are associated with the brainstem; remaining terms are associated with the cerebrum. The terms medial and lateral imply nearness and remoteness respectively, to or from the central midline axis of the brain. (b) A simplified diagram of the CNS showing a typical general sense pathway from the periphery (neuron 1) to the brain (neuron 3). Note that the axon of the secondary neuron (2) in the pathway decussates (crosses) to the opposite side of the cord.

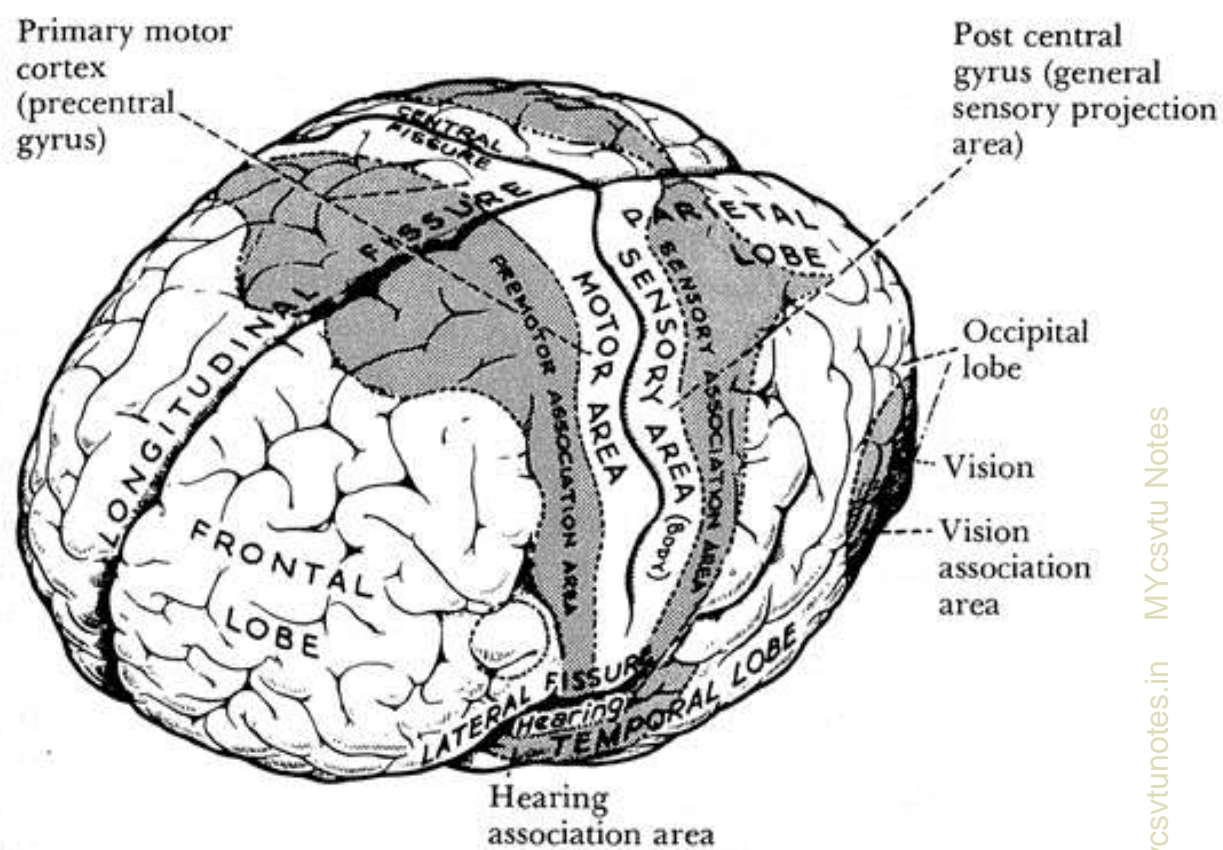


(a)



(b)

The cerebrum, showing the four lobes (frontal, parietal, temporal, and occipital), the lateral and longitudinal fissures, and the central sulcus.

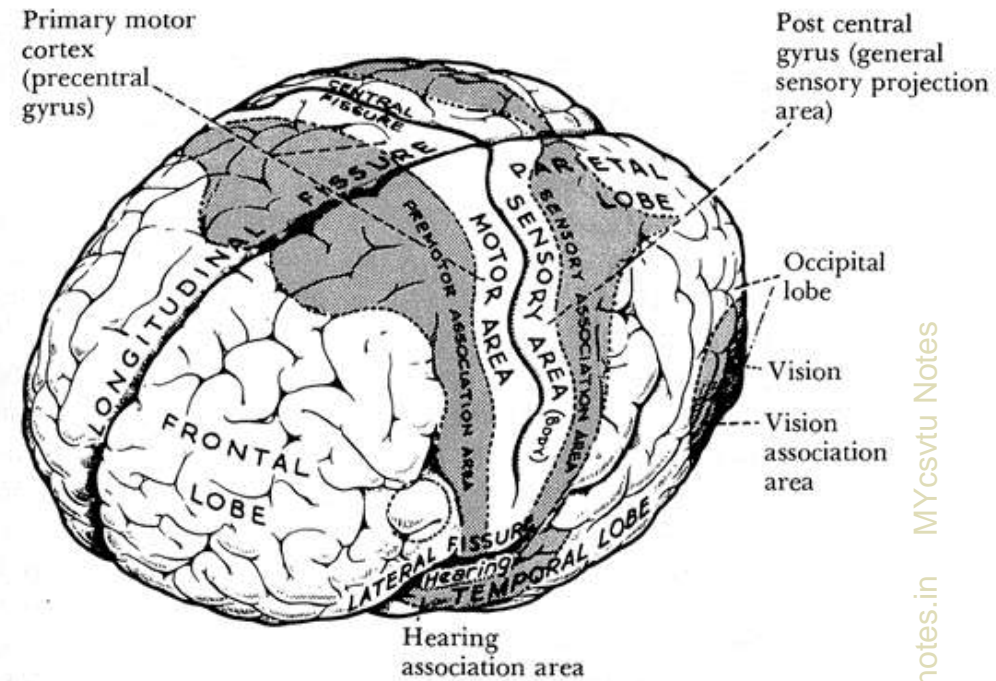


The cortex receives sensory information from skin, eyes, ears, and other receptors. This information is compared with previous experience and produces movements in response to these stimuli.

SER: somatosensory evoked response

AER: auditory evoked response

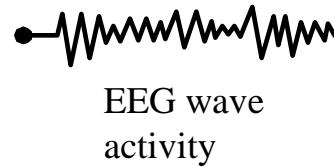
VER: visual evoked response



The outer layer (1.5 – 4.0 mm) of the cerebrum is called cerebral cortex and consist of a dense collection of nerve cells that appear gray in color (gray matter).

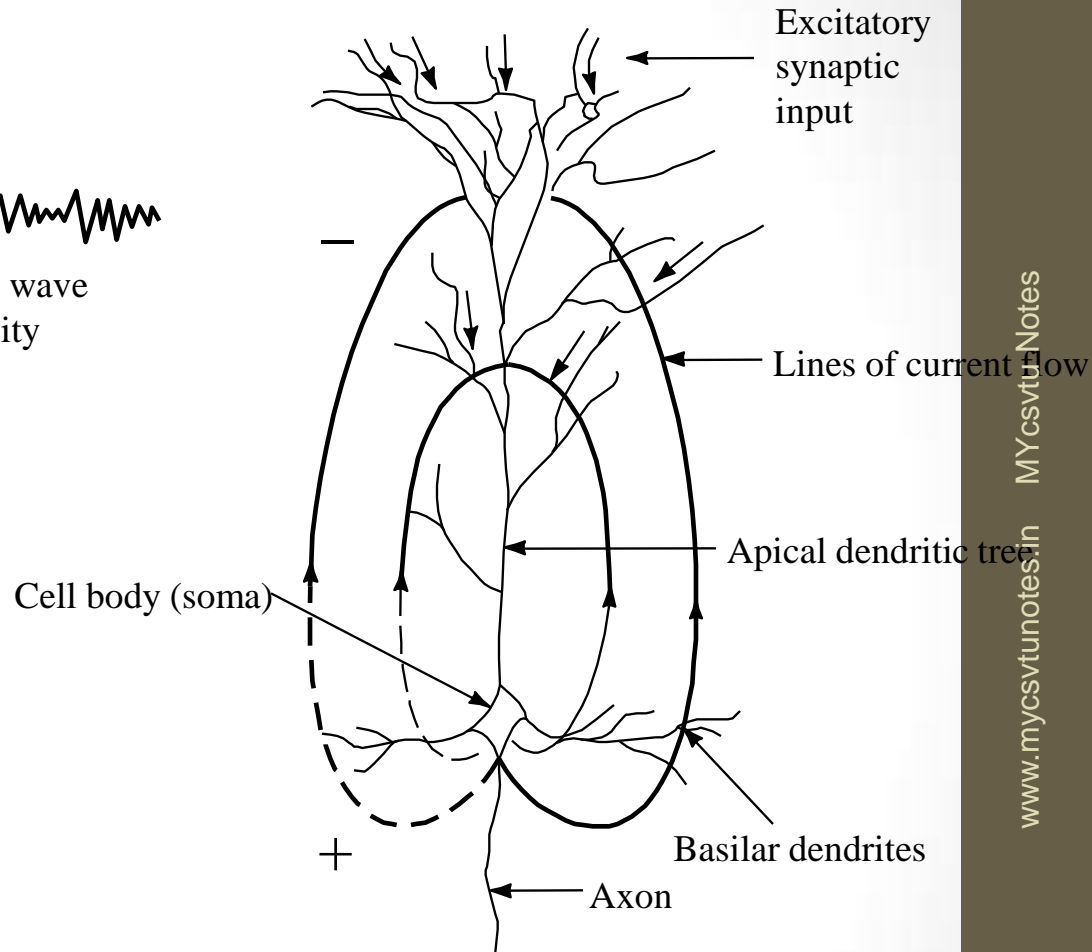
The deeper layer consists of axons (or white matter) and collection of cell body.

Neuron Cell in the Cortex



Two type of cells in the cortex

- Pyramidal cell
- Nonpyramidal cell
 - small cell body
 - Dendrites spring in all direction
 - Axons most of the times don't leave the cortex



Electrogenesis of cortical field potentials for a net excitatory input to the apical dendritic tree of a typical pyramidal cell. For the case of a net inhibitory input, polarity is reversed and the apical region becomes a source (+). Current flow to and from active fluctuating synaptic knobs on the dendrites produces wave-like activity.

Bioelectric Potential From the Brain

Conducted action potentials in axons contribute little to surface cortical records, because they usually occur asynchronously in time and at different spatial directions.

Pyramid cells of the cerebral cortex are oriented vertically, with their long apical dendrites running parallel to one another. So, the surface records obtained signal principally the net effect of local postsynaptic potentials of cortical cells.

Nonpyramidal cells in the neocortex are unlikely to contribute substantially to surface records because their dendritic trees are radially arranged around their cells, so the current sum to zero when viewed by electrode at a distance.

When the sum of dendritic activity is negative relative to the cell, the cell is depolarized and quite excitable. When it is positive, the cell is hyperpolarized and less excitable.

Bioelectric Potential From the Brain

Wave group of the normal cortex

-Alpha wave

- 8 to 13 Hz, 20-200 μ V,
- Recorded mainly at the occipital region
- disappear when subject is sleep, change when subject change focus, see Fig. 4.27b

-Beta wave (I and II)

- 14 to 30Hz,
- during mental activity $f=50$ Hz, beta I disappear during brain activity while beta II intensified.
- Recorded mainly at the parietal and frontal regions

-Theta wave

- 4 to 7 Hz, appear during emotional stress such as disappointment and frustration
- Recorded at the parietal and temporal regions

Bioelectric Potential From the Brain

-Delta wave

-Below 3.5 Hz, occur in deep sleep, occur independent of activity

- Occur solely within the cortex, independent of activities in lower regions of the brain.

-Synchronization is the underline process that bring a group of neurons into unified action. Synaptic interconnection and extracellular field interaction cause Synchronization.

- Although various regions of the cortex capable of exhibiting rhythmic activity they require trigger inputs to excite rhythmicity. The **reticular activation system** (RAS) provide this pacemaker function.

EEG Waves

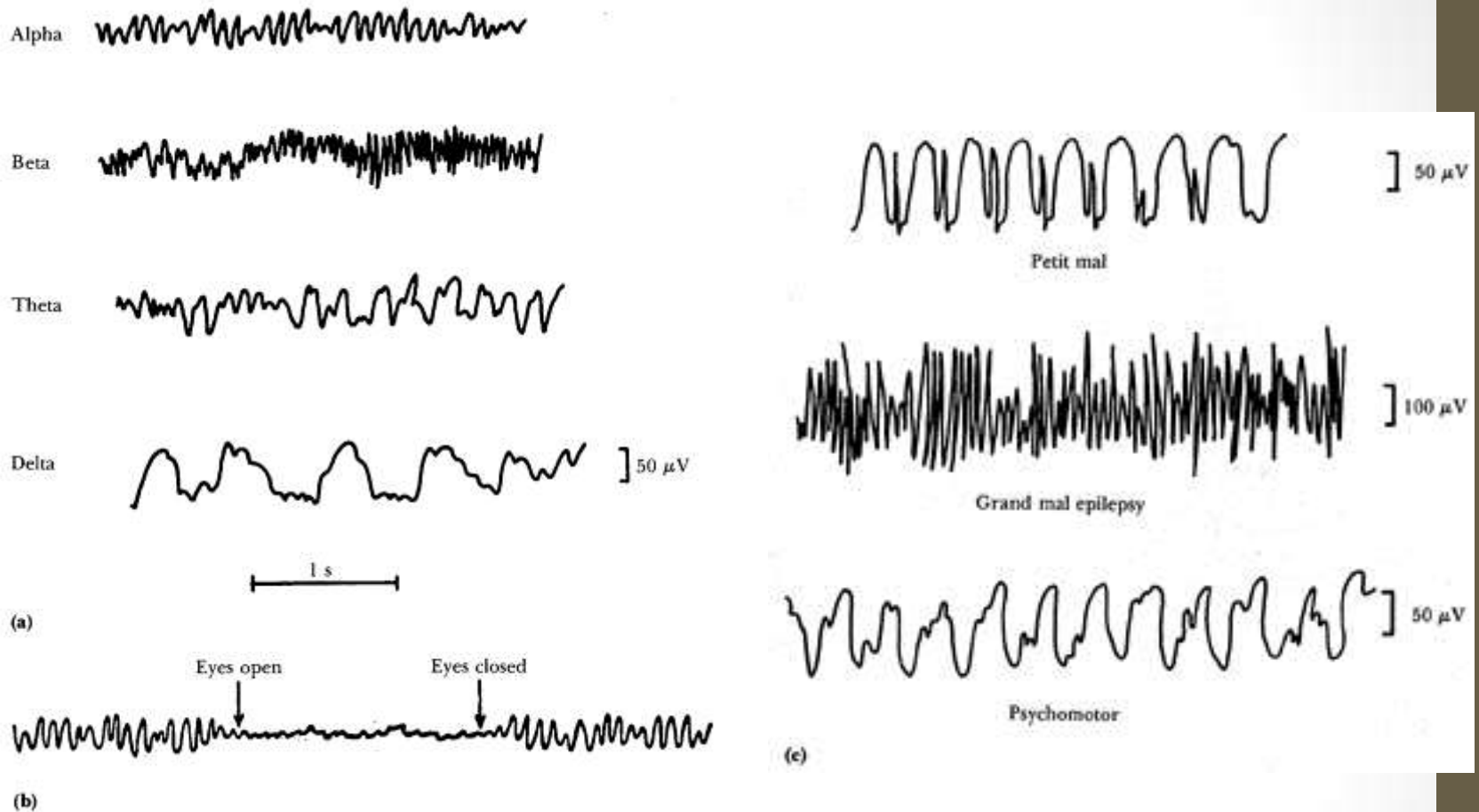
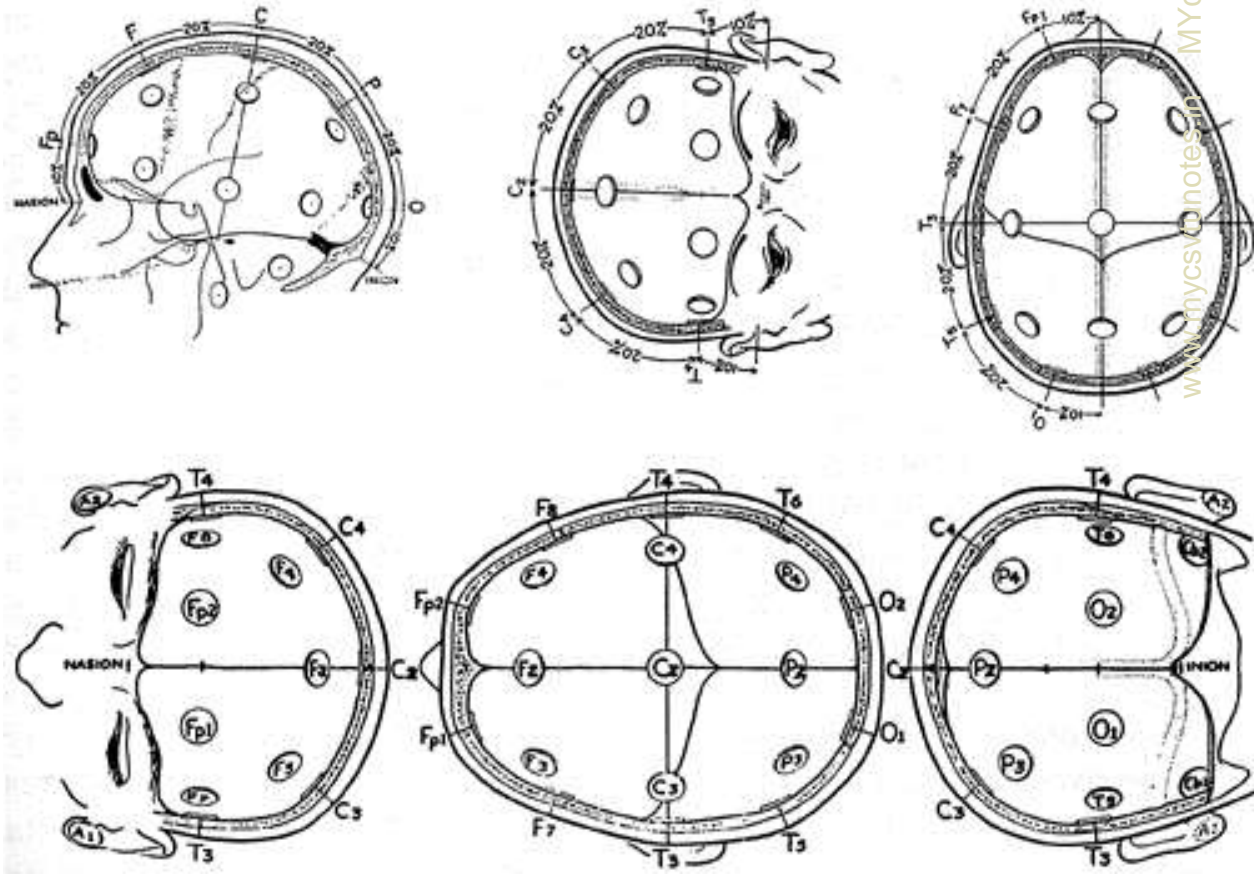


Fig 4.27 (a) Different types of normal EEG waves. (b) Replacement of alpha rhythm by an asynchronous discharge when patient opens eyes. (c) Representative abnormal EEG waveforms in different types of epilepsy.

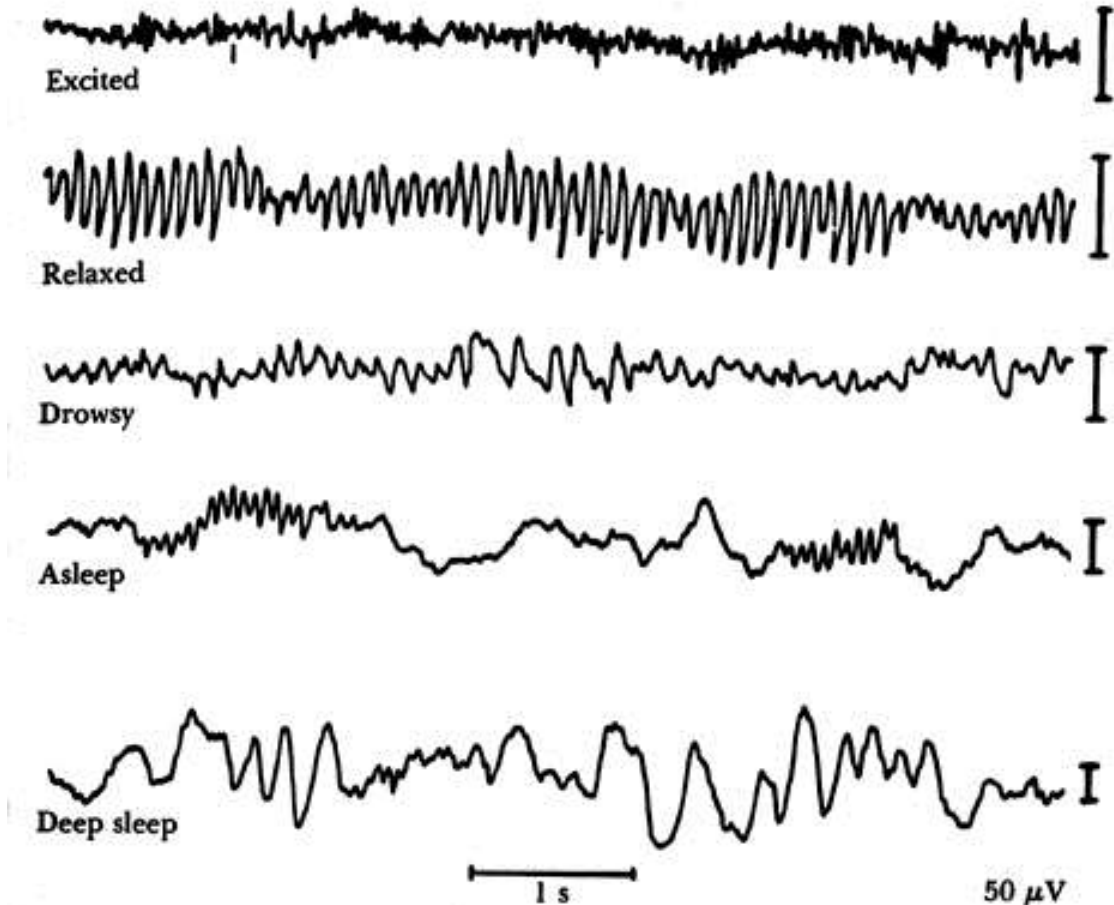
International Federation 10-20 System

Type of electrode connections

- 1- Between each member of a pair (bipolar)
- 2- Between one monopolar lead and a distant reference
- 3- Between one monopolar lead and the average of all.



EEG Waves During Sleep



The electroencephalographic changes that occur as a human subject goes to sleep. The calibration marks on the right represent 50 μ V.

The Abnormal EEG

EEG is used to diagnose different type of epilepsy and in the location of the focus in the brain causing the epilepsy.

Causes of epilepsy could be intrinsic hyperexcitability of the neurons that make up the reticular activation system (RAS) or abnormality of the local neural pathways of this system.

Two type of epilepsy

1- Generalized epilepsy

a- Grand mal

b- petit mal (myoclonic form and absence form)

2- Partial epilepsy

a- Jacksonian epilepsy

b- Psychomotor seizure

(amnesia, abnormal rage, sudden anxiety or fear, incoherent speech)



Petit mal

50 μ V



Grand mal epilepsy

100 μ V



Psychomotor

50 μ V

(c)