BIO-MEDICAL INSTRUMENTATION

(TIC 701)

PRERARED BY
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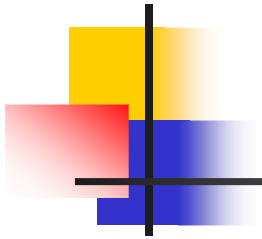
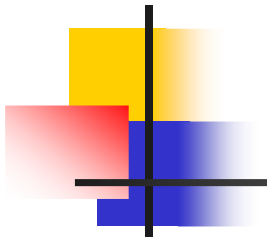
Lect….(H.C.S.T.Mathura)



BIO-MEDICAL INSTRUMENTATION

UNIT-I

INTRODUCTION



Bio-medical

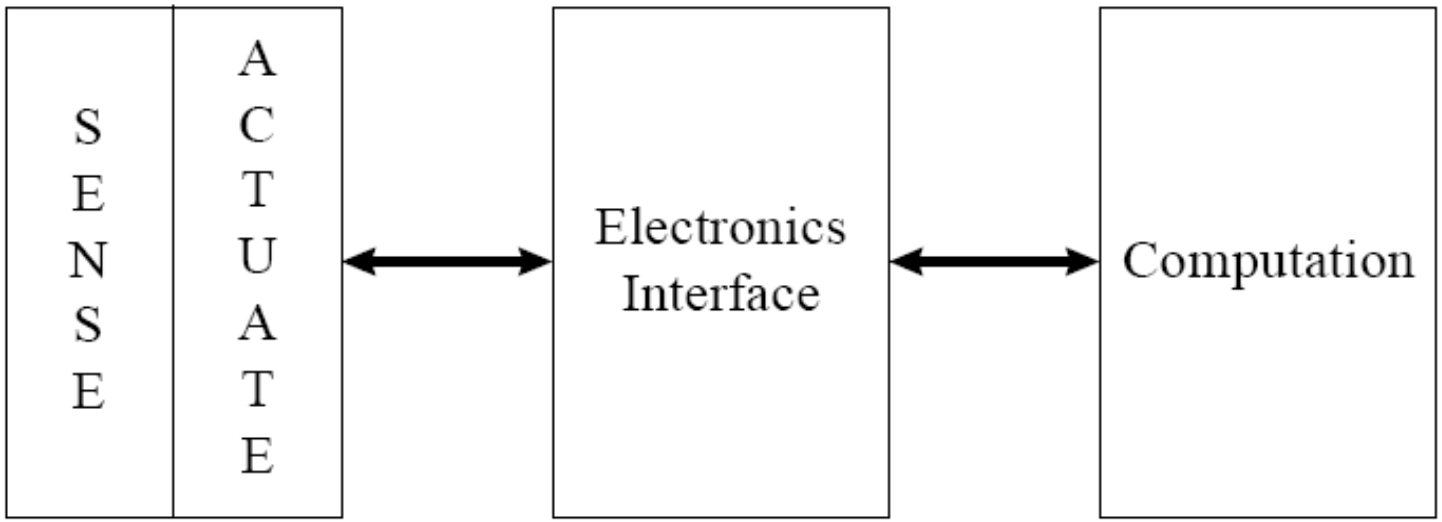
- Diagnosis and therapy depend heavily on the use of medical instrumentation.
- Medical procedures:

  Medicine can be defined as a multistep procedure on an individual by a physician, group of physician, or an institute, repeated until the symptoms disappear

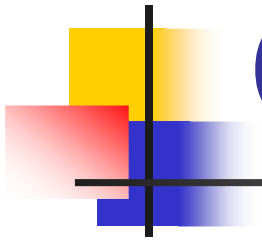
The Importance of Bio-medical Instrumentation

- Medical procedure
- 1) Collection of data - qualitative and/or quantitative
- 2) Analysis of data
- 3) Decision making
- 4) Treatment planning based on the decision

Biomedical Instrumentation System



- All biomedical instruments must interface with biological materials. That interface can by direct contact or by indirect contact



Questions

- What is the bio-medical science?
- What is Medical procedures ?
- Draw a block of Biomedical Instrumentation System?

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Digital Course Content
Check list by Topic

Dept/ Year / Semester	EI/ 2009/ VII	Content Creator	ANUJ BHARDWAJ
Subject Code	TIC-701	Subject Coordinator	
Subject Description	BIO-MEDICAL INSTRUMENTATION	Reviewer	
Content Format	Digital (Slides in PPT)		

Unit	I	Lecture - Topic	Bio-medical Instrumentation	Sub-Topic	Instrumentation System

Fill Up the Following Check List (Should be filled by the Content Creator)	Yes	No
Did you included the diagrams/references to diagrams related to this topic? (Including flow of Diagram)	√	
Did you explained the Problem Solving Approach for the Problems related to this topic ?	√	
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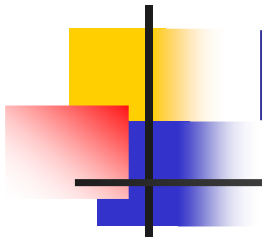


Reference Books

- Basic Concepts of Medical Instrumentation Medical Instrumentation: Application and Design Third Edition

  John G. Webster, Editor

  Cromwell- Biomedical Instrumentation and Measurements- PHI

Components Biomedical Instrumentation System

- A sensor

  Detect biochemical, bioelectrical, or biophysical parameters

  Provide a safe interface with biological materials

Components Biomedical Instrumentation System

- An actuator

  Deliver external agents via direct or indirect

  contact

  Control biochemical, bioelectrical, or

  biophysical parameters

  Provide a safe interface with biologic

  materials

Components Biomedical Instrumentation System

- The electronics interface
- Match electrical characteristics of the sensor/actuator with computation unit
- Preserve signal to noise ratio of sensor
- Preserve efficiency of actuator
- Preserve bandwidth (i.e., time response) of sensor/actuator
- Provide a safe interface with the sensor/actuator
- Provide a safe interface with the computation unit
- Provide secondary signal processing functions for the system

Components Biomedical Instrumentation System

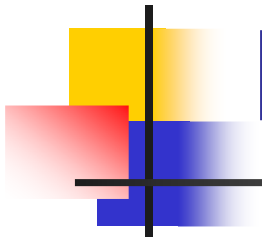
- The computation unit
- provide primary user interface
- provide primary control for the overall system
- provide data storage for the system
- provide primary signal processing functions for the system
- maintain safe operation of the overall system

Classifications of Biomedical Instruments

- The sensed quantity
- The principle of transduction
- The organ system for measurement
- The clinical medicine specialities

Classifications of Biomedical Instruments

- Based on the activities involved in the medical care, medical instrumentation may be divided into three categories:
- Diagnostic devices
- Therapeutic devices
- Monitoring devices



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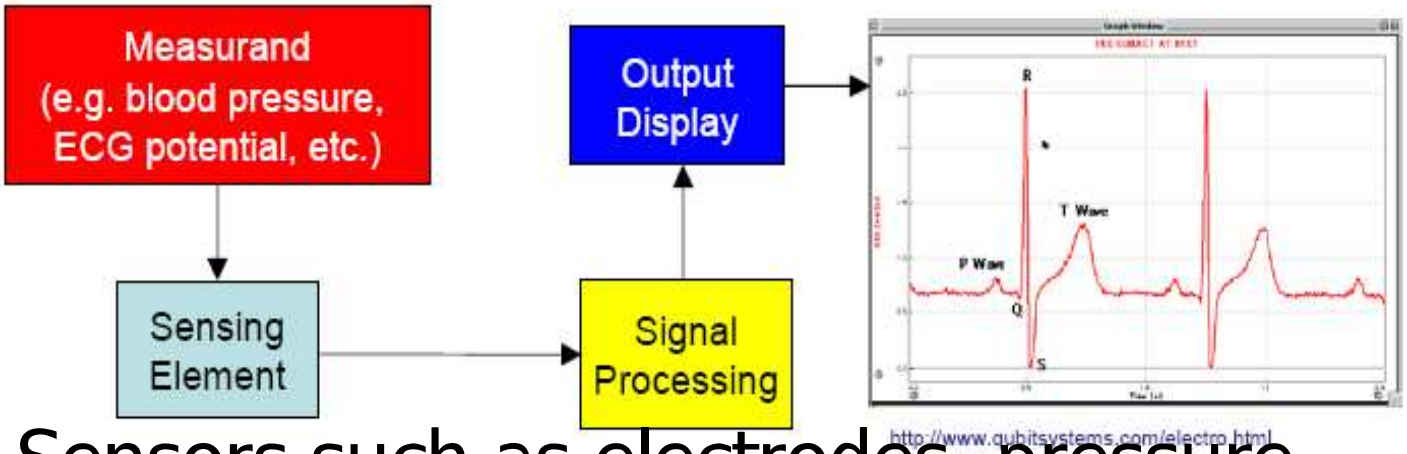
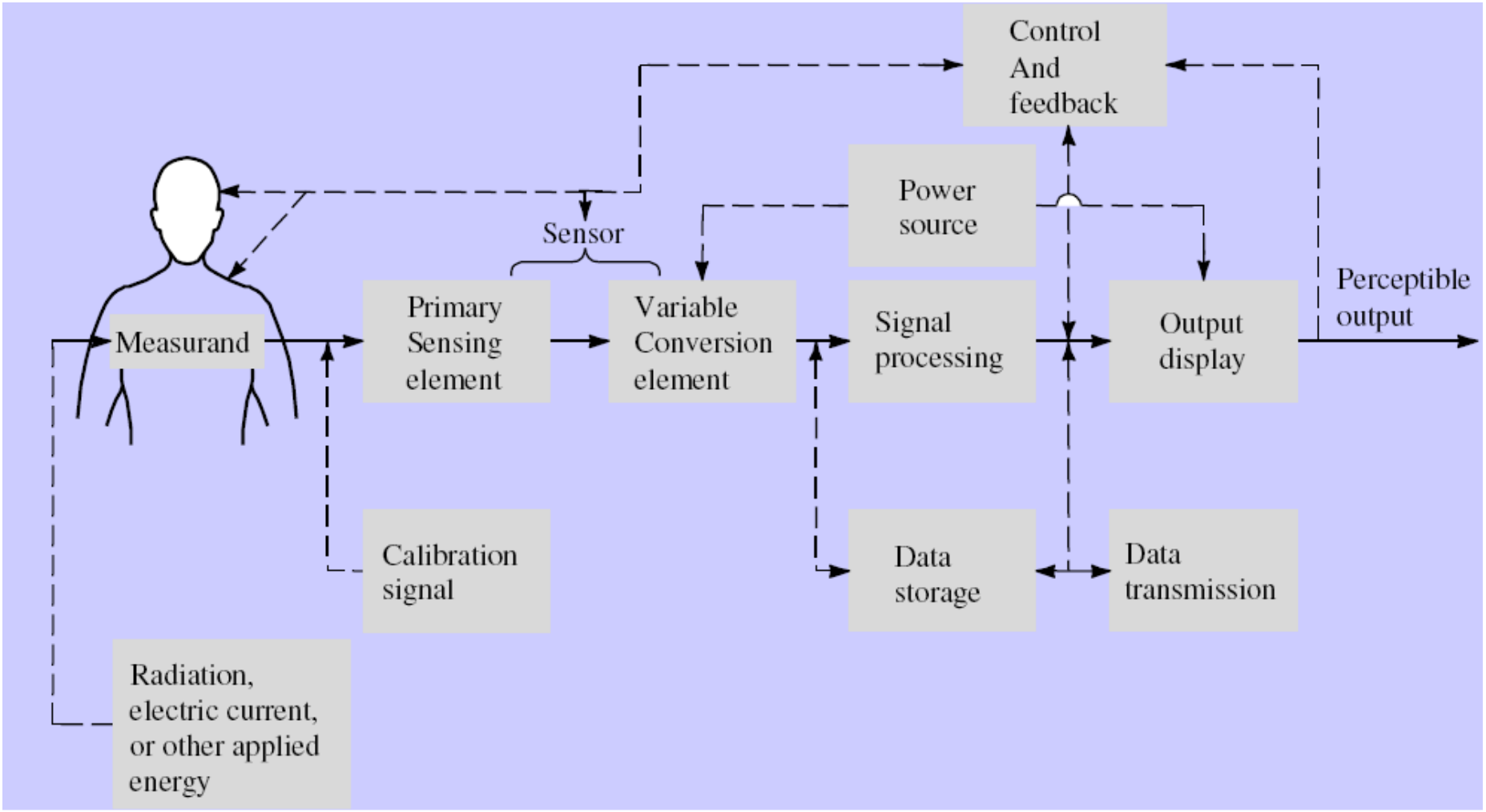
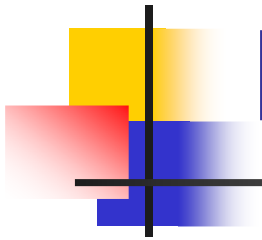
General Medical Instrumentation System



- Sensors such as electrodes, pressure transducer
- Instrumentation: amplifier, filter, signal conditioning
- Microprocessor, telemetry, Internet interface
- Case study (student project)

Man-Instrumentation system





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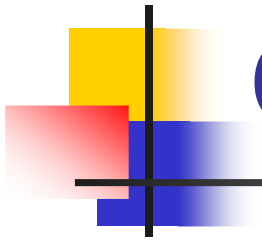
Pandey & Kumar-Biomedical Electronics and Instrumentation. – Kataria

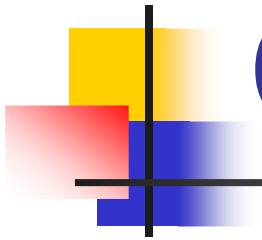


Man-Instrumentation system Components

- Measurand
- Sensor
- Signal conditioning
- Output display
- Auxiliary elements

Problems Encountered in Measuring a Living System

- Many crucial variables in living systems are inaccessible.
- Variables measured are seldom deterministic.
- Nearly all biomedical measurements depend on the energy.
- Operation of instruments in the medical environment imposes important additional constraints.



Questions

- What is the General Medical Instrumentation System?
- What is Man-Instrumentation system ?
- Draw a block of Man-Instrumentation system?
- What are the Classifications of Biomedical Instruments ?
- Explain Components Biomedical Instrumentation System?

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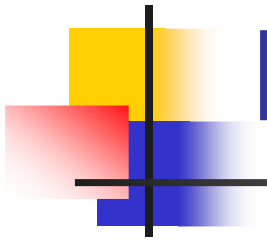

Reference

http://www.americanheart.org/presenter.jhtml;jsessionid=FSDQY0VWDWIEECQFCXPSCZQ?q=&identifier=10000015&submit.x=36&submit.y=11

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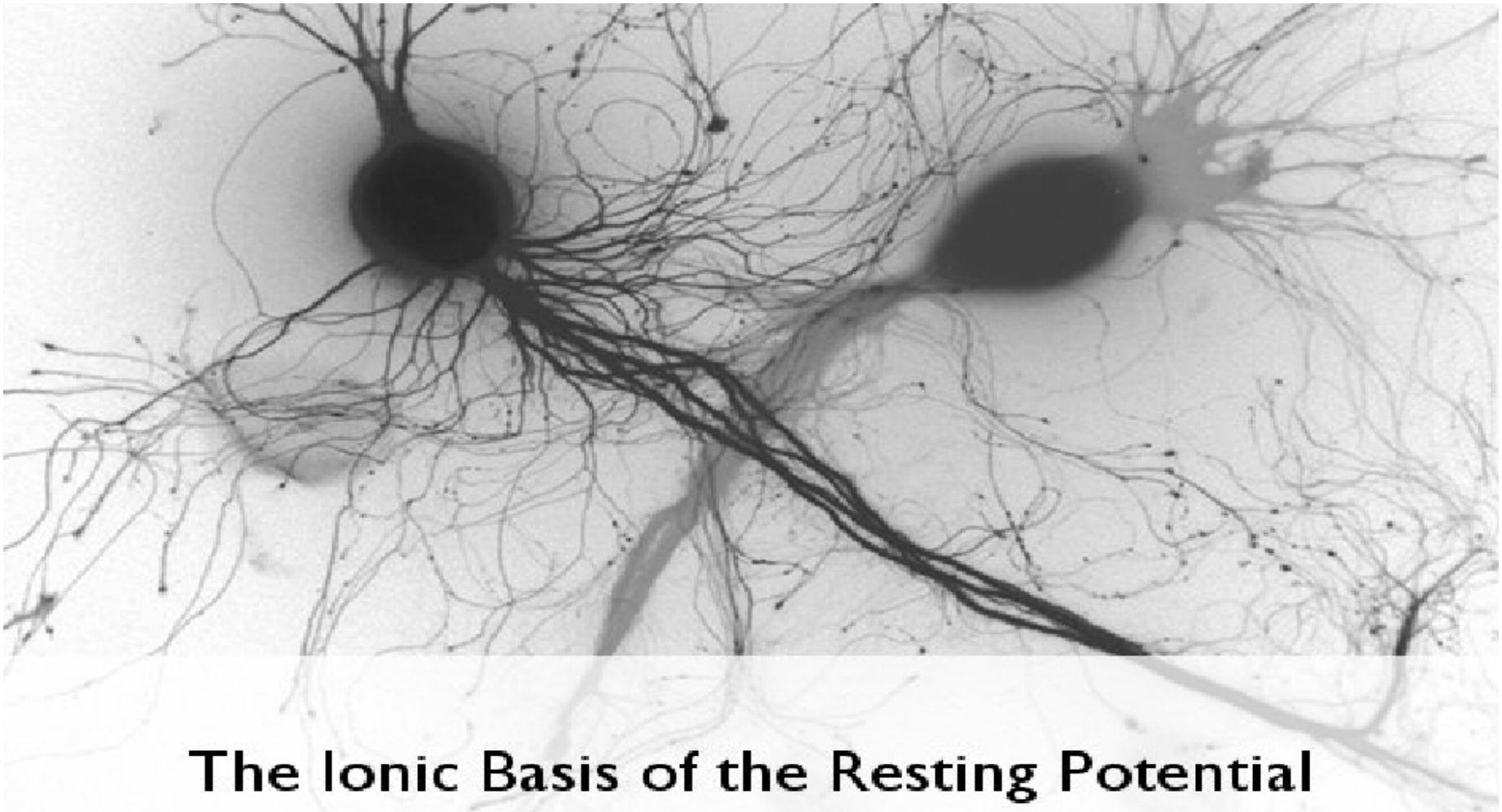
Bioelectric potentials



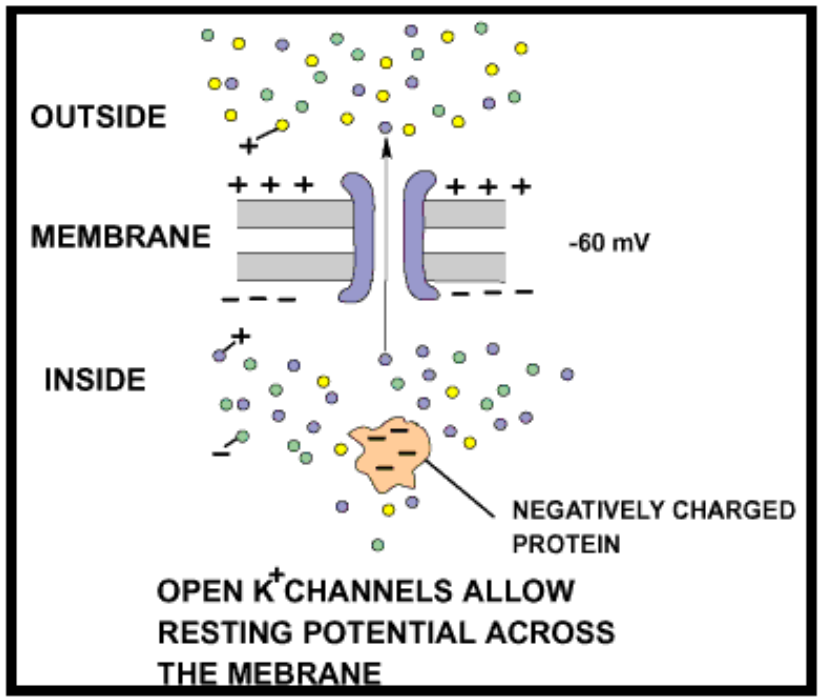
RESTING POTENTIAL

BASIC CONCEPT-

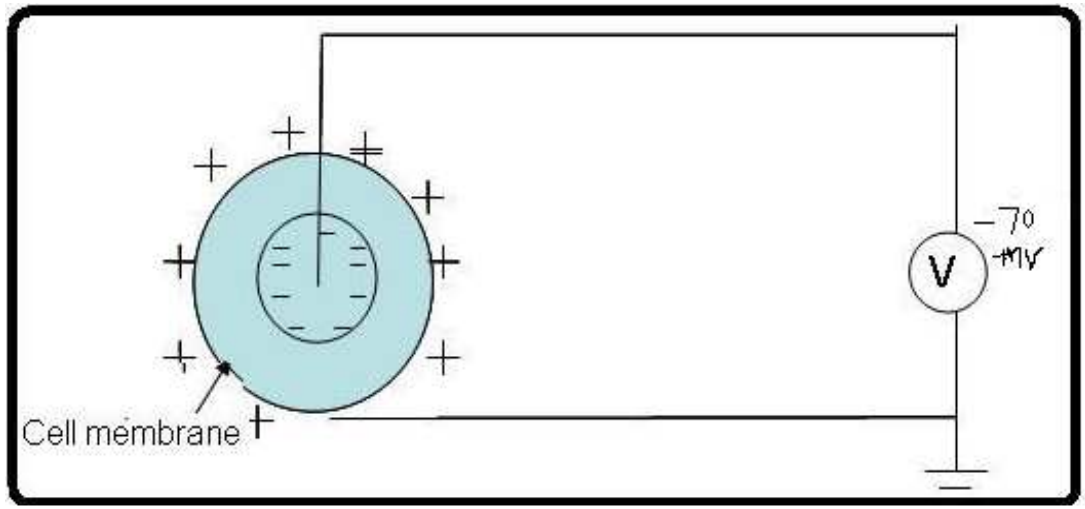
- Cell membranes are typically permeable to only a subset of ionic species like pottasium(K+),Chloride(Cl-) & effectively blocks the entry of sodium(Na+) ions.
- The various ions seeks a balance between inside & outside the cell according to concentration & electric charge.
- Two effects result from inability of Na+ ions to penetrate membrane-

  → Concentration of Na+ ions inside cell is much lower than outside. Hence,outside of cell becomes more positive than inside.

  → In an attempt to to balance electric charge,additional K+ ions enters the cell,causing higher concentration of K+ ion inside the cell.
- Charge balance can never be reached.
- Equilibrium is reached with a potential difference across the membrane ,negative on inside and positive on outside called **Resting Potential**.

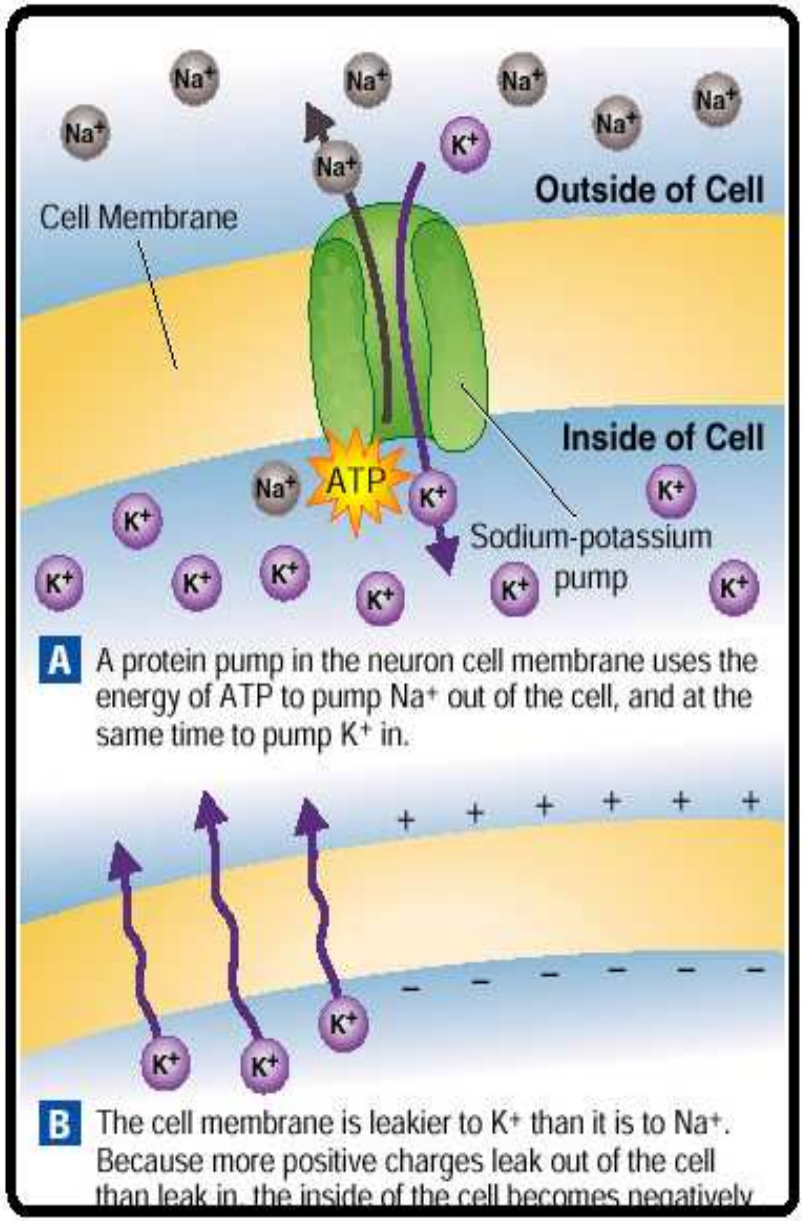


Polarized Cell during RP →

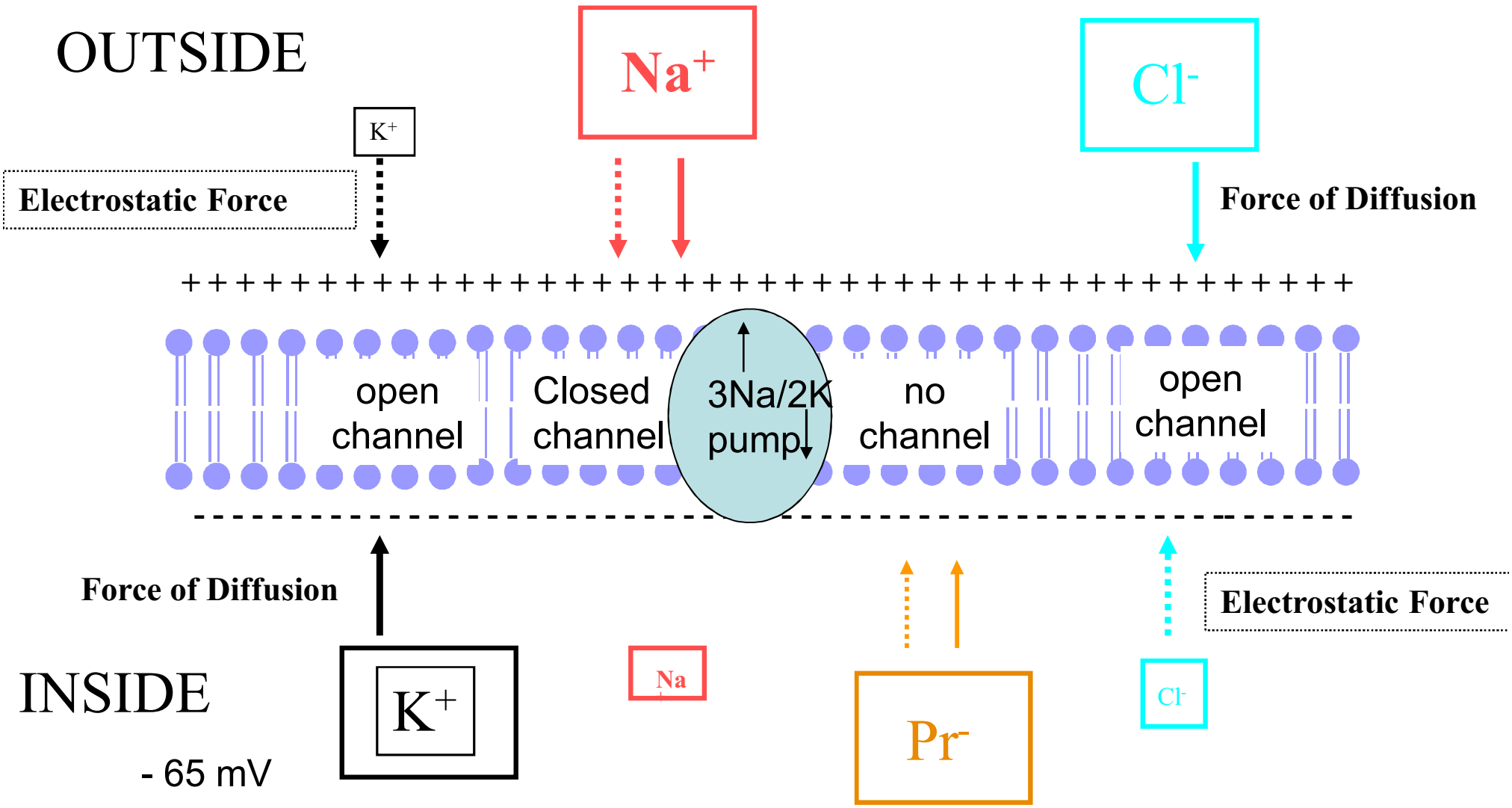


RESTING POTENTIAL IN NERVE CELL

- A nerve cell has an electrical potential, or voltage, across its cell membrane of approximately 70 millivolts (mV). This means that this tiny cell produces a voltage roughly equal to 1/20th that of a flashlight battery (1.5 volts).
- The potential is produced by the actions of a cell membrane pump, powered by the energy of ATP.
- **As shown in Figure**, this membrane protein forces sodium ions (Na+) out of the cell, and pumps potassium ions (K+) in. As a result of this active transport, the cytoplasm of the neuron contains more K+ ions and fewer Na+ ions than the surrounding medium. However, the neuron cell membrane is much leakier to K+ than it is to Na+. As a result, K+ ions leak out of the cell to produce a negative charge on the inside of the membrane.
- This charge difference is known as the **Resting Potential** of the neuron. The neuron, of course, is not actually "resting" because it must produce a constant supply of ATP to fuel active transport.



RESTING POTENTIAL PROPOGATION

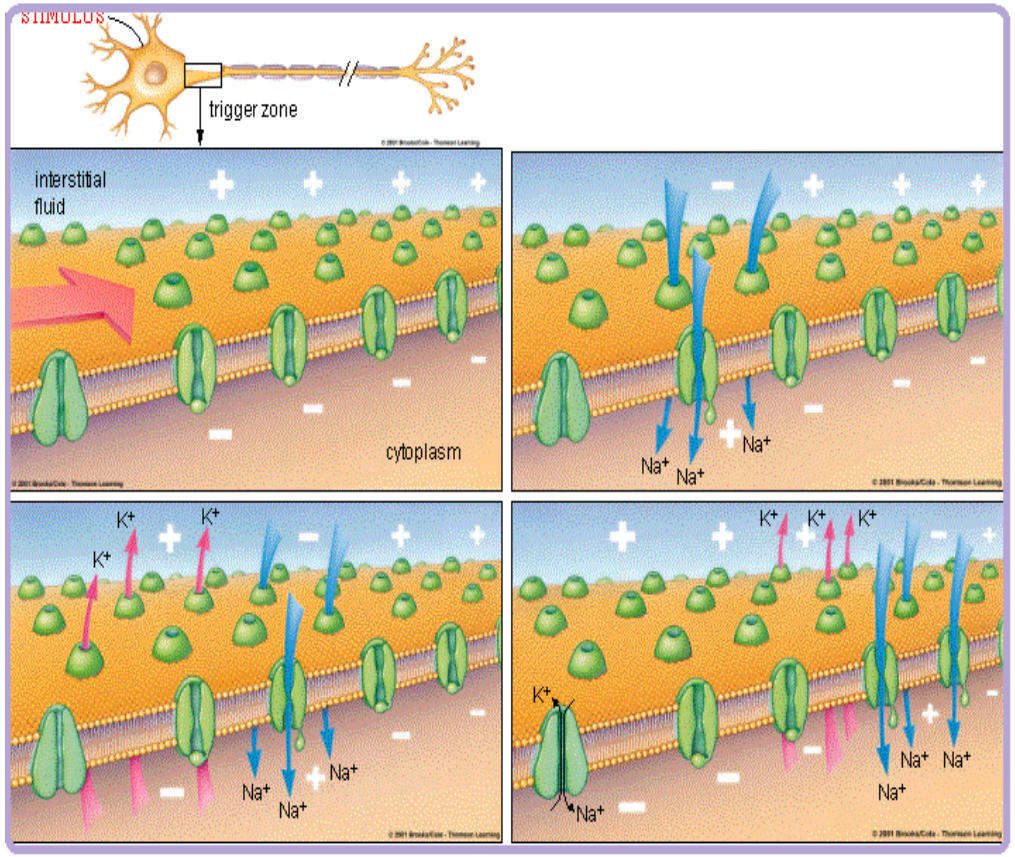


K^+ = Potassium; Na^+ = Sodium; Cl^- = Chloride; Pr^- = proteins

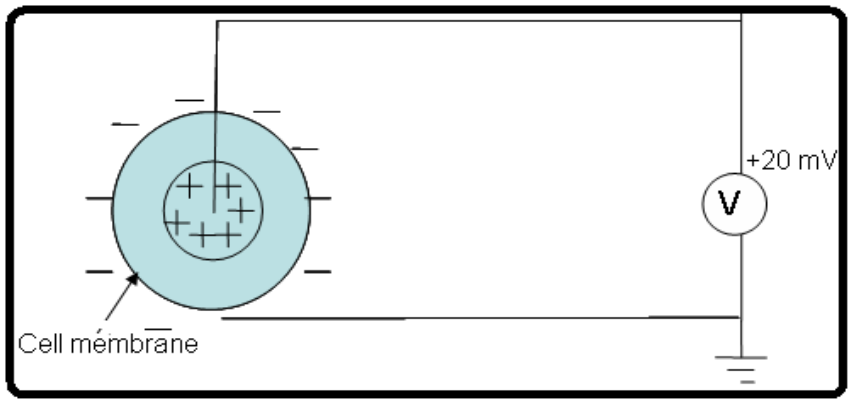
ACTION POTENTIAL

BASIC CONCEPT-

- When section of cell membrane is excited by some form of externally applied energy ,membrane characteristics changes & begins to allow some sodium ions to enter.
- This movement of Na+ ions constitutes an ionic current that further reduces the barrier of the membrane to Na+ ions.
- *Result-Avalanche effect* ,Na+ ions rush into the cell to balance with the ions outside .
- At the same time K+ ions which were in higher concentration inside the cell during resting state,try to leave the cell but are unable to move as rapidly as Na+ ions.
- As a result the cell has slightly positive potential on inside due to imbalance of K+ ions.
- .
- This potential is called as **Action Potential** .

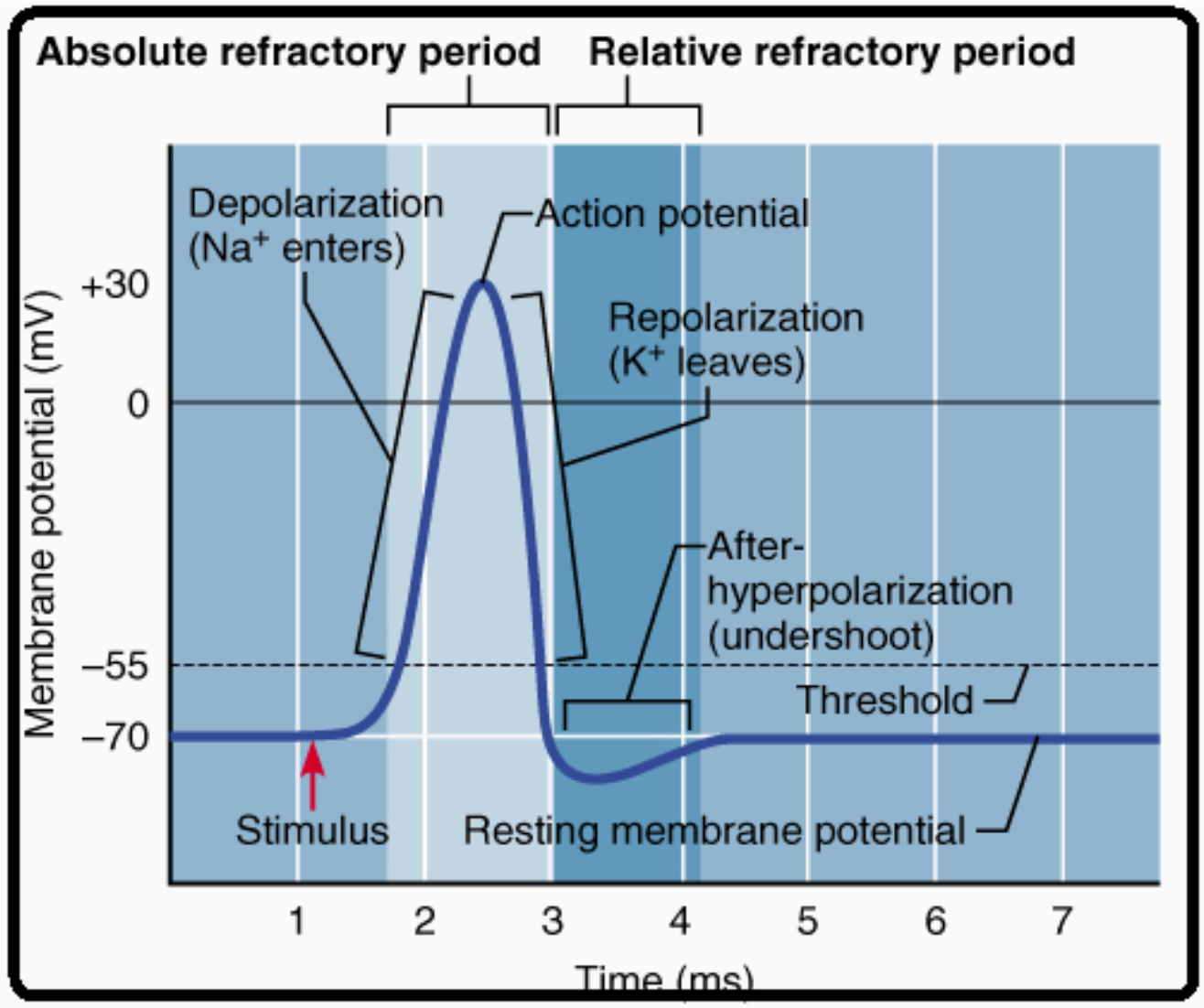


Depolarized cell during AP →



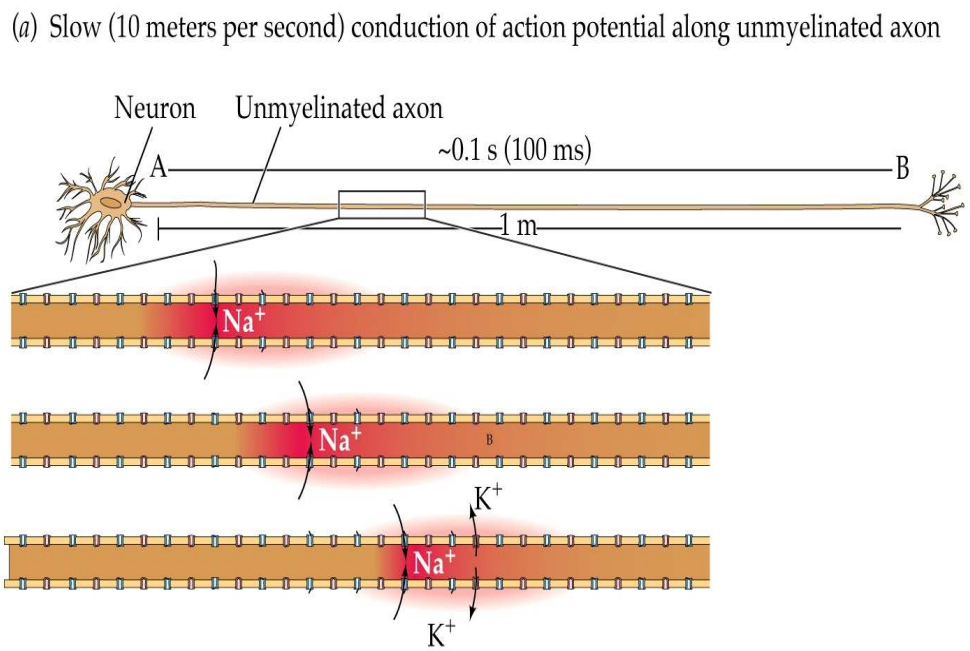
WAVEFORM SHOWING DEPOLARIZATION &REPOLARIZATION IN ACTION POTENTIAL

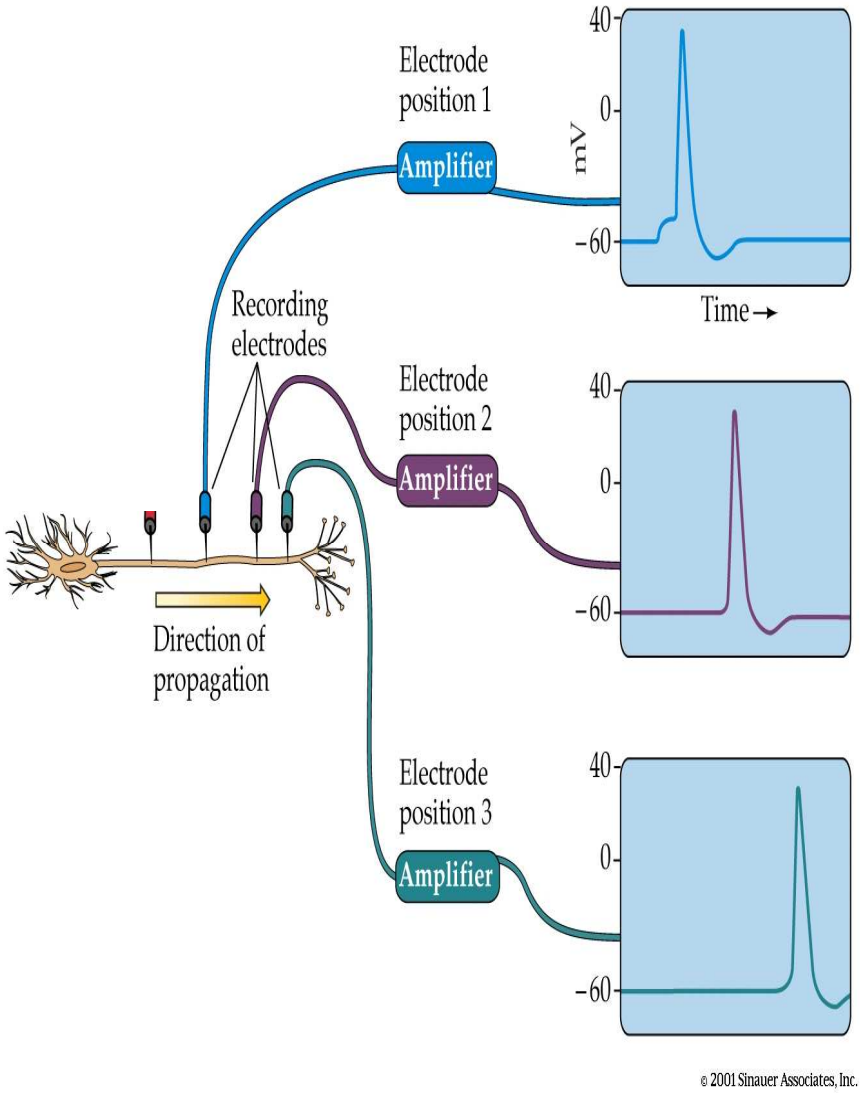
- The cell that displays an action Potential is said to be depolarized; the process of changing from resting state to action potential is called **Depolarization**.
- Once the rush of Na+ ions through the cell membrane has stopped .the membrane reverts back to its original condition wherein the passage of Na+ ions from outside to inside is blocked This process is called **Repolarization**.



ACTION POTENTIAL PROPOGATION

It "travels" down the axon (Actually, it does not move. Rather the potential change resulting from Na+ influx disperses to the next voltage-gated channel, triggering another action potential there).



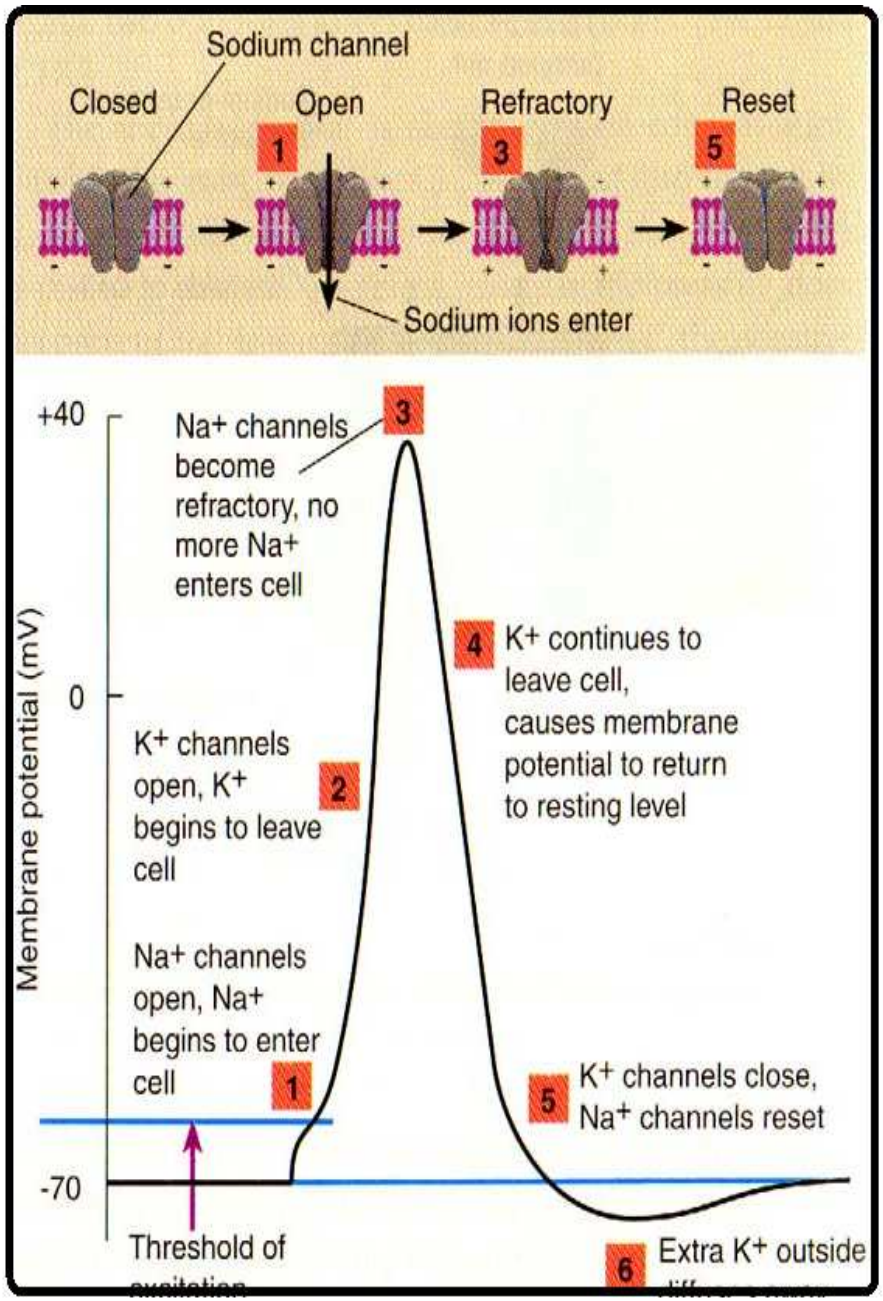


PROPOGATION OF POTENTIALS IN NERVE IMPULSE

The Moving Impulse An impulse begins when a neuron is stimulated by another neuron or by the environment. Once it begins, the impulse travels rapidly down the axon away from the cell body and towards the axon terminals.

As **Figure** shows, an impulse is a sudden reversal of the membrane potential. *What causes the reversal?* The neuron membrane contains thousands of protein channels or gates, that allow ions to pass through. Generally, these gates are closed. At the leading edge of an impulse, however, sodium gates open, allowing positively charged Na+ ions to flow inside. The inside of the membrane temporarily becomes more positive than the outside, reversing the resting potential. This reversal of charges is called an **Action Potential**. As the action potential, potassium gates open, allowing positively charged K+ ions to flow out. This restores the **Resting Potential** so that the neuron is once again negatively charged on the inside of the cell membrane and positively charged on the outside.

A nerve impulse is *self-propagating*. That is, an impulse at any point on the membrane causes an impulse at the next point along the membrane. We might compare the flow of an impulse to the fall of a row of dominoes. As each domino falls, it causes its neighbor to fall. Then, as the impulse passes, the dominoes set themselves up again, ready for another **Action Potential**.



Questions

- What is the Bioelectric potentials?
- What is ACTION POTENTIAL ?
- Draw a graph of **DEPOLARIZATION & REPOLARIZATION**?
- What are the **RESTING POTENTIAL** ?
- Explain PROPOGATION OF POTENTIALS ?

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Reference

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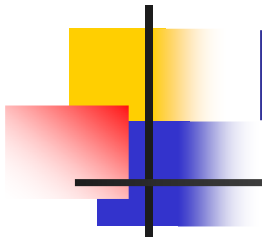
Basic Concepts of Medical Instrumentation
Medical Instrumentation: Application and Design Third Edition
John G. Webster, Editor

IEEE TRANSACTIONS ON INSTRUMENTATION AND MEASUREMENT

Resting and action potentials

The resting potential is the result of an unequal distribution of ions across the membrane.

- The resting potential is sensitive to ions in proportion to their ability to permeate the membrane.



Resting potentials

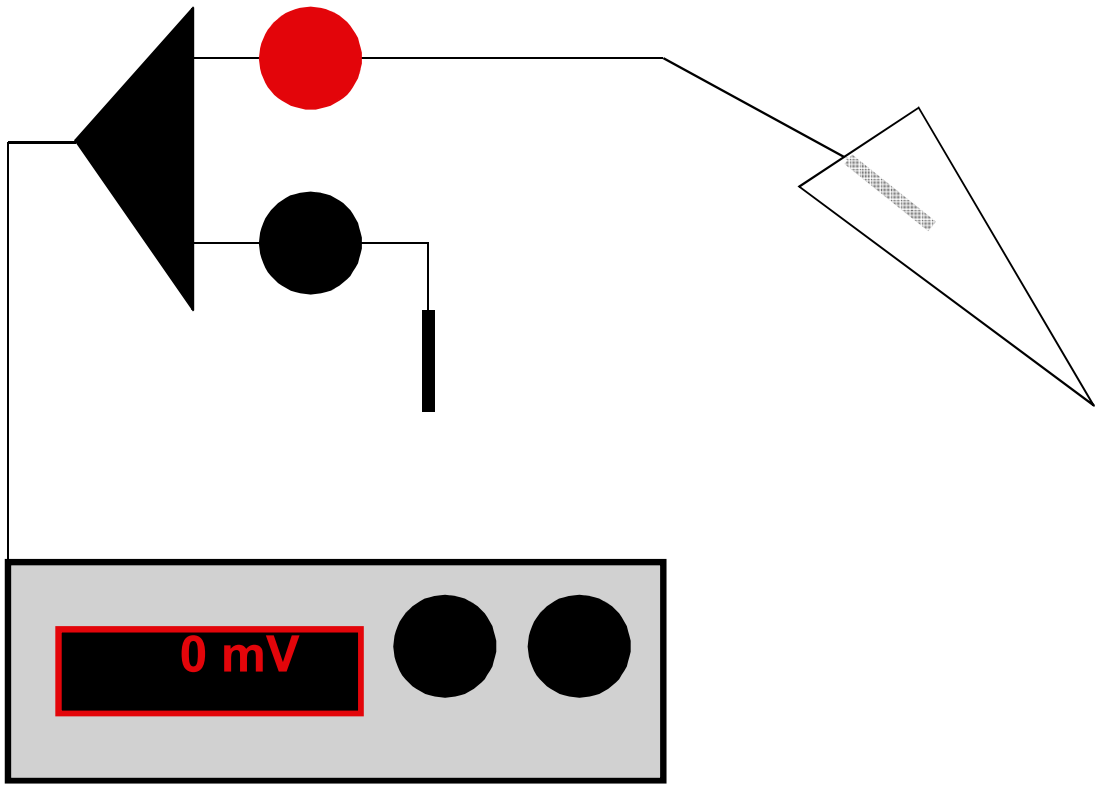
- Forget the membrane and consider what factors determine the movement of ions in solution.

Aqueous diffusion

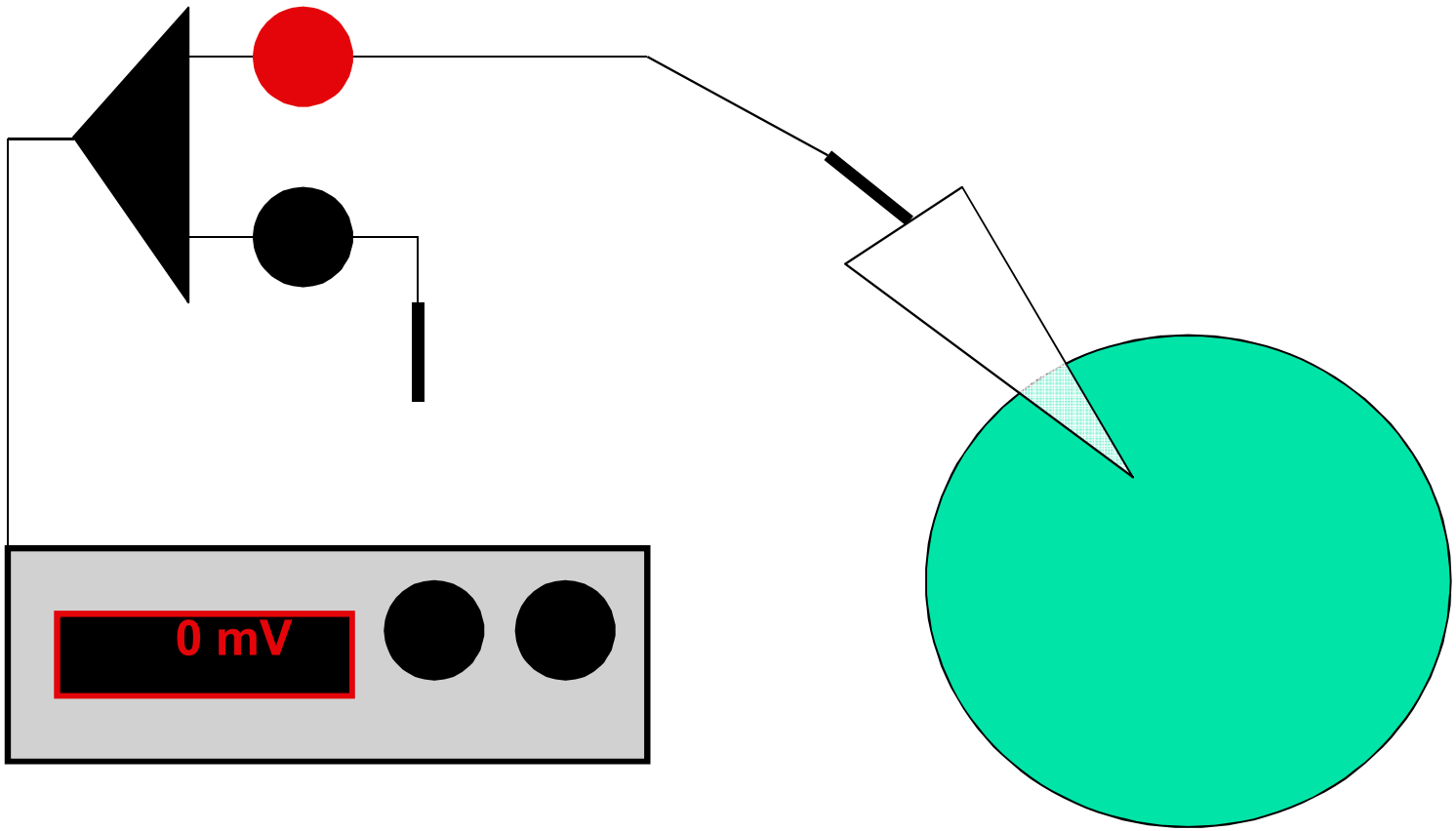
-and-

Electrophoretic movement

Resting potentials



Resting potentials



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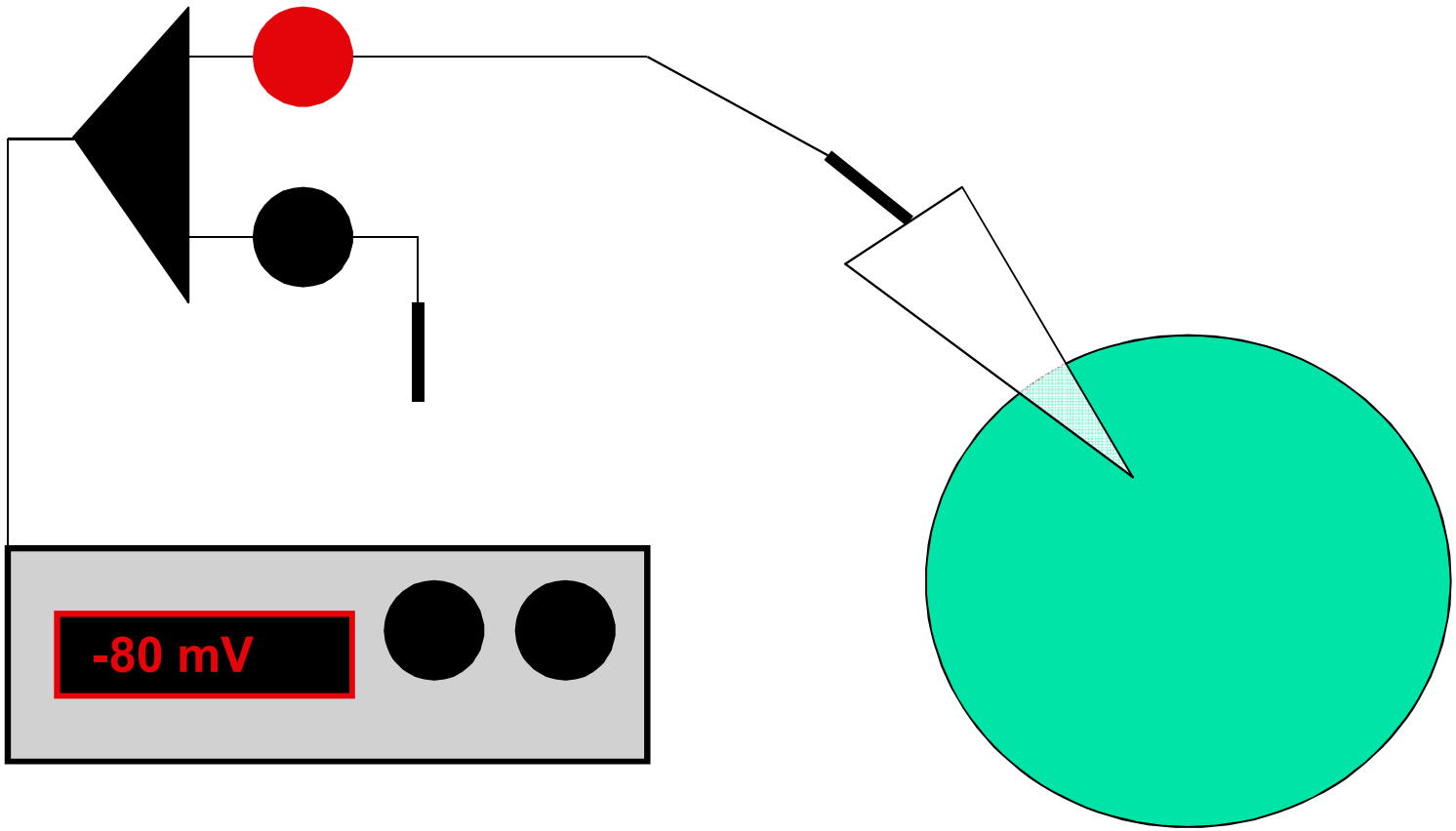

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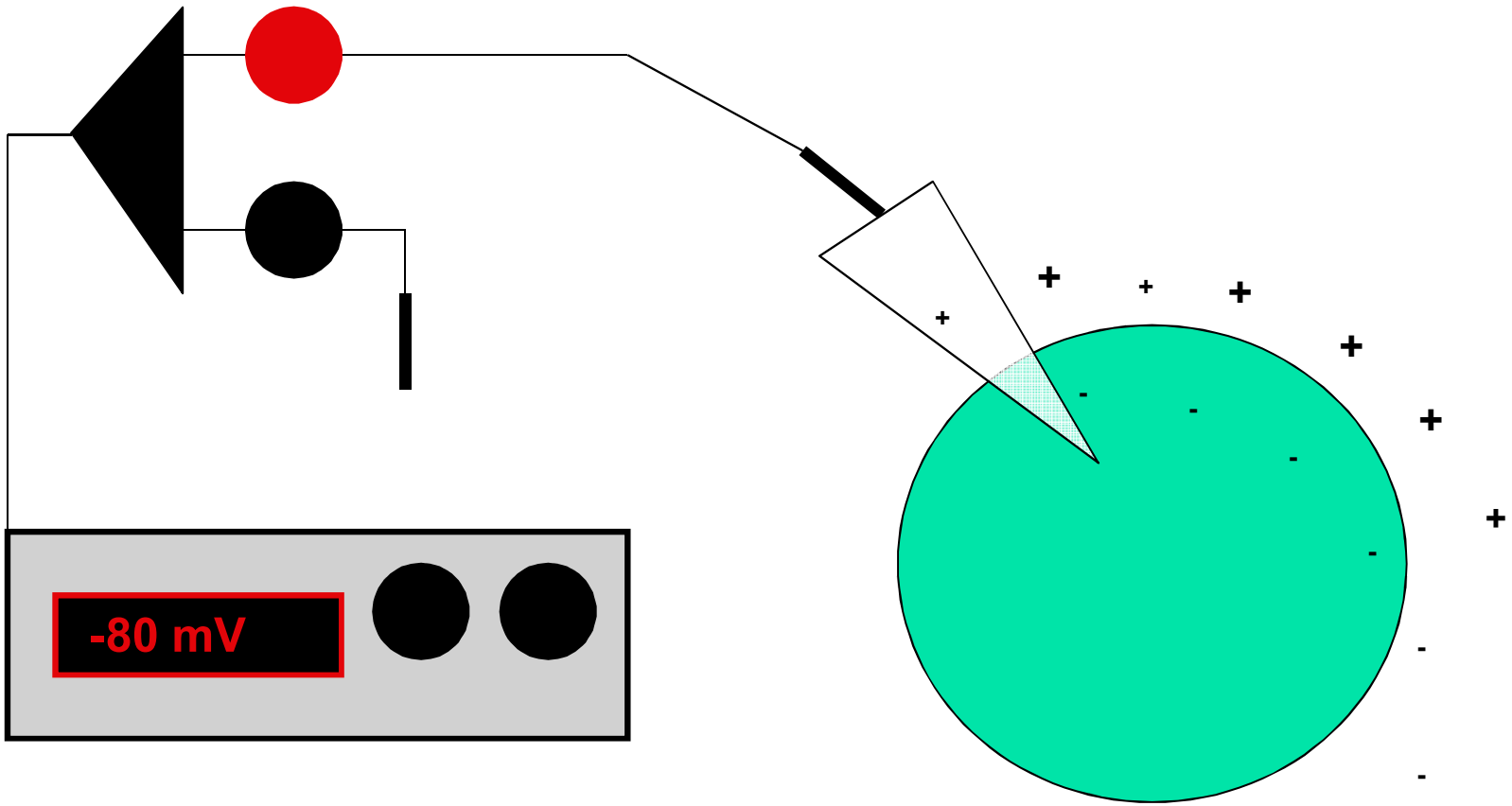

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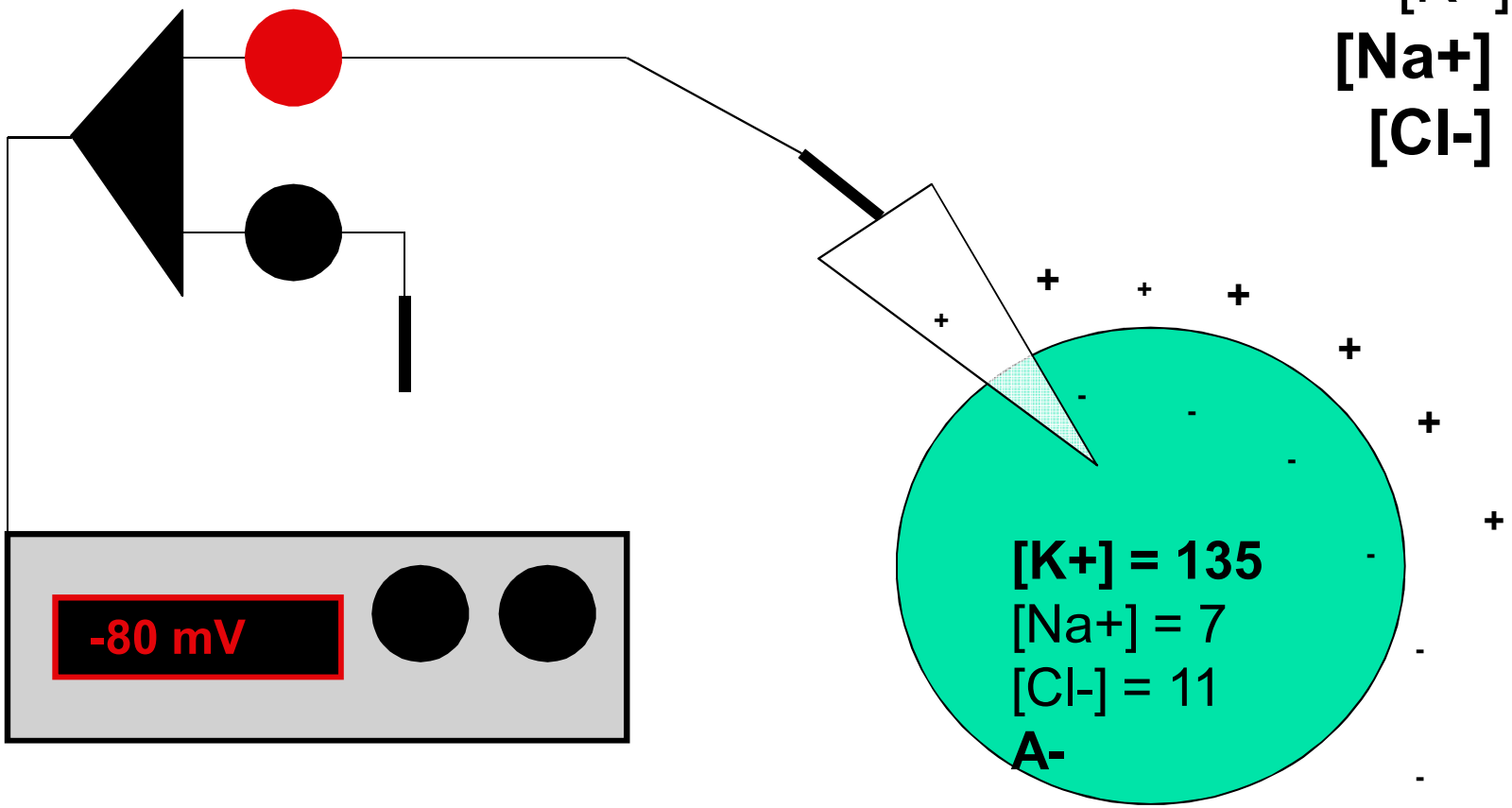
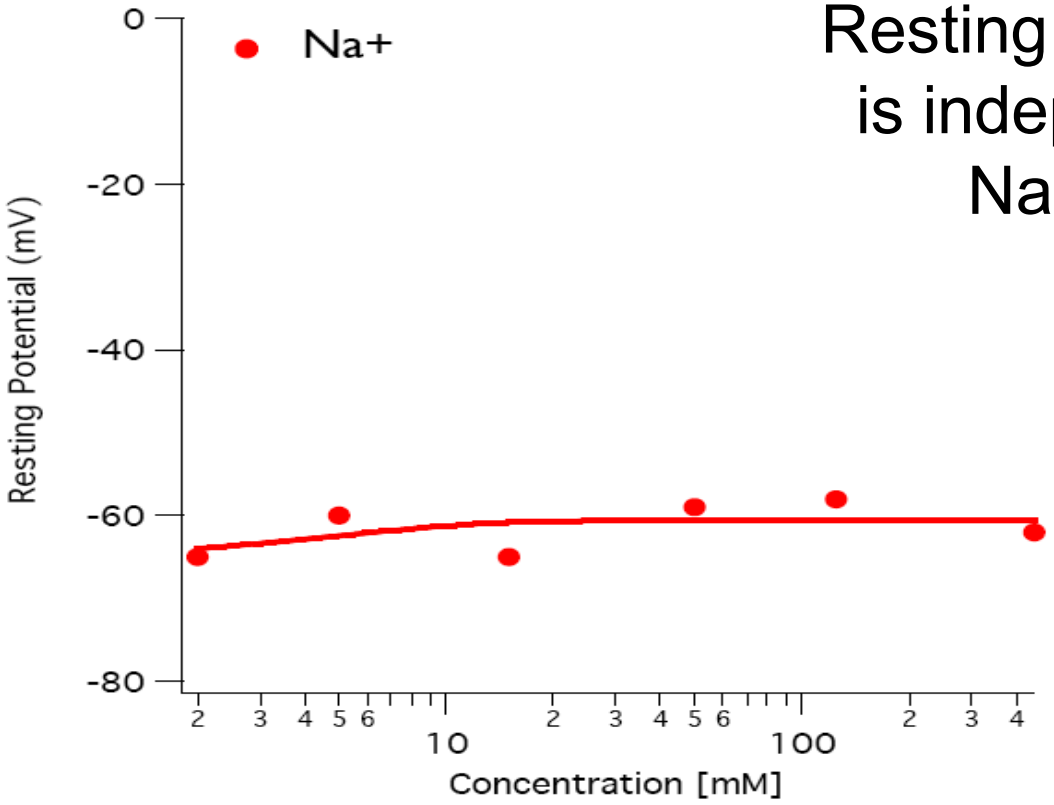
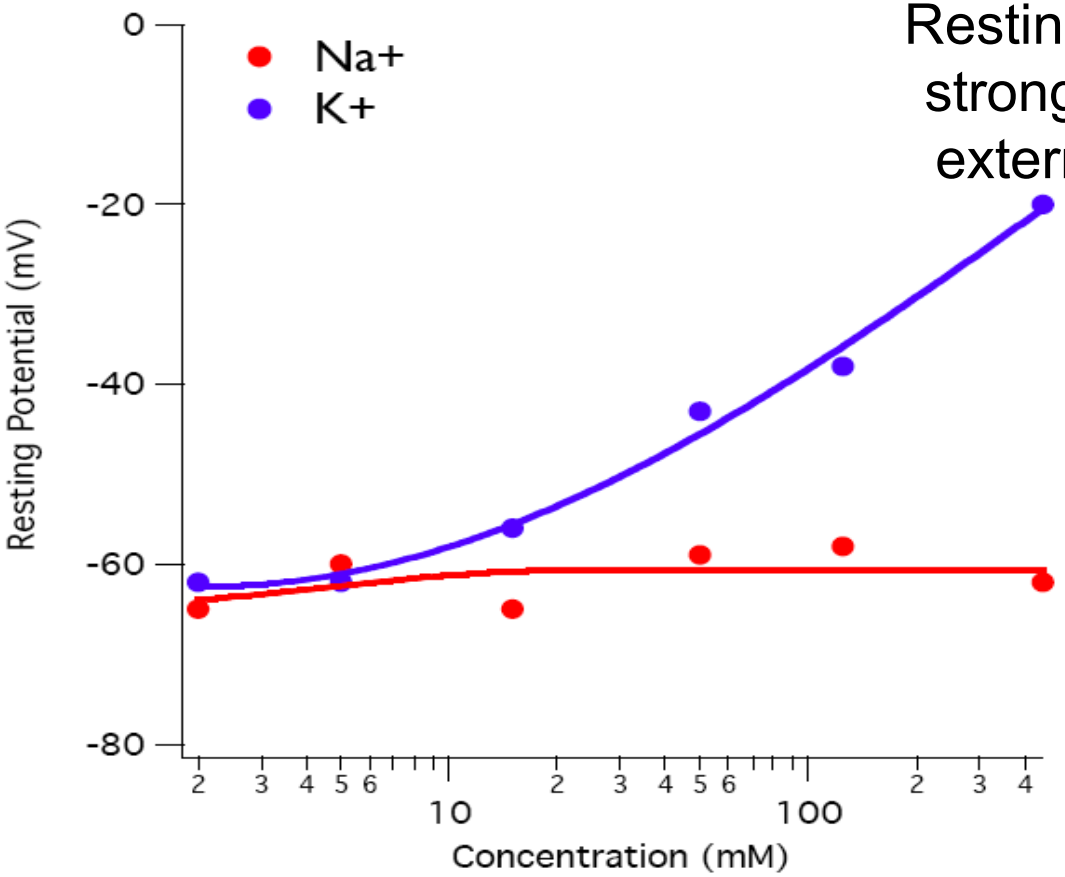


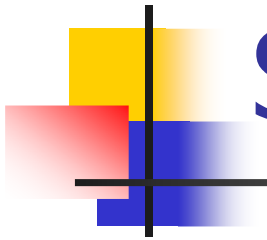
Resting potentials



Resting membrane potential is independent of external Na+ concentration

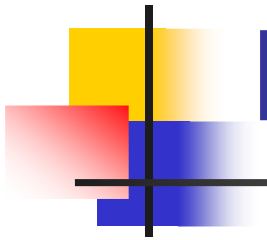


Resting membrane potential strongly depends upon the external K+ concentration



Summary

- The membrane conducts ions very poorly and allows the separation of ionic species. This results is a potential difference between the outside and the inside of the membrane.
- The magnitude of the resting potential is determined by the selective permeability of the membrane to ionic species.
- We can quantify the the magnitude of the resting potential by considering both the diffusive and electrophoretic properties.
- In order to understand the time dependence and individual contributions of ionic species to the membrane potential it is convenient to use an electrical equivalent circuit.



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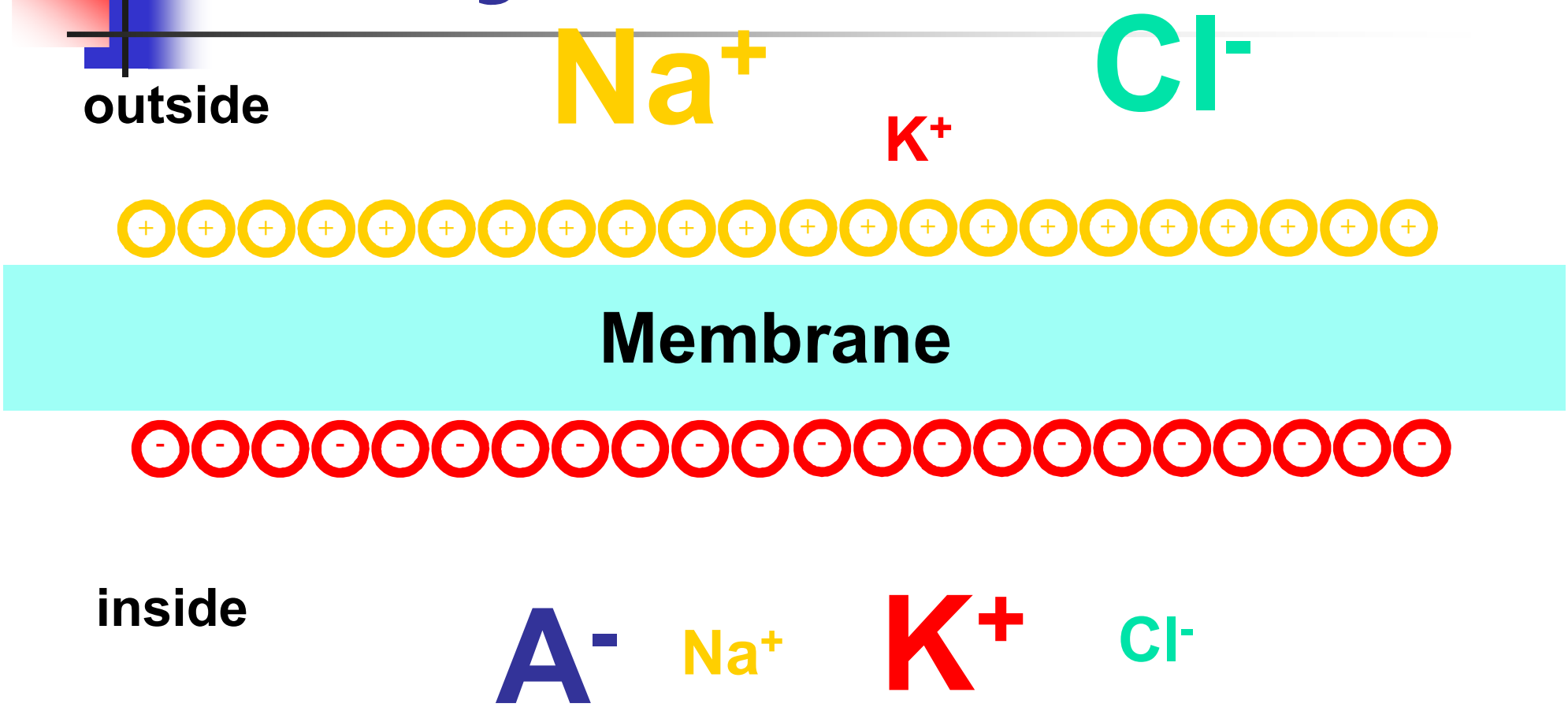
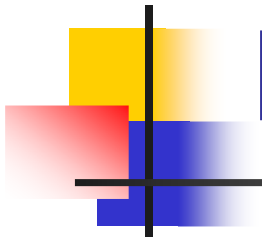
Resting Membrane Potential

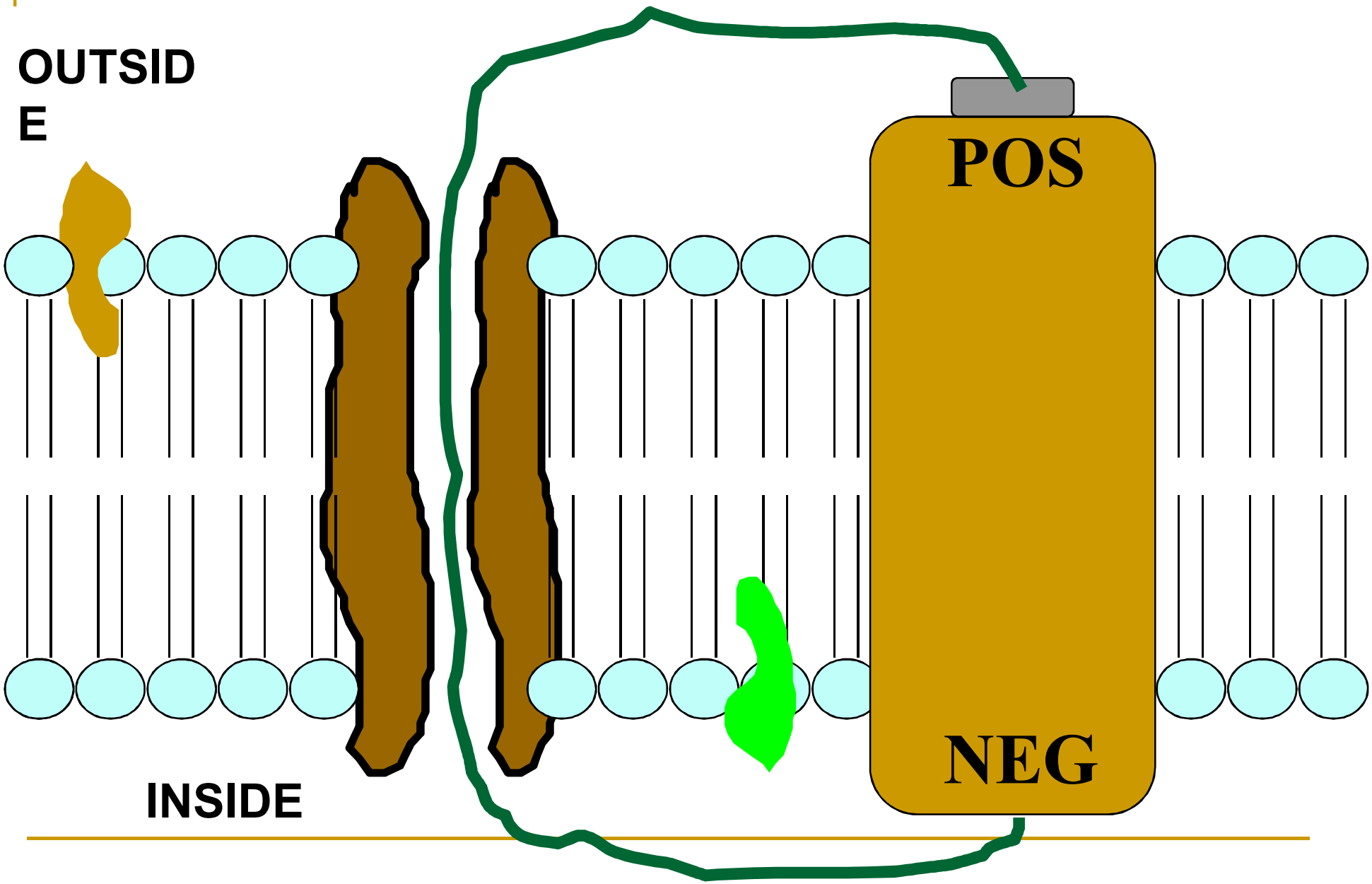




Membrane is polarized

- more negative particles in than out
- Bioelectric Potential
  - like a battery
  - Potential for ion movement
    - current ~

Bioelectric Potential



Questions

- What is the Bioelectric potentials?
- What is Membrane is polarization?
- Draw a graph of Resting membrane potential ?
- What are Resting Membrane Potential?
- Explain PROPOGATION OF POTENTIALS ?

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Dept/ Year / Semester	EI/2009/VII			Content Creator	ANUJ BHARDWAJ
Subject Code	TIC-701			Subject Coordinator	
Subject Description	BIO-MEDICAL INSTRUMENTATION			Reviewer	
Content Format	Digital (Slides in PPT)				
Unit	I	Lecture - Topic	Bioelectric potentials	Sub-Topic	Resting and action potentials

Fill Up the Following Check List (Should be filled by the Content Creator)	Yes	No
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Did you explained the Problem Solving Approach for the Problems related to this topic ?	√	
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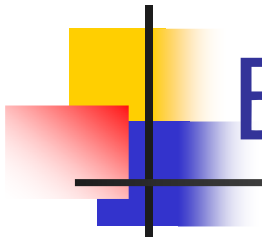


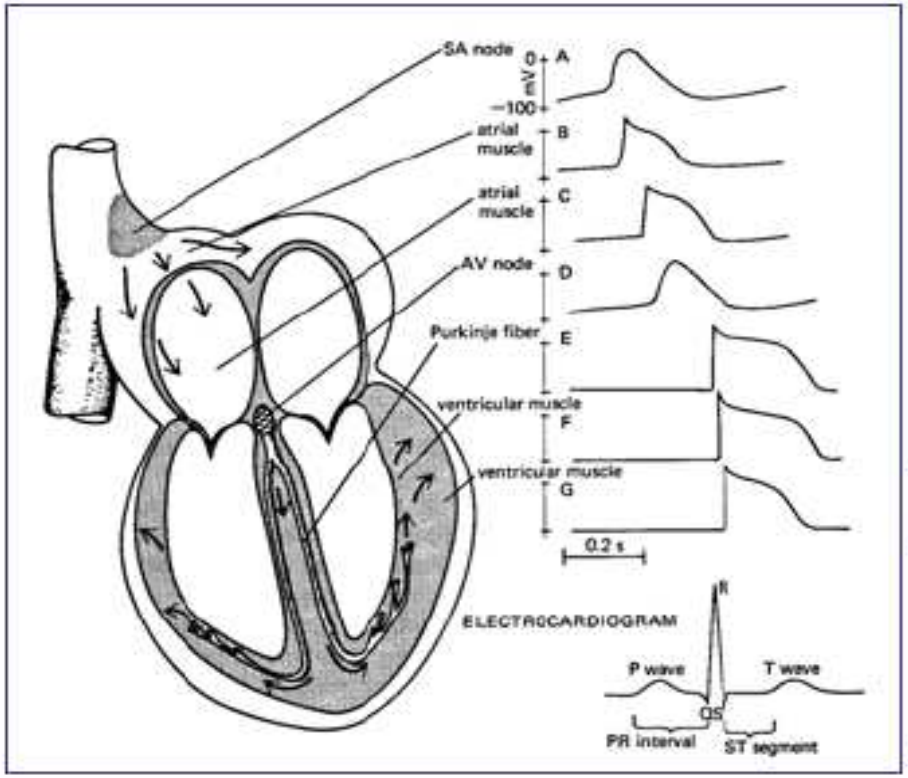
Biopotentials

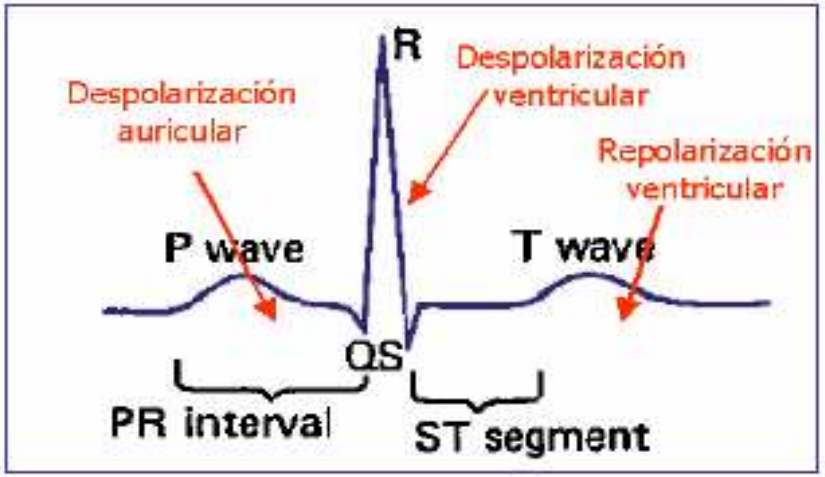
- ECG
- EEG
- EMG
- ERG…

Frequencies of Biopotentials

Signal	Frequency range (Hz)	Amplitude range(mV)
ECG	0.01 – 100	0.05 – 3
EEG	0.1 – 80	0.001 – 1
EOG	0.01 – 10	0.001 – 0.3
EMG	50 – 3000	0.01 – 100

Electrocardiogram (ECG)

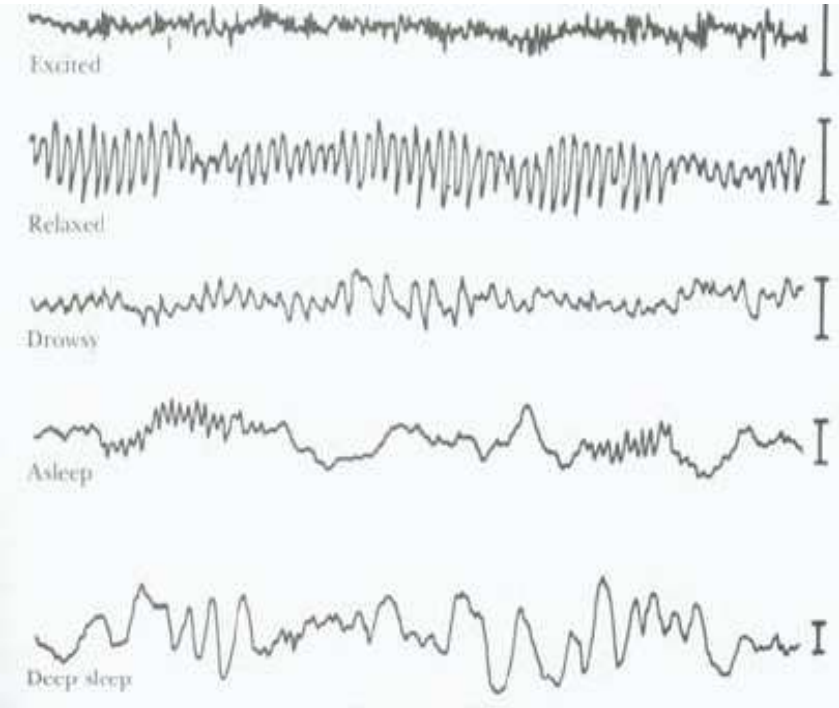


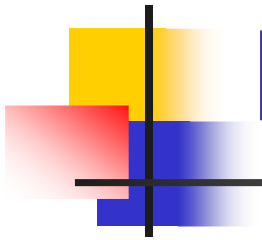


P: Contracción auricular
QRS: Contracción ventricular
T: Repolarización ventricular

Recording System EEG

- EEG recording is done using a standard lead system called 10-20 system
- Recall dipole concept to identify source of brain activity



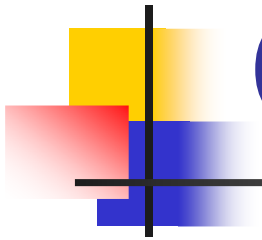


Electromyogram (EMG)

- Measures muscle activity
- Recordintramuscularly through needle electrodes
- Record surface EMG using electrodes on biceps,triceps…
- Use in muscular disorders,muscle based prosthesis –prosthetic arm, leg

Electroretinogram
Electroretinogram (ERG)

- Biopotential of the eye (retina)
- Indicator of retinal diseases such as retinal degenration, macular degernation
- Invasive recording



Questions

- What is Electroretinogram Electroretinogram ?
- What is EEG?
- Draw a graph of Resting membrane potential ?
- What are the Frequencies of Biopotentials?
- Explain EMG

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Unit	I	Lecture - Topic	Biopotentials
Sub-Topic			

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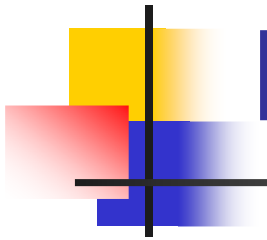


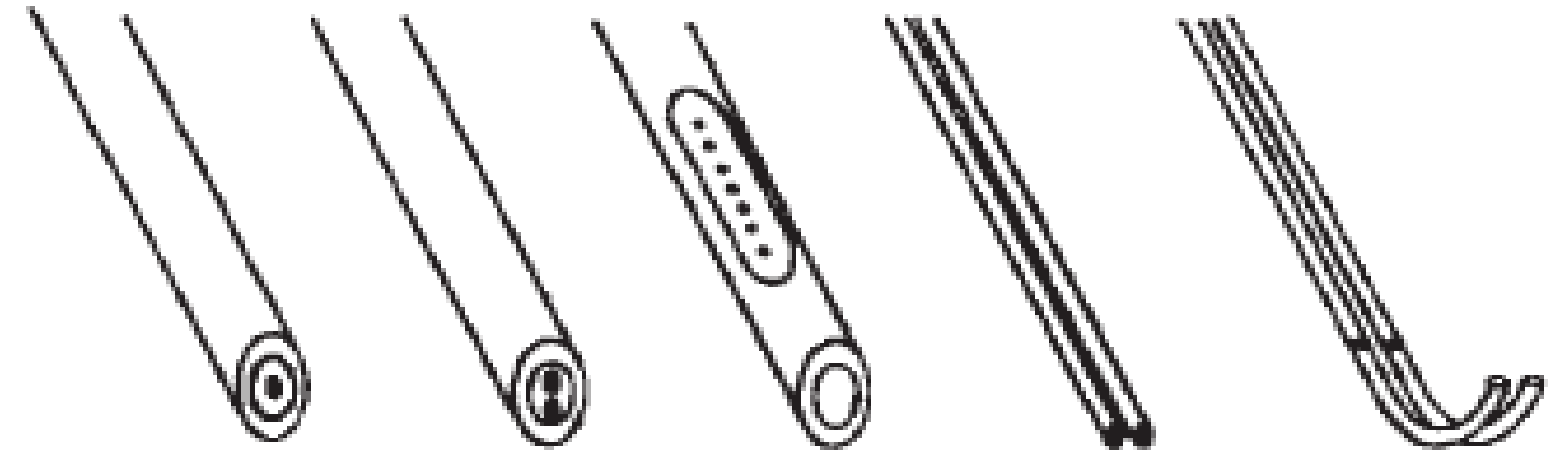
Reference

• IEEE TRANSACTIONS ON INSTRUMENTATION AND MEASUREMENT.

• Medical instrumentation application and design contributing authors, John W. Clark, Jr... [et al.] . Webster, John G

KINDS OF ELECTRODES

Electromyography

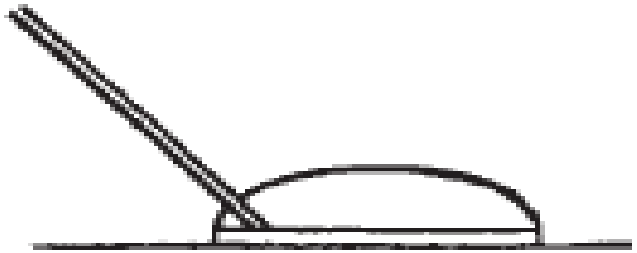


• Detection site

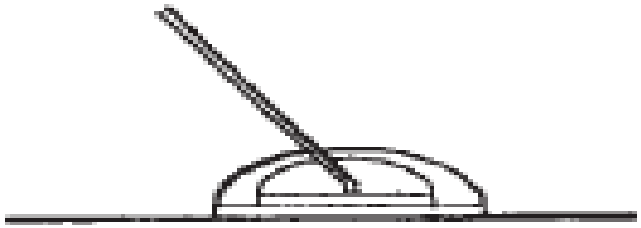
Needle electrodes

Wire electrodes

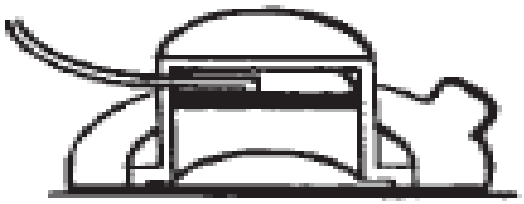
ELECTRODES

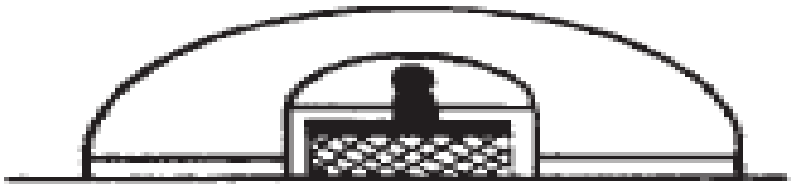


Dry electrode

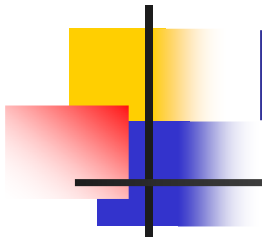


Wet gel electrode





Surface electrodes



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Basic Concepts of Medical Instrumentation

Medical Instrumentation: Application and Design Third Edition

John G. Webster, Editor

Biomedical Instrumentation & Design

Matt O'Donnell

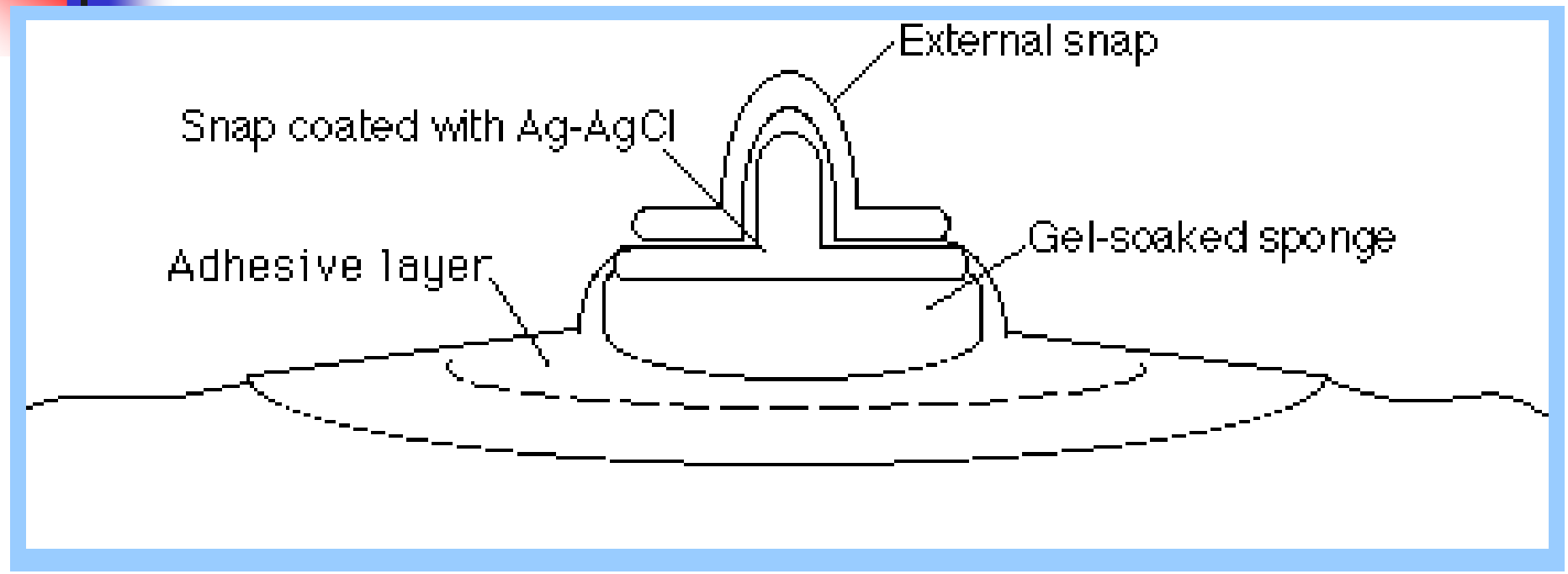
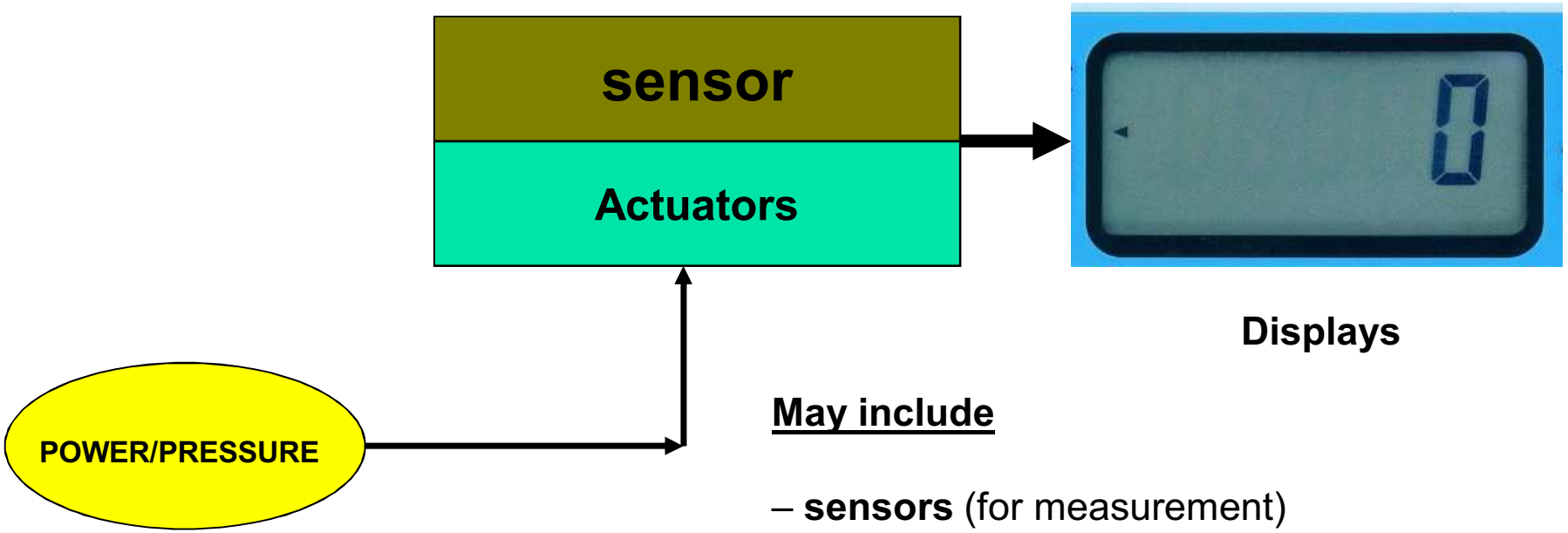


Figure A disposable surface electrode. A typical surface electrode used for ECG recording is made of Ag/AgCl. The electrodes are attached to the patients' skin and can be easily removed.

SENSOR IN BIOMEDICAL

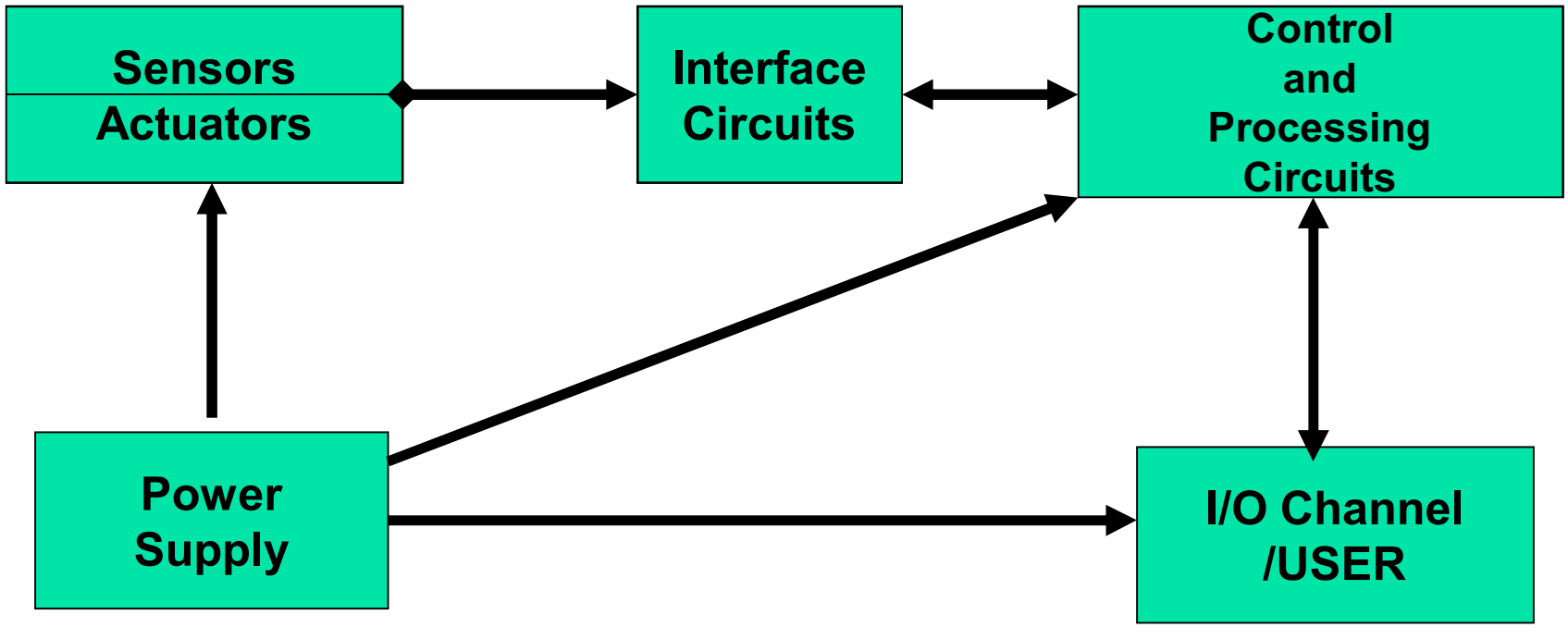


Displays

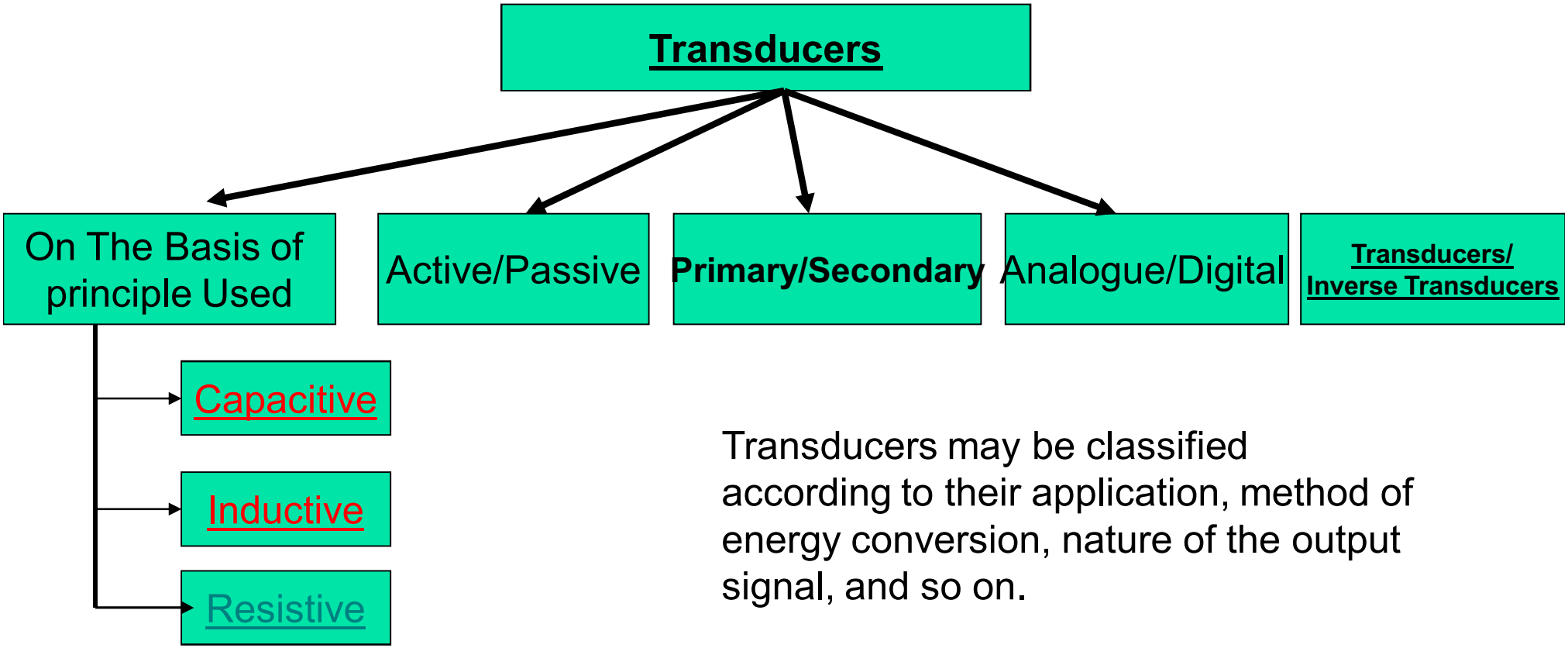
May include

– **sensors** (for measurement)
– **actuators** (for doing work)
– **displays**

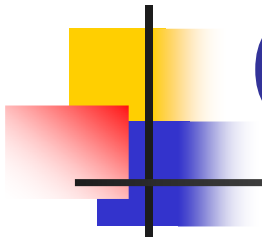
Transducer Systems



Classification of Transducers



Transducers may be classified according to their application, method of energy conversion, nature of the output signal, and so on.



Questions

- What is bio-potential ELECTRODES?
- What Transducer Systems?
- What are the KINDS OF ELECTRODES?
- Explain Classification of Transducers

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Subject Code	TIC-701	Subject Coordinator	
Subject Description	BIO-MEDICAL INSTRUMENTATION	Reviewer	
Content Format	Digital (Slides in PPT)		
Unit	I	Lecture - Topic	Transducer Systems
Sub-Topic	SENSOR IN BIOMEDICAL		

Fill Up the Following Check List (Should be filled by the Content Creator)	Yes	No
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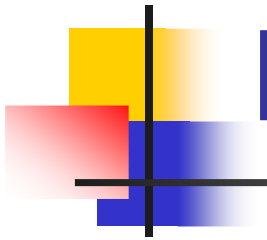


Reference

Webster,j.g. –Bio- Instrumentation ,Wiley (2004)

E.M.M.I by…. A.K.Sahani

SPECIAL REQUIREMENTS OF SENSOR IN BIOMEDICAL APPLICATIONS

- Appliances for diagnosis: measuring or mapping a parameter at a given time
- Monitoring devices for measuring parameters within a given period
- Built-in controlling units containing not only sensors but also actuators

TYPES OF TRANSDUCERS

Electrical parameter and class of transducer	*Principle of operation and nature of device*	*Typical application*
	PASSIVE TRANSDUCERS (EXTERNALLY POWERED)	
Resistance		
Potentiometric device	Positioning of the slider by an external force varies the resistance in a potentiometer or a bridge circuit.	Pressure, displacement
Resistance strain gage	Resistance of a wire or semiconductor is changed by elongation or compression due to externally applied stress.	Force, torque, displacement
Pirani gage or hot-wire meter	Resistance of a heating element is varied by convection cooling of a stream of gas.	Gas flow, gas pressure
Resistance thermometer	Resistance of pure metal wire with a large positive temperature coefficient of resistance varies with temperature.	Temperature, radiant heat
Thermistor	Resistance of certain metal oxides with negative temperature coefficient of resistance varies with temperature.	Temperature
Resistance hygrometer	Resistance of a conductive strip changes with moisture content.	Relative humidity
Photoconductive cell	Resistance of the cell as a circuit element varies with incident light.	Photosensitive relay

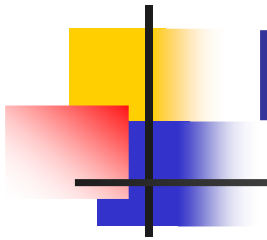
PASSIVE TRANSDUCERS (EXTERNALLY POWERED) (*cont.*)

Capacitance		
Variable capacitance pressure gage	Distance between two parallel plates is varied by an externally applied force	Displacement, pressure
Capacitor microphone	Sound pressure varies the capacitance between a fixed plate and a movable diaphragm.	Speech, music, noise
Dielectric gage	Variation in capacitance by changes in the dielectric.	Liquid level, thickness
Inductance		
Magnetic circuit transducer	Self inductance or mu ual inductance of ac-excited coil is va ied by changes in the magnetic circuit.	Pressure, displacement
Reluctance pickup	Reluctance of the magnetic circuit is varied by changing the position of the iron core of a coil.	Pressure, displacement, vibration, position
Differential transformer	The differential voltage of two secondary windings of a transformer is varied by positioning the magnetic core through an externally applied force.	Pressure, force, displacement, position
Eddy current gage	Inductance of a coil is varied by the proximity of an eddy current plate.	Displacement, thickness
Magnetostriction gage	Magnetic properties are varied by pressure and stress.	Force, pressure, sound
Voltage and current		
Hall effect pickup	A potential difference is generated across a semiconductor plate (germanium) when magnetic flux interacts with an applied current.	Magnetic flux, current
Ionization chamber	Electron flow induced by ionization of gas due to radioactive radiation.	Particle counting, radiation
Photoemissive cell	Electron emission due to incident radiation on photoemissive surface.	Light and radiation
Photomultiplier tube	Secondary electron emission due to incident radiation on photosensitive cathode.	Light and radiation, photosensitive relays

ACTIVE TRANSDUCERS

SELF-GENERATING TRANSDUCERS (NO EXTERNAL POWER)

Thermocouple and thermopile	An emf is generated across the junction of two dissimilar metals or semiconductors when that junction is heated	Temperature, heat flow, radiation
Moving-coil generator	Motion of a coil in a magnetic field generates a voltage.	Velocity, vibration
Piezoelectric pickup	An emf is generated when an external force is applied to certain crystalline materials, such as quartz.	Sound, vibration, acceleration, pressure changes
Photovoltaic cell	A voltage is generated in a semiconductor junction device when radiant energy stimulates the cell.	Light meter, solar cell



Reference

E.M.M.I by…. A.K.Sahani

Selecting a Transducer

- What is the physical quantity to be measured?
- Which transducer principle can best be used to measure this quantity?
- What accuracy is required for this measurement?
  - Fundamental transducer parameters
  - Physical conditions
  - Environmental conditions
  - Compatibility of the associated equipment
- Reducing the total measurement error :
  - Using in-place system calibration with corrections performed in the data reduction
  - Artificially controlling the environment to minimize possible errors

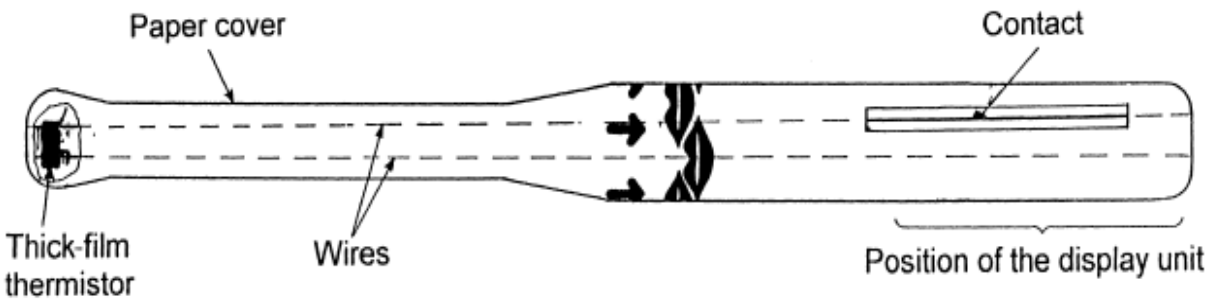
Measuring Core Temperature

Because skin temperature cannot directly be correlated with interior body temperature, *body (core) temperature* measurement is traditionally performed inside a body cavity

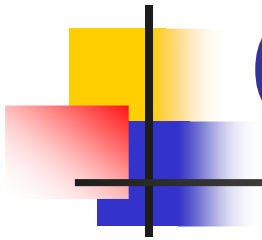
An old and traditional device used for body temperature measurement is the mercury thermometer that does not contain sensors Its drawbacks are slow operation and difficult reading and registration of the result

Electronic thermometers

They generally contain diodes as temperature-sensing elements with a special package design that can assure small therm alcapacity and good thermal conductivity to the environment. They have relatively short response times and good visible display units



Structure of a disposable oral thermometer.



Questions

- What is ACTIVE TRANSDUCERS?
- What is Electronic thermometers?
- What is passive TRANSDUCERS?
- What are the APPLICATIONS of SENSOR IN BIOMEDICAL?
- Explain the process of Measuring Core Temperature

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Unit	I	Lecture - Topic	SENSOR IN BIOMEDICAL APPLICATIONS	Sub-Topic	

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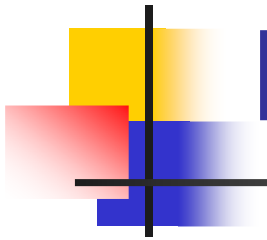


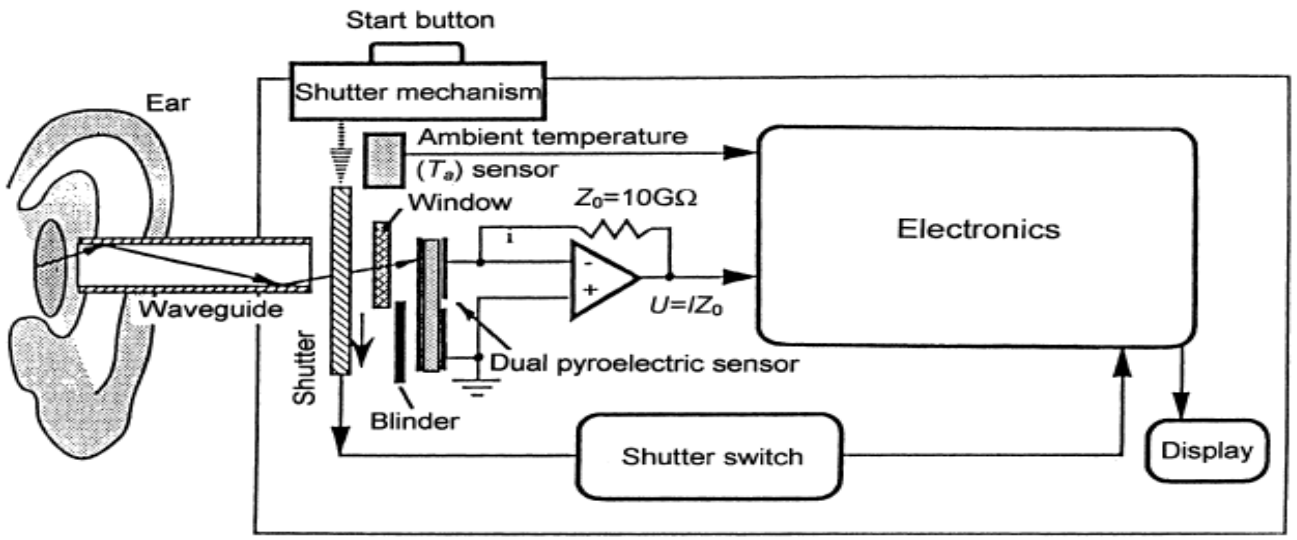
Reference

IEEE TRANSACTIONS ON INSTRUMENTATION AND MEASUREMENT

***nptel**.iitm.ac.in*

*en.wikipedia.org/wiki/**Biomedical_engineering***

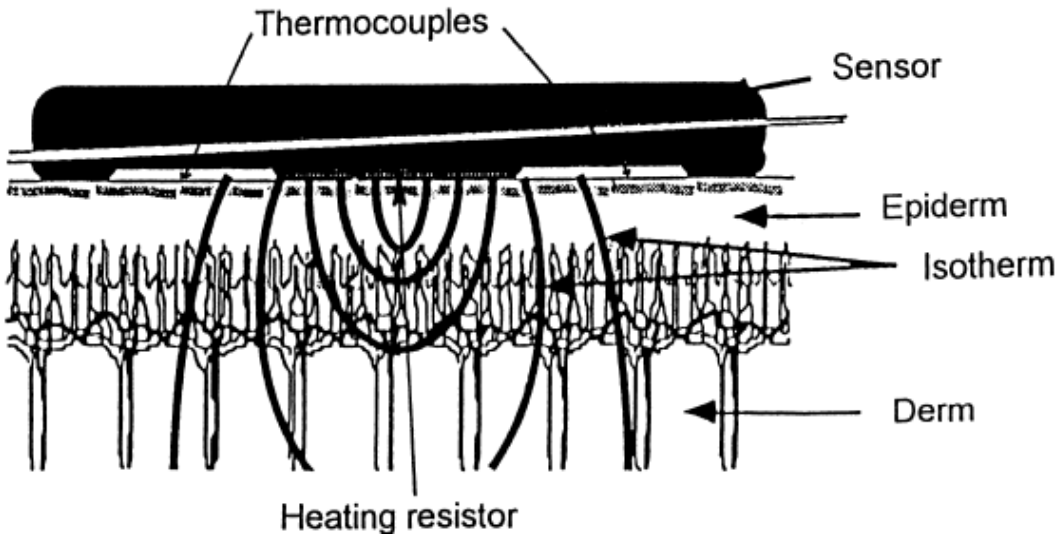
Radiation Ear Thermometer



This version is based on a pyroelectric sensor. Thermal radiation flux from the auditory canal is channeled by the optical waveguide toward the pyroelectric sensor. When pressing the start button, the shutter opens momentarily, exposing the sensor to thermal radiation and replacing the radiation coming from the shutter itself. An ambient temperature sensor element is behind the shutter. The radiation reaches the sensor where it is converted into electric current impulse due to the pyroelectric effect

Skin Blood-Flow Sensor

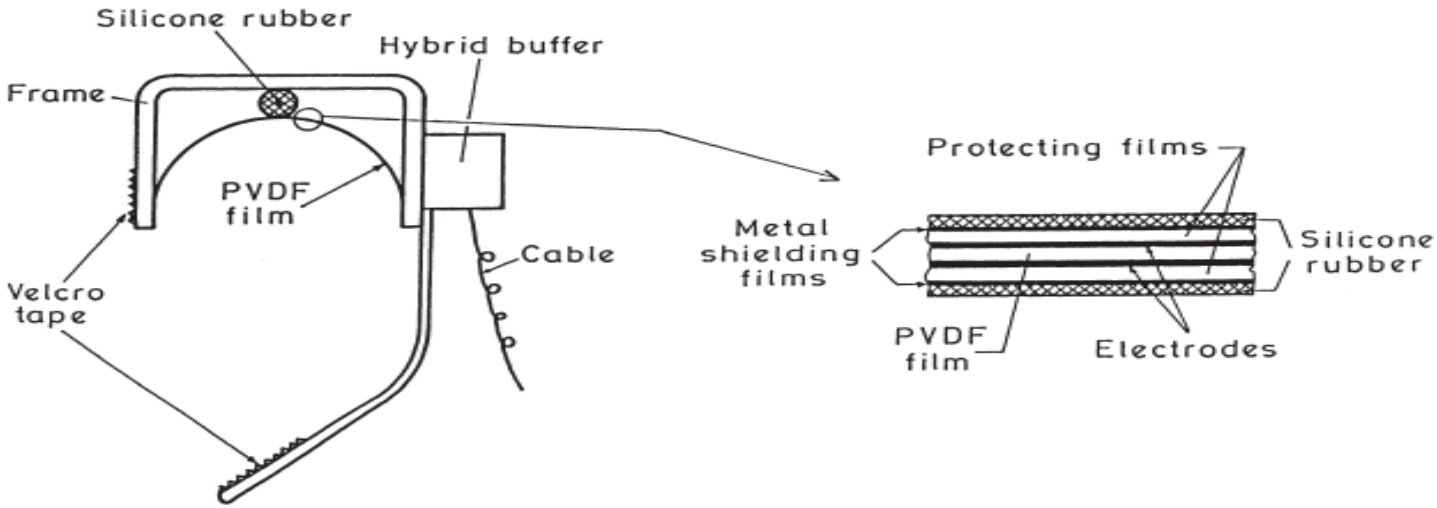
Skin blood flow (SBF) or skin perfusion is a complex phenomenon that occurs in capillaries. In perfused tissue, thermal conductivity depends not only on the thermal conductivity of the tissue materials, but also on the heat convection transferred by the blood flow in capillaries. Thus, thermal conductivity of the skin can vary within a wide range; its minimum value, 2.5 mW/cm°C



A Thermal Conductivity Sensor for the Measurement of Skin Blood Flow

Sensors for Pressure Pulses and Movement

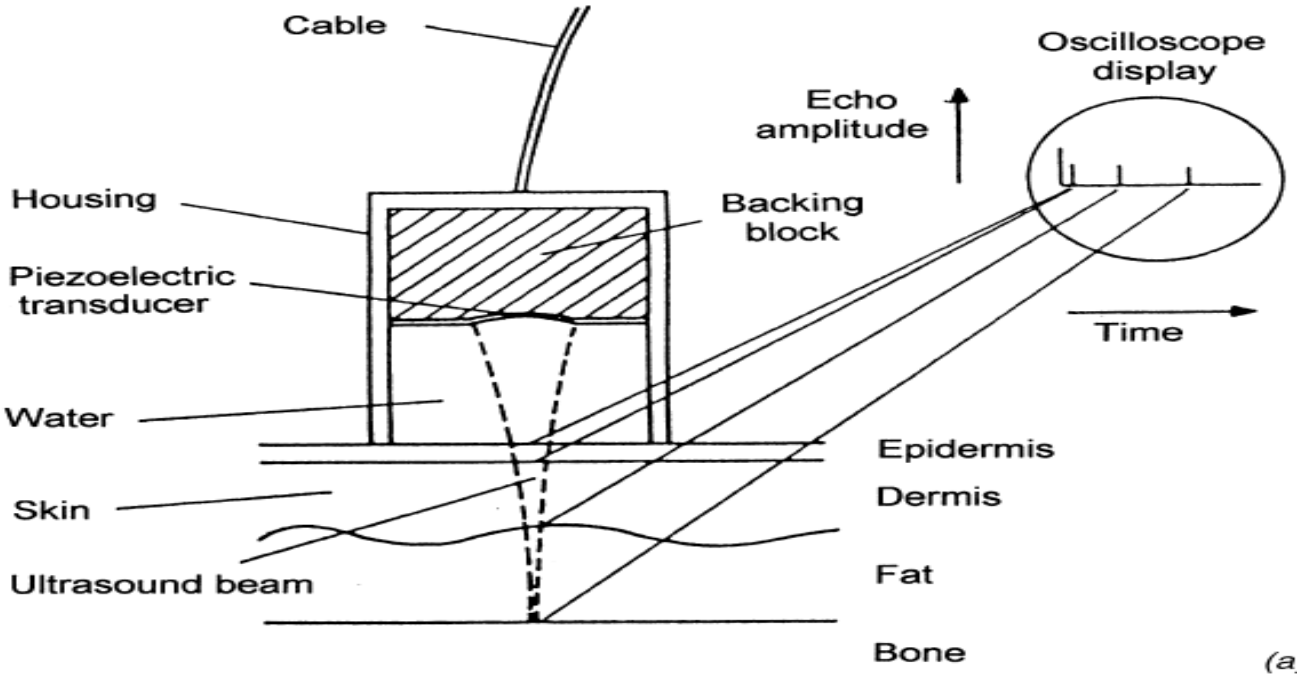
Pulse sensing is a convenient and efficient way of acquiring important physiological information concerning the cardiovascular system. Finger pulse pickups can be employed in systems that measure blood pressure, heart ra



The pulse-wave signal is sent through the buffer to the signal-processing electronics. The PVDF film is in direct contact with the finger therefore, its metallized surfaces have to be shielded on both sides with thin metallized protecting polymer films and sealed with highly insulating silicone rubber to avoid damage to the surface electrodes

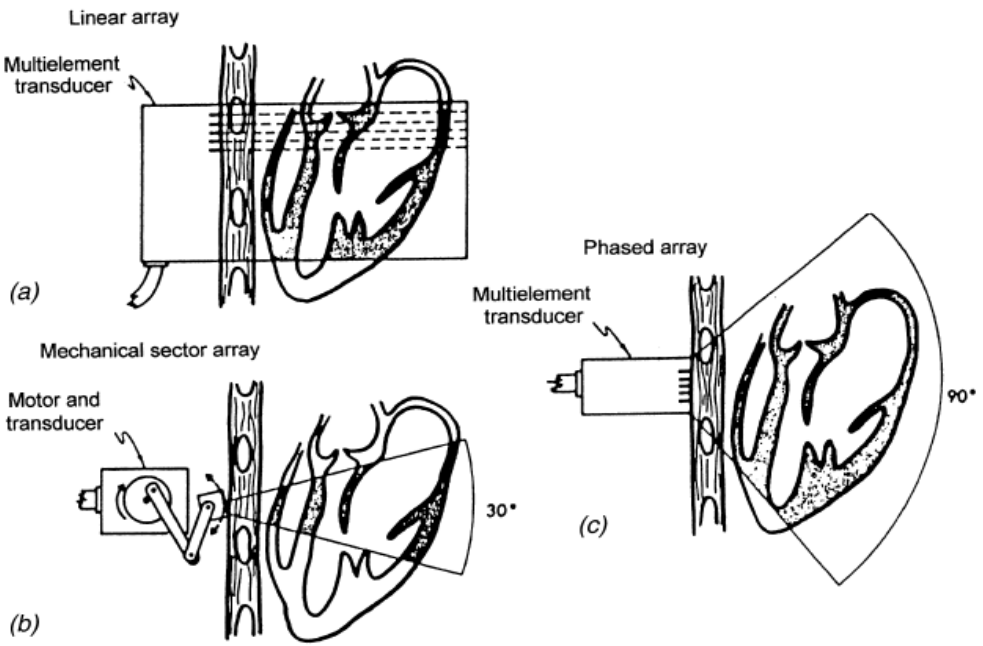
SENSORS IN ULTRASOUND IMAGING

The first and simplest ultrasound imaging systems applied the *A-mode (amplitude modulation)* imaging illustrated in Figure



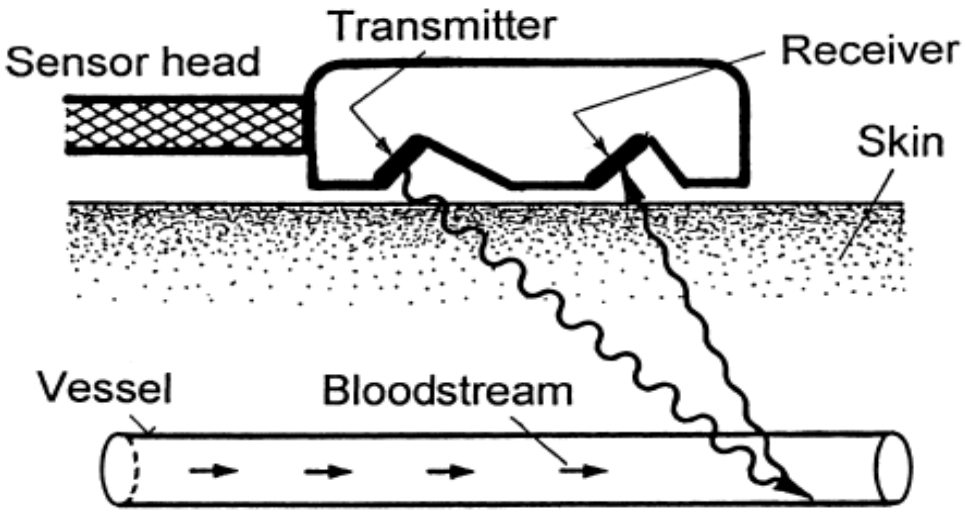
ULTRASOUND IMAGING

In *B-mode (brightness modulation)* imaging, all echo impulses are represented by a pixel on the display, and the brightness corresponds to the amplitude of the echo. To get a two-dimensional cross-sectional image, an appropriate scanning of the desired cross section is necessary



Scanning methods in B-mode ultrasound imaging: (a) sequential linear array scanner, (b) mechanical sector scanner, and (c) phased array sector scanne

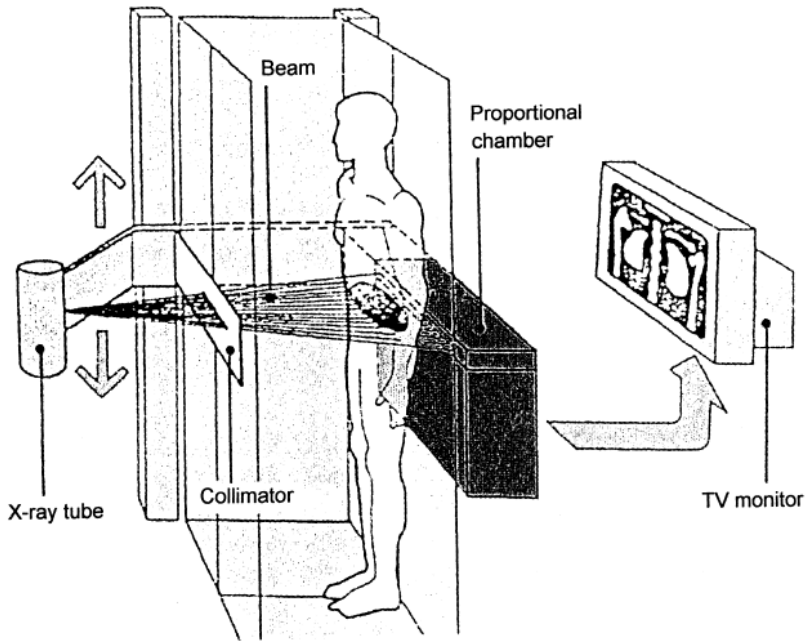
The Doppler blood-flow measurement



Doppler blood flow detectors operate by means of continuous sinusoidal excitation. The frequency difference calibrated for flow velocity can be displayed or transformed by a loudspeaker into an audio output.

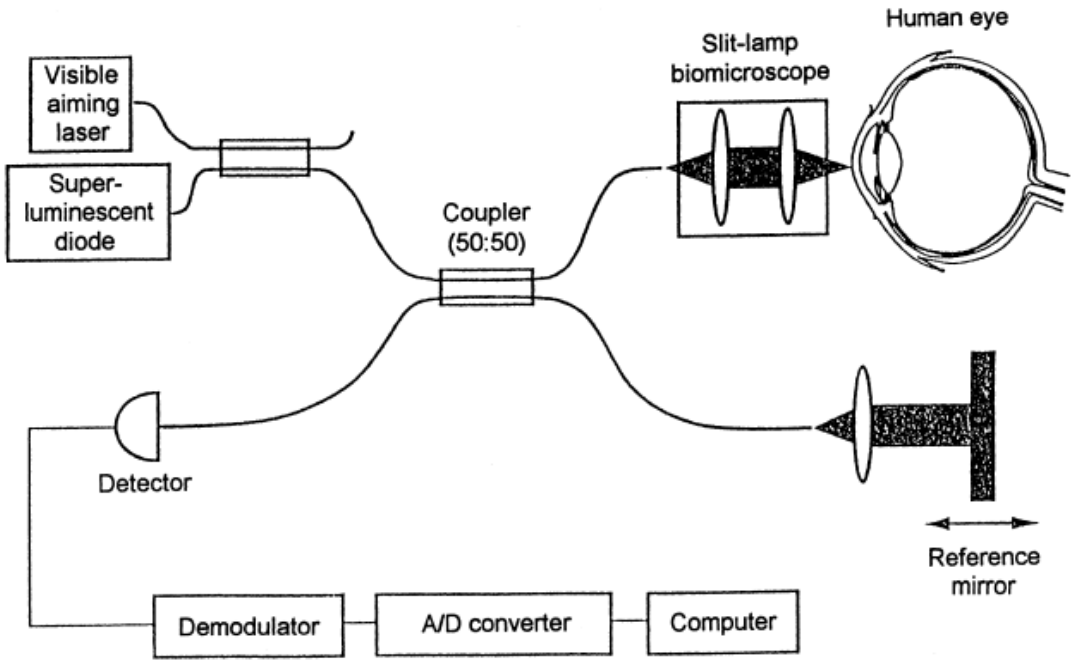
X-ray imaging system

In optically coupled CCD X-ray imaging system, X rays are impinged into a fluorescent screen and the image produced is then transferred onto the surface of an individual CCD by optical lenses.

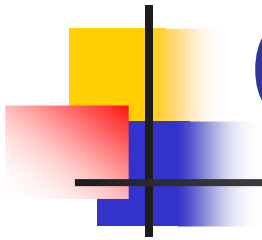


optical coherence tomography

The technique of *optical coherence tomography (OCT)* provides a micronscale resolution cross-sectional image from the overall eyeball, not only from the retina. OCT is similar to B-scan ultrasonic imaging



Schematic diagram of optical coherence tomography instrumentation



Questions

- What is The Doppler blood-flow measurement?
- What is ULTRASOUND IMAGING??
- What are the APPLICATIONS of SENSOR IN BIOMEDICAL?
- Explain the use of Sensors for Pressure Pulses

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Unit	I	Lecture - Topic	SENSOR IN BIOMEDICAL APPLICATIONS	Sub-Topic	SENSOR APPLICATIONS

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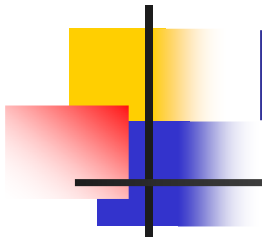

Reference

SENSORS *in* BIOMEDICAL APPLICATIONS

Fundamentals, Technology and Applications

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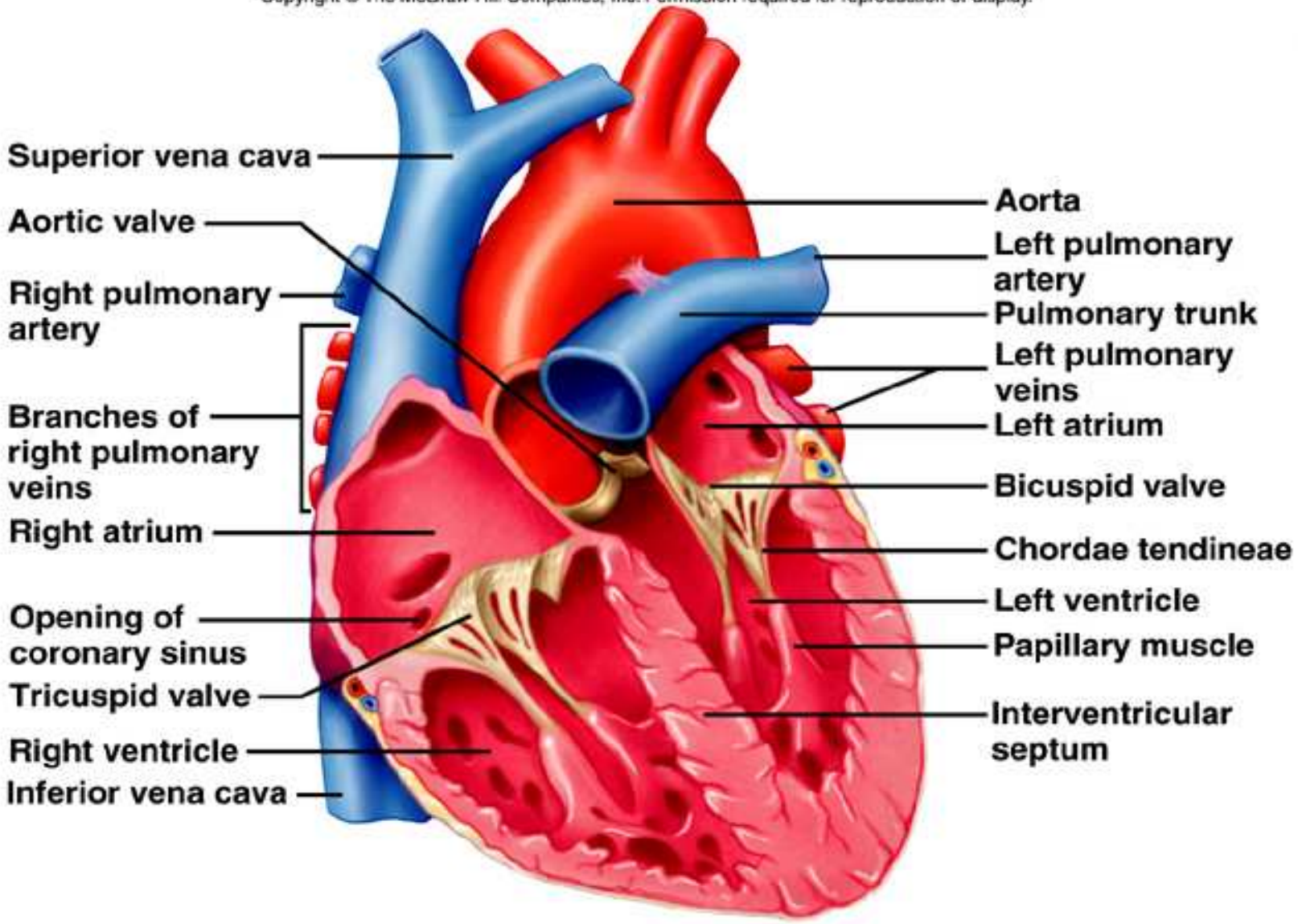
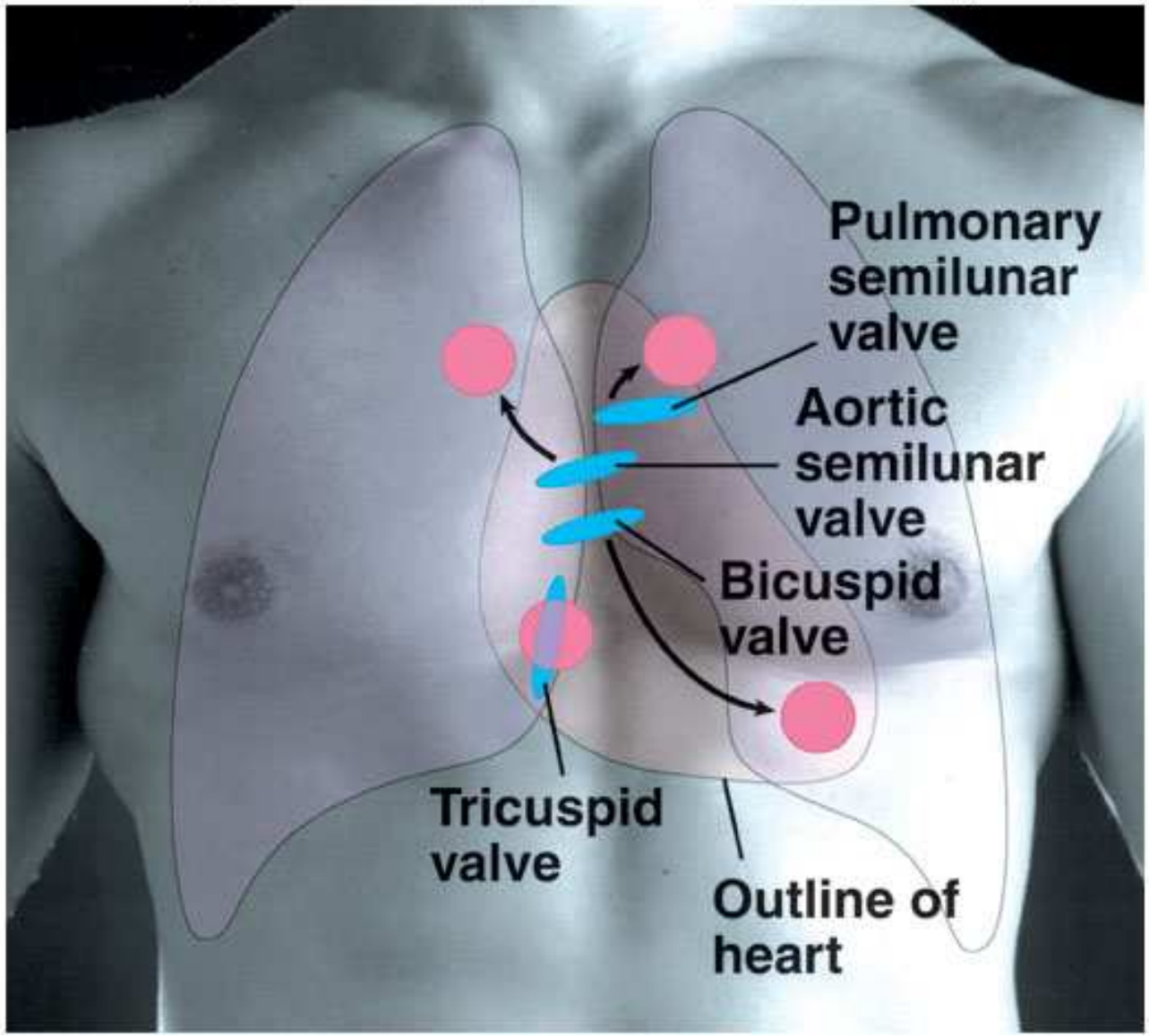
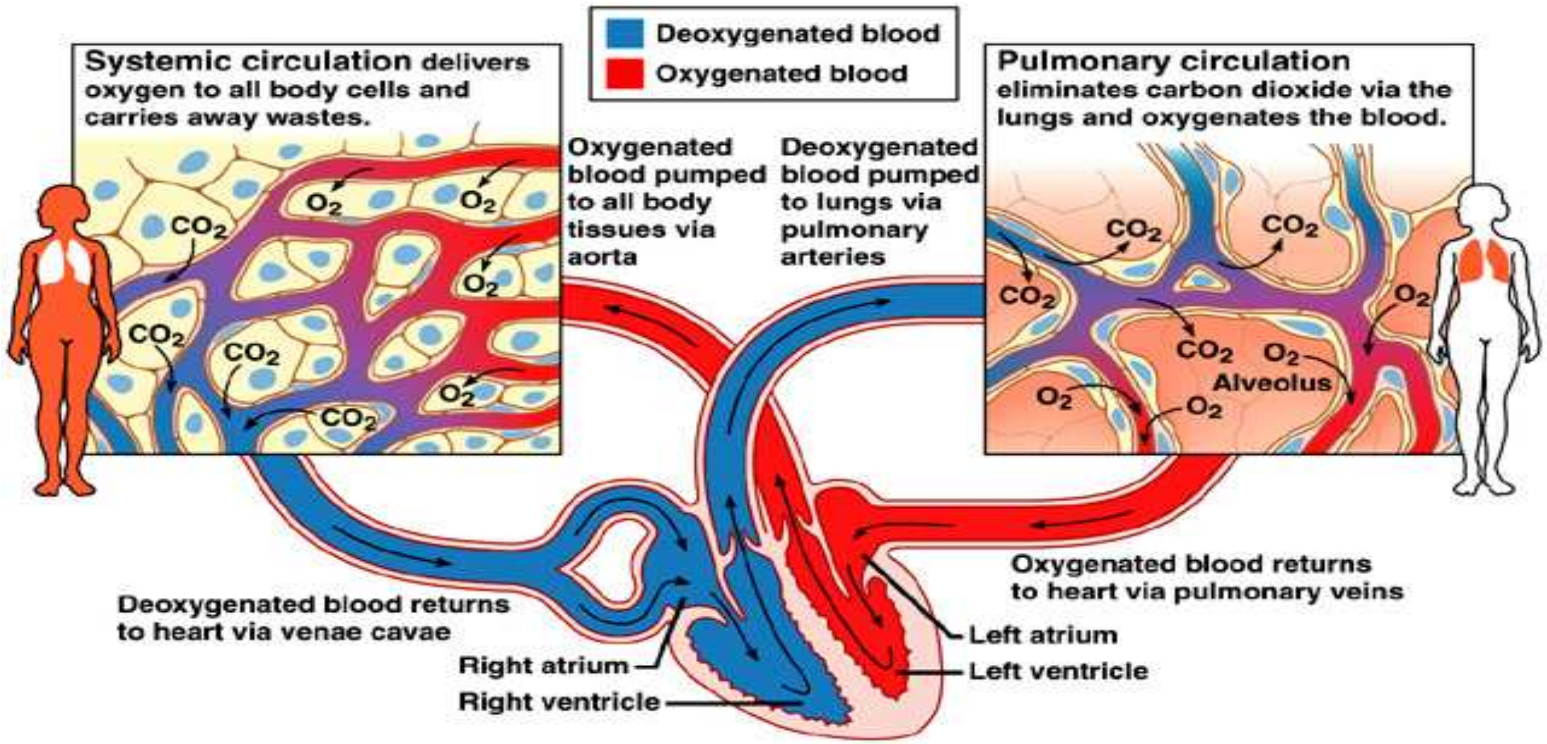
Anatomy and Physiology of the body

CARDIOVASCULAR SYSTEM



Location of Heart Valves





THE DOUBLE PUMP

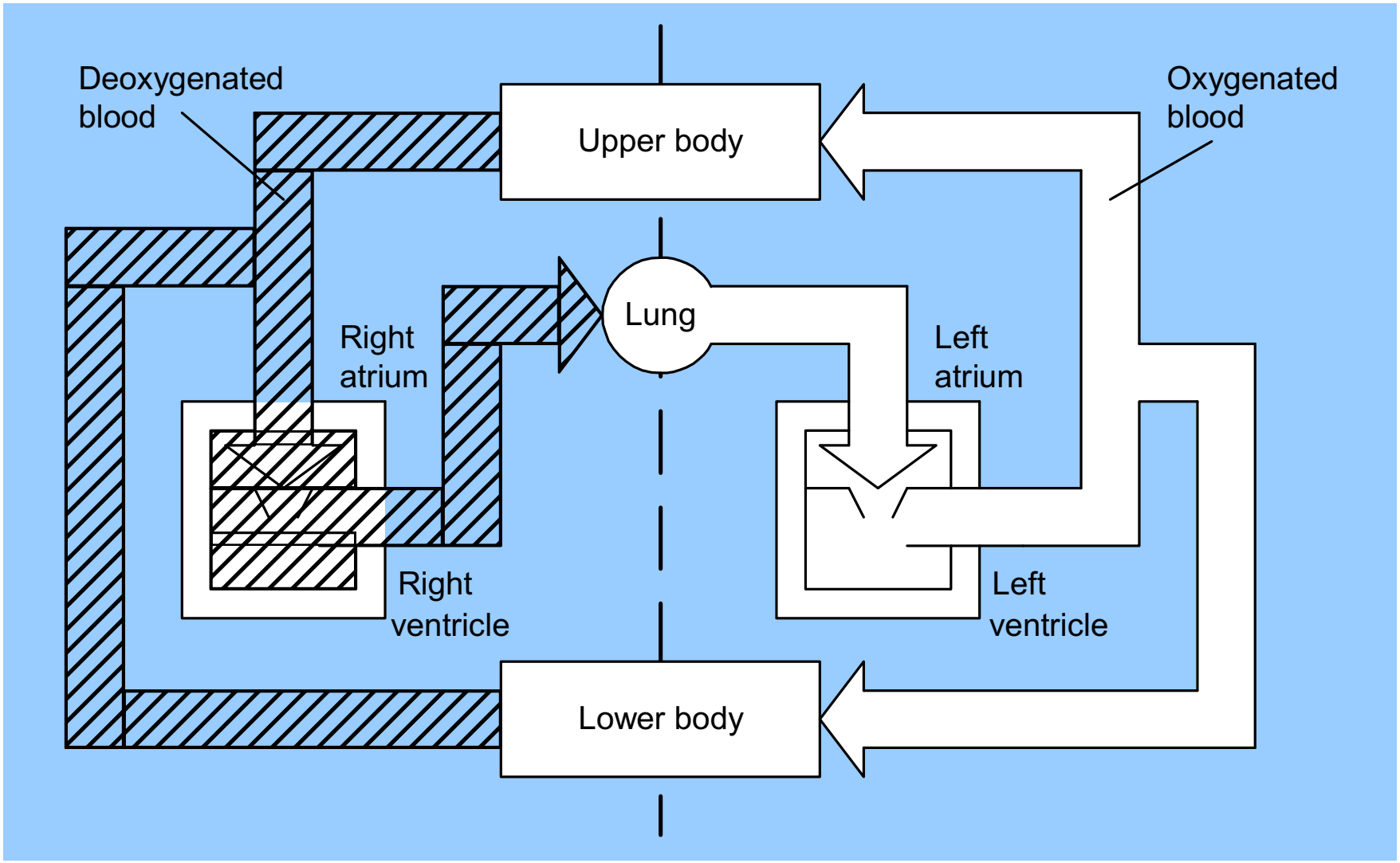


Figure The simplified circulatory system. The blood is delivered from the right ventricle to the lung. The oxygenated blood from the lung is then returned to the left atrium before being sent throughout the body from the left ventricle. Deoxygenated blood from the body flows back to the right atrium and the cycle repeats.

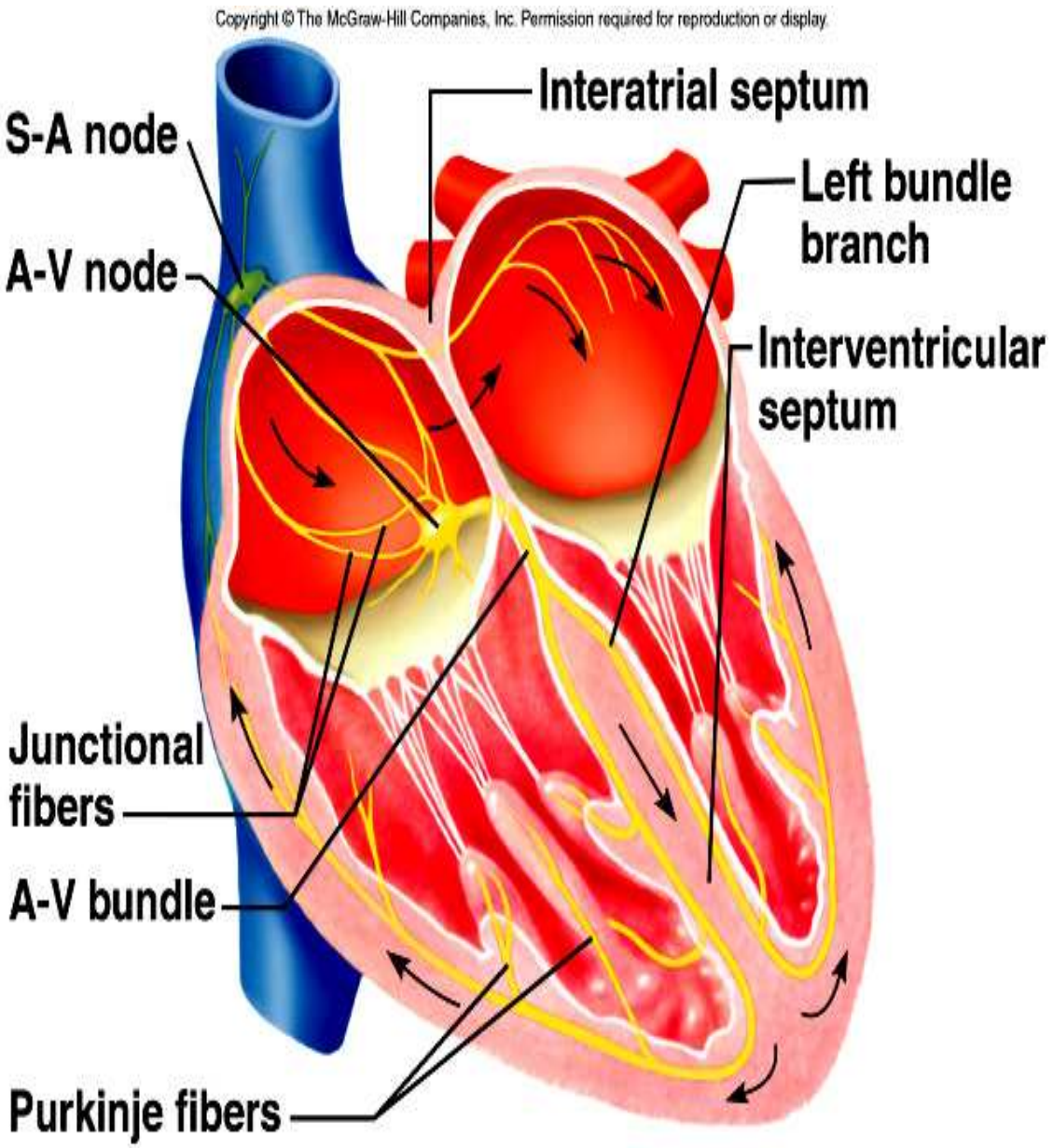
CONDUCTION SYSTEM OF THE HEART

Heart contracts as a unit

Atrial and ventricular syncytia help conduct electrical signals through the heart

Sinoatrial (S-A) node is continuous with atrial syncytium

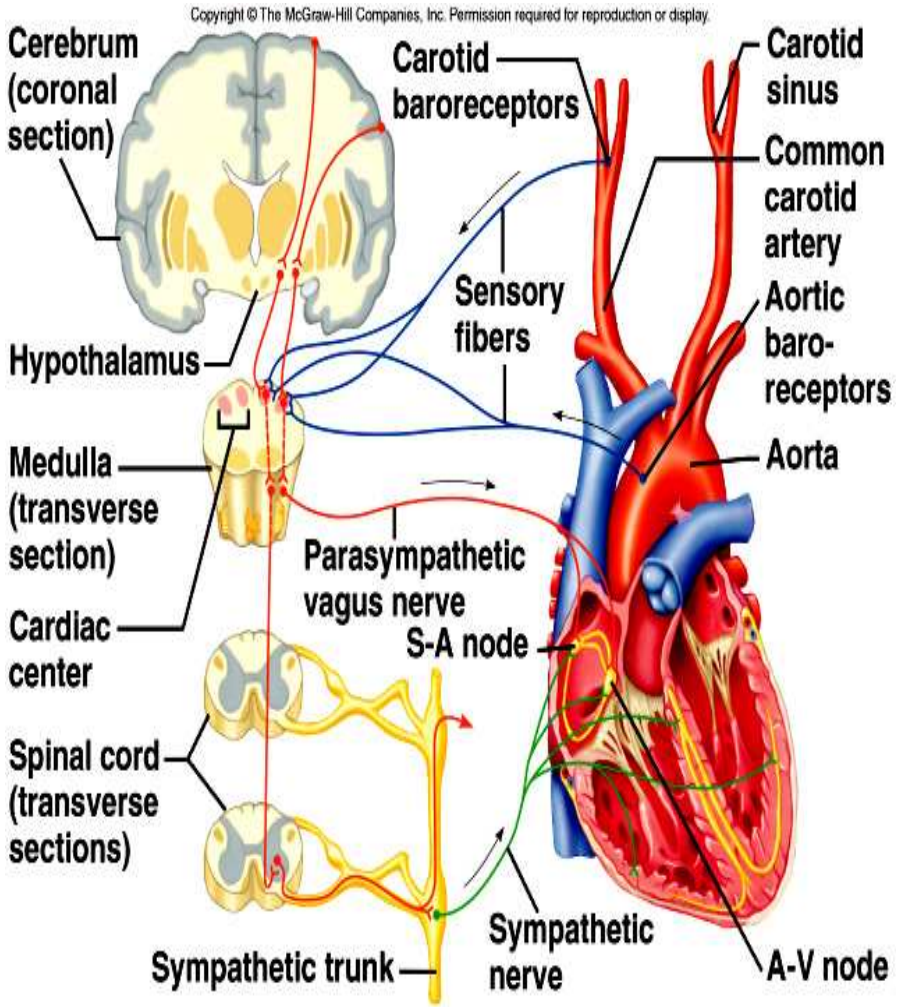
S-A node cells can initiate impulses on their own; activity is rhythmic



CARDIOVASCULAR CIRCULATION

- The cardiac cycle is regulated by the cardiac

  center in the medulla oblongata which regulates sympathetic and parasympathetic input



Questions

- What is **CARDIOVASCULAR SYSTEM**?
- **Give the detail study of Anatomy and Physiology of the body?**
- Explain the CARDIOVASCULAR CIRCULATION?

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Reference

Cromwell- Biomedical Instrumentation and Measurements- PHI

www.hartnell.edu/faculty/awright/powerpoint/cardiovascular%20system.ppt -

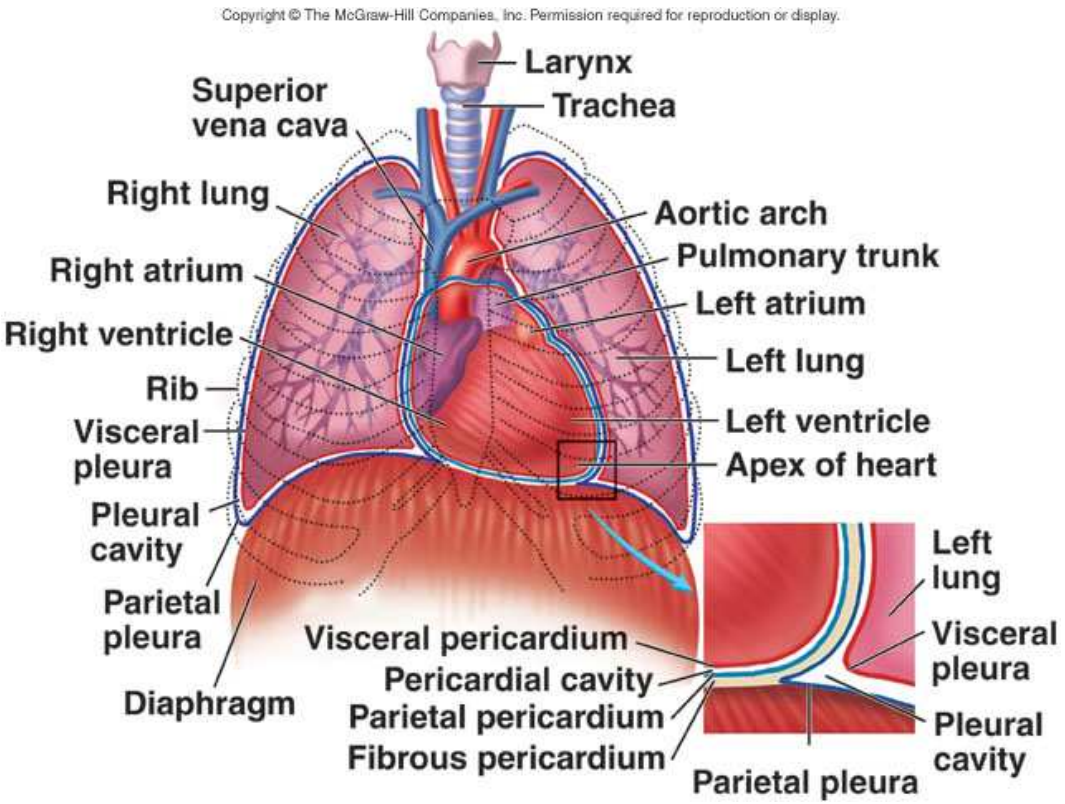
***Encyclopedia of* Biomaterials and Biomedical engineering**
second edition, Volume 1
Edited by
gary e. Wnek, gary l. BoWlin

www.knowitall.org/educatorplus/files/vsi/resources/
The%20Cardiovascular%20System.ppt -

Functions of the Heart

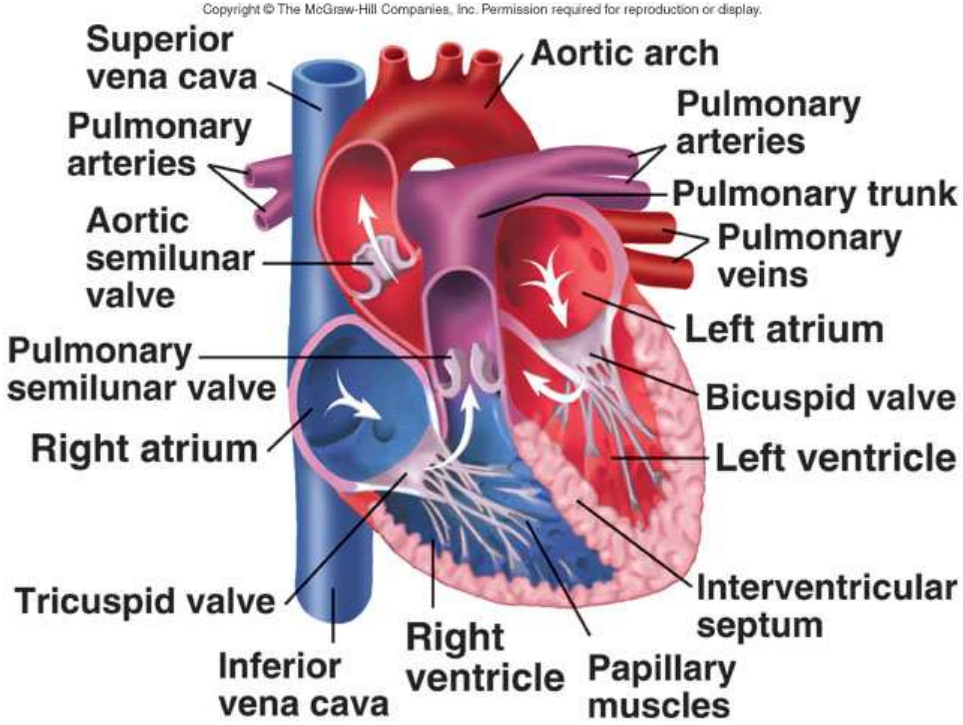
- Generating blood pressure
- Routing blood
  - Heart separates pulmonary and systemic circulations
- Ensuring one-way blood flow
  - Heart valves ensure one-way flow
- Regulating blood supply
  - Changes in contraction rate and force match blood delivery to changing metabolic needs

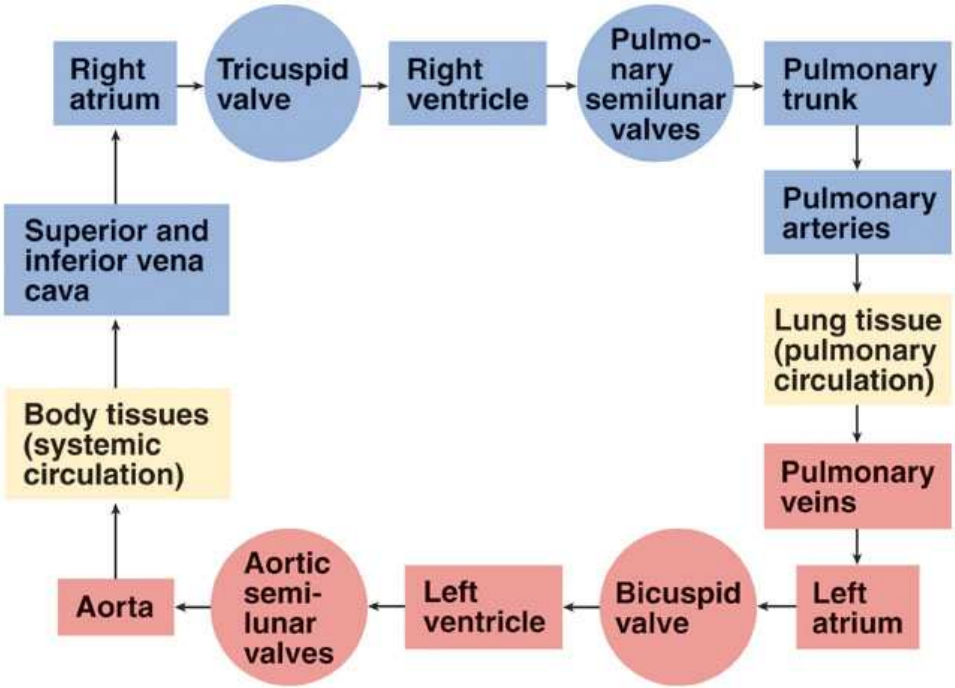
Size, Shape, Location of the Heart



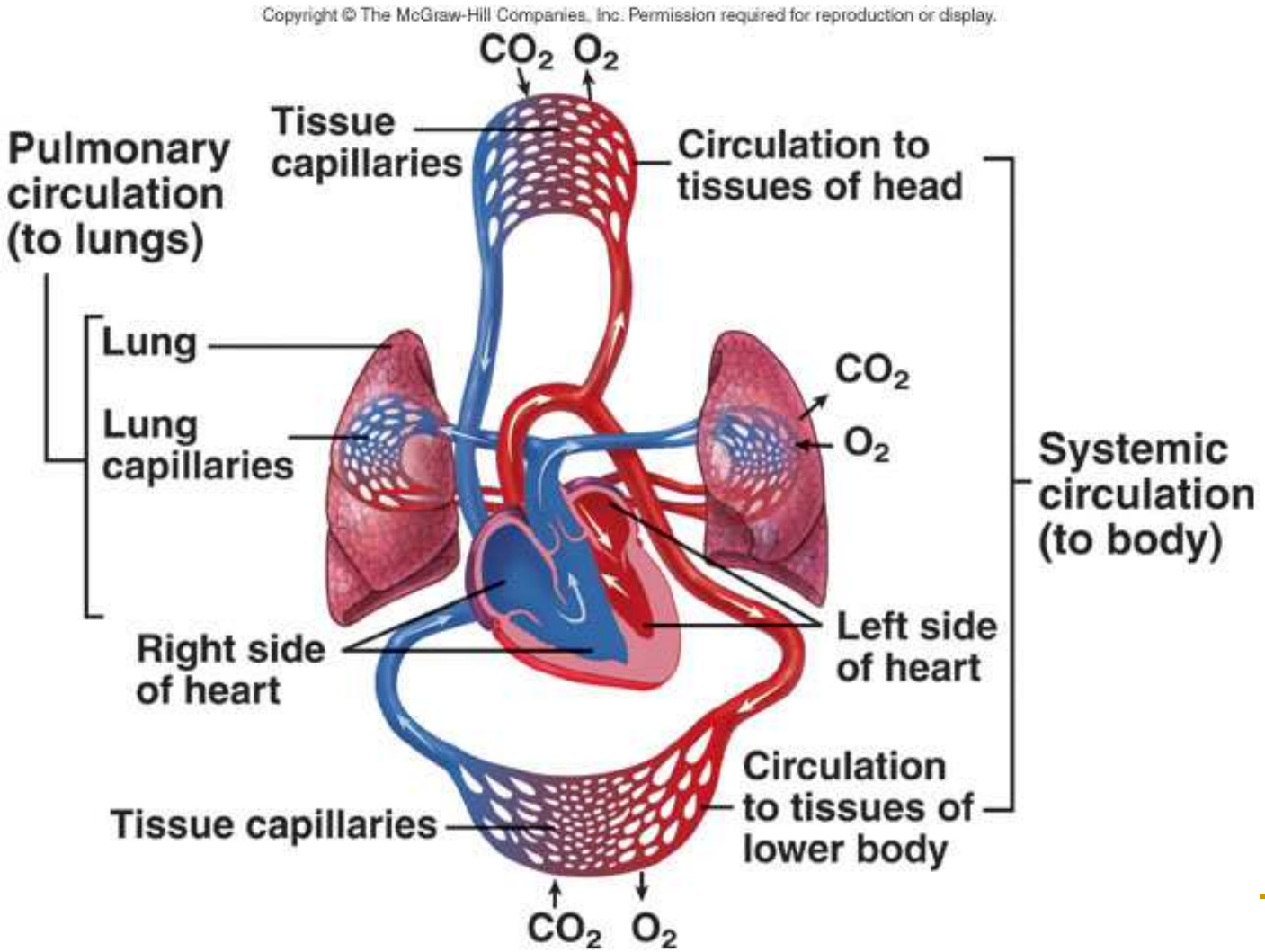
- Size of a closed fist
- Shape
  - Apex: Blunt rounded point of cone
  - Base: Flat part at opposite of end of cone
- Located in thoracic cavity in mediastinum

Blood Flow Through Heart





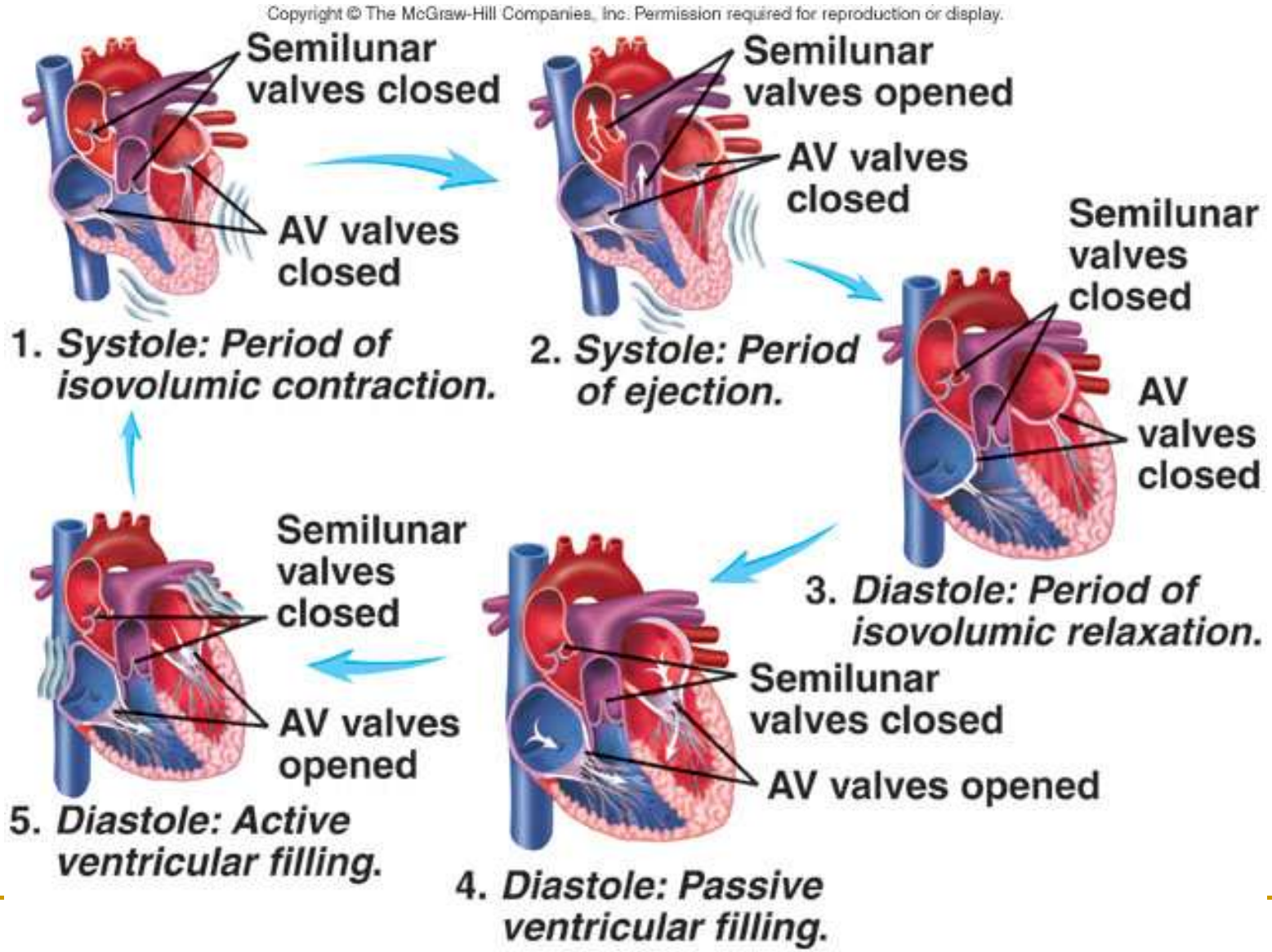
Systemic and Pulmonary Circulation

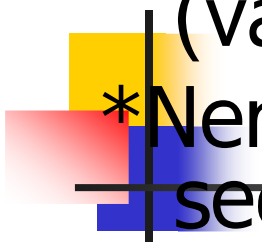


Cardiac Cycle

- Heart is two pumps that work together, right and left half
- Repetitive contraction (systole) and relaxation (diastole) of heart chambers
- Blood moves through circulatory system from areas of higher to lower pressure.
  - Contraction of heart produces the pressure

Cardiac Cycle





*Parasympathetic: from medulla oblongata (vagus nerve)

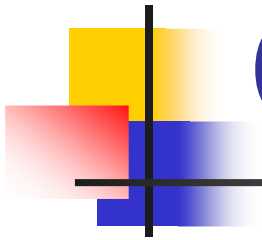
*Nerve branches to S-A and A-V nodes, and secretes acetylcholine (slows rate)

*Parasympathetic activity can increase (slow heart rate) or decrease (increase heart rate)

*Sympathetic nervous system through celiac plexus to heart secretes norepinephrine increases force of contractions

*Cardiac control center in medulla oblongata maintains balance between the two

*Normally both sympathetic and parasympathetic function at a steady background level



Questions

- What is Pulmonary Circulation?
- How the Blood Flow Through Heart?
- What are the Functions of the Heart?
- Explain the Cardiac Cycle?

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Unit	I	Lecture - Topic	Functions of the Heart	Sub-Topic	Cardiac Cycle

Fill Up the Following Check List (Should be filled by the Content Creator)	Yes	No
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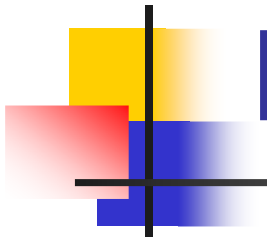

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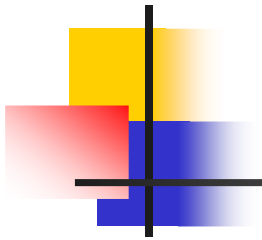
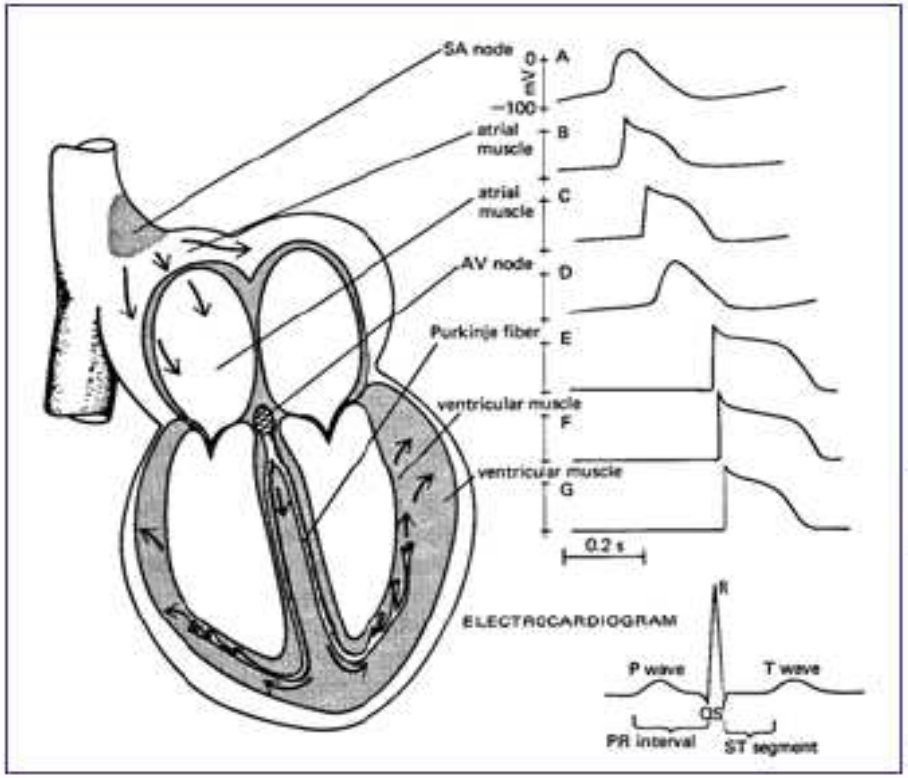
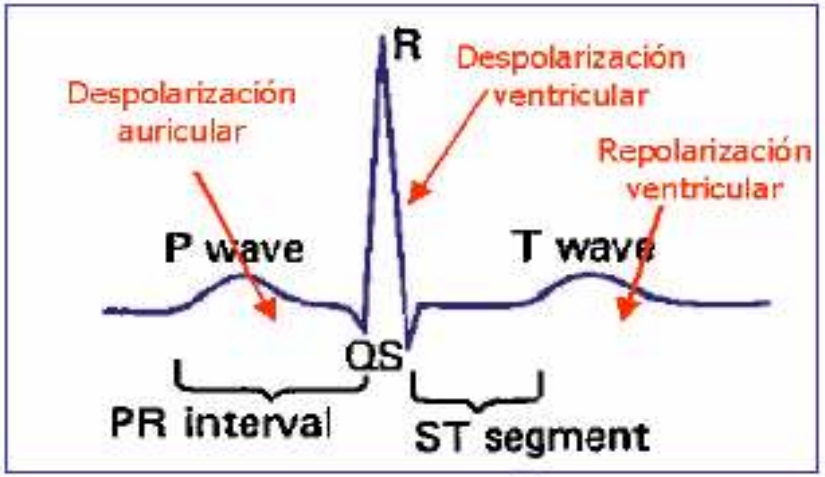


BIO-MEDICAL INSTRUMENTATION

UNIT-2

Electrocardiogram (ECG)





P: Contracción auricular
QRS: Contracción ventricular
T: Repolarización ventricular

Dipole Model

- Dipole represents electric activity of the heart Changes in the dipole magnitude and orientation cause detectable changes in the electric field

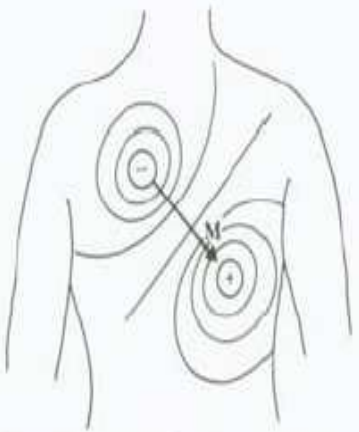


Figure 6.1 Rough sketch of the dipole field of the heart when the R wave is maximal The dipole consists of the points of equal positive and negative charge separated from one another and denoted by the dipole moment vector **M**.

Vector Algebra

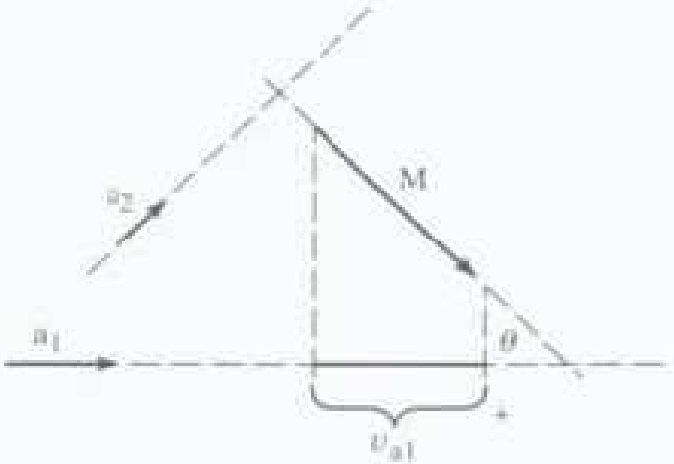


Figure 6.2 Relationships between the two lead vectors $\mathbf{a}_1$ and $\mathbf{a}_2$ and the cardiac vector $\mathbf{M}$. The component of $\mathbf{M}$ in the direction of $\mathbf{a}_1$ is given by the dot product of these two vectors and denoted on the figure by v_{a1}. Lead vector $\mathbf{a}_2$ is perpendicular to the cardiac vector, so no voltage component is seen in this lead.

ECG: ECG: Einthoven's Triangle

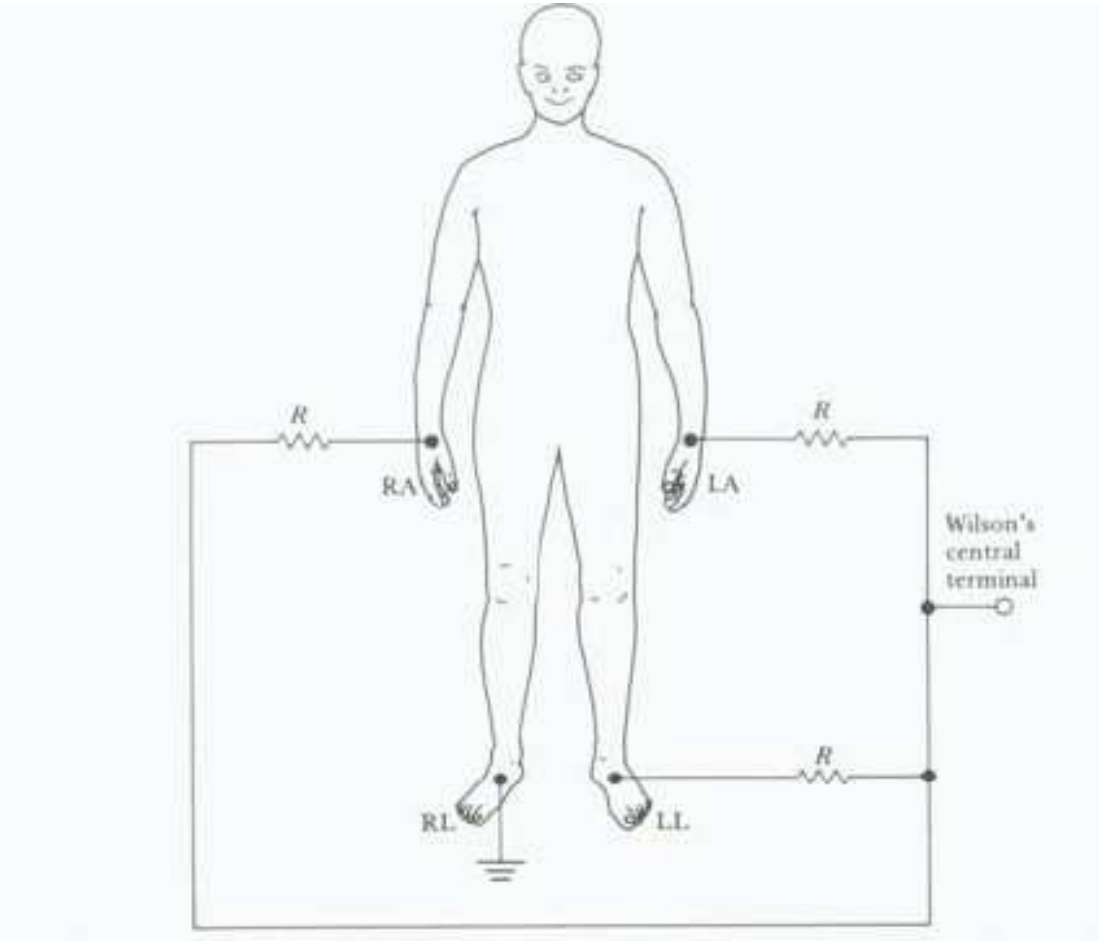
Figure 6.3 Cardiologists use a standard notation such that the direction of the lead vector for lead I is 0°, that of lead II is 60°, and that of lead III is 120°. An example of a cardiac vector at 30° with its scalar components seen for each lead is shown.

- Three vectors used to fully identify the electrical activity
  - ✓ vector shown in frontal plane of the body
- Kirchhoff's law is used for the three leads

  $I - II + III = 0$

Leads I, II, III

ECG: Electrode Placement



Augmented leads:
aVR, aVL, aVF
Right, left, foot
With respect to central terminal

ECG Wave

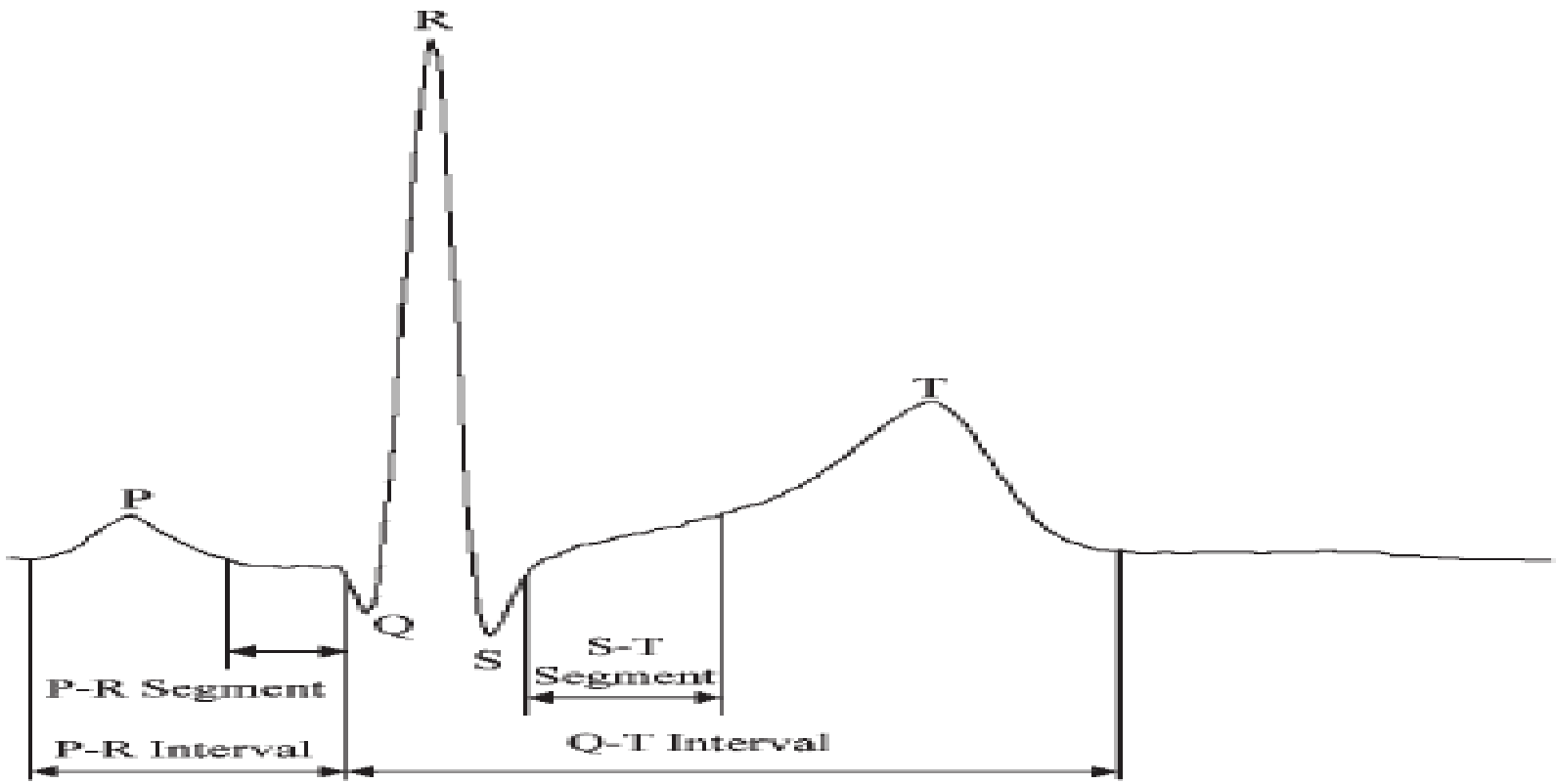
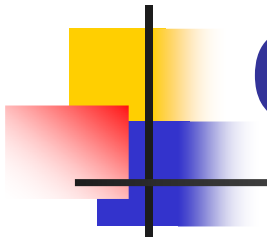


Fig. 6 One cycle of a typical ECG showing P, Q, R, S, and T waves with segments and intervals.



Components of ECG Wave

Ventricular Repolarization and the T Wave

The T wave is a manifestation of ventricular repolarization. In most leads, the T wave is an upward deflection in the range of 0 to 0.8mV with a duration of 0.1 to 0.25 seconds.[6]

Atrial Repolarization

The atrial repolarization wave is normally not seen in the ECG because it coincides with and is obscured by the electrically dominant QRS complex.

Components of ECG Wave

The U Wave

The U wave is a rare occurrence in some ECGs immediately after the T wave, with a similar shape and size but an amplitude that is 5 to 20% of the T wave. It is believed to be caused by the repolarization of the papillary muscles.[4]

The S-T Segment

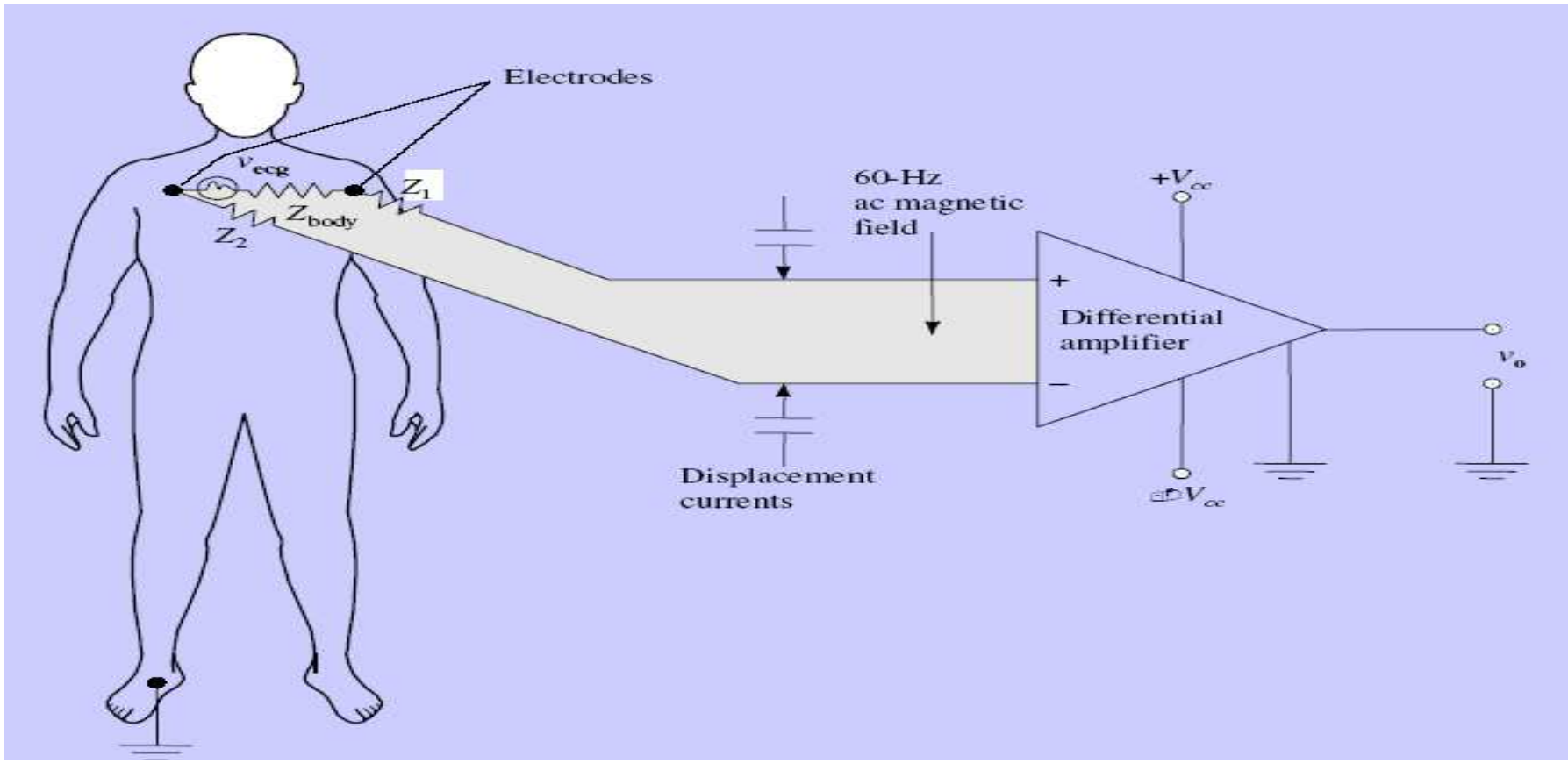
This is a flat segment from the end of the QRS complex to the beginning of the T wave

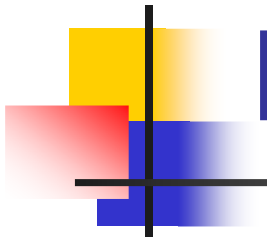
ECG AMPLIFIER

a difference amplifier (also called a differential amplifier) must be used.Because the difference amplifier amplifies the difference between two input quantities, the electrode potentials, if equal in magnitude and phase, will cancel each other out. In reality, however, small differences in the surface characteristics—such as motion artifact—will cause wild swings of the amplified signal.

Another important advantage of the difference amplifier is the rejection of common mode inputs such as 60 and 120 Hz noise from the surrounding environment.

Difference Amplifier





ECG AMPLIFIER

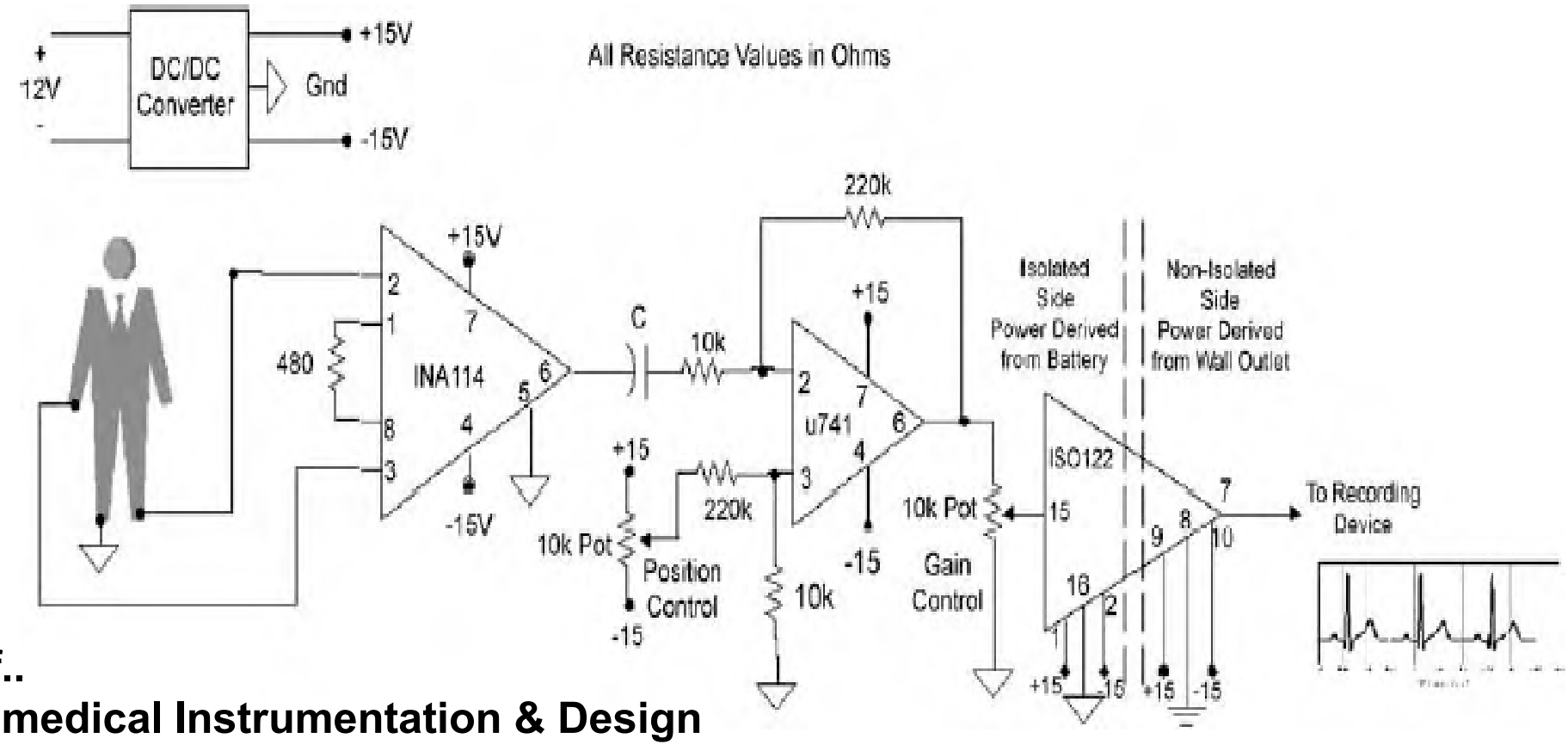
Partial Parts List

Special components

INA114 Instrumentation amplifier
ISO122 Isolation amplifier
AEE00-12Vin DC/DC converter

Commercial instrumentation amplifiers with common mode rejection ratios (CMRR) of W100 db are readily available and provide a good rejection of 60 and 120 Hz noise.

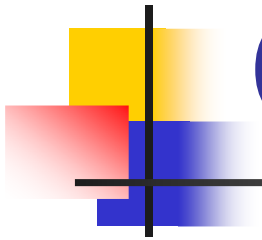
Circuit diagram for a practical ECG amplifier



Ref..

Biomedical Instrumentation & Design

Matt O'Donnell



Questions

- What is Einthoven's Triangle?
- What is Difference Amplifier and how it is used in BMI?
- What are the Components of ECG Wave?
- Explain the Circuit diagram for a practical ECG amplifier?

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Unit	II	Lecture - Topic	Electrocardiogram (ECG)	Sub-Topic	ECG AMPLIFIER, ECG Wave, Electrode Placement

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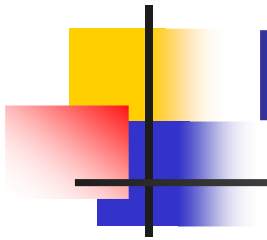

Reference

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Biomedical Instrumentation & Design
Matt O'Donnell

IEEE TRANSACTIONS ON INSTRUMENTATION AND MEASUREMENT

ECG Paper

The conventional recording devices plot the ECG onto a special paper strip that has major gridlines (5 mm) and minor gridlines (1 mm). In the horizontal axis (time), each 1mm represents 0.04 sec and each 5mm (major grid) represents 0.2 sec. On the vertical axis (volts), each major gridline represents 0.5 mV.

Three Augmented Limb Leads

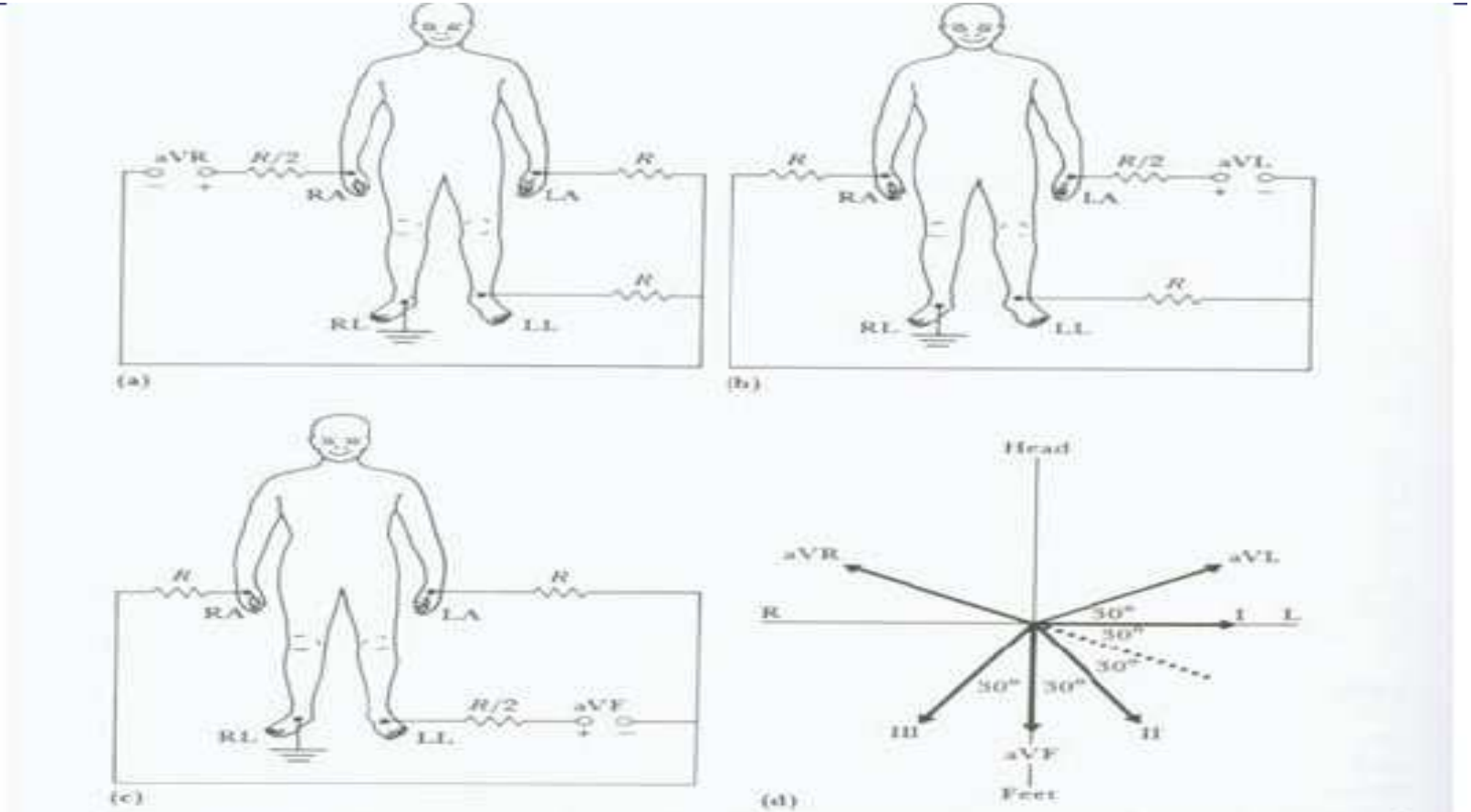
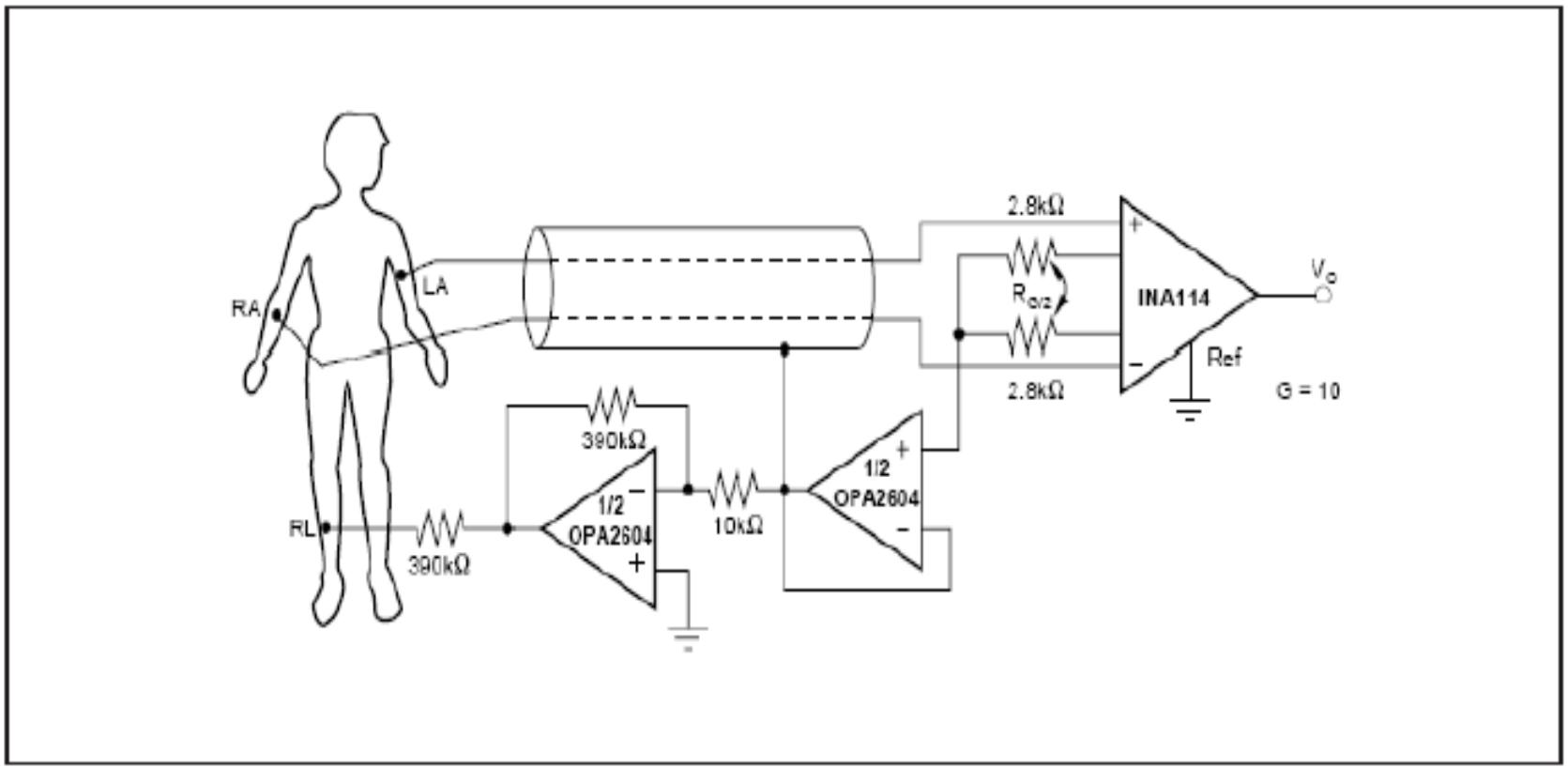


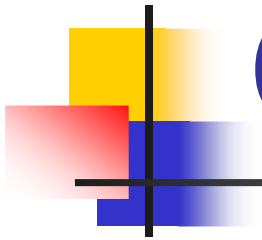
Figure 6.5 (a), (b), (c) Connections of electrodes for the three augmented limb leads. (d) Vector diagram showing standard and augmented lead-vector directions in the frontal plane.

Table 2 Connections for standard leads

	Positive electrode	Negative electrode
Standard limb leads		
Lead I	Left arm	Right arm
Lead II	Left leg	Right arm
Lead III	Left leg	Left arm
Augmented unipolar leads		
aVL	Left arm	All other limbs
aVR	Right arm	All other limbs
aVF	Left leg	All other limbs
Precordial (chest) leads		
V1–V6	Corresponding chest electrode	"Common terminal" of all the limb electrodes

ECG





Questions

- What kind of ECG Paper used in BMI?
- What are Three Augmented Limb Leads?

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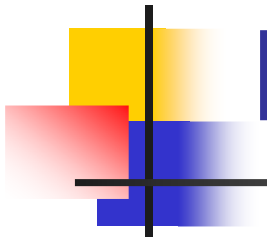


Reference

Cromwell- Biomedical Instrumentation and Measurements- PHI

Biomedical Instrumentation & Design
Matt O'Donnell

IEEE TRANSACTIONS ON INSTRUMENTATION AND MEASUREMENT

Pacemaker

- When are pacemakers used?

Pacemakers may be prescribed for a number of conditions, including:

Bradycardia – a condition in which the heart beats too slowly, causing symptoms such as fatigue, dizziness or fainting spells. Bradycardia may be caused by the wear and tear of age or by conditions such as sick sinus syndrome (SSS) or heart block.

Conditions of Pacemaker

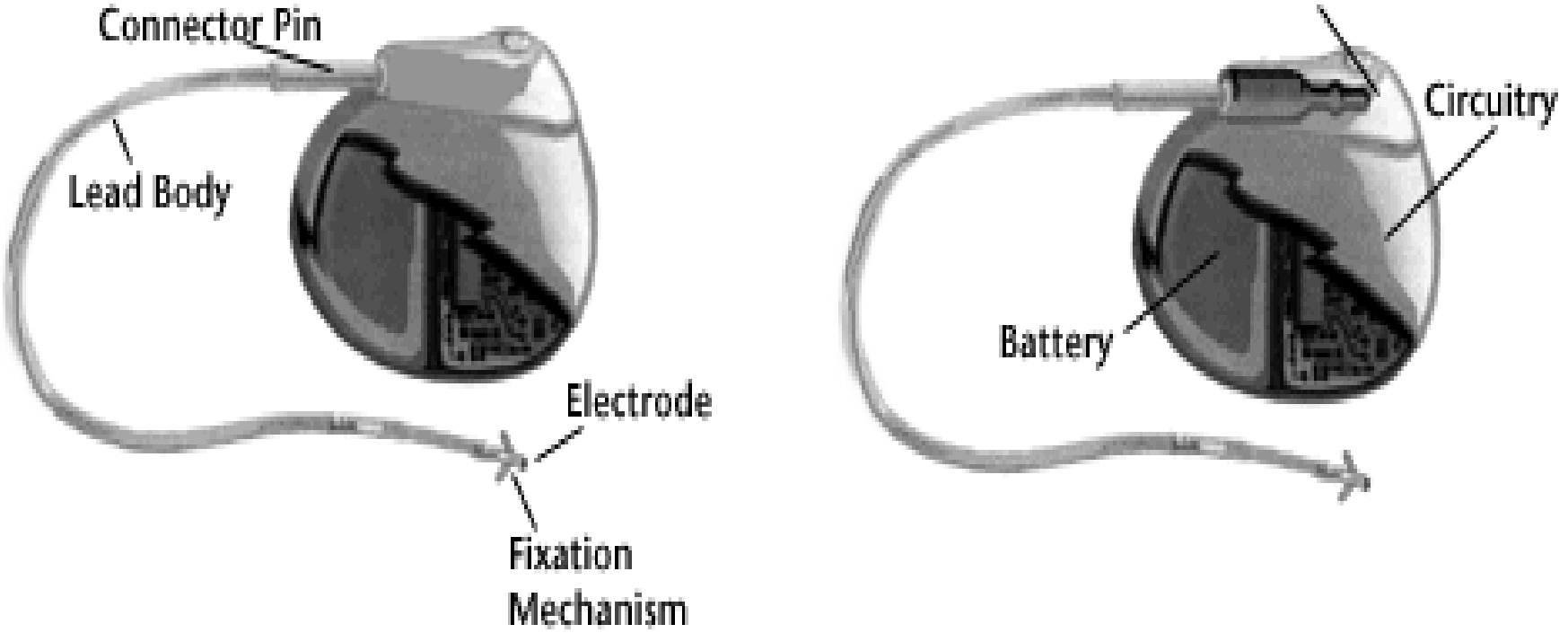
Atrial fibrillation – a common heart rhythm disorder in which the upper chambers of the heart beat rapidly and chaotically. Sometimes people with atrial fibrillation can also have slow rhythms. Medicines used to control atrial fibrillation may result in slow rhythms which are treated by pacemakers.

Heart failure – a condition in which the heartbeat is not sufficient to supply a normal volume of blood and oxygen to the brain and other parts of the body. A special pacemaker can be carefully programmed to increase the force of muscle contractions in the heart. This is called “biventricular pacing” or “resynchronization” therapy.

Conditions of Pacemaker

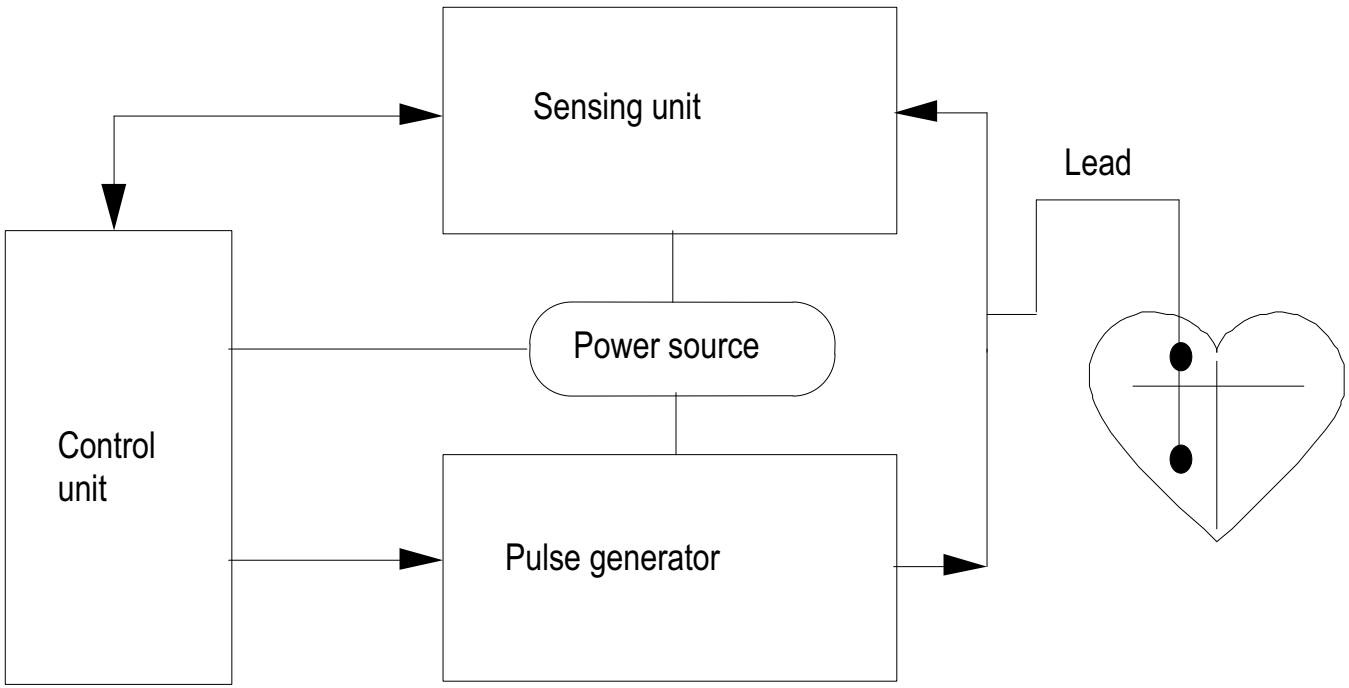
Syncope – a condition best known as the common faint, is usually not serious. Some patients faint when their heart rhythm becomes very slow. For a small percentage of people who experience severe and frequent fainting spells, a pacemaker may prevent the heart rate from slowing to the point of fainting.

A practical pacemaker



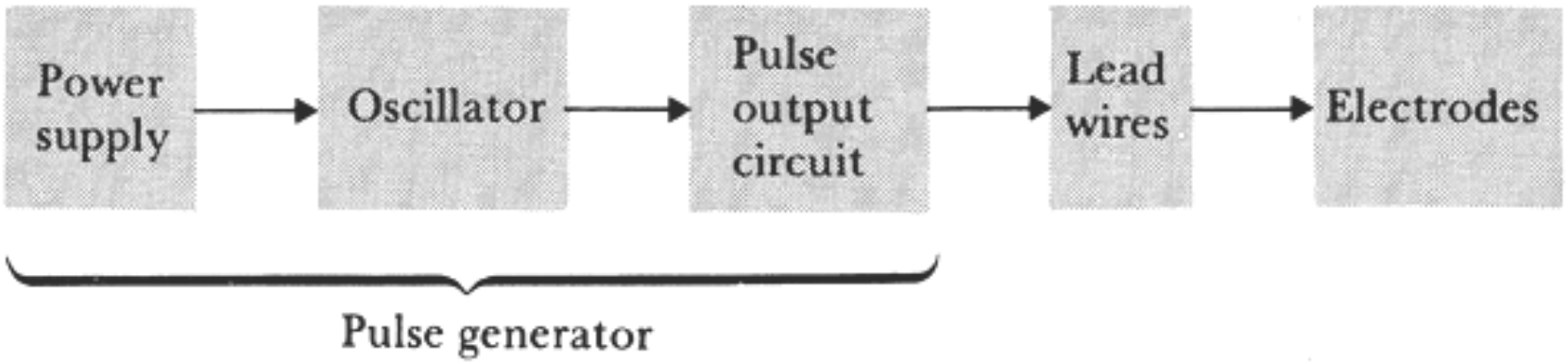
A practical pacemaker (Medtronic inc., 2001)

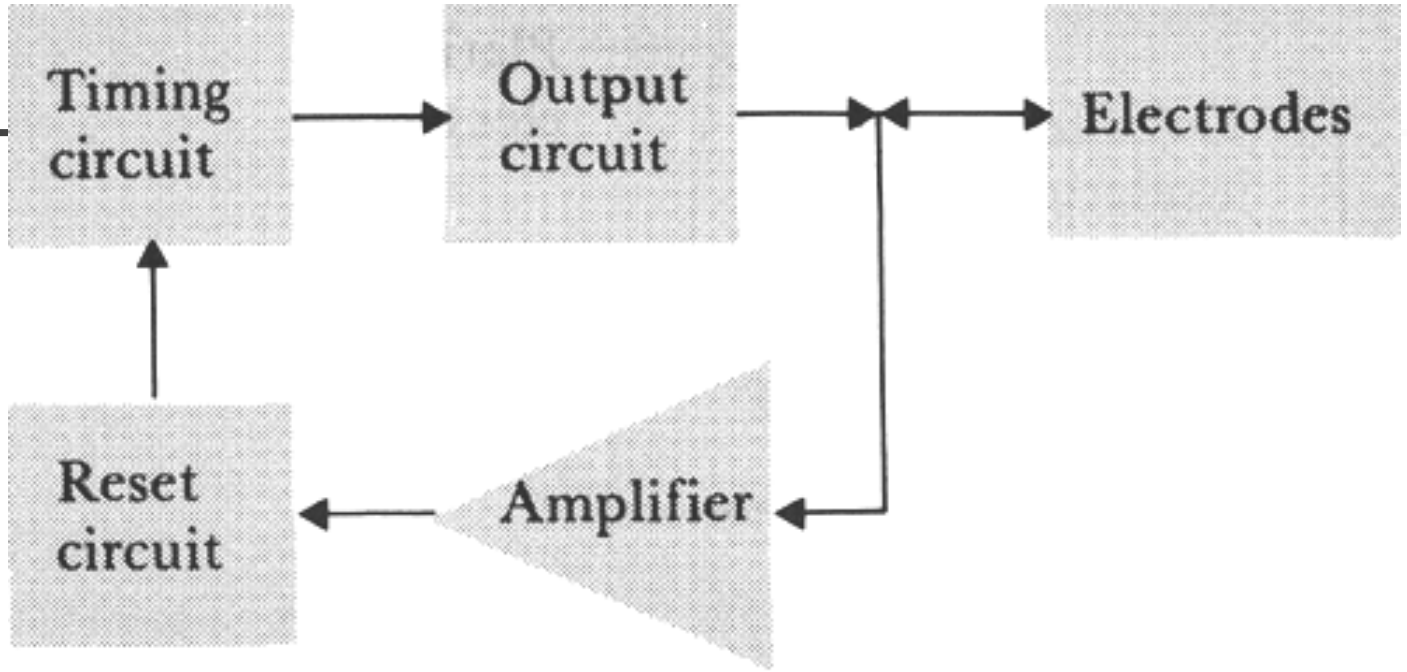
- A simplified version of a pacemaker stimulating a load. In this case, the load is simply a cell membrane



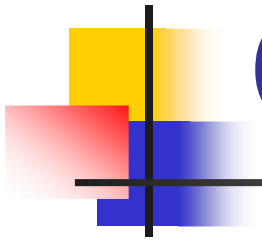
The pacemaker senses from the heart and applies pulses to the heart

Block diagram of an asynchronous cardiac pacemaker





A demand-type synchronous pacemaker Electrodes serve as a means of both applying the stimulus pulse and detecting the electric signal from spontaneously occurring ventricular contractions that are used to inhibit the pacemaker's timing circuit.



Questions

- What is pacemaker?
- Draw Block diagram of an asynchronous cardiac pacemaker?
- What are the Conditions of Pacemaker?
- Explain the block diagram for a practical pacemaker?

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Unit	II	Lecture - Topic	Pacemaker	Sub-Topic	Block diagram

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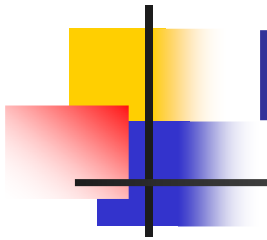


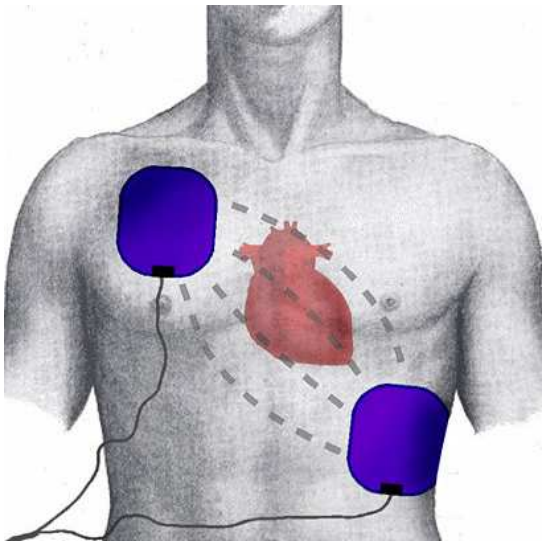
Reference

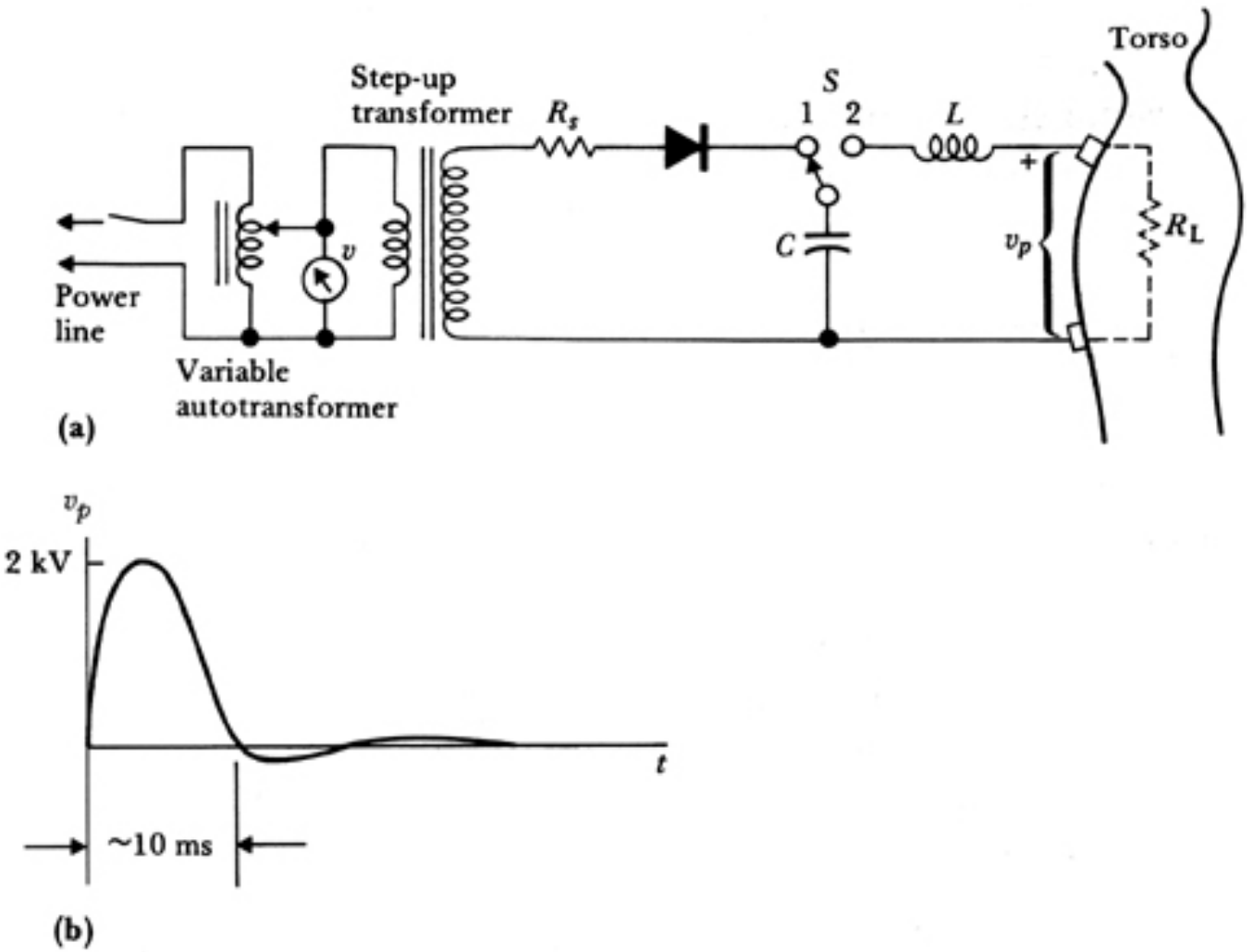
J. G. Webster (ed.), Design of cardiac pacemakers, IEEE Press, 1995

Pandey & Kumar-Biomedical Electronics and Instrumentation. – Kataria

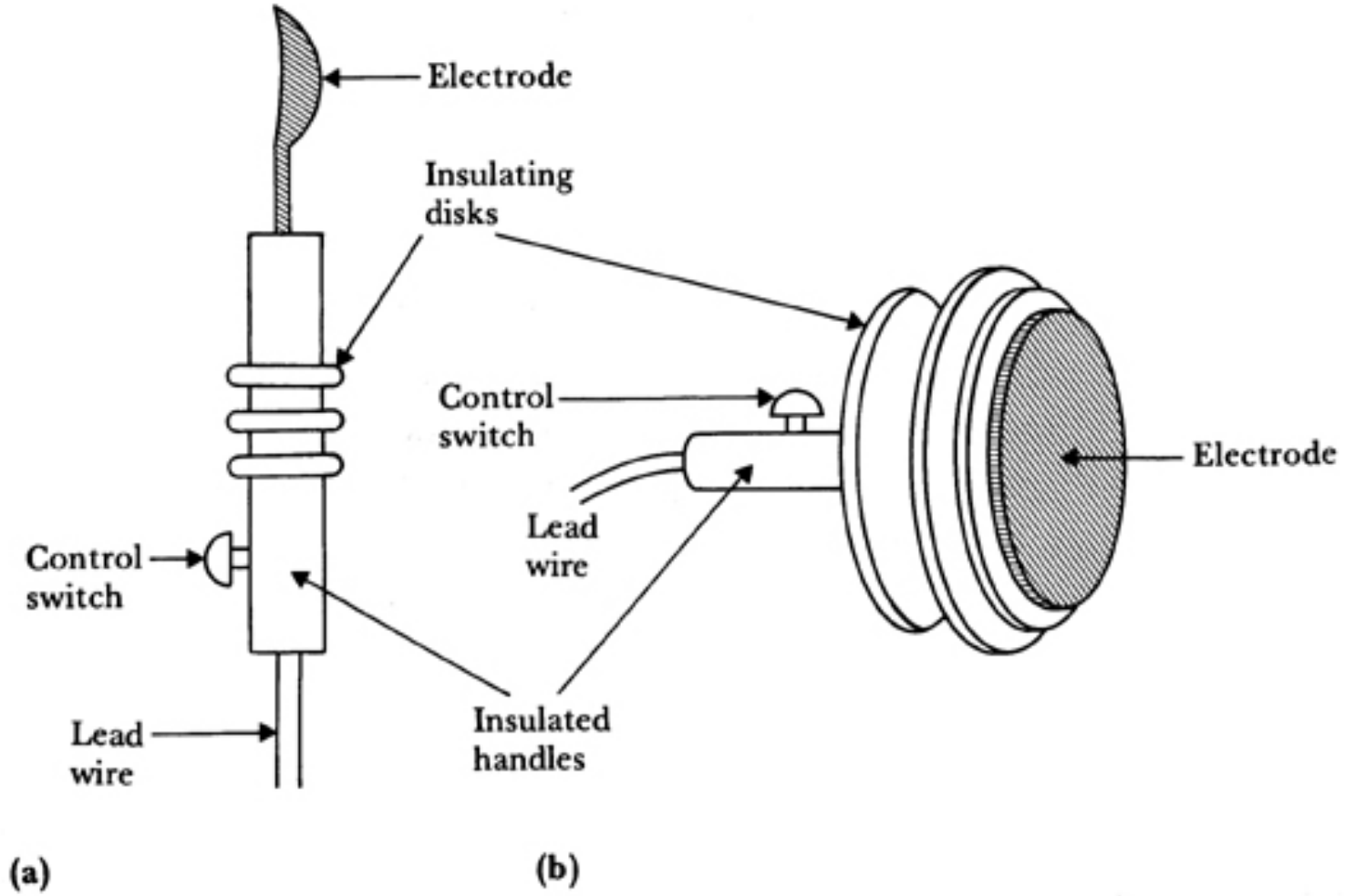
Defibrillation

Defibrillation Defibrillation is the definitive treatment for the life-threatening cardiac arrhythmias, ventricular fibrillation and ventricular tachycardia. Defibrillation consists of delivering a therapeutic dose of electrical energy to the affected heart with a device called a defibrillator. This depolarizes a critical mass of the heart muscle, terminates the arrhythmia, and allows normal sinus rhythm to be reestablished by the body's natural pacemaker, in the sinoatrial node of the heart.

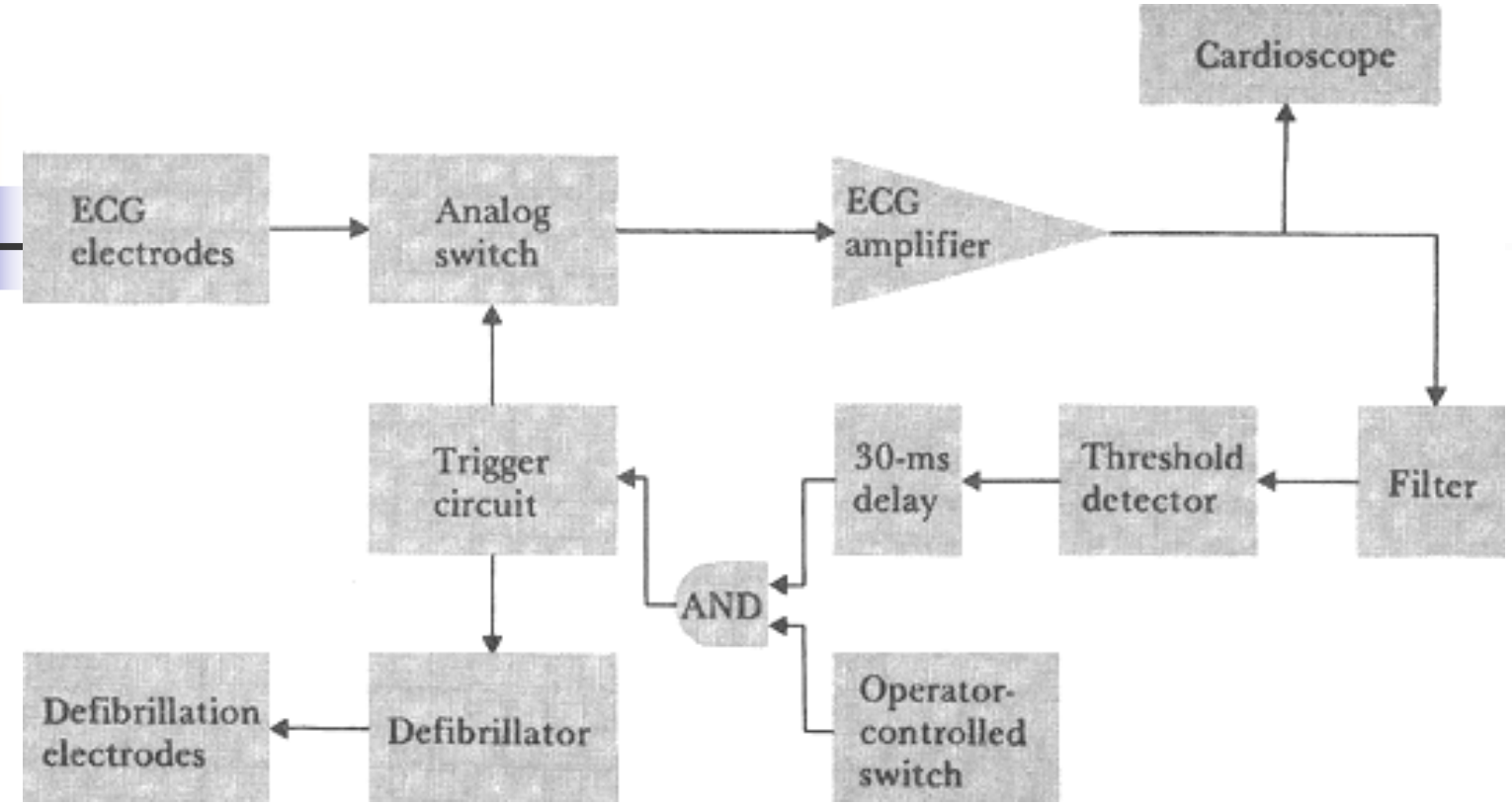




(a) Basic circuit diagram for a capacitive–discharge type of cardiac defibrillator. (b) A typical waveform of the discharge pulse. The actual waveshape is strongly dependent on the values of L, C, and the torso resistance R_L.



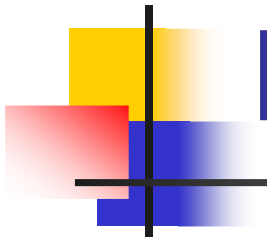
Electrodes used in cardiac defibrillation (a) A spoon-shaped internal electrode that is applied directly to the heart. (b) A paddle-type electrode that is applied against the anterior chest wall.



A cardioverter The defibrillation pulse in this case must be synchronized with the R wave of the ECG so that it is applied to a patient shortly after the occurrence of the R wave.

reference

J. G. Webster (ed.), Design of cardiac pacemakers, IEEE Press, 1995.



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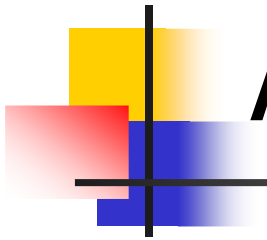
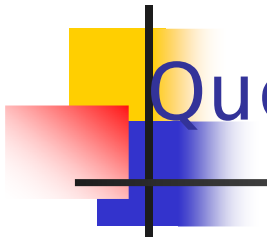


AC Defibrillator

These early defibrillators used the alternating current from a power socket, transformed from the 110-240 volts available in the line, up to between 300 and 1000 volts, to the exposed heart by way of 'paddle' type electrodes. The technique was often ineffective in reverting VF while morphological studies showed damage to the cells of the heart muscle post mortem. The nature of the AC machine with a large transformer also made these units very hard to transport, and they tended to be large units on wheels.

Direct Current Defibrillator

In 1959 Bernard Lown commenced research into an alternative technique which involved charging of a bank of capacitors to approximately 1000 volts with an energy content of 100-200 joules then delivering the charge through an inductance such as to produce a heavily damped sinusoidal wave of finite duration (~5 milliseconds) to the heart by way of 'paddle' electrodes. The work of Lown was taken to clinical application by engineer Barouh Berkovits with his "cardioverter".



Questions for Pacemakers & Defibrillators.

1 State the arrhythmias that require a pacemaker and how to diagnose them.

2 Identify the type of pacemaker used for each arrhythmia.

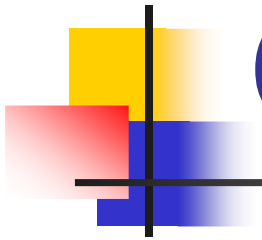
3 Create block diagrams for asynchronous, synchronous, demand, and rate-adaptive pacemakers.

4 Distinguish types of pacemaker electrodes and leads.

5 Distinguish between defibrillation, cardioversion and tiered therapy.

6 Create block diagrams for defibrillator

7 Given current, duration and resistance, calculate defibrillator energy delivered.



Questions

- What is Defibrillator?
- What do you understand by the condition fibrillation?
- What are the Electrodes used in cardiac defibrillation ?
- Explain the block diagram for a Defibrillation?

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Unit: II	Lecture - Topic: Defibrillation	Sub-Topic	Block diagram,WORKING

Fill Up the Following Check List (Should be filled by the Content Creator)	Yes	No
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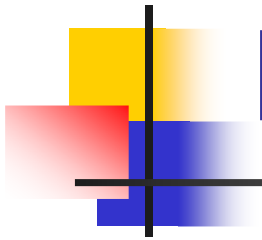


Reference

Pandey & Kumar-Biomedical Electronics and Instrumentation. – Kataria

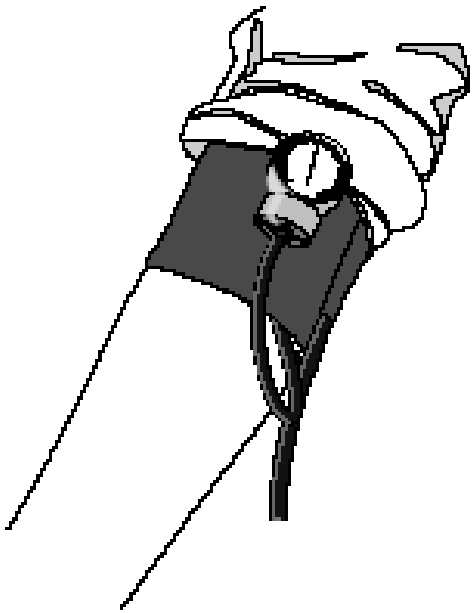
Cromwell- Biomedical Instrumentation and Measurements- PHI

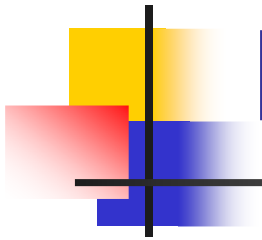
Blood pressure measurement

Some definitions

The measure of the force of blood against the arterial walls

- Expressed in a improper fraction
- Numerator equals systolic or first sound you will hear.
- Denominator is the diastolic or change or last sound you hear.
- Systolic is when the ventricles contract or the greatest pressure.
- Diastolic is when the ventricles relax or lowest pressure





Blood pressure

Blood pressure depends on the

- Volume of blood.
- Force of the heartbeat
- Arteries that have lost their elasticity, give more resistance.
- Distance from the heart.
- Would blood pressure in the legs be lower or higher?

Blood pressure

Blood Pressure is elevated by:

- • Sex and age of patient
- • Exercise, eating, emotions
- • Stimulants
- • Obesity, age
- • Arteriosclerosis
- • Elevated cholesterol
- • Diabetes
- • Heredity factors
- • Pain
- • Some drugs

Blood pressure

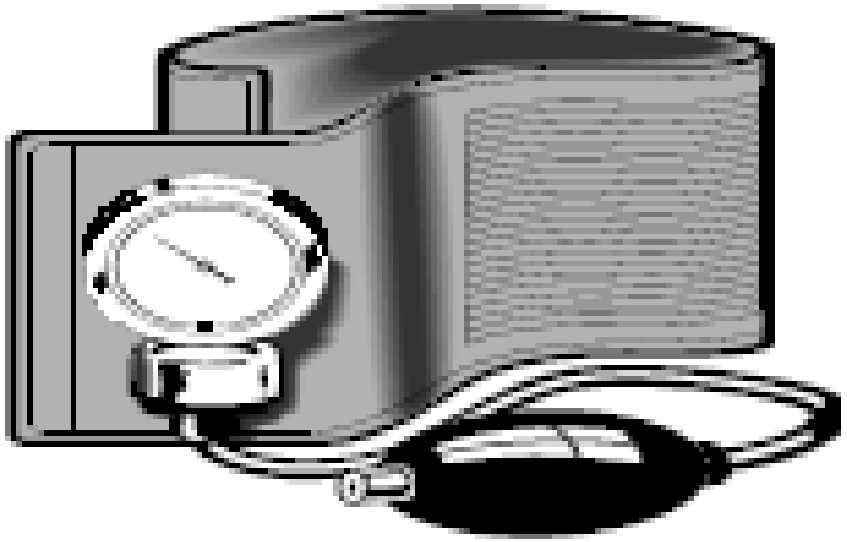
Blood Pressure is Lowered by

- • Fasting
- • Rest
- • Depressants
- • Weight loss
- • Emotions (grief)
- • Loss of blood or shock

Blood pressure Measuring Equipment

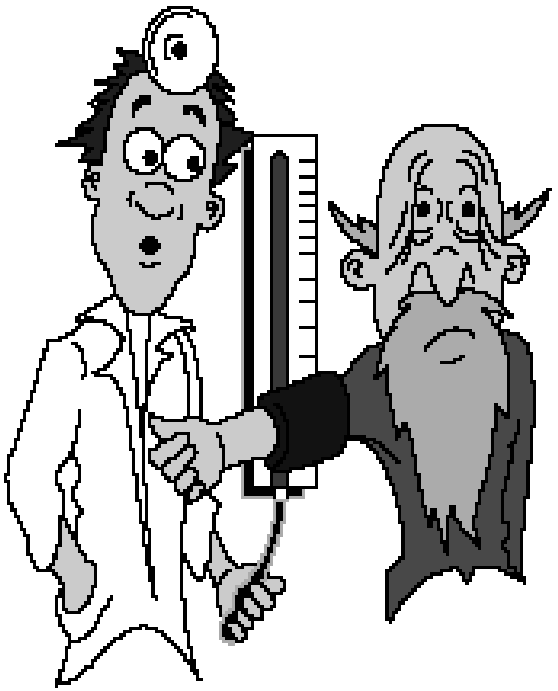
Equipment

- • Sphygmomanometer- the blood pressure measuring apparatus.
- • Use the proper width cuff
- • Width should be approx. 80% of arm
- • Stethoscope- magnifies sounds, consists of bell and diaphragm.
- • Use the bell (smaller portion) for taking a blood pressure.



Measuring the blood pressure

- • Readings taken anywhere else requires Dr's order.
- • Cuff applied smoothly over brachial artery (1 inch above the antecubital area)
- • Place bell over brachial artery.
- • Where is the brachial artery?
- • Inflate the rubber bladder in the cuff to stop the flow of blood.
- • Release pressure slowly and listen for sounds of heart valves closing.



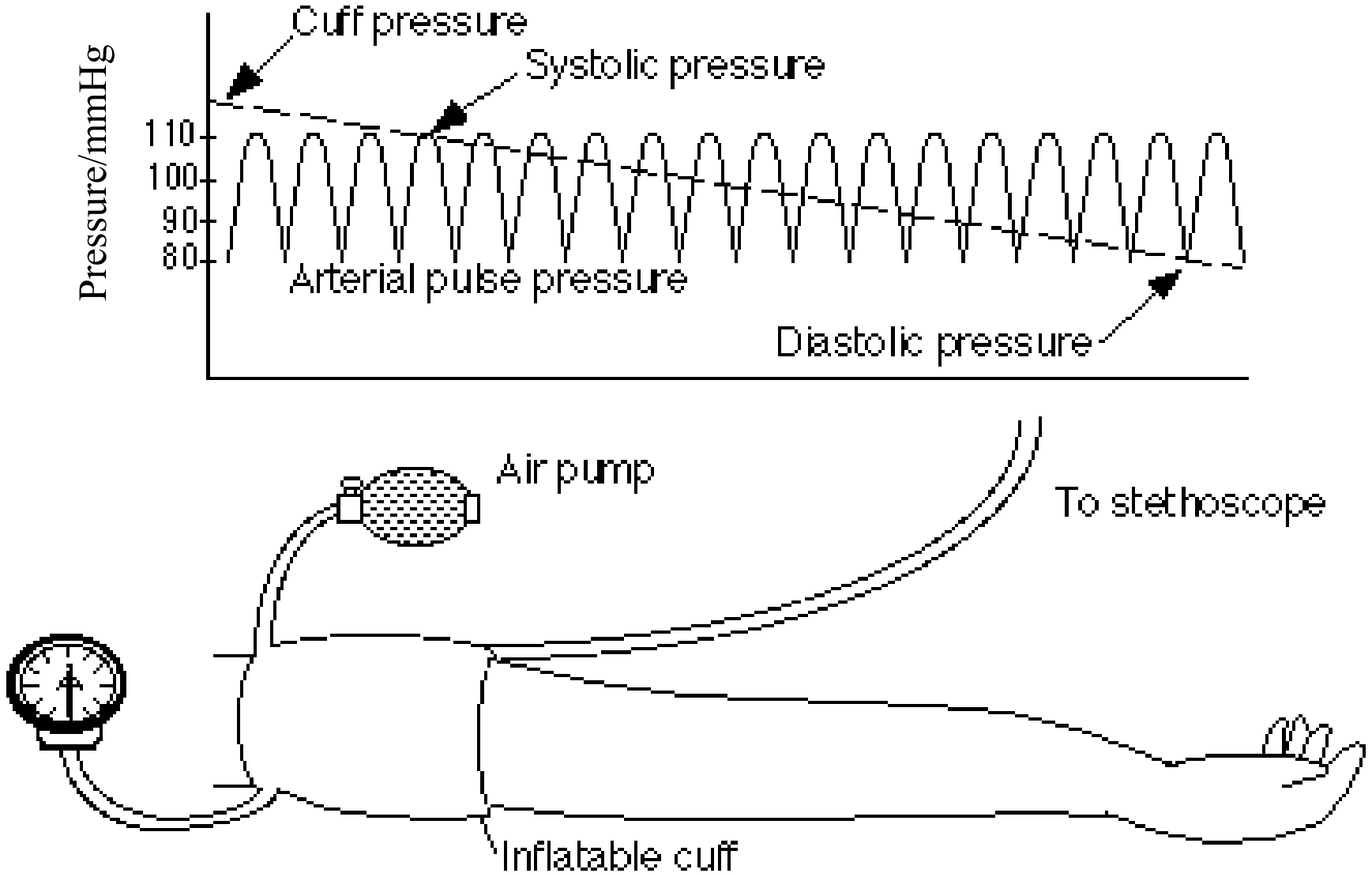
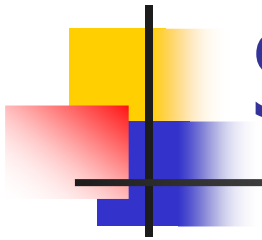
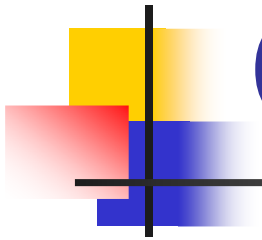


Figure The sphygmomanometer detects arterial opening and closing that occurs between systolic and diastolic pressures.



Some more info.

- • Pulse pressure- the difference between systolic and diastolic pressure.Approx. 40 millimeters of mercury.
- • Systolic normal range 90-140mm
- • Diastolic normal range 60-90mm



Questions

- How we can Measure the blood pressure?
- What are the factor that effect the Blood pressure?
- What are the Blood pressure Measuring Equipment?

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Unit	II	Lecture - Topic	Blood pressure measurement	Sub-Topic	Measuring the blood pressure

Fill Up the Following Check List (Should be filled by the Content Creator)	Yes	No
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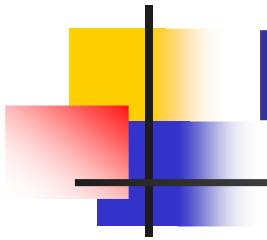

Reference

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Pandey & Kumar-Biomedical Electronics and Instrumentation. – Kataria

Heart sound measurement.

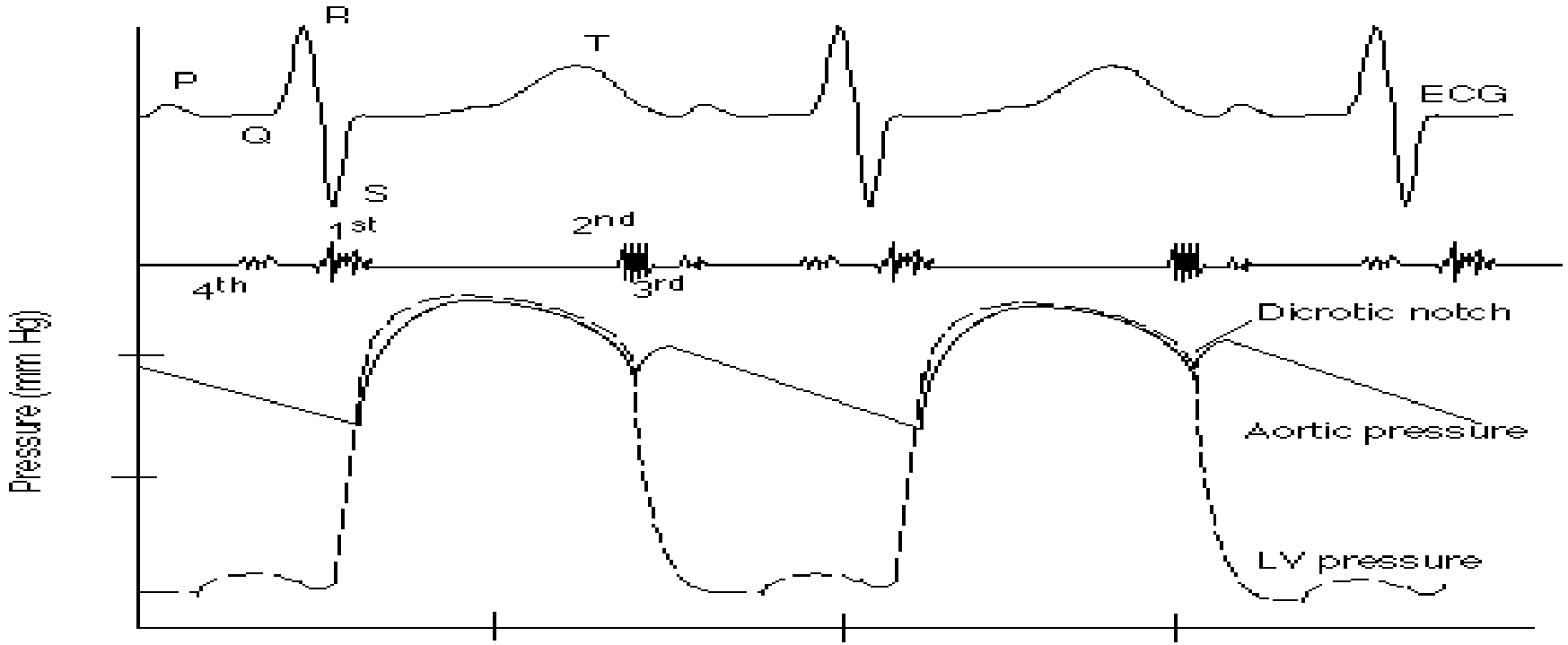


Figure In the top figure, the electrocardiogram (ECG) initiates the cardiac cycle. The cardiac sounds are also shown. The bottom figure shows that ejection occurs when the pressure in the left ventricle exceeds that in the arteries.

Heart sound

Sound	Origin
1st sound	Closure of mitral and tricuspid valves
2nd sound	Closure of aortic and pulmonary valves
3rd sound	Rapid ventricular filling in early diastole
4th sound	Ventricular filling due to atrial contraction

Table The heart sounds. The 1st and 2nd heart sounds are most prominent.

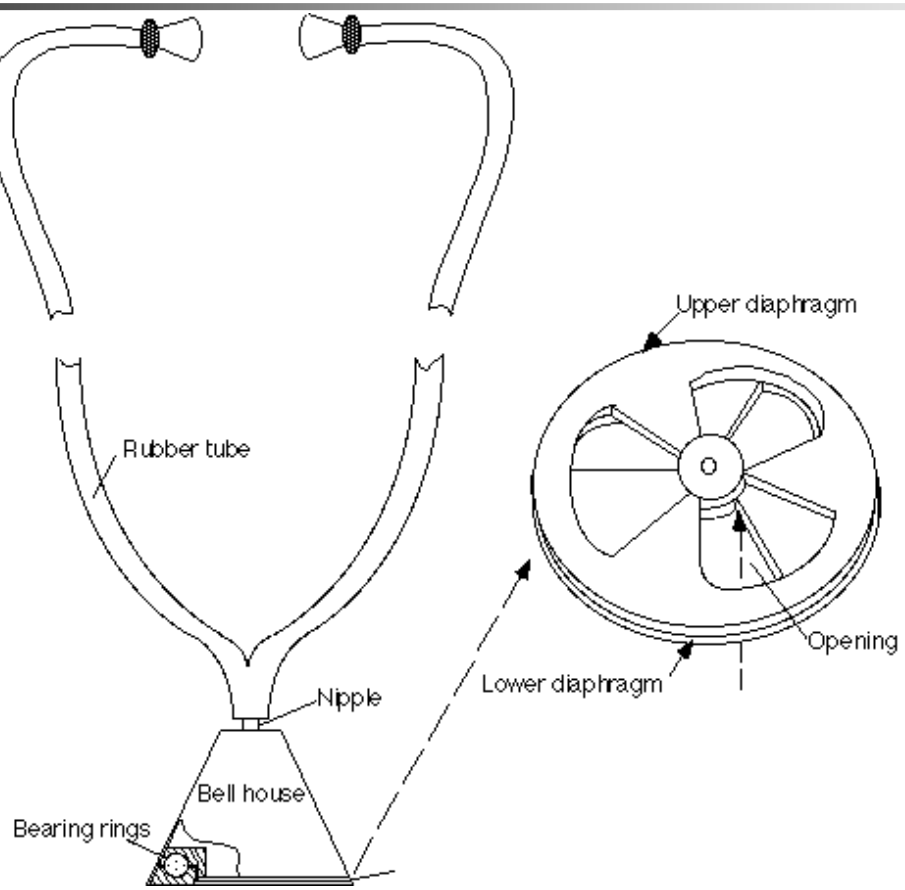
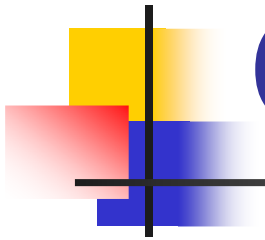


Figure A stethoscope with bell and diaphragm modes. (Adapted from Mohrin, C. M., 1995. Stethoscope. US Patent, 5,389,747.)



Questions

- What is stethoscope ?
- What is the Heart sound measurement?

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Unit	II	Lecture - Topic	Heart sound measurement	Sub-Topic	

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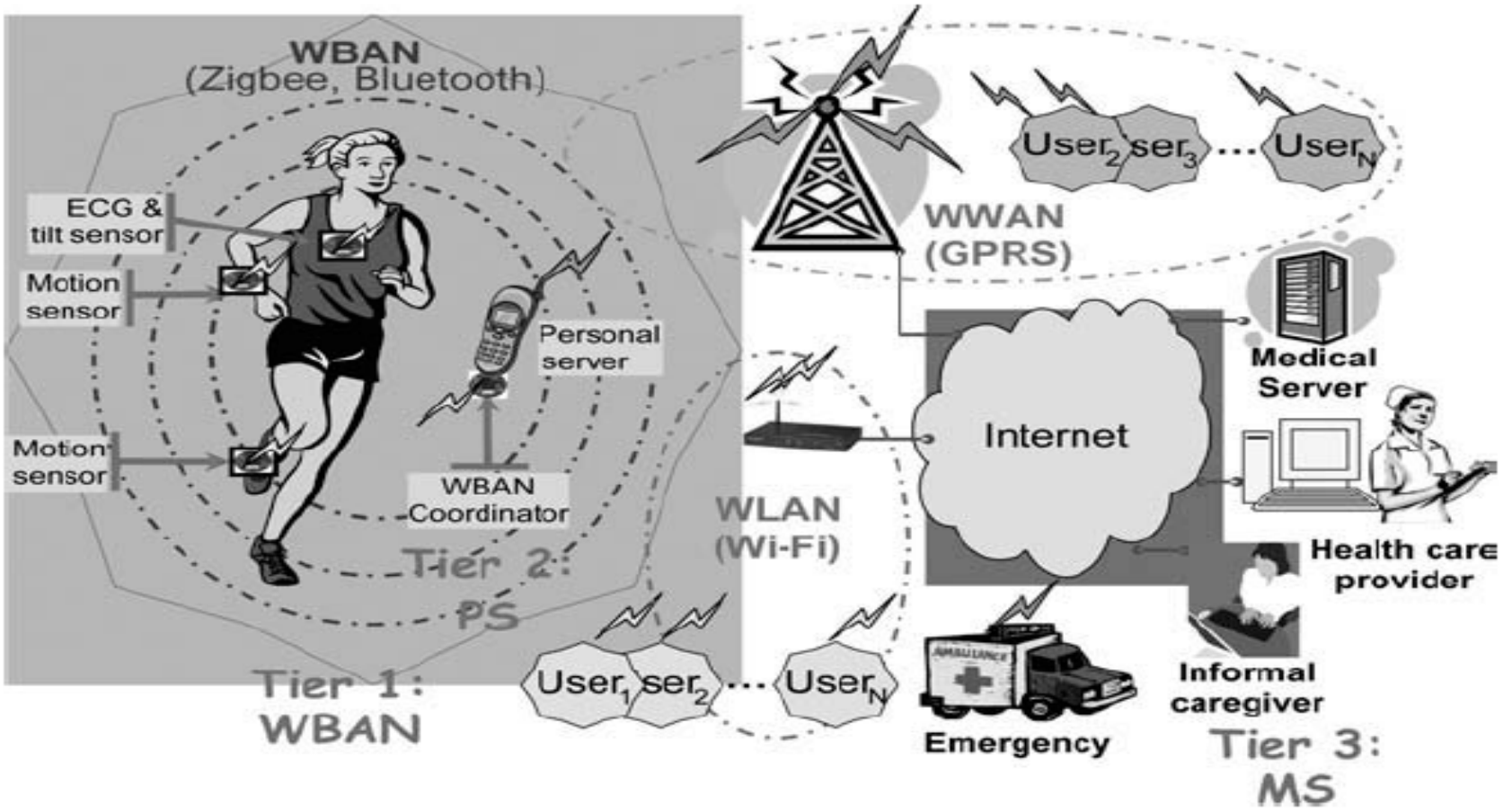
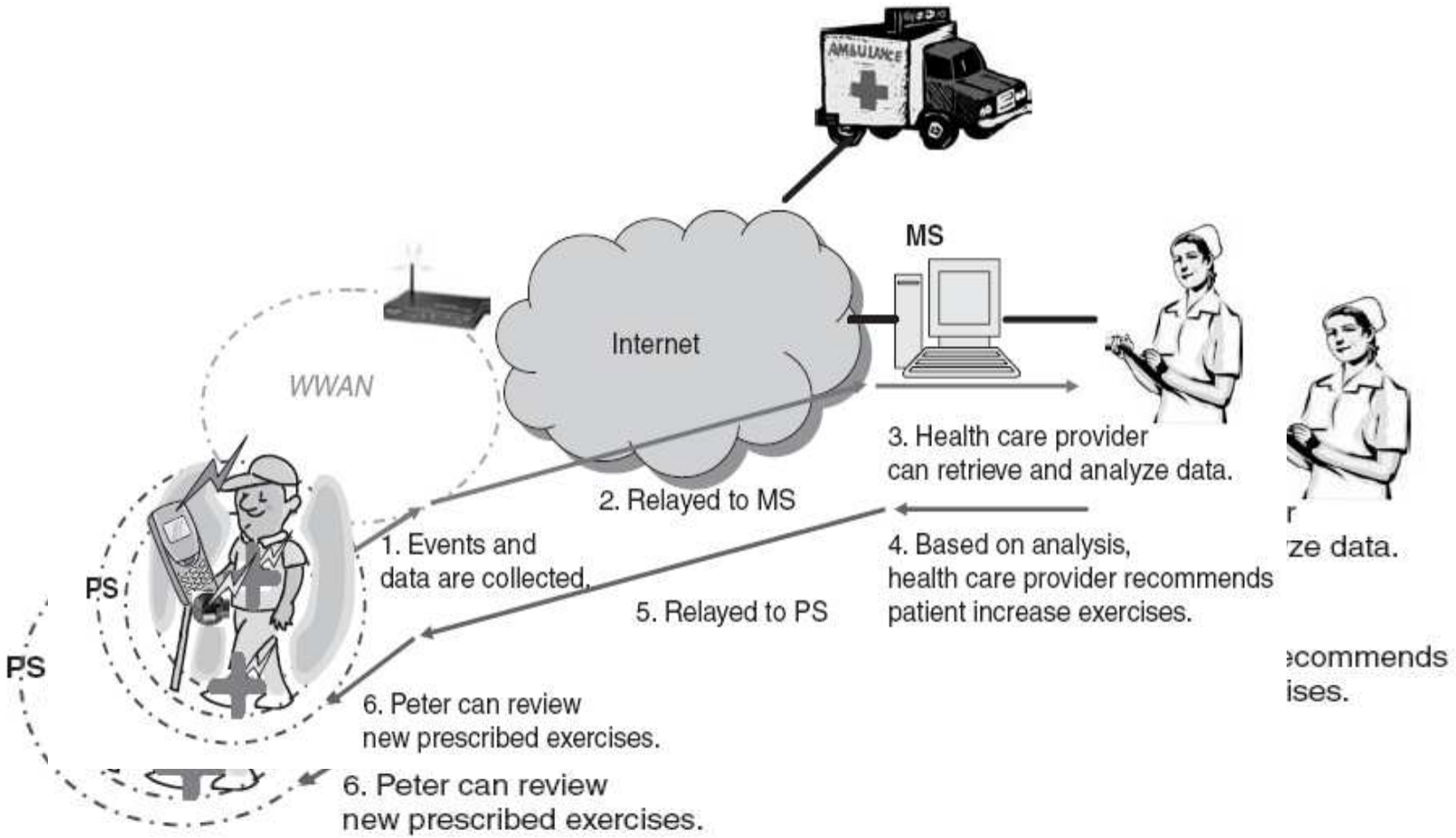
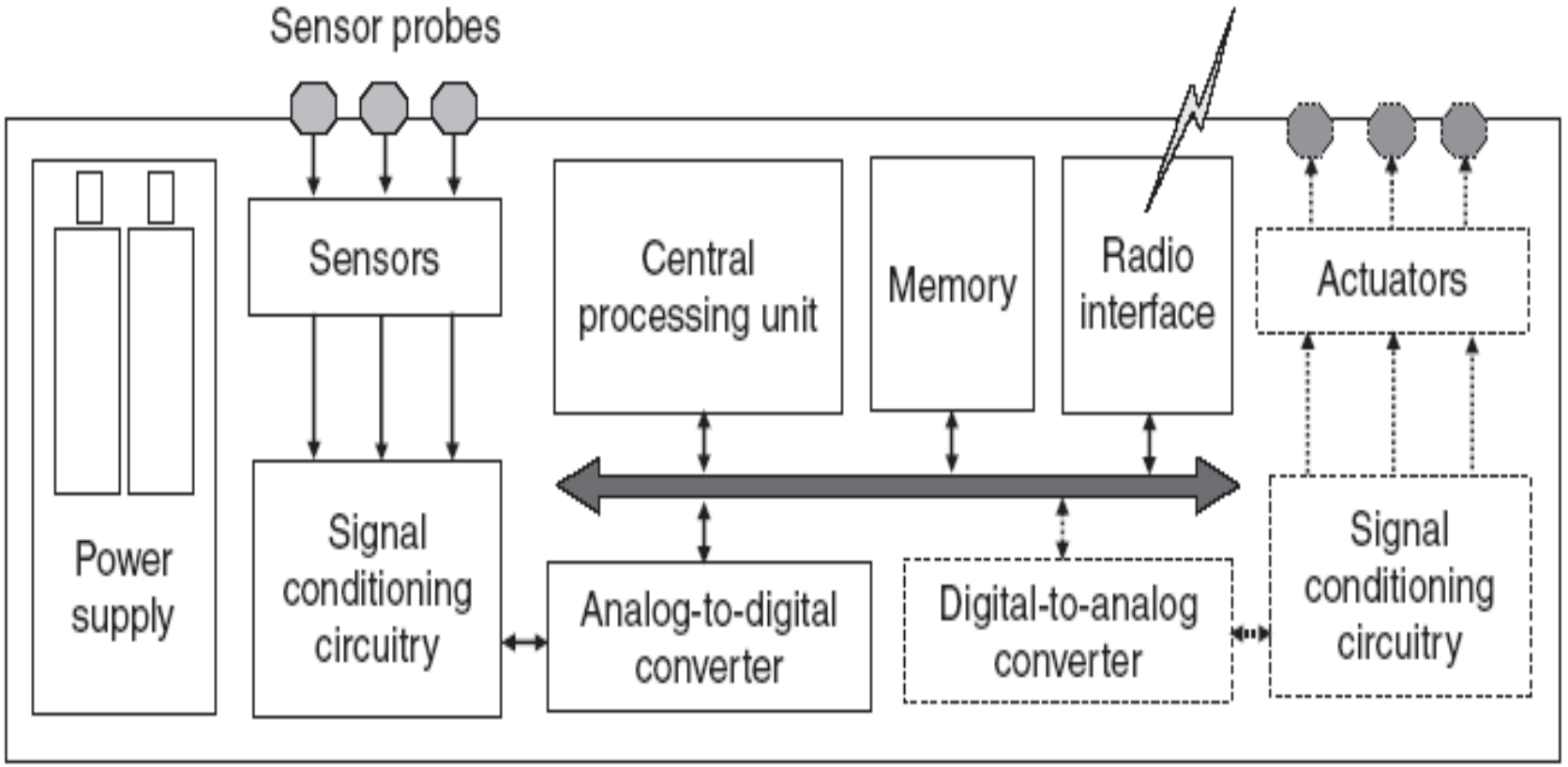
Patient Care & Monitoring

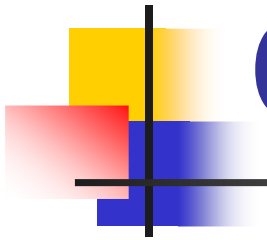


patient monitoring equipment



patient monitoring equipment





Questions

- What are patient monitoring equipment ?
- Explain the patient monitoring equipment?

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Unit	II	Lecture - Topic	Patient Care & Monitoring	Sub-Topic	patient monitoring equipment

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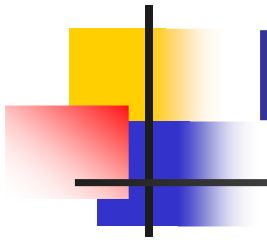


Reference

Pandey & Kumar-Biomedical Electronics and Instrumentation. – Kataria

Medical instrumentation application and design contributing authors, John W. Clark, Jr... [et al.] . Webster, John G

www.ieee.or.com/Archive/Welch_Allyn.pdf

Sensor Architecture

Physical sensors are devices that detect and convert natural physical quantities into analog signals (voltages and currents).Electrophysiological signals, such as ECG, EEG, EMG, are sensed directly through contact or contactless electrodes attached to certain parts of the human body. Parameters of physical quantities such as blood pressure, blood glucose level, and body motion are converted into electrical signals using corresponding transducer

Computing

They are responsible for coordinating sampling activities; preprocessing sampled data performing storage requirements

Monitoring Equipment

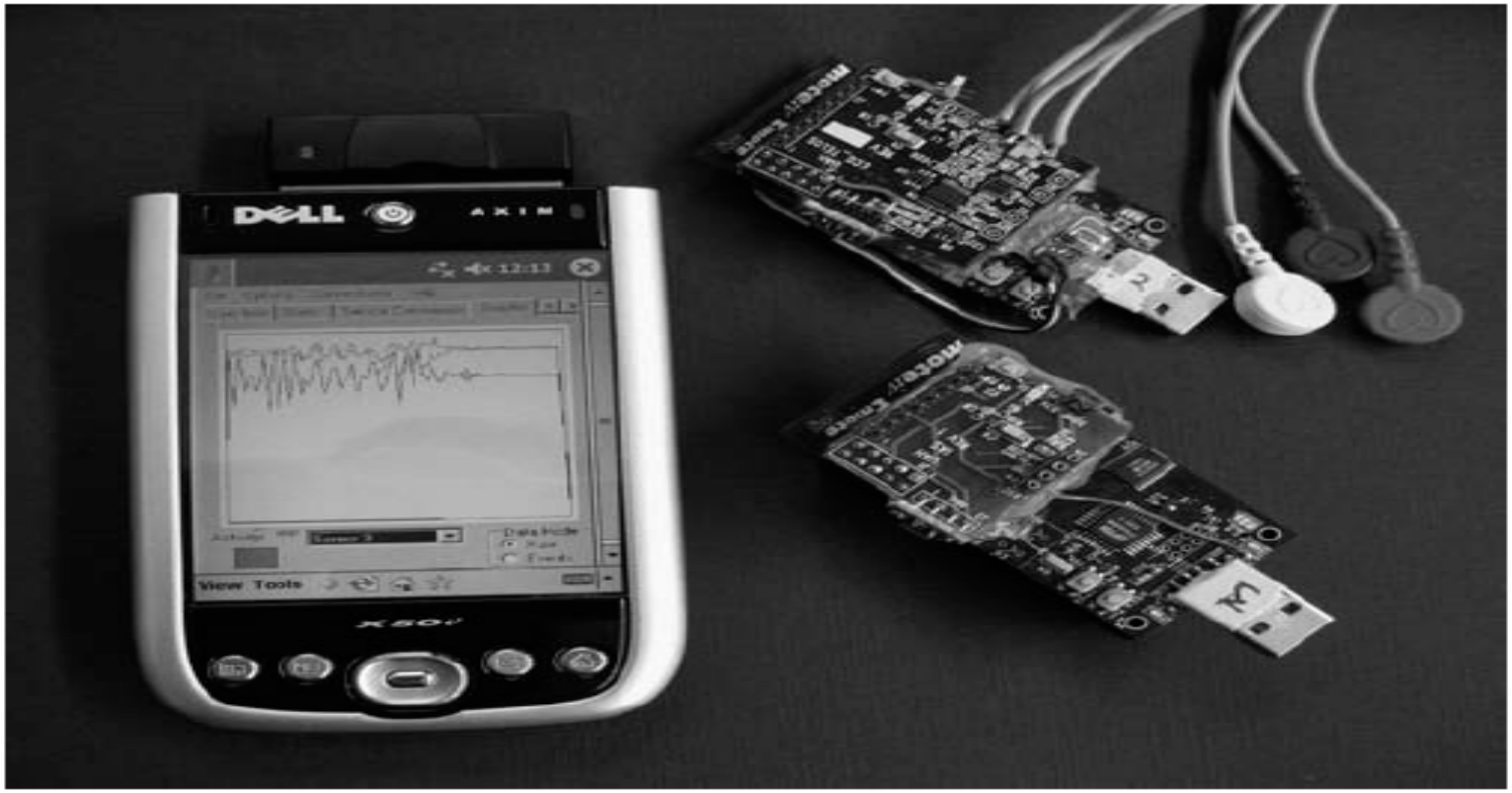
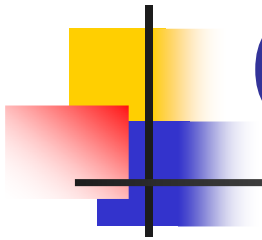


FIGURE 22.6 Prototype WBAN. From left to right: the personal server with network coordinator, ECG sensor with electrodes, and a motion sensor.



Questions

- What do you understand by Monitoring Equipment?
- Explain the Sensor Architecture?

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Unit	II	Lecture - Topic	Monitoring Equipment	Sub-Topic	

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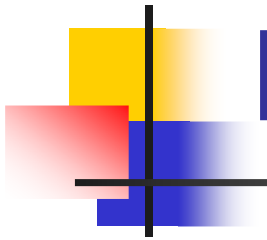
Did you include References to the answers for the short and descriptive questions?	√	
Did you include references of the published content in the Web/other resources (if you have referred it)	√	



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Medical instrumentation application and design contributing authors, John W. Clark, Jr... [et al.] . Webster, John G

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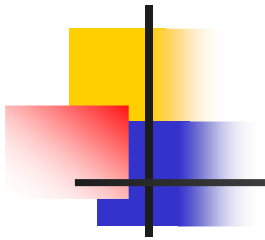
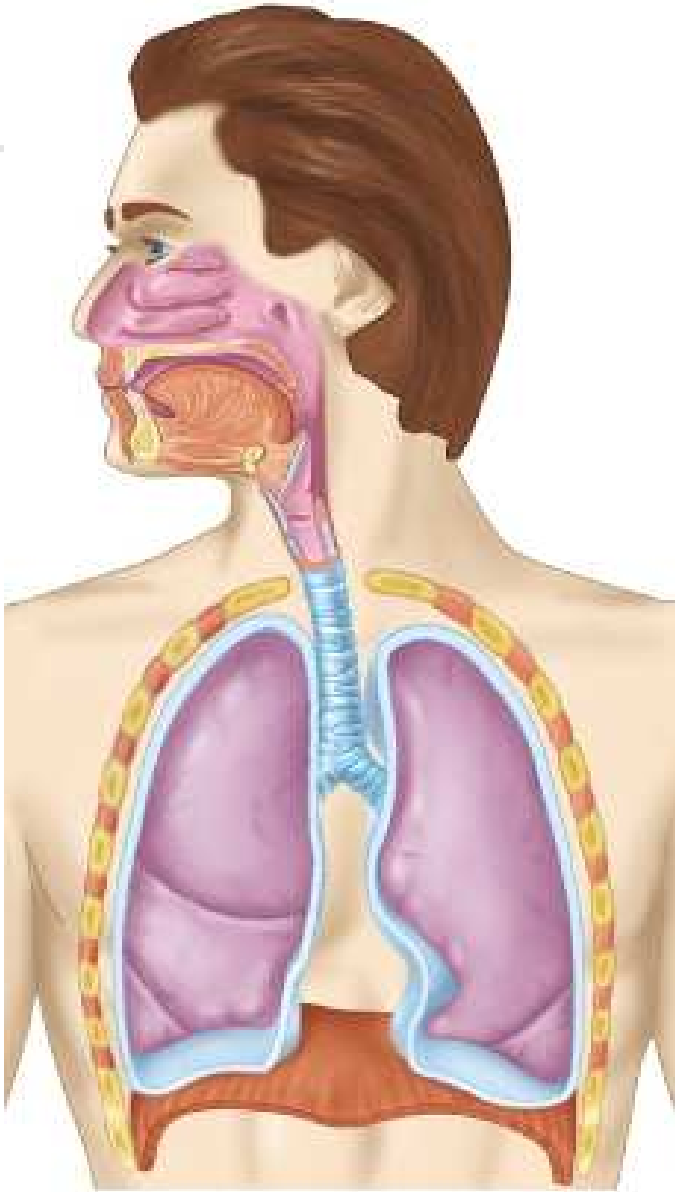


BIO-MEDICAL INSTRUMENTATION

UNIT-3

Respiratory System

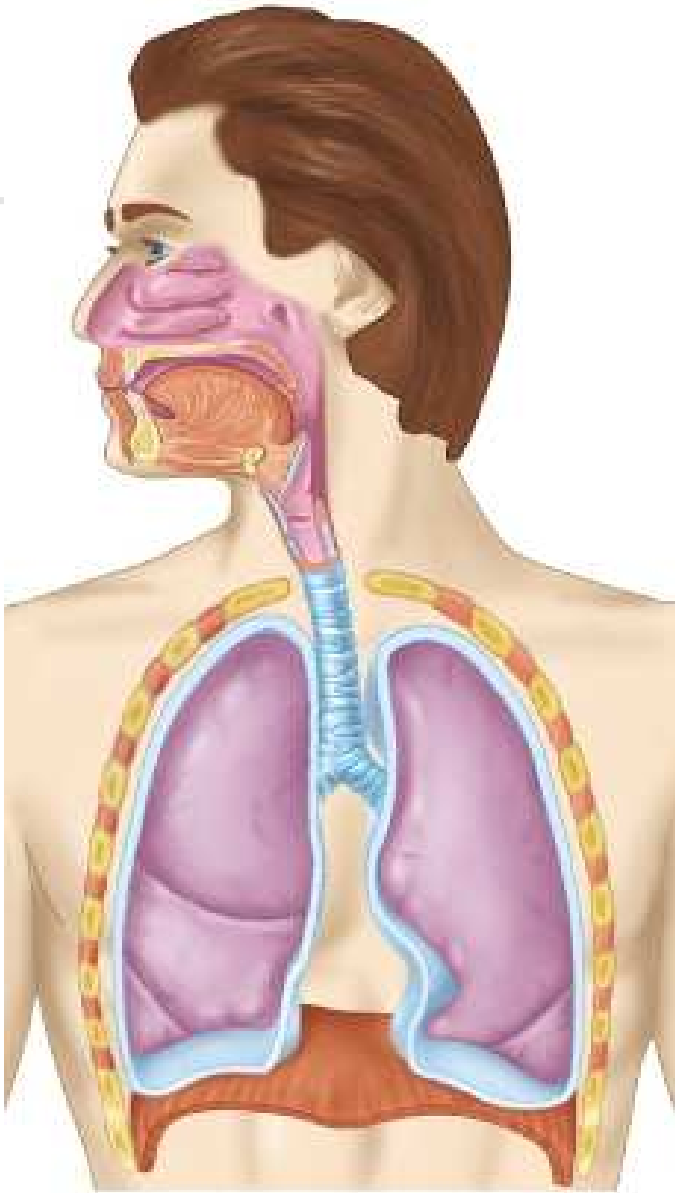
- Main structures
- Nose and nasal cavity
- Pharynx
- Larynx
- Trachea
- Bronchial tree
- Lungs



ngs, an imprint of Addison Wesley Longman, Inc.

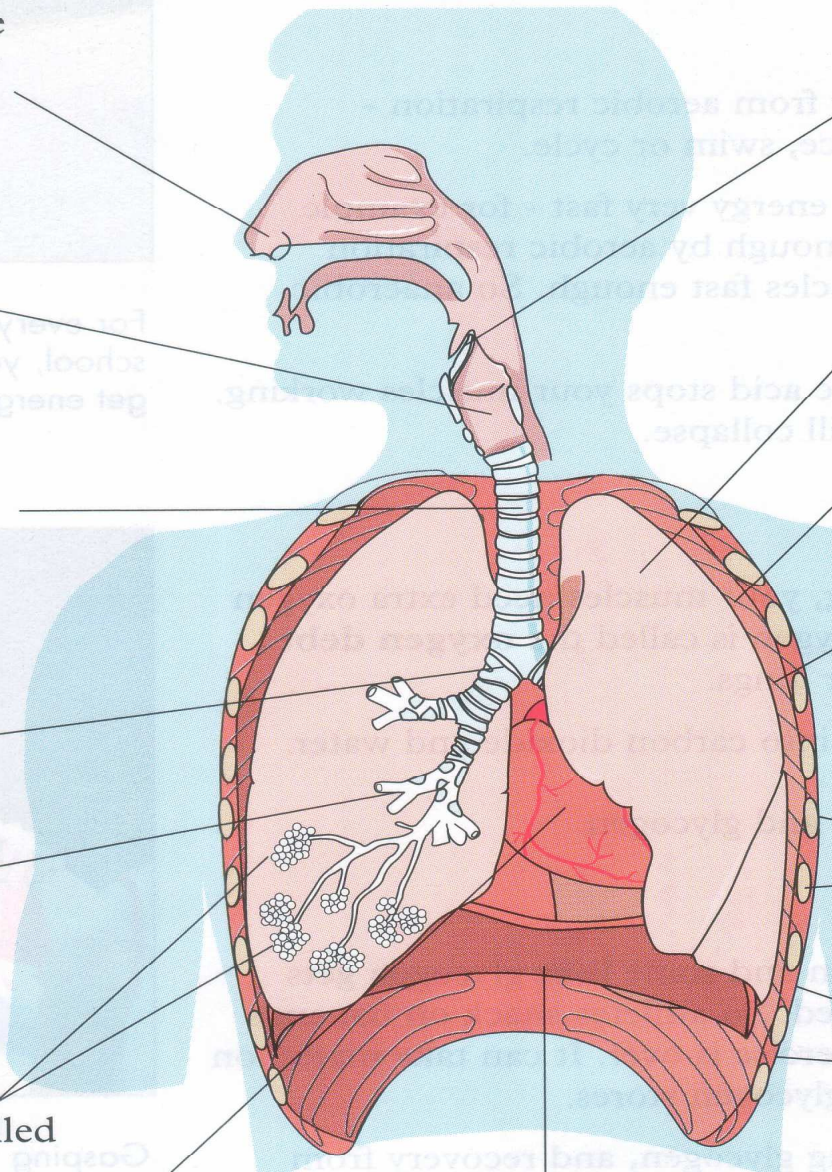
Conducting Zone

- Nose to bronchioles
- Conduct air
  - Warm
  - Moisten
  - Cleanse



The respiratory system

Your cells obtain energy by aerobic respiration. That needs oxygen. Your body takes it from the air via the **respiratory system**.



Air is drawn in through the nose, where it is filtered by tiny hairs and warmed and moistened by **mucus**.

The voice box or **larynx**, which makes sounds for speaking.

The windpipe or **trachea**. This is a flexible tube held open by rings of cartilage.

In the lungs, the trachea branches into two **bronchi**. Each is a **bronchus**.

The bronchi branch into smaller tubes called **bronchioles**.

The bronchioles end in bunches of tiny air sacs called **alveoli**. Their walls are so thin that gases can pass through them.

heart

The **diaphragm** is a sheet of muscle below the lungs. It helps you breathe in and out.

A small flap of cartilage stops food going into the windpipe instead of the gullet. It is called the **epiglottis**.

The lungs are soft and spongy.

The lungs are in a space called the **thoracic cavity**.

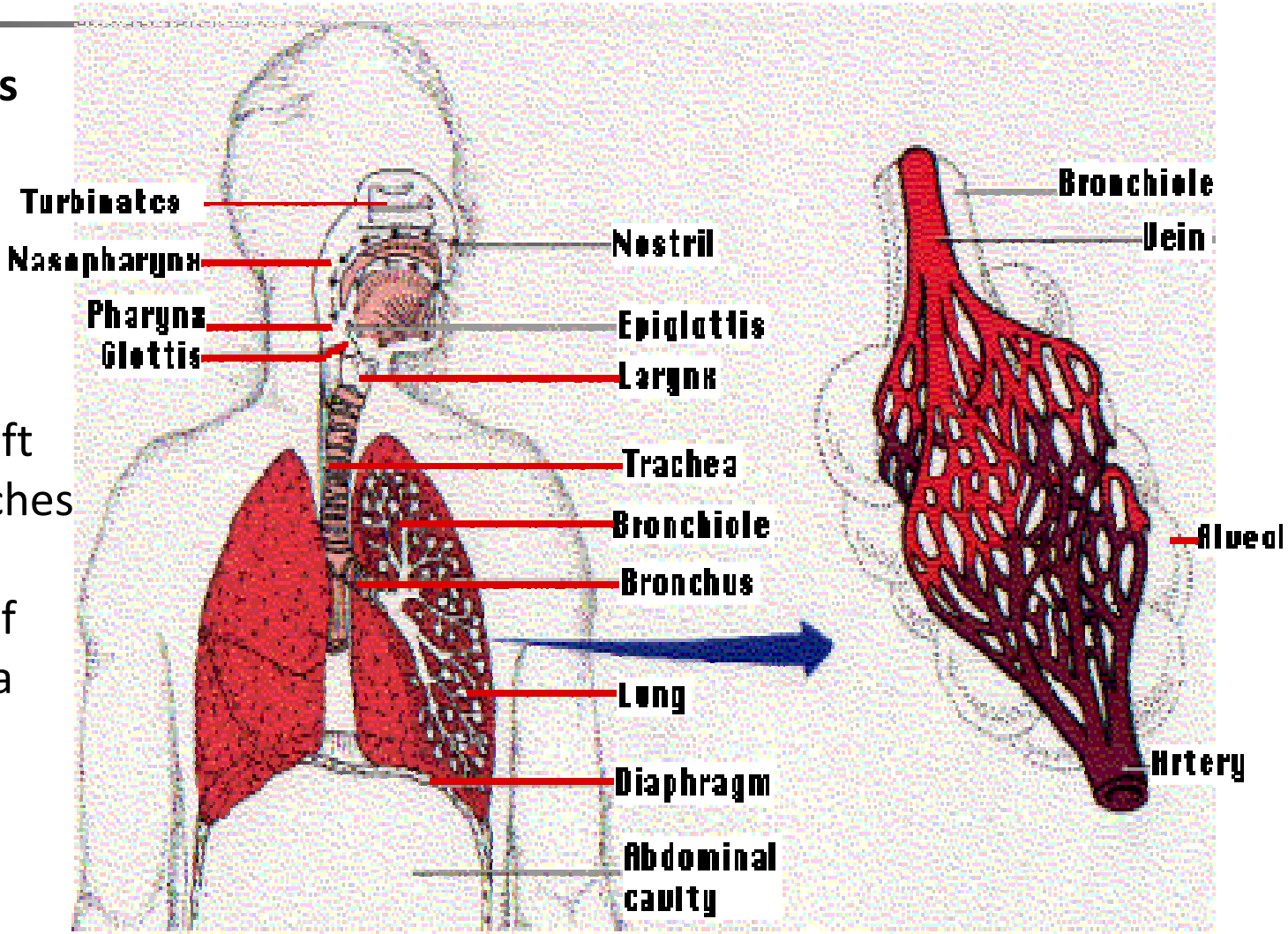
The **pleural membrane** is a slippery skin lining the cavity. It protects the lungs as they rub against the ribs.

The **ribs** protect the lungs.

The **intercostal muscles** between the ribs help you breathe in and out.

The Pathway

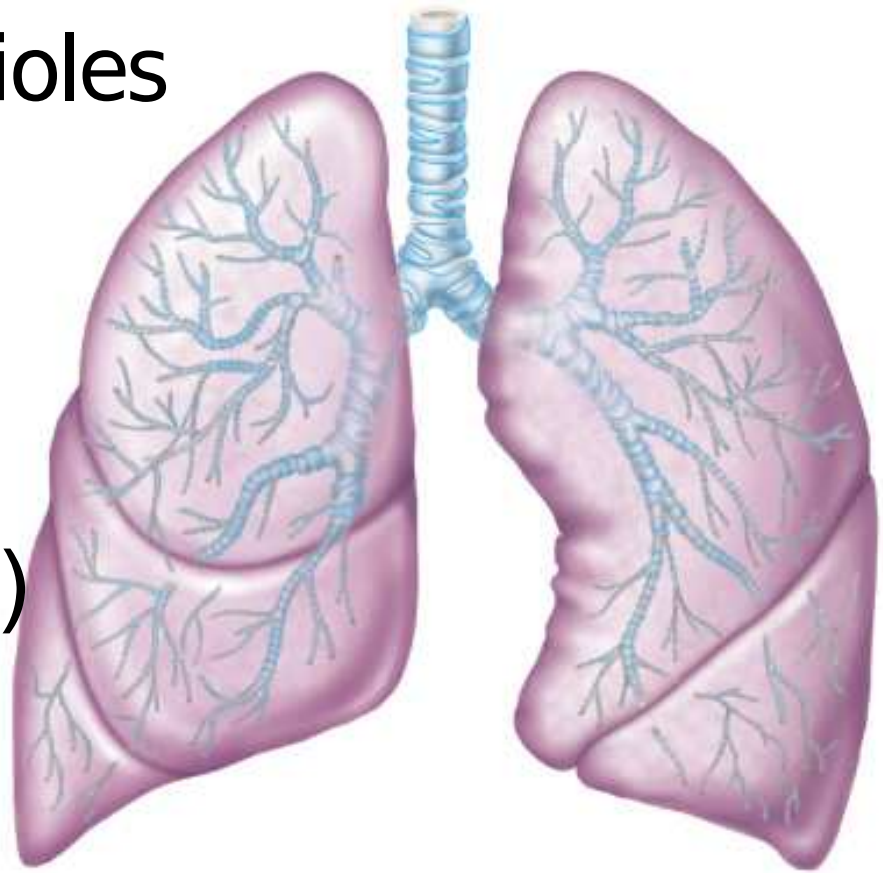
Air enters the **nostrils**
- passes through the **nasopharynx**,
- the **oral pharynx**
- through the **glottis**
- into the **trachea**
- into the right and left **bronchi**, which branches and rebranches into
- **bronchioles**, each of which terminates in a cluster of
- **alveoli**



Respiratory zone

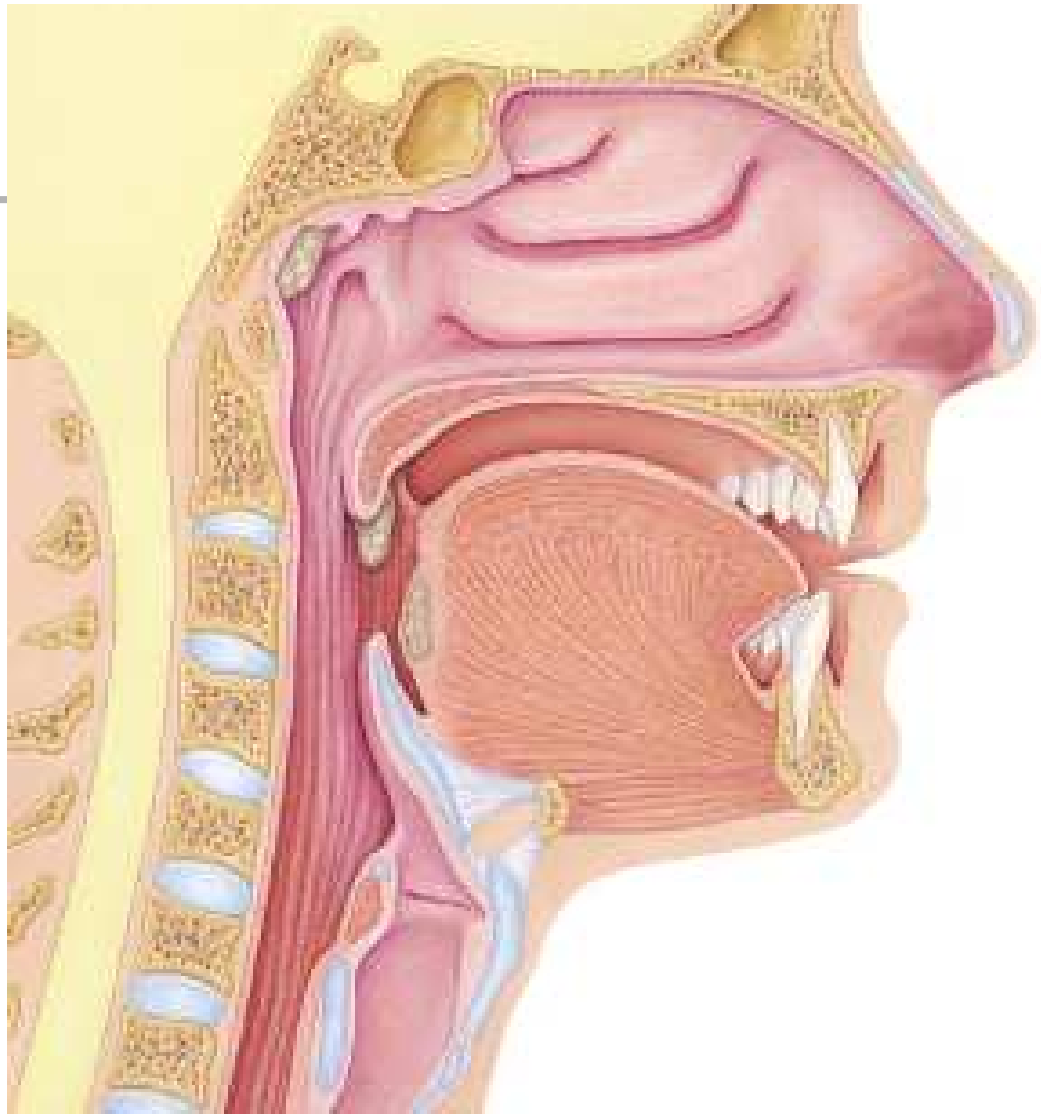
- Respiratory bronchioles
- Alveolar ducts
- Alveolar sacs
- Respiration

(=exchange of gases)



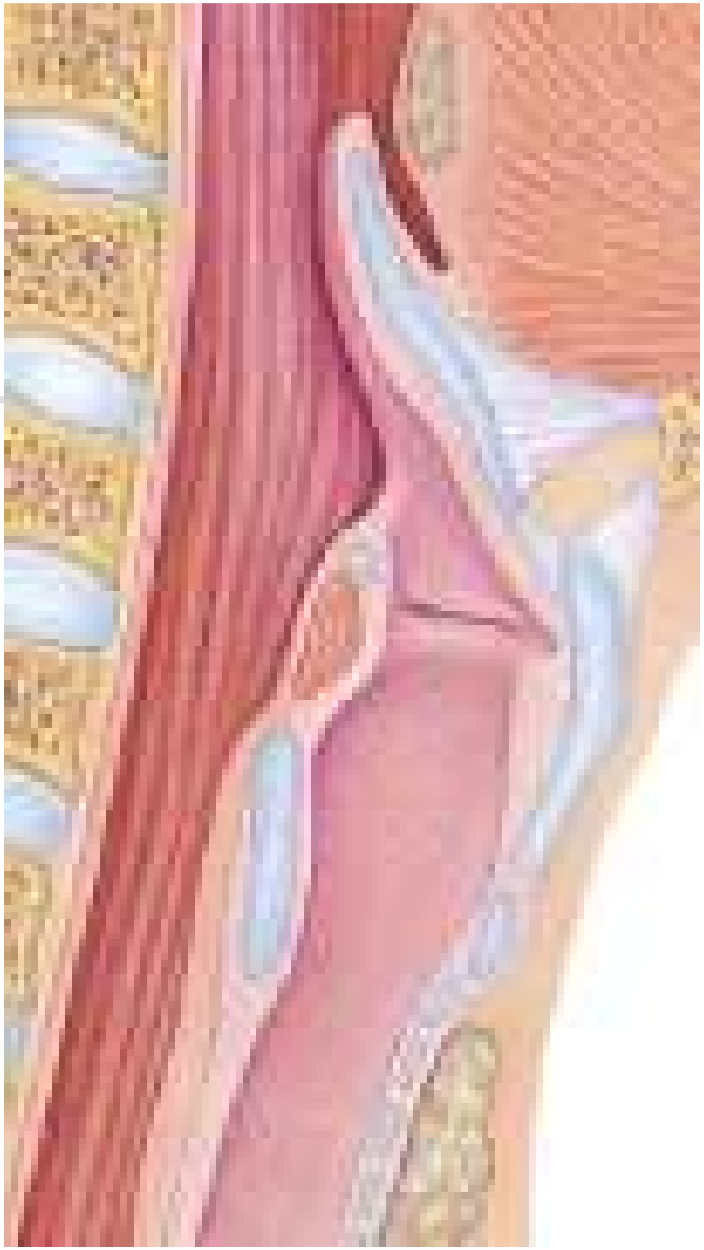
Pharynx

- Skeletal muscle tube
- Respiratory & digestive systems



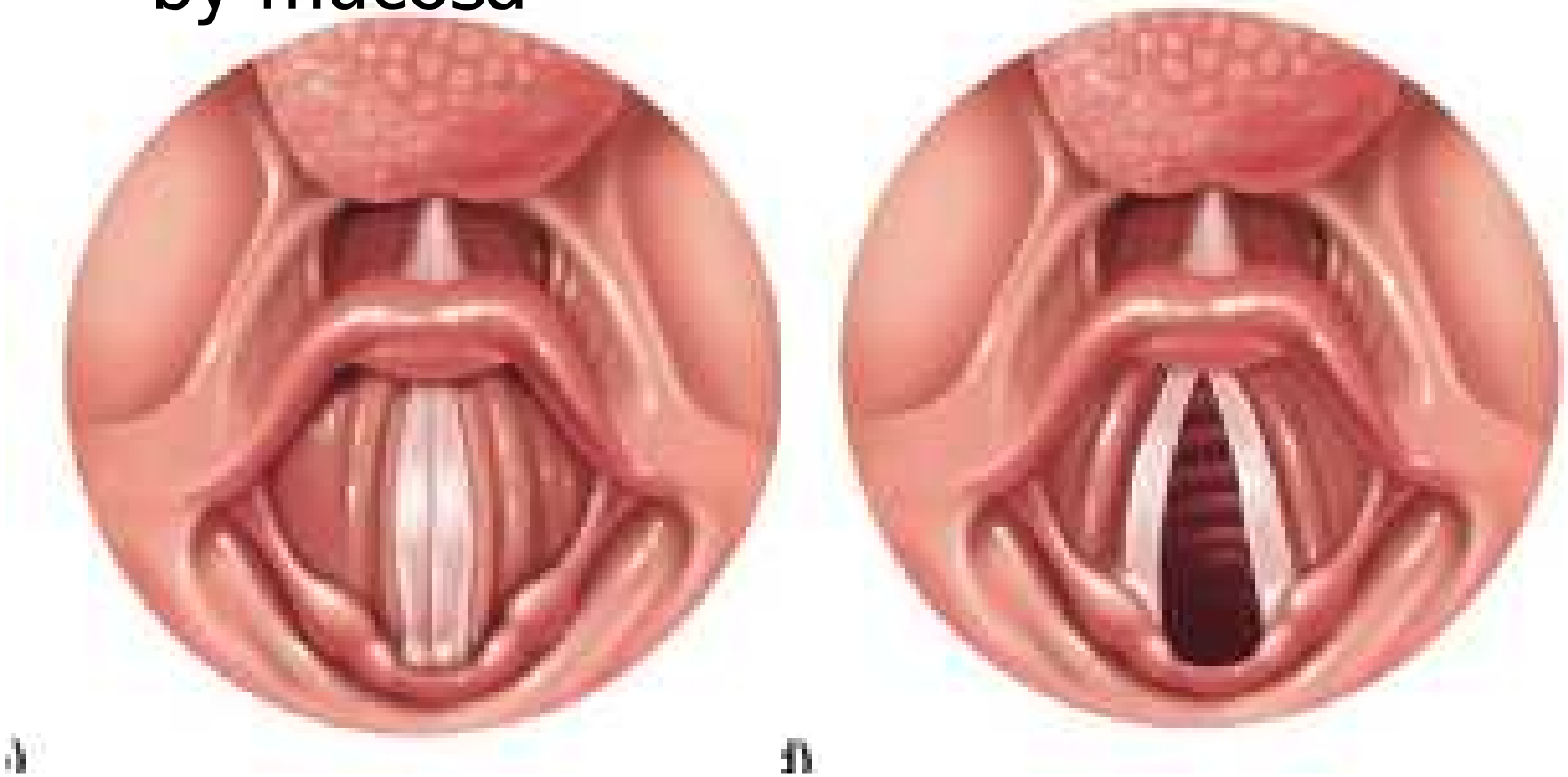
Larynx

- C4-C6 vertebral levels
- Attached to hyoid
- Functions
  - Speech
  - Air pathway
  - Swallowing



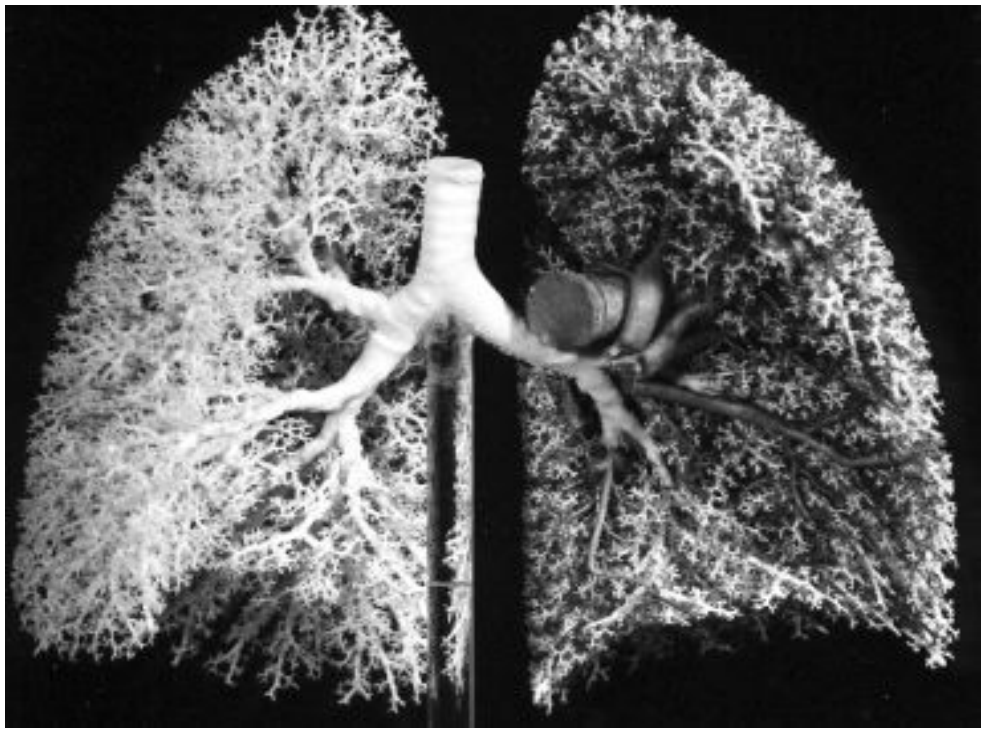
Vocal cords

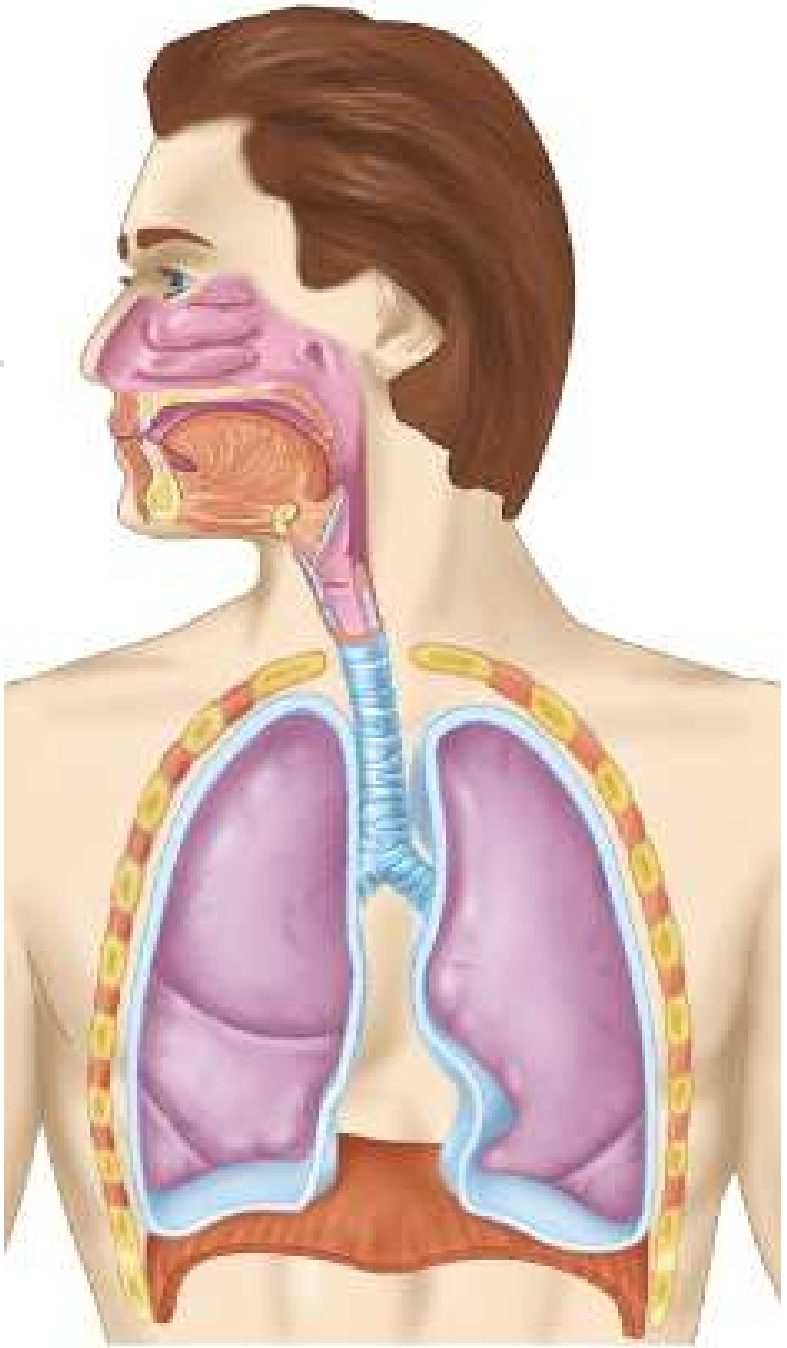
- Vocal folds/cords = vocal ligaments covered by mucosa



Trachea

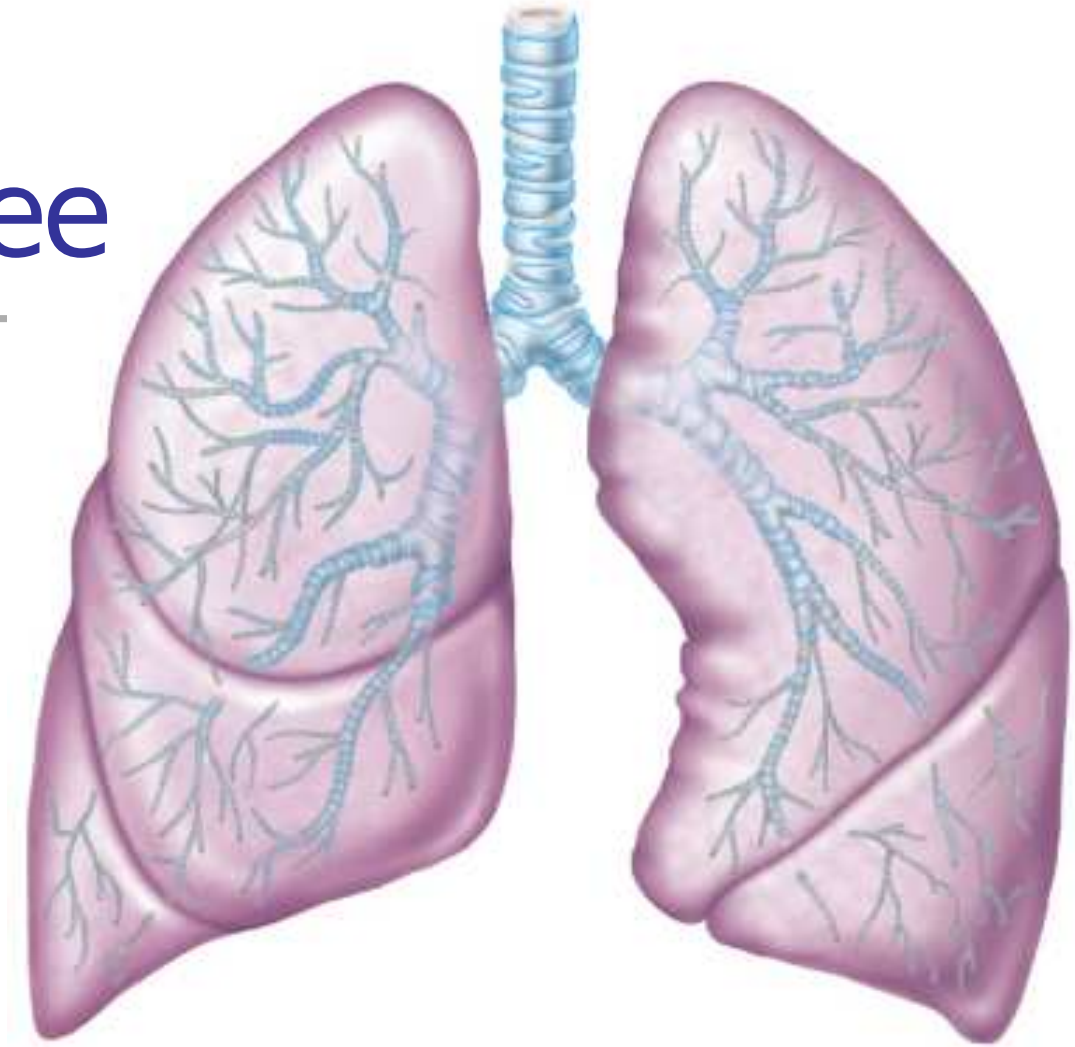
- Larynx to bronchi (C6-T7)
- Air passageway



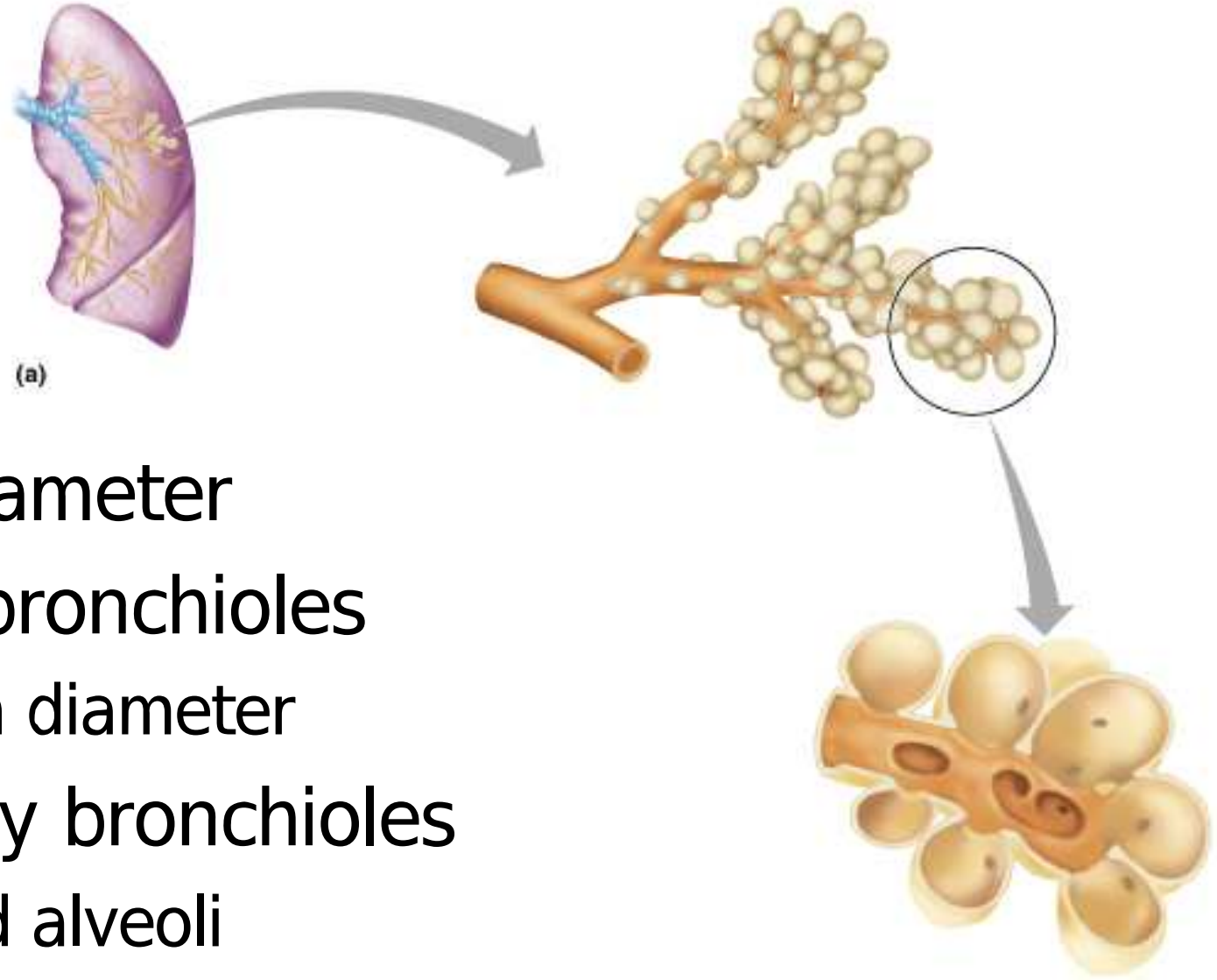


Bronchial tree

- 1° bronchi
- 2° bronchi
- 3° bronchi
- ~23 branches



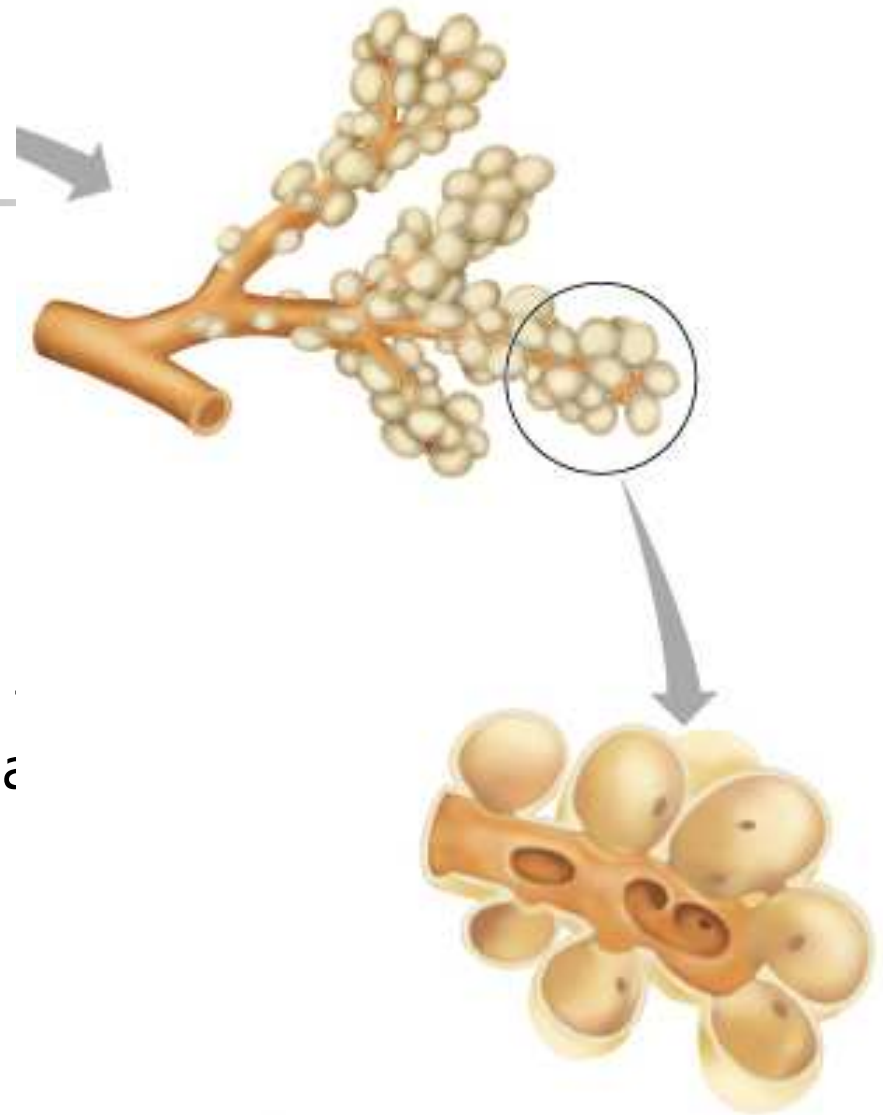
Bronchioles



- <1 mm diameter
- Terminal bronchioles
  - <0.5 mm diameter
- Respiratory bronchioles
  - Scattered alveoli

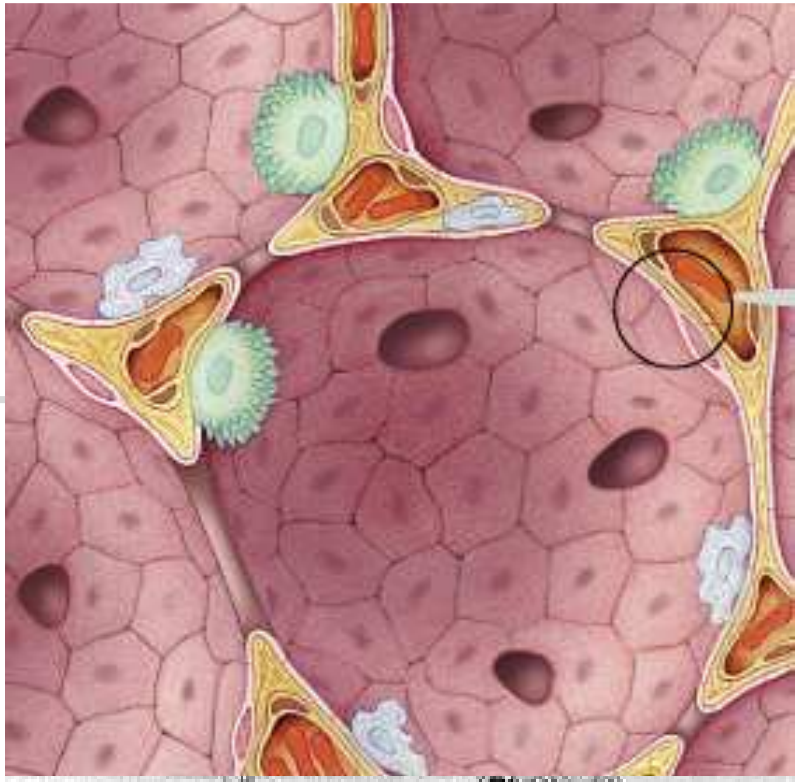
Alveolar ducts

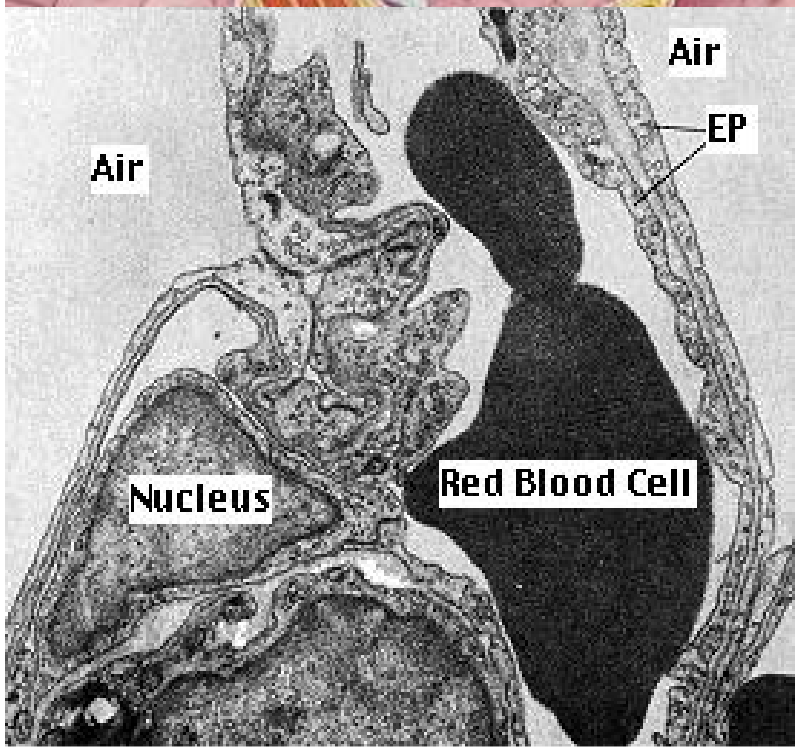
- Continuous alveoli
- Atrium
- Leads to alveolar sacs
- There are some 300 million alveoli in adult lungs. These provide a surface a of some 160 m^2 (almost equal to the singles area of a tennis court and 80 times the area of our skin!).



Alveolar wall

- Respiratory membrane
  - Note the thinness of the epithelial cells (EP) that line the alveoli and capillary (except where the nucleus is located). At the closest point, the surface of the red blood cell is only 0.7 µm away from the air in the alveolus.



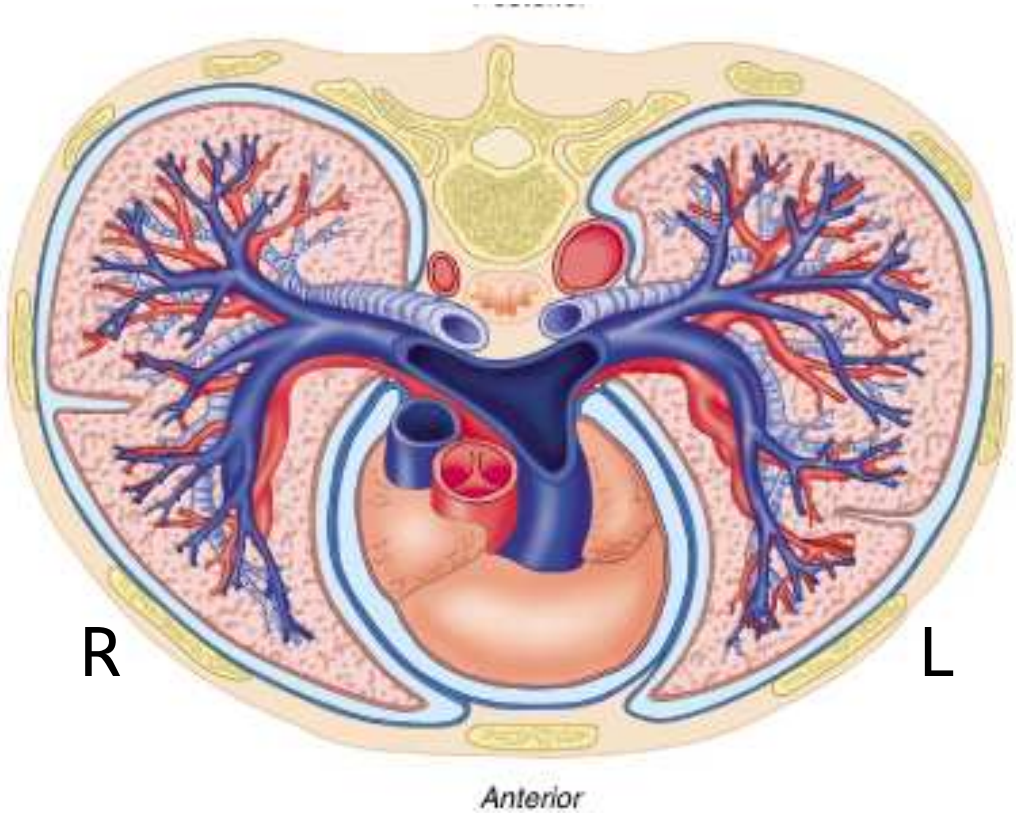


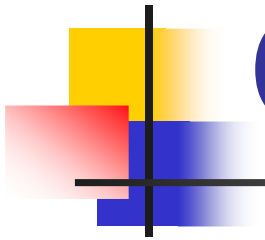
Composition of atmospheric air and expired air in a typical subject. Note that only a fraction of the oxygen inhaled is taken up by the lungs

Component	Atmospheric Air (%)	Expired Air (%)
N_2 (plus inert gases)	78.62	74.9
O_2	20.85	15.3
CO_2	0.03	3.6
H_2O	0.5	6.2
	100.0%	100.0%

Blood supply to the lungs

- Pulmonary arteries
  - Deoxygenated blood from R ventricle
- Pulmonary veins
  - Oxygenated blood to L atrium





Questions

- What is Respiratory System?
- What are components Respiratory zone?
- Explain the anatomy of the lungs?

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Content Format	Digital (Slides in PPT)		

Unit	III	Lecture - Topic	anatomy of the lungs	Sub-Topic	

Fill Up the Following Check List (Should be filled by the Content Creator)	Yes	No
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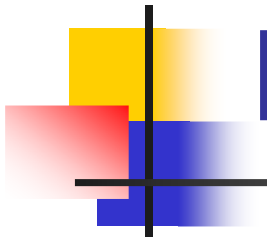


Reference

Cromwell- Biomedical Instrumentation and Measurements- PHI

Medical instrumentation application and design contributing authors, John W. Clark, Jr... [et al.] . Webster, John G

Measurement of breathing

SPIROMETRY

Ventilation:

- the process of exchange of air between the lungs and the ambient air
- Airflow in respiratory system is directly proportional to the pressure gradient and inversely related to the resistance of the airways.
- A single respiratory cycle = inspiration + expiration

Measurement of breathing

Inspiration

- Lung air pressure < Atmosphere air pressure

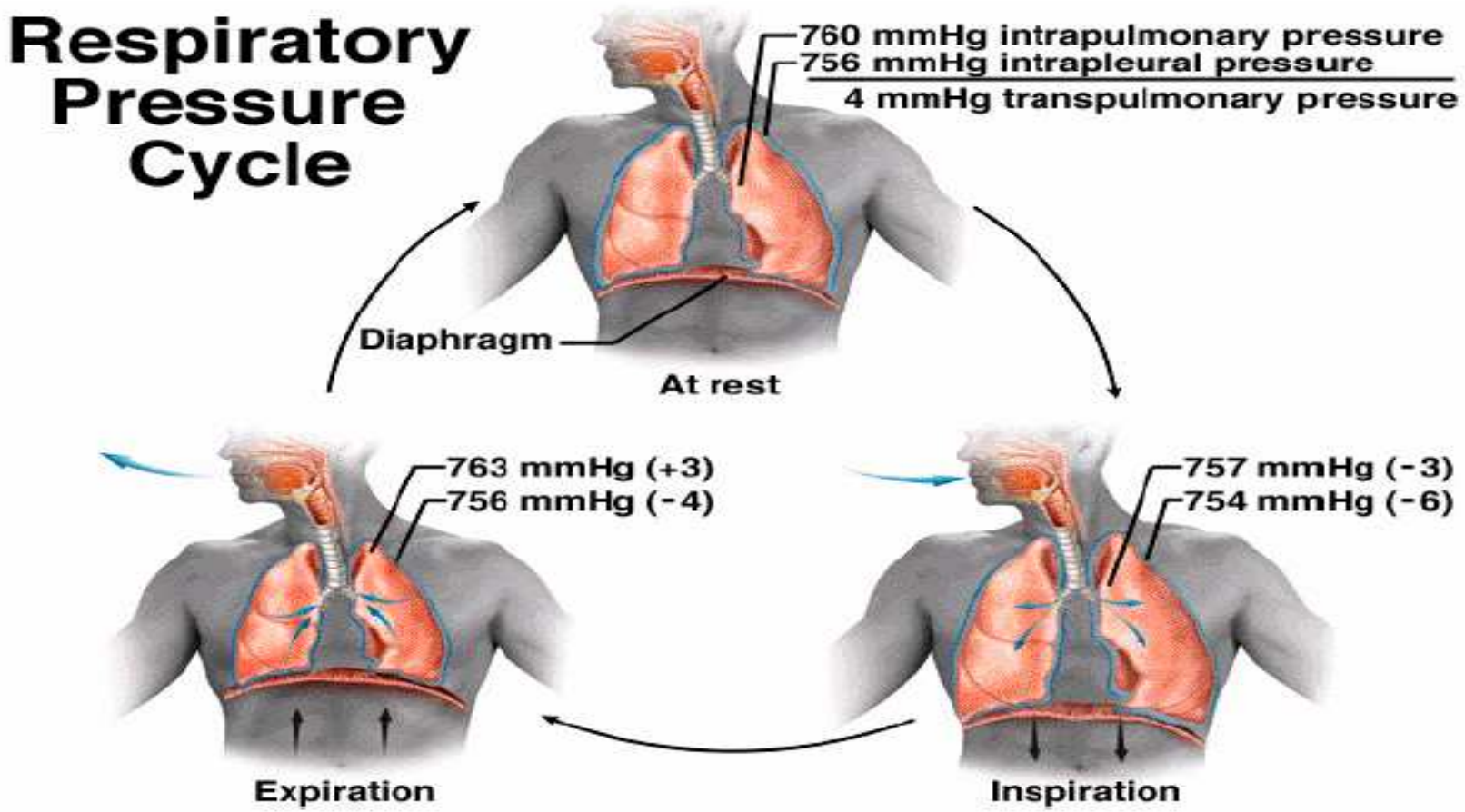
Diaphragm & inspiratory muscles contract → Thoracic cavity expands → negative pressure → air flows into lungs

Expiration

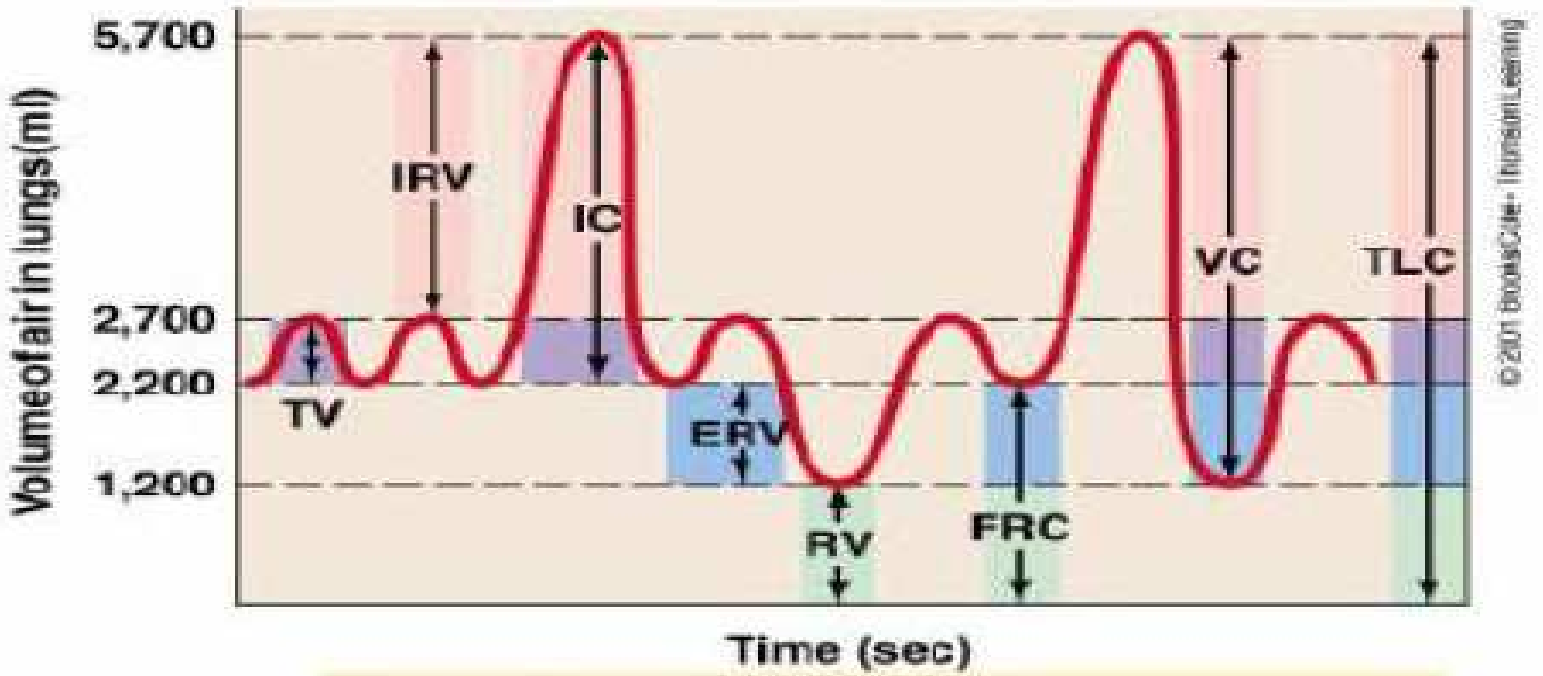
Expiration

- Passive process resulting from natural elastic recoil of the expanded lung walls.
- During rapid breathing, internal intercostal and abdominal muscles contract to help force air out at a more forceful, rapid rate)

PRESSURE CYCLE



lung volumes and capacities



TV = Tidal volume (500 ml)
IRV = Inspiratory reserve volume (3,000 ml)
IC = Inspiratory capacity (3,500 ml)
ERV = Expiratory reserve volume (1,000 ml)
RV = Residual volume (1,200 ml)
FRC = Functional residual capacity (2,200 ml)
VC = Vital capacity (4,500 ml)
TLC = Total lung capacity (5,700 ml)

lung volumes and capacities

Static lung volumes and capacities

Tidal Volume	TV	The volume of air inhaled & exhaled at each breath during normal quiet breathing
Inspiratory Reserve Volume	IRV	The volume of air that can be forcefully inspired following a normal quiet inspiration
Expiratory Reserve Volume	ERV	The volume of air that can be forcefully expired after a normal or resting expiration
Vital Capacity	VC	The maximum amount of air that can be exhaled after the fullest inspiration possible (TV + ERV + IRV)
Inspiratory Capacity	IC	The maximum amount of air that can be inhaled after a normal exhalation (TV + IRV)

lung volumes and capacities

Residual Volume	RV	The volume of air remaining in the lungs after a forceful expiration
Total Lung Capacity	TLC	The total volume of the lungs (VC + RV)
Functional Residual Capacity	FRC	The amount of air remaining in the lungs after a normal quiet expiration (ERV + RV)

Dead space: the part of each breath that remains in the upper respiratory tract does not exchange.

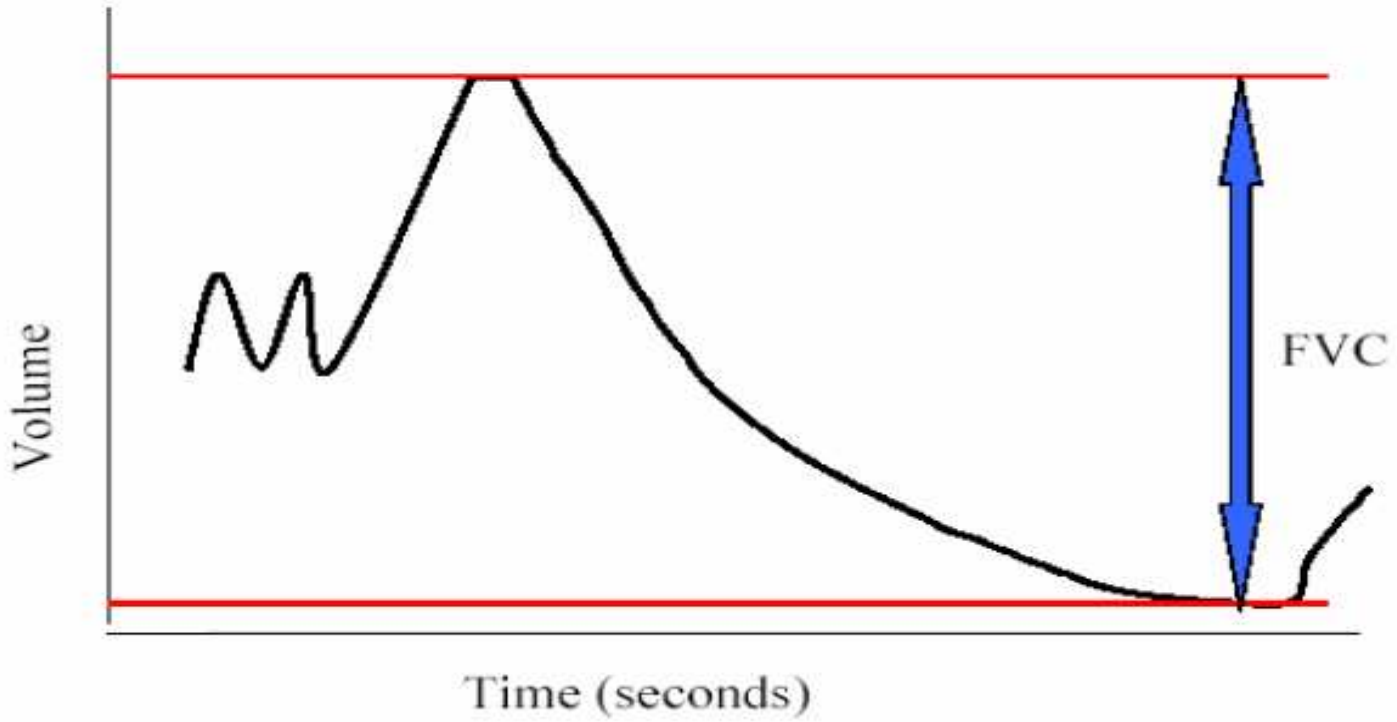
Dynamic Lung Volumes

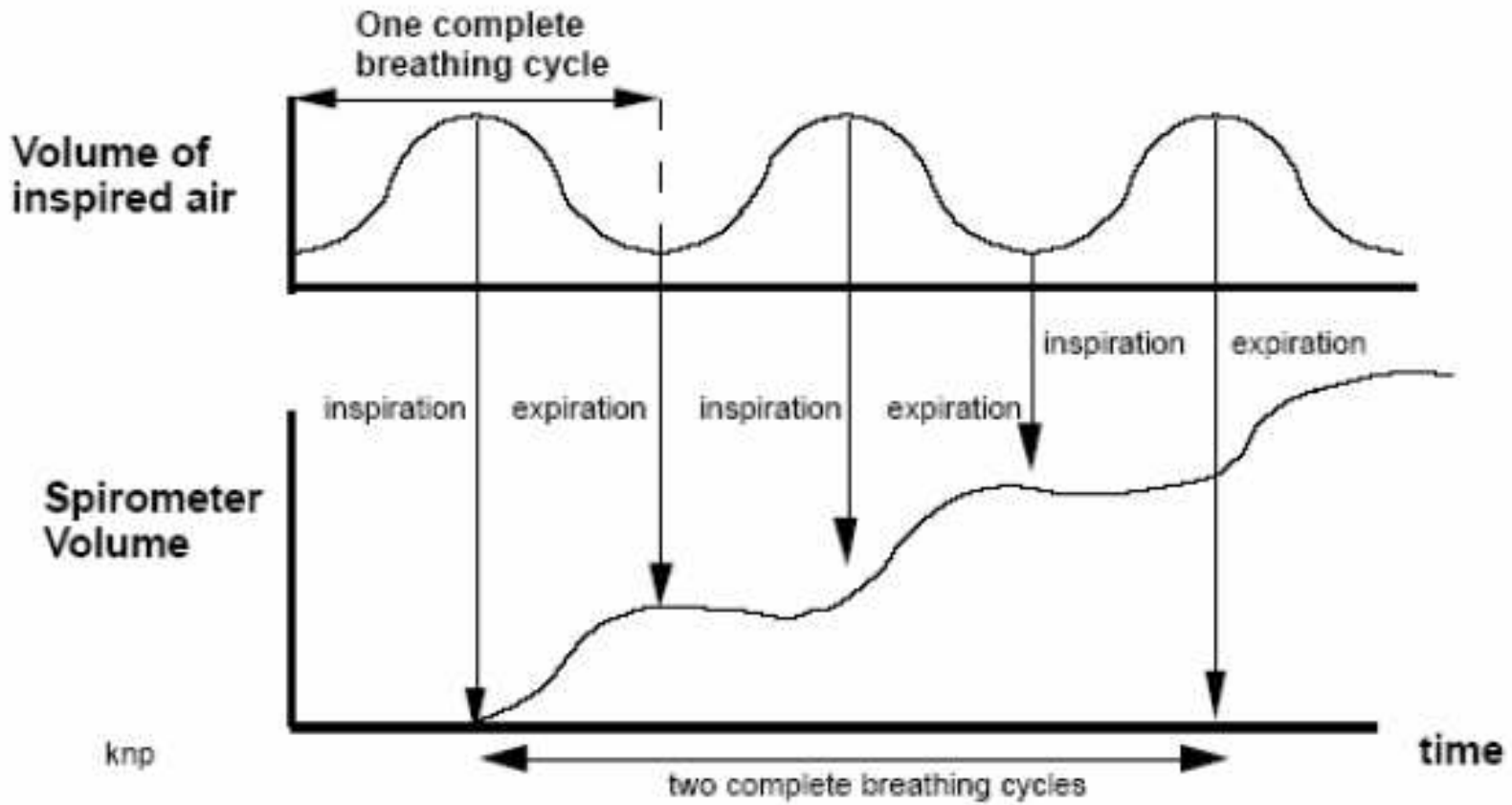
Forced Vital Capacity	FVC	The total volume expired by a forced maximal expiraion from a position of maximal inhalation
Forced Expiratory Volume in 1 sec	$FEV_{1.0}$	The volume of air expired in the first second of maximal forced expiration from a position of full inspiration
Forced Expiratory Flow from 25-75% of exhalation	FEF_{25-75}	The average flow rate during the middle 50% of the forced vital capacity maneuver.

or Maximum Mid-expiratory Flow (MMEF)

Dynamic Lung Volumes

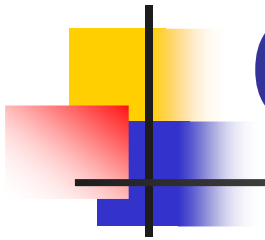
Calculating FVC





Lung volumes & capacities depend on

- • Age
- • Body size (height & weight)
- • Gender
- • Pulmonary health
- • Altitude
- • Irritants



Questions

- How we can Measure Lung volumes?
- What are lung volumes and capacities?
- Explain the terms
- TV
- IRV
- ERV
- VC
- IC

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Sub-Topic			

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Spirometer

- Apparatus used to measure static & dynamic lung volumes/capacities using a closed system
- • Registers the amount and rate of air moved into or out of the lungs

2 main types;

- 1. Volume: records the amount of air exhaled or inhaled within a certain time*
- 2. Flow: measures how fast the air flows in or out as the volume of air inhaled or exhaled increases

Volume Spirometers

- Real time tracings record volume in relation to time

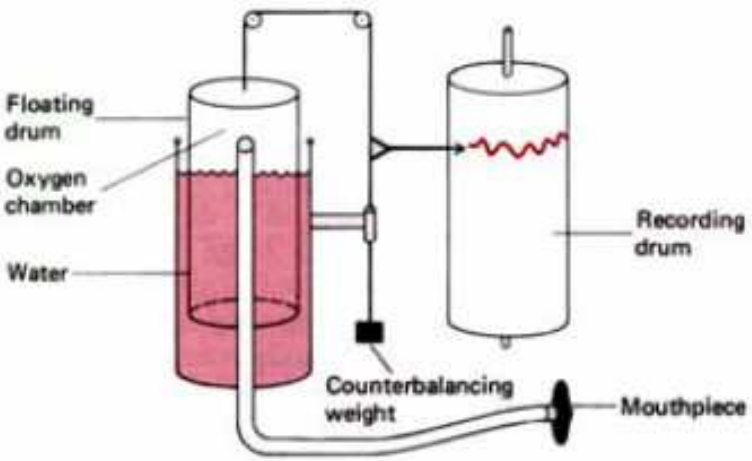
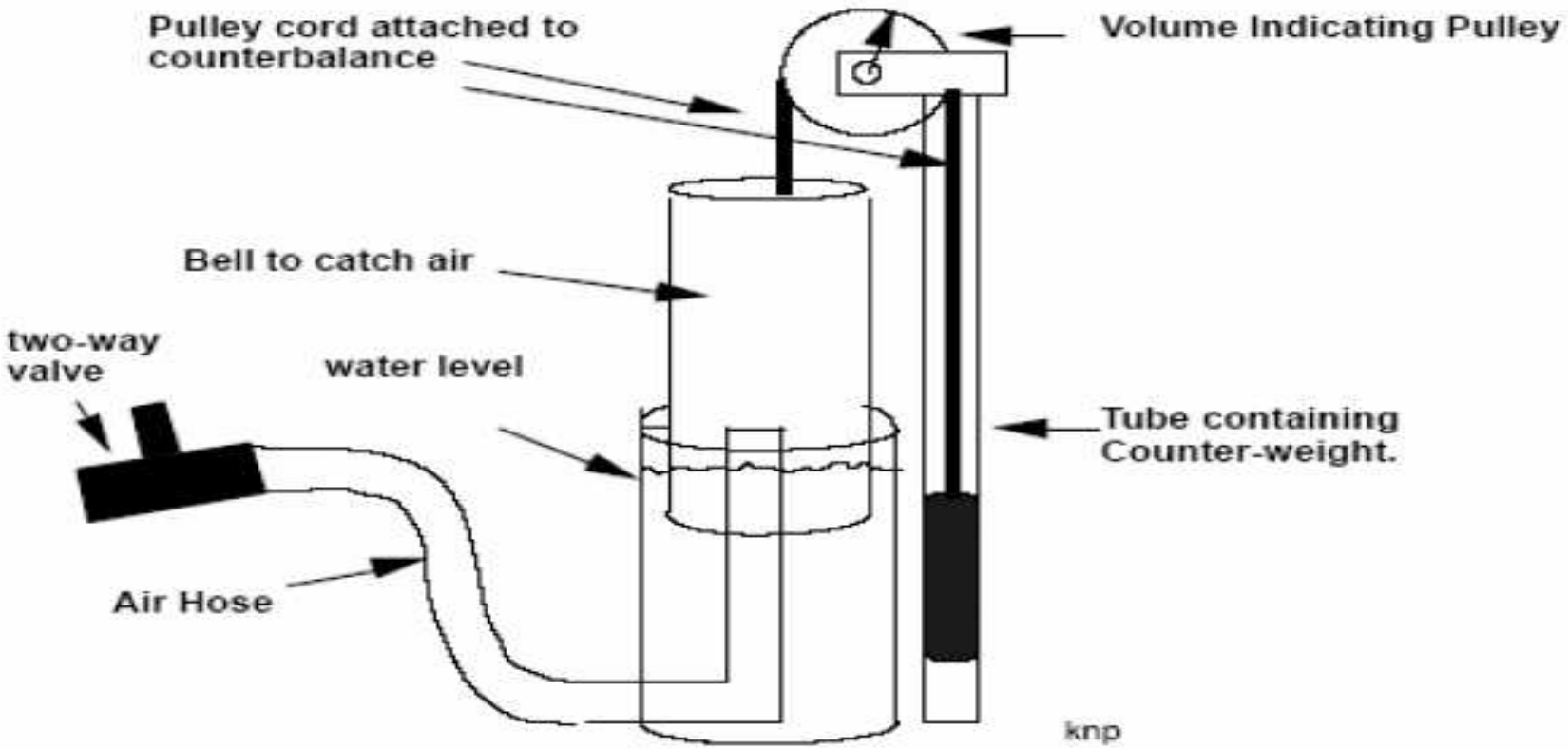


Figure 39–4. A spirometer.

Spirometers

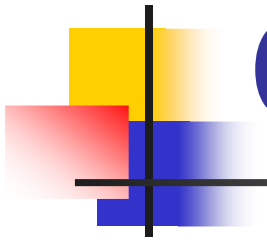


Advantages – Volume Spirometers

- • Some are portable versions
- • Leak tests and calibrations are easy to perform
- • Many can produce flow/volume curves and loops with the addition of special electronic or digital circuitry.
- • Volume spirometers hold their calibration months to years better than flow spirometers

Disadvantages – Volume Spirometer

- Not practical by hand to determine peak expiratory flow or instantaneous volumes,
- • Coughs and submaximal efforts are not as obvious
- • Some are heavy, cumbersome and may be prone to fostering mold or bacterial growth if not cleaned properly



Questions

- How we can Measure the measure static & dynamic lung volumes/capacities?
- What is Volume Spirometer?
- What are the Advantages – Volume Spirometers?
- What is Spirometers

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Inhalators

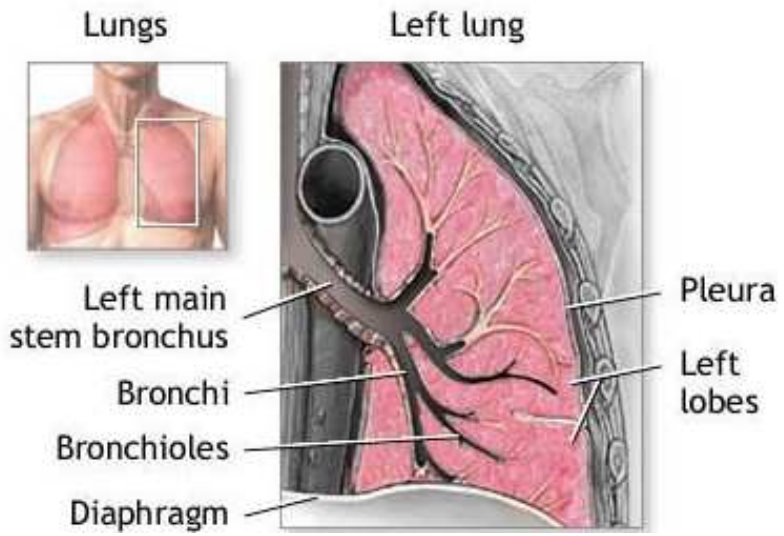
Purpose of inhalers

Delivery of fast-acting medication for conditions such as asthma and COPD
- Rescue medications generally work within 5 to 15 minutes

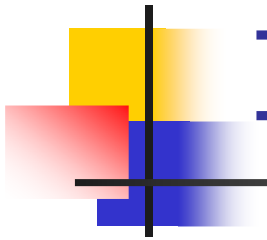
Local actions of medication

- Problem is in the airways
- Reduce systemic side effects

Patients are rarely prescribed a single inhaler to manage their respiratory disease(s)



"Next to pills, the inhaler is the most common medication form in the world."

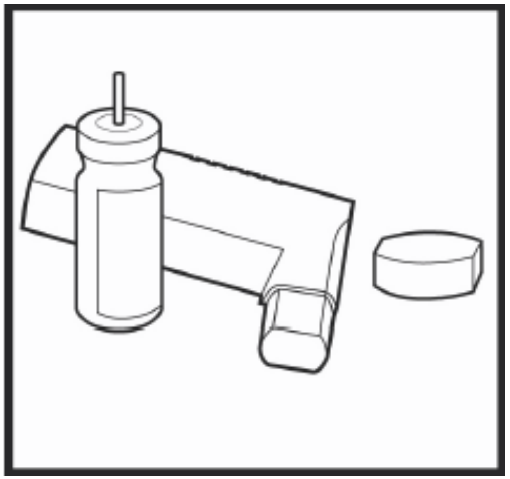


Inhalators

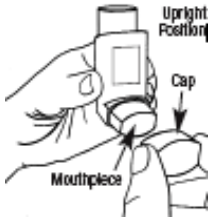
Metered dose inhaler (MDI)
– Pressurized, hand-held device
– Uses propellants (CFC, HFA) to deliver dose of medication to the lungs

• Dry powder inhaler (DPI)
– Breath-activated, hand-held device
– Uses force of inhalation to deliver dose of medication to the lungs

Using Inhalators



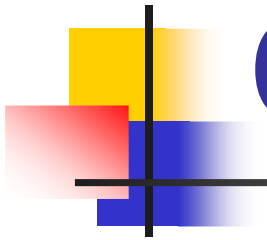
SHAKE



UNCAP

INHALE

Reference
http://pharmacy.wingate.edu/phideltachi/PDF_Forms/Respiratory%20Inhalers%20color%20handout.pdf



Questions

- How we can use Inhalators?
- What are the Inhalators?
- What are Purpose of inhalers?

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Unit	III	Lecture - Topic	INHALATOR
Sub-Topic			

Fill Up the Following Check List (Should be filled by the Content Creator)	Yes	No
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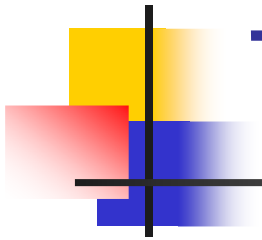
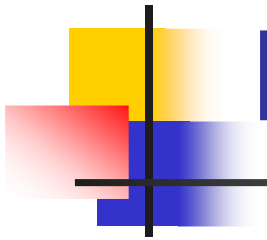


Types of Ventilator

- Positive Pressure Ventilators
  - Gas blown into lungs
  - All Current Itu and Theatre Ventilators
  - Unphysiological but practical
- Negative Pressure Ventilators
  - “Iron Lung”
  - Cuirass (breastplate) ventilators
  - Physiological but impractical



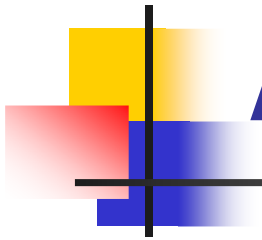
History

- Need arose from polio epidemics in 1950s and changes in anaesthetic techniques (muscle relaxants)
- Originally engineering challenge
- Inflexible

Classification

- Most classifications obsolete but need to be known
- Based on cycling
  - Pressure cycling – cycles when pressure attained in system
    - Compensates for leaks
    - Vt changes with changes in compliance
  - Volume cycling – cycles when preset volume delivered
    - Doesn't compensate for leaks
    - Will generally deliver preset volume (unless limit reached)
  - Time cycling – cycles after given time
    - Unresponsive to leaks or compliance changes
- or Inspiratory flow patterns
  - Flow generation
    - High powered ventilator can deliver constant flow through inspiration – flow rate unaffected by patient characteristics
  - Pressure generation

    Low powered ventilator delivering decreasing flow through inspiration -

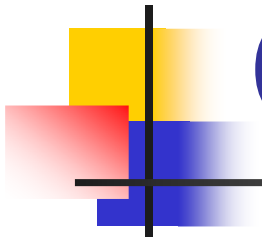


Anaesthetic Ventilators

- Need to be capable of being attached to anaesthetic machine and scavenging
- Less sophisticated / flexible than itu ventilators
- Nowadays , generally must be usable with circle

Manley Ventilator

- Minute Volume divider
- Vt set by operator. Rate=FGF/Vt
- Driving Force = Fresh Gas Pressure



Questions

- What is Ventilator?
- What are Classification of Ventilator?

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Unit	III	Lecture - Topic	VENTILATOR
Sub-Topic			

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Reasons for Respirators?

- Certain Breathing conditions are hazardous to life and lung.
- The air can be contaminated with:
  - Dusts, Mists, Fumes
  - Toxic Vapors
- The air can have too little oxygen.

Types of Respirators

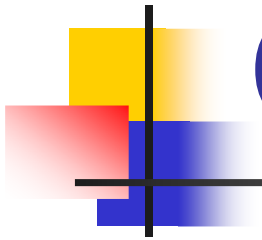
- Air Purifying Respirators
  - Used to filter out or neutralize contaminants
  - Examples: Dust; Organic Vapor
- Air Supply Respirators
  - Used when there is a lack of oxygen, when the hazard is unknown or is undetectable by smell or taste.
  - Examples: Compressor & Hose; SCBA

Filtering Respirators

- Particulates - Dusts, Mists & Fumes
  - New Classes; N, R, P; 95, 99, 100
  - Non-Resistant(Oil), Resistant(Oil), (Oil) Proof
- Toxins - Organics, Acids, etc.
  - Neutralizing or Absorbing
- Filtering Respirators are Hazard Specific
  - Don't expect one respirator to protect you from all hazards!

Health Conditions that Interfere with Respirator Use

- Heart Conditions
- Asthma or other breathing problem
- Claustrophobia (fear of enclosed space)
- Missing Teeth



Questions

- What is respirator?
- What are Classification of respirator?
- When we use respirator?

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Unit	III	Lecture - Topic	RESPIRATOR	Sub-Topic	

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Reference

- Reference Books...
- 1. Cromwell- Biomedical Instrumentation and Measurements- PHI
- 2. Webster,j.g. –Bio- Instrumentation ,Wiley (2004)
- 3. Ananthi,S. –A Text Book of Medical Instruments-2005-New Age International
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- Reference web address..
- IEEE TRANSACTIONS ON INSTRUMENTATION AND
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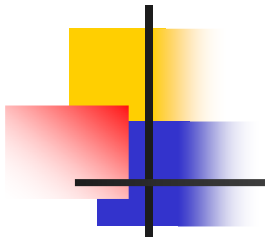
- www.ieee.or.com/ Archive/ Welch Allyn.pdf

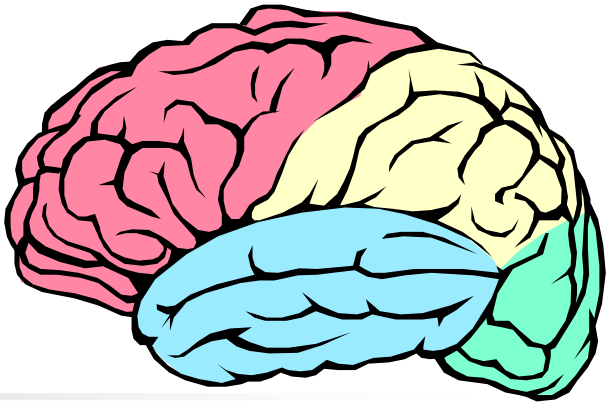
- Reference e-books.
- 1-Encyclopedia of Biomaterials and Biomedical engineering
- second edition, Volume 1
- Edited by
- gary e. Wnek, gary l. BoWlin
- 2-BIOMEDICAL INFORMATION TECHNOLOGY
- EDITED BY
- DAVID DAGAN FENG
- 3-SENSORS in BIOMEDICAL APPLICATIONS
- Fundamentals, Technology and Applications
- Edited by
- GÁBOR HARSÁNYI(CRC PRESS)
- 4- Medical instrumentation application and design contributing
- authors, John W. Clark, Jr... [et al.] . Webster, John G
- 5-Basic Concepts of Medical Instrumentation
- Medical Instrumentation: Application and Design Third Edition
- John G. Webster, Editor
- 6- Biomedical Instrumentation & Design
- Matt O'Donnell



BIO-MEDICAL INSTRUMENTATION

UNIT-4

The Nervous System



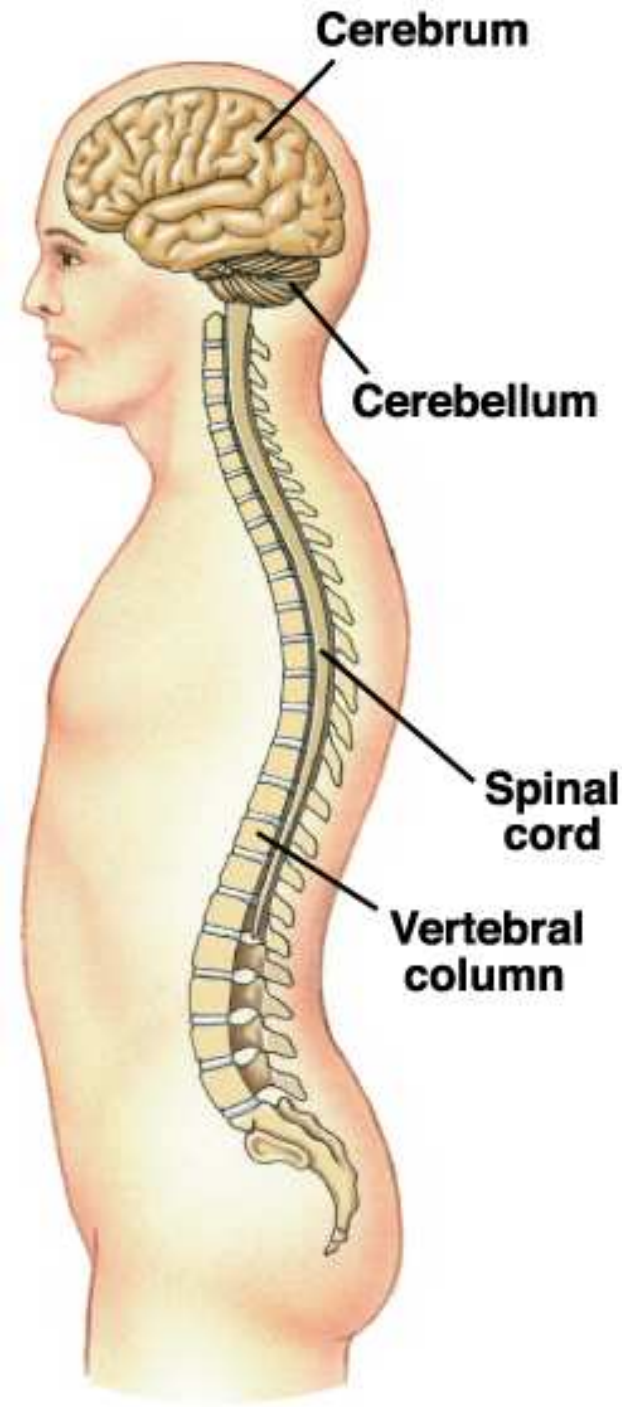
- A network of billions of nerve cells linked together in a highly organized fashion to form the rapid control center of the body.
- Functions include:
  - Integrating center for homeostasis, movement, and almost all other body functions.
  - The mysterious source of those traits that we think of as setting humans apart from animals

Basic Functions of the Nervous System

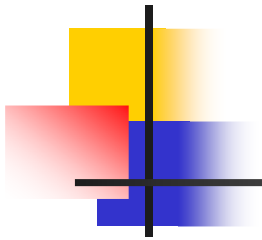
1. Sensation
   - Monitors changes/events occurring in and outside the body. Such changes are known as stimuli and the cells that monitor them are receptors.
2. Integration
   - The parallel processing and interpretation of sensory information to determine the appropriate response
3. Reaction
   - Motor output.
     - The activation of muscles or glands (typically via the release of neurotransmitters (NTs))

Organization of the Nervous System

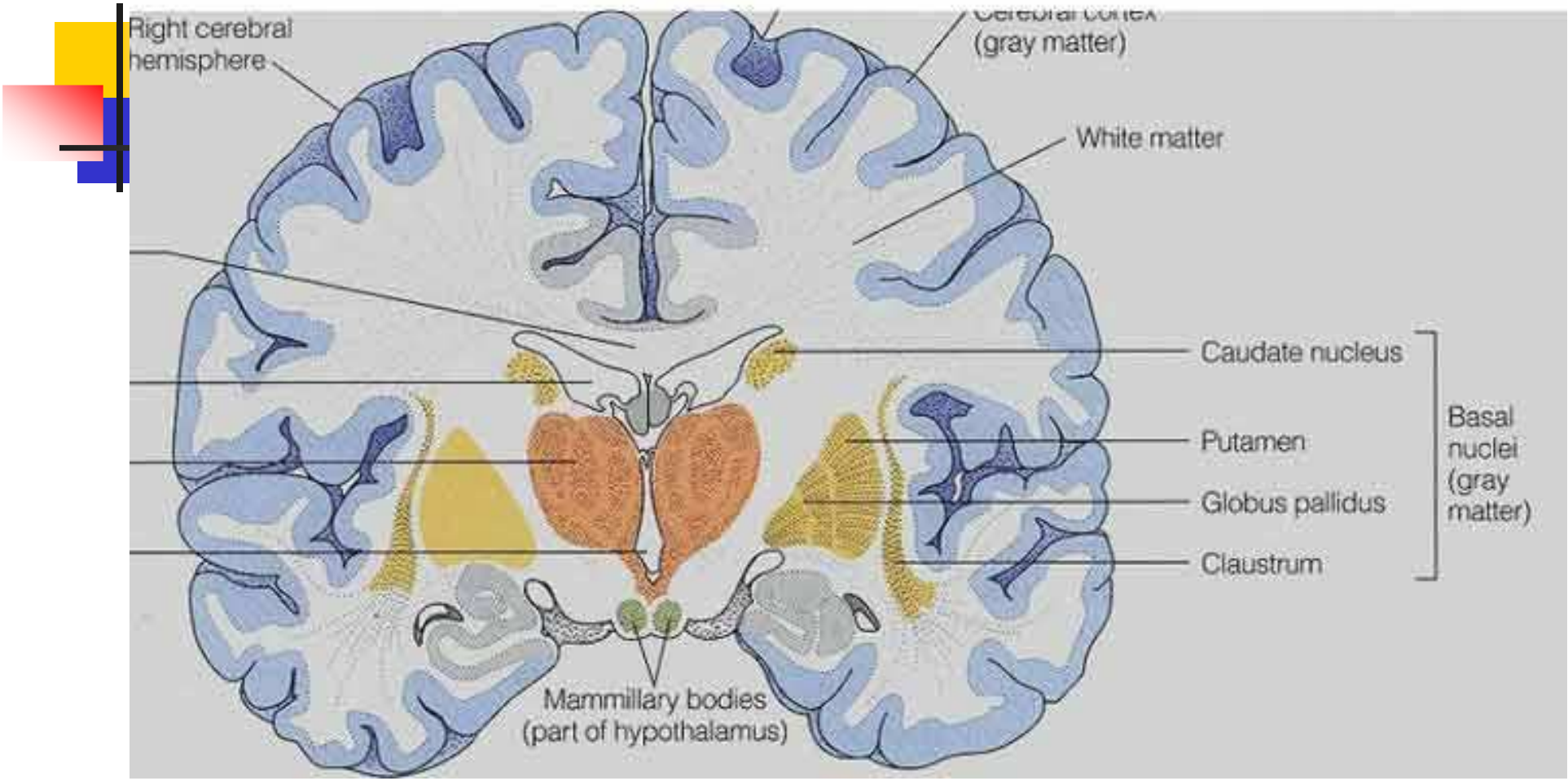
- 2 big initial divisions:
  1. Central Nervous System
     - The brain + the spinal cord
       - The center of integration and control
  2. Peripheral Nervous System
     - The nervous system outside of the brain and spinal cord
     - Consists of:
       - 31 Spinal nerves
         - Carry info to and from the spinal cord
       - 12 Cranial nerves
         - Carry info to and from the brain

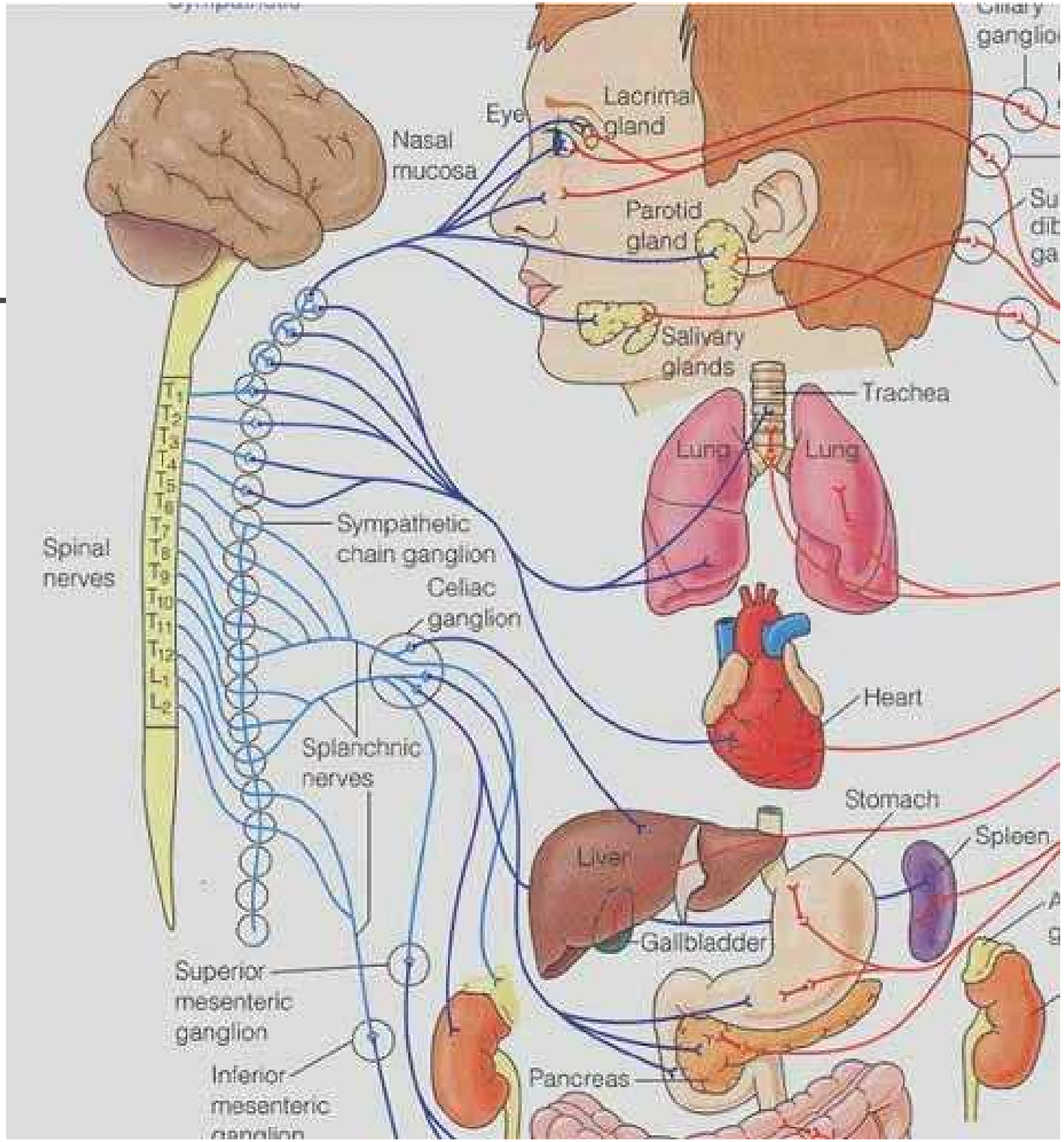


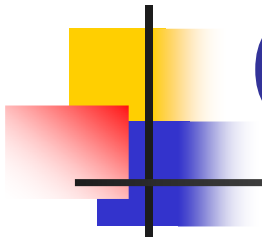
Central Nervous System (CNS)



- Brain
- Spinal Cord







Questions

- What is Basic Functions of the Nervous System ?
- What is Central Nervous System (CNS)?
- Explain the parts of Nervous System?

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Unit: IV	Lecture - Topic: The Nervous System	Sub-Topic	Central Nervous System

Fill Up the Following Check List (Should be filled by the Content Creator)	Yes	No
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Peripheral Nervous System (PNS)

- Cranial Nerves – emerge through cranial foramina of the skull
- Spinal Nerves – emerge through intervertebral foramina
- Ganglia – groups of nerve cell bodies outside of the brain and spinal chord
- Autonomic Nervous System – innervates smooth muscle, cardiac muscle, and glands

Nucleus

Cell body

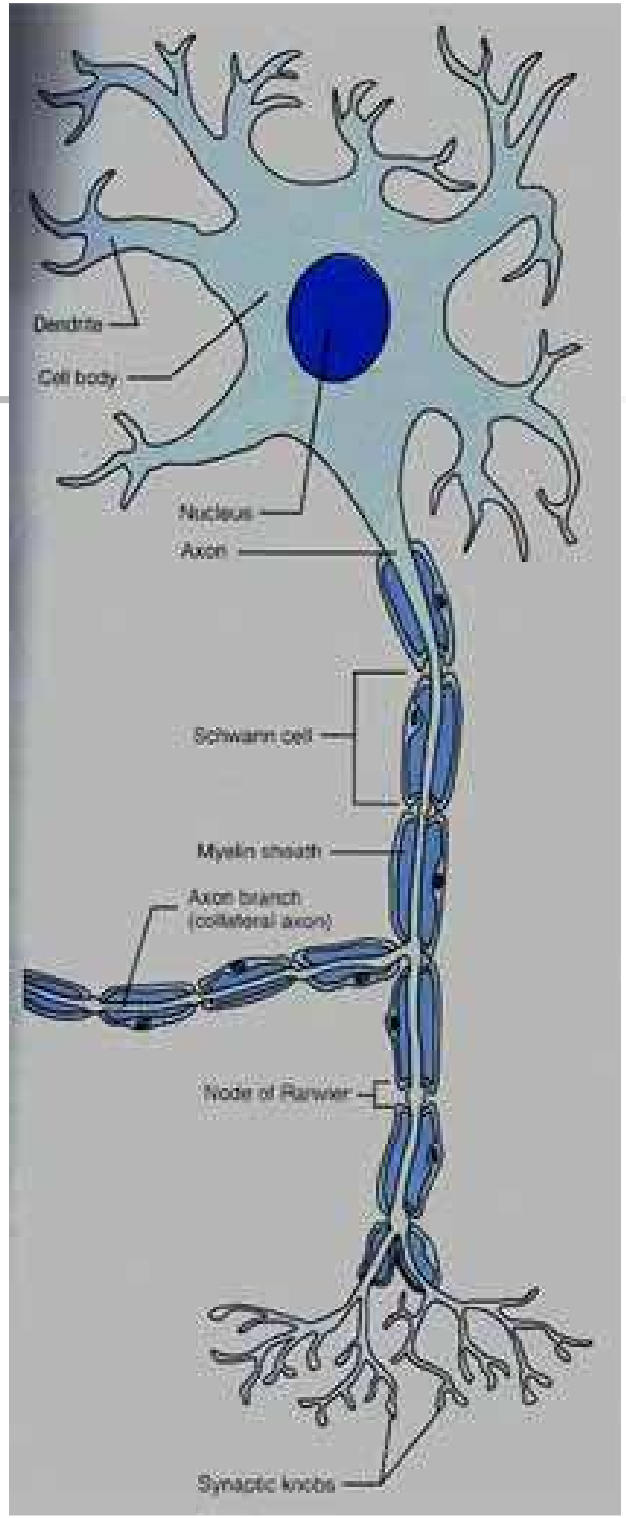
Dendrite

Axon

Schwann cell

Synaptic knobs

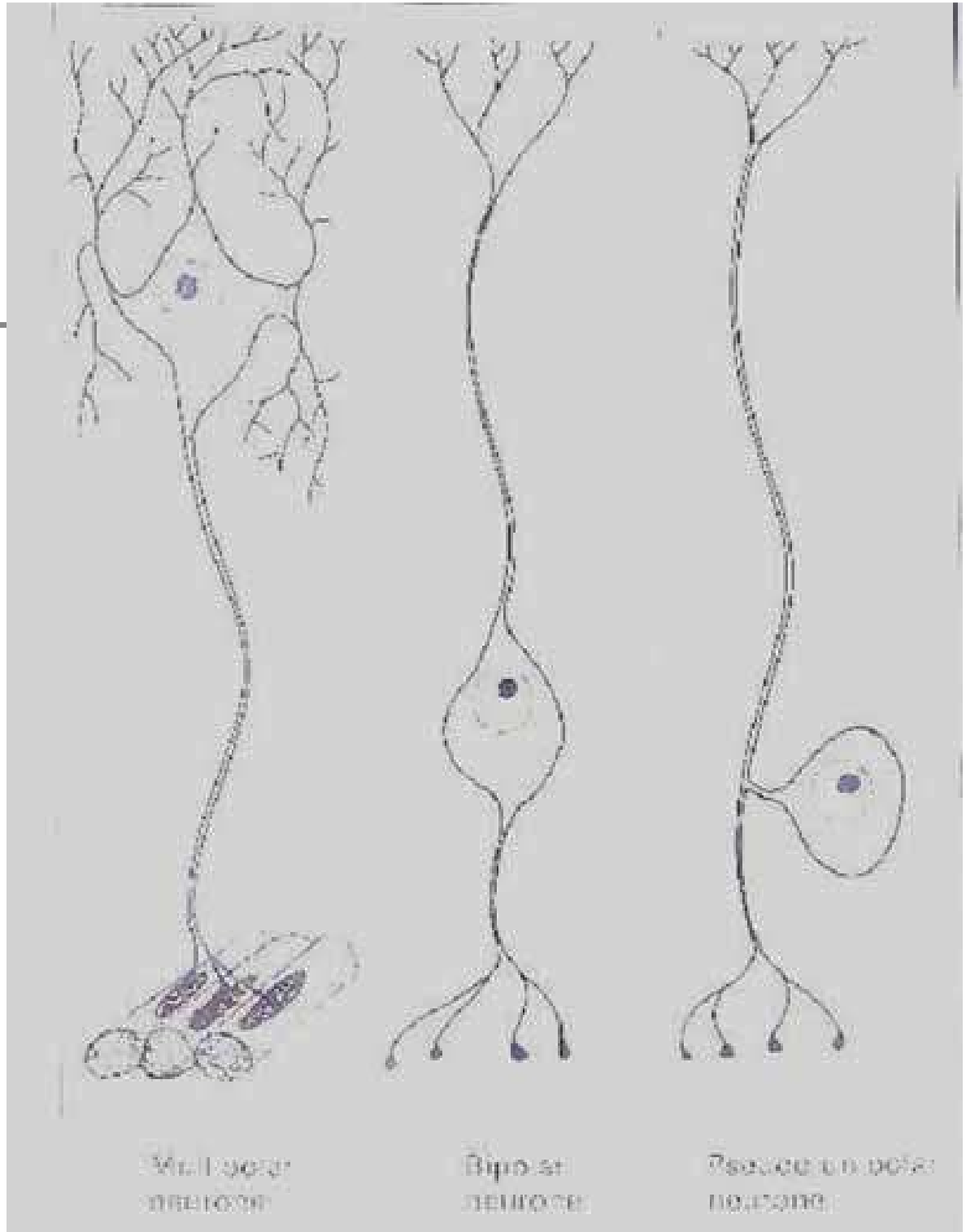
Node of Ranvier



Classification of Nerve Cells (Neurons)

- By # of Processes:
  - A. Unipolar – one process
  - B. Bipolar – one dendrite and one axon
  - C. Multipolar – branching to create more than one of each

99% are Multipolar



By Function:

- A. Sensory (afferent)
- B. Motor (efferent)
- C. Interneurons – interposed between sensory and motor neurons

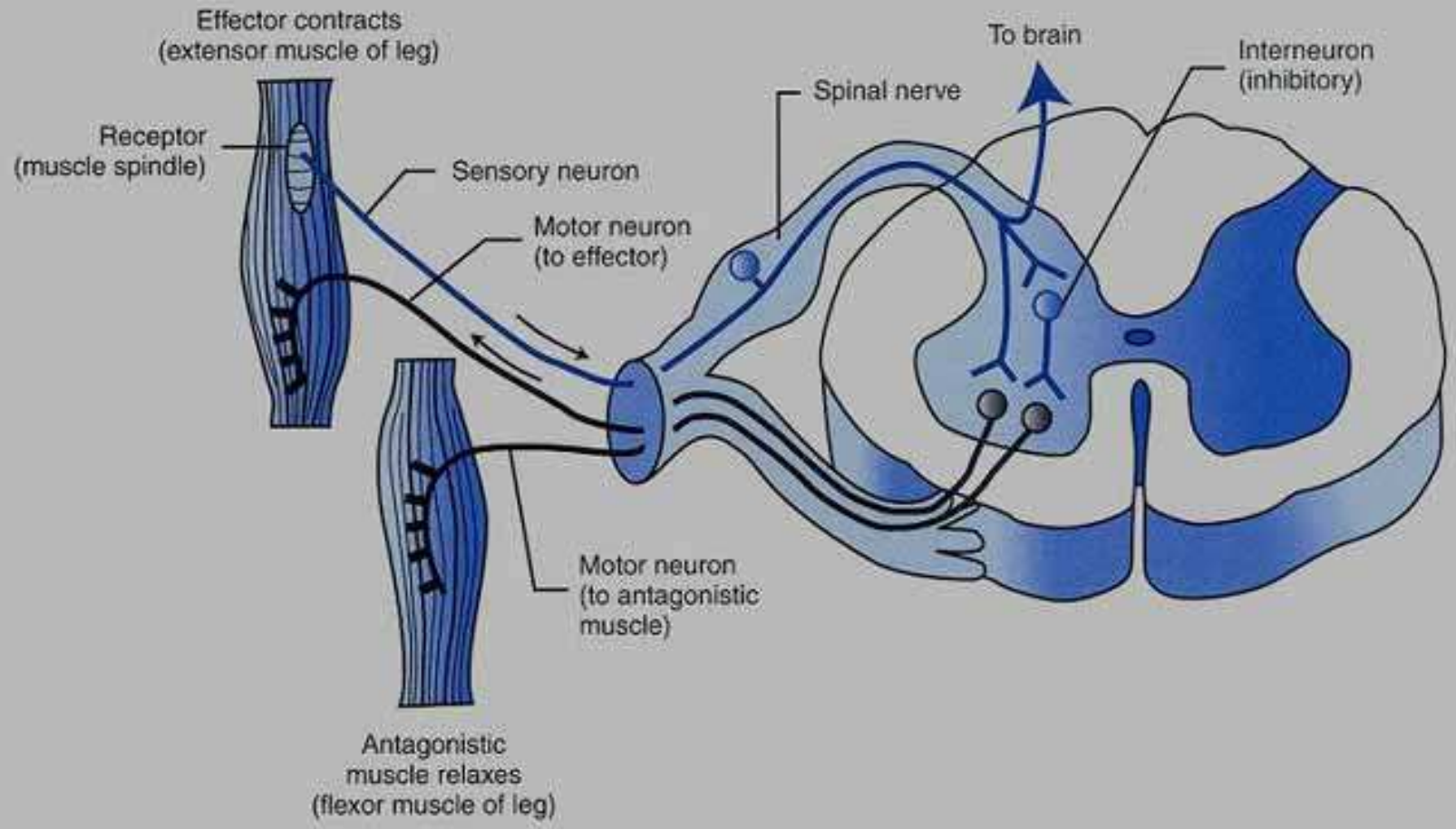
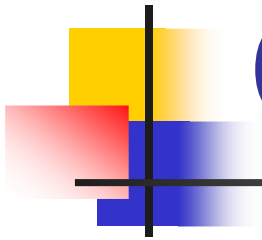


FIGURE 7-12 Basic Reflex Arc as Illustrated by Simple Stretch Reflex.

Myelinization

- Myelin Sheath – The specialized glial cells that wrap around the axon of neurons.
  - Within the CNS Oligodendrocytes
  - Within the PNS Schwann Cells



Questions

- What is Peripheral Nervous System (PNS)?
- What are Classification of Nerve Cells ?
- Explain the construction of neuron with diagram?

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Neuronal Communication

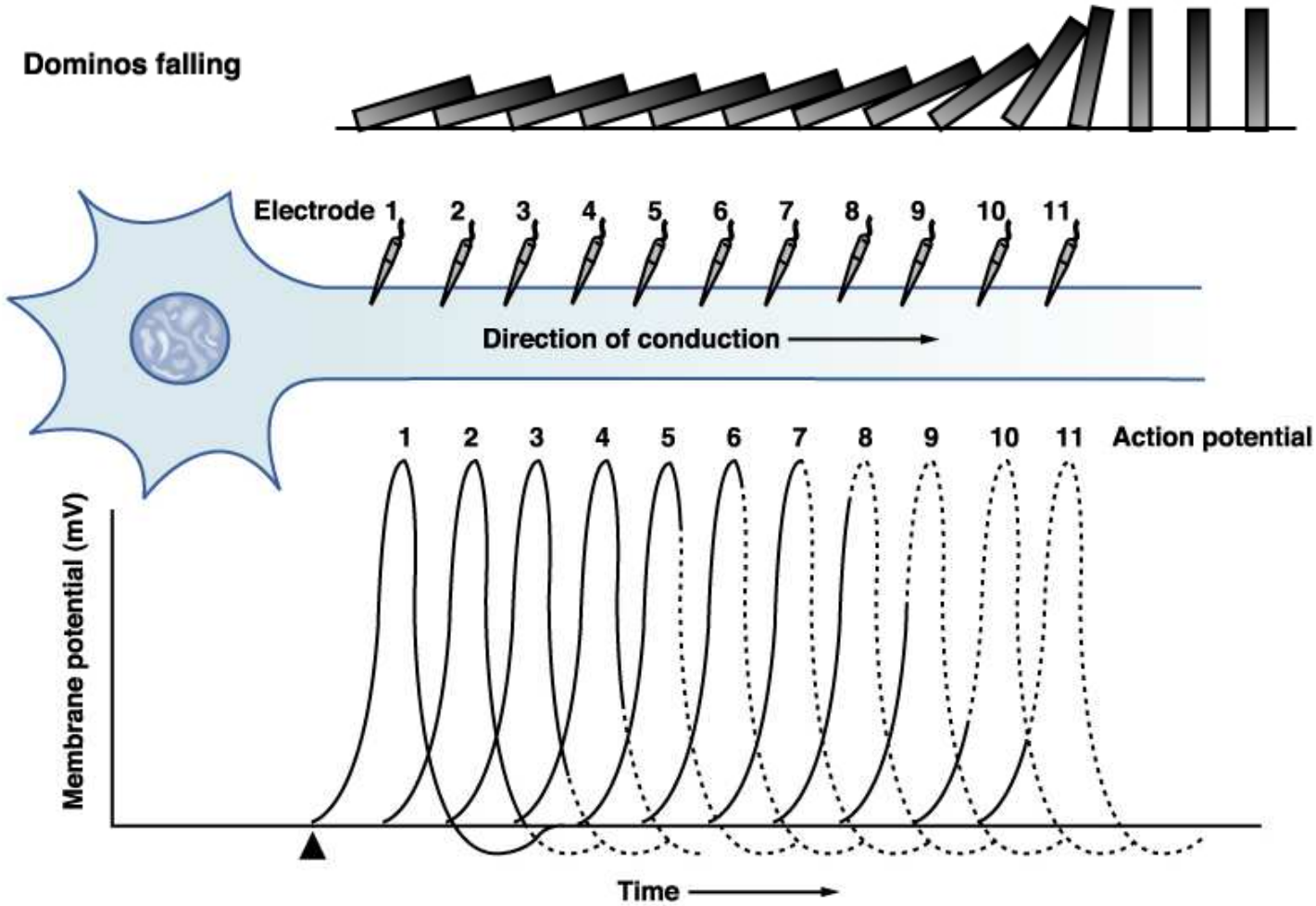
- Begins with the stimulation of a neuron.
  - One neuron may be stimulated by another, by a receptor cell, or even by some physical event such as pressure.
- Once stimulated, a neuron will communicate information about the causative event.
  - Such neurons are sensory neurons and they provide info about both the internal and external environments.
  - Sensory neurons (a.k.a. afferent neurons) will send info to neurons in the brain and spinal cord. There, association neurons (a.k.a. interneurons) will integrate the information and then perhaps send commands to motor neurons (efferent neurons) which synapse with muscles or glands.

Communication

- Thus, neurons need to be able to conduct information in 2 ways:
  1. From one end of a neuron to the other end.
  2. Across the minute space separating one neuron from another. (What is this called?)
     - The 1st is accomplished electrically via APs.
     - The 2nd is accomplished chemically via neurotransmitters.

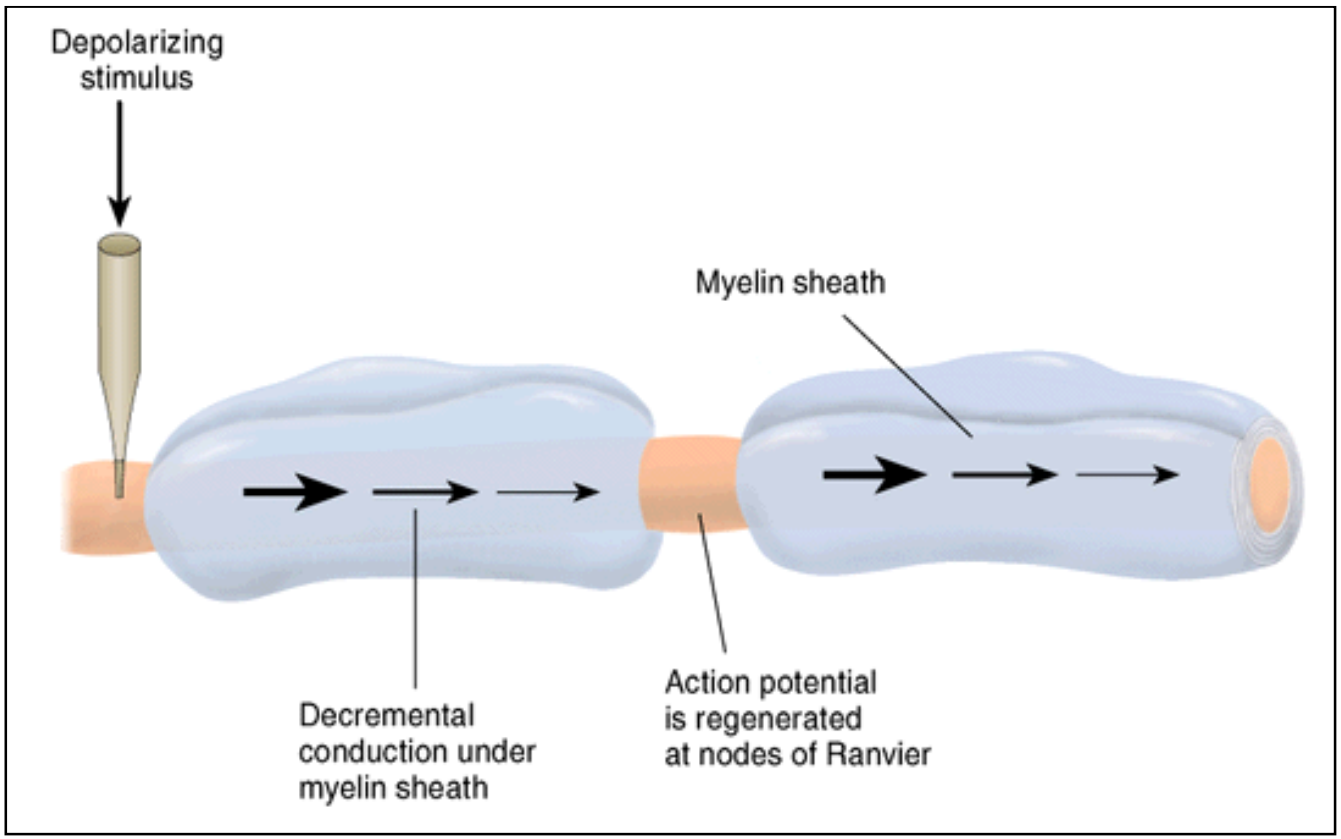
Continuous Conduction

- Occurs in unmyelinated axons.
- In this situation, the wave of de- and repolarization simply travels from one patch of membrane to the next adjacent patch.
- APs moved in this fashion along the sarcolemma of a muscle fiber as well.
- Analogous to dominoes falling.



Saltatory Conduction

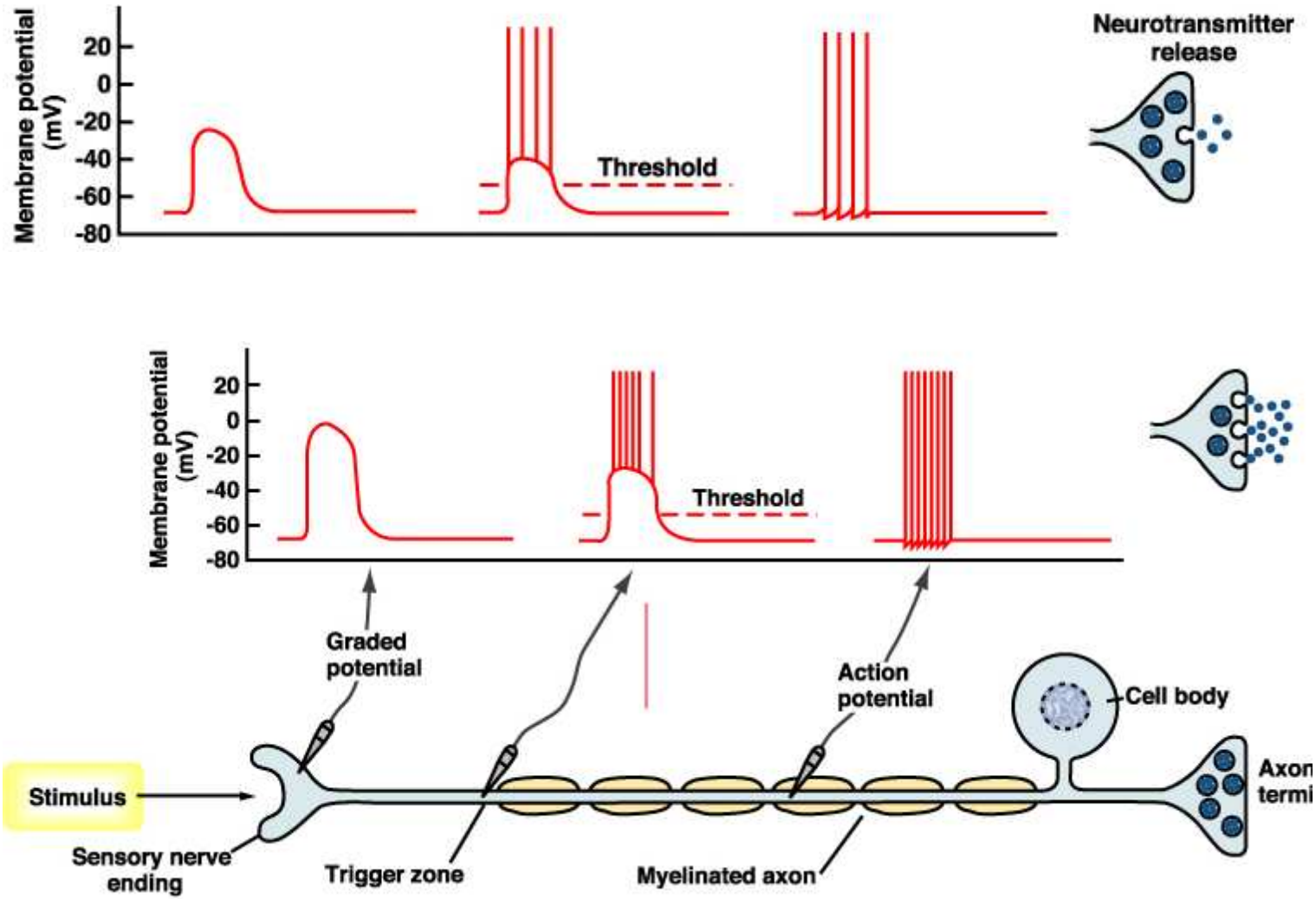
- Occurs in myelinated axons.
- Saltare is a Latin word meaning "to leap."
- Recall that the myelin sheath is not completed. There exist myelin free regions along the axon, the nodes of Ranvier.



Now we know how signals get from one end of an axon to the other, but how exactly do APs send information?

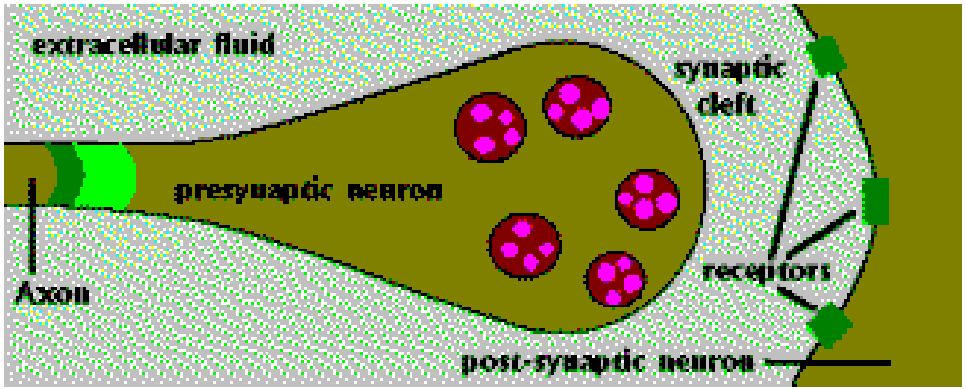
- Info can't be encoded in AP size, since they're "all or none."

In the diagram on the right, notice the effect that the size of the graded potential has on the frequency of AP's and on the quantity of NT released. The weak stimulus resulted in a small amt of NT release compared to the strong stimulus.



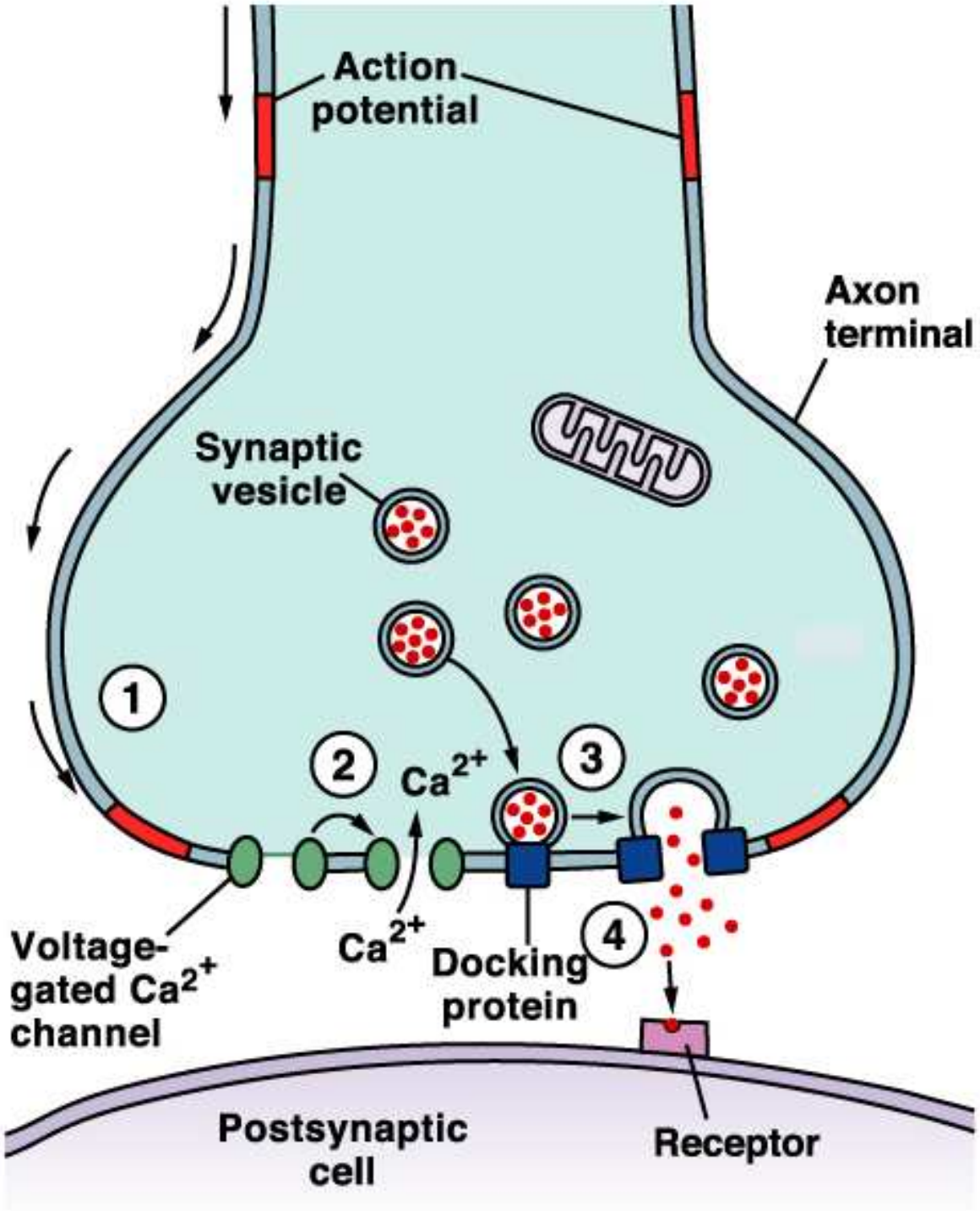
Chemical Signals

- One neuron will transmit info to another neuron or to a muscle or gland cell by releasing chemicals called neurotransmitters.
- The site of this chemical interplay is known as the synapse.
  - An axon terminal (synaptic knob) will abut another cell, a neuron, muscle fiber, or gland cell.
  - This is the site of transduction – the conversion of an electrical signal into a chemical signal.



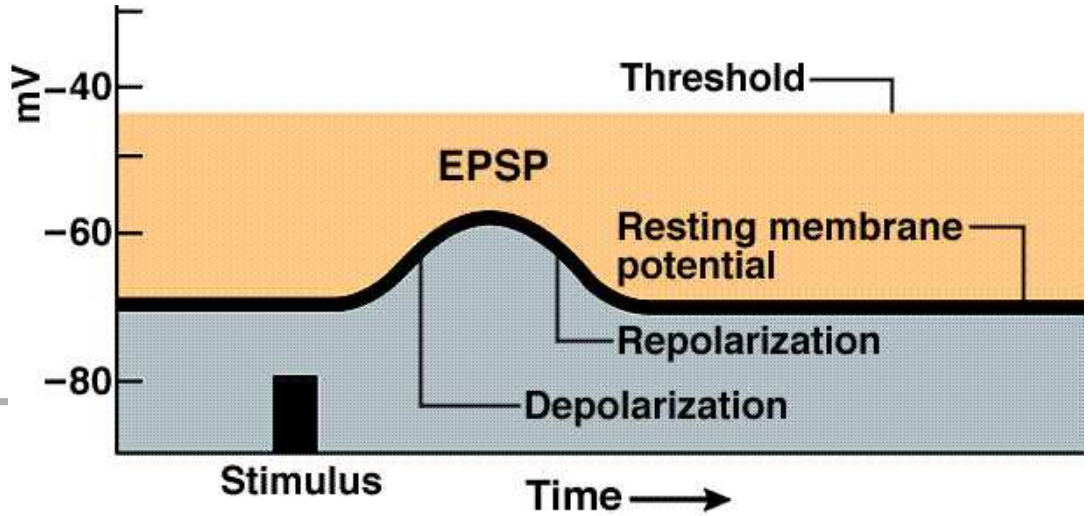
Synaptic Transmission

- An AP reaches the axon terminal of the presynaptic cell and causes V-gated Ca^{2+} channels to open.
- Ca^{2+} rushes in, binds to regulatory proteins & initiates NT exocytosis.
- NTs diffuse across the synaptic cleft and then bind to receptors on the postsynaptic membrane and initiate some sort of response on the postsynaptic cell.

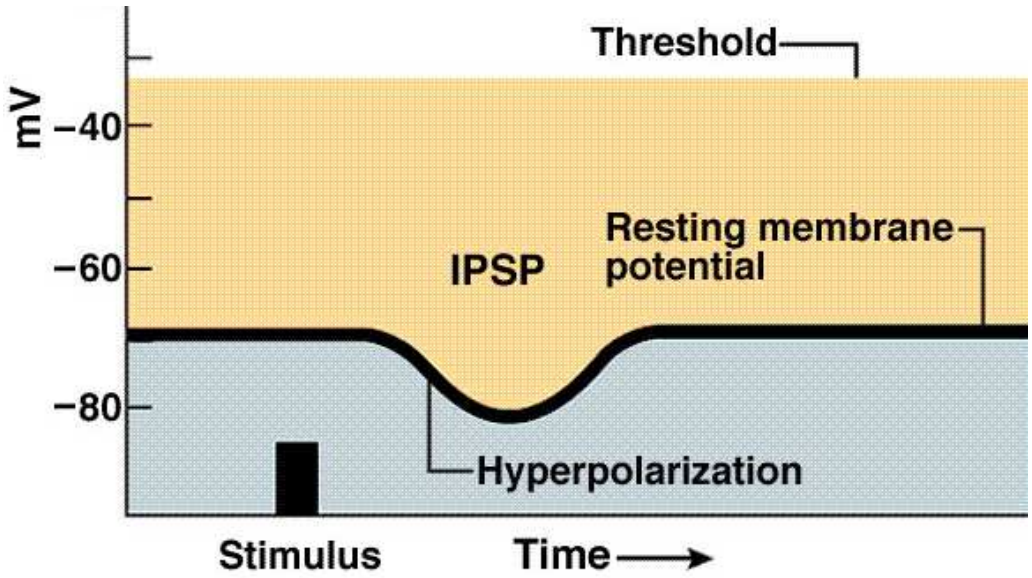


EPSPs & IPSPs

- Typically, a single synaptic interaction will not create a graded depolarization strong enough to migrate to the axon hillock and induce the firing of an AP.

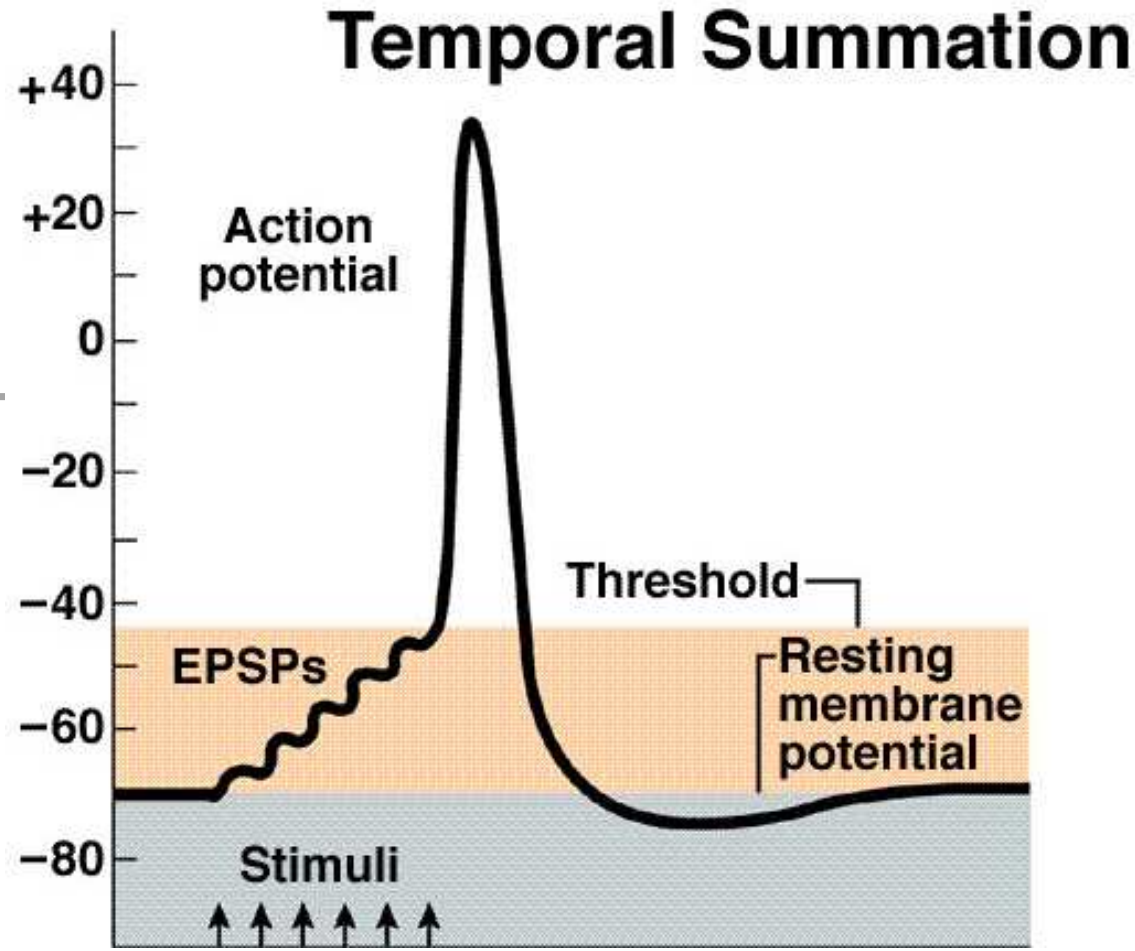


  - However, a graded depolarization will bring the neuronal V_M closer to threshold. Thus, it's often referred to as an excitatory postsynaptic potential or EPSP.
  - Graded hyperpolarizations bring the neuronal V_M farther away from threshold and thus are referred to as inhibitory postsynaptic potentials or IPSPs.

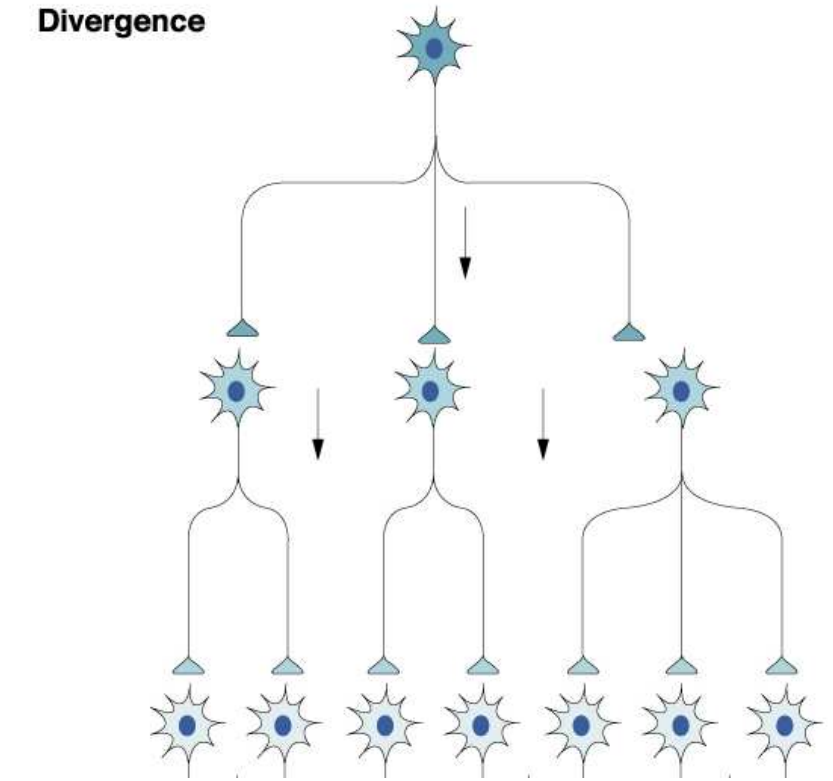


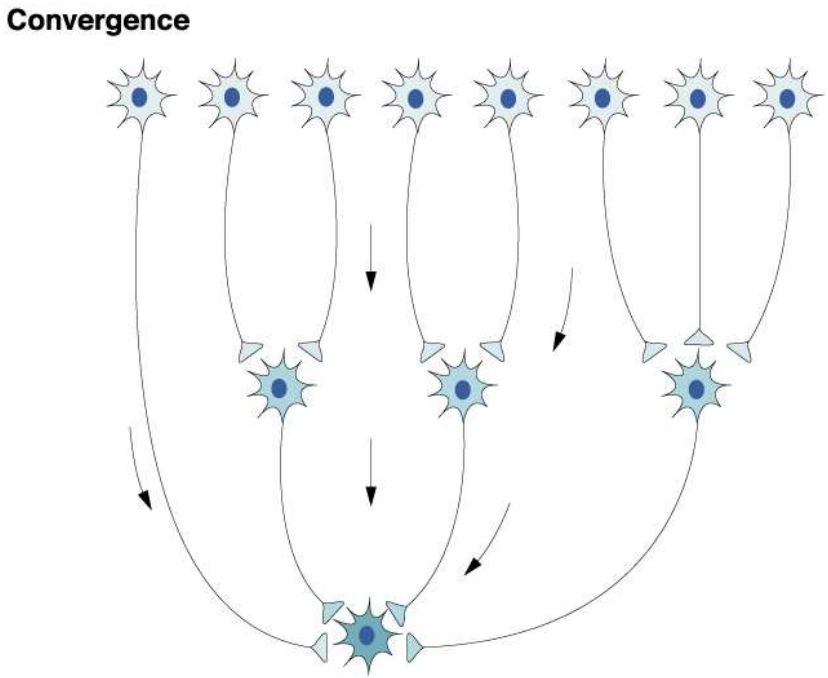
Summation

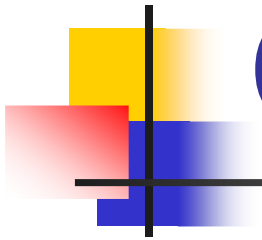
- One EPSP is usually not strong enough to cause an AP.
- However, EPSPs may be summed.
- Temporal summation
  - The same presynaptic neuron stimulates the postsynaptic neuron multiple times in a brief period. The depolarization resulting from the combination of all the EPSPs may be able to cause an AP.
- Spatial summation
  - Multiple neurons all stimulate a postsynaptic neuron resulting in a combination of EPSPs which may yield an AP



- Communication btwn neurons is not typically a one-to-one event.
  - Sometimes a single neuron branches and its collaterals synapse on multiple target neurons. This is known as divergence.
  - A single postsynaptic neuron may have synapses with as many as 10,000 postsynaptic neurons. This is convergence.
  - Can you think of an advantage to having convergent and divergent circuits?







Questions

- Explain the Neuronal Communication?
- What is EPSPs & IPSPs?
- What is synapse?

SHARDA GROUP OF INSTITUTIONS
Digital Course Content
Check list by Topic

Dept/ Year / Semester	EI/ 2009/ VII	Content Creator	ANUJ BHARDWAJ
Subject Code	TIC-701	Subject Coordinator	
Subject Description	BIO-MEDICAL INSTRUMENTATION	Reviewer	
Content Format	Digital (Slides in PPT)		

Unit	IV	Lecture - Topic	Neuronal Communication	Sub-Topic	Synaptic Transmission

Fill Up the Following Check List (Should be filled by the Content Creator)	Yes	No
Did you included the diagrams/references to diagrams related to this topic? (Including flow of Diagram)	√	
Did you explained the Problem Solving Approach for the Problems related to this topic ?	√	
Did you include Applications related to this topic in the Industry		√
Did you include Current Research and Development initiatives related to this topic?		√
Did you include Reading Assignment from the Reference Text Books?	√	
Did you Include Objective/ Interactive Questions/Answers related to this topic?		√
Did you include short and descriptive questions related to this topic?	√	
Did you include References to the answers for the short and descriptive questions?	√	
Did you include references of the published content in the Web/other resources (if you have referred it)	√	

Reference

- Reference Books...
- 1. Cromwell- Biomedical Instrumentation and Measurements- PHI
- 2. Pandey & Kumar-Biomedical Electronics and Instrumentation. – Kataria

- Reference web address..
- IEEE TRANSACTIONS ON INSTRUMENTATION AND
- MEASUREMENT

- Provided by the IEEE-EMBS Buenaventura Chapter
- J. G. Webster (ed.), Design of cardiac pacemakers, IEEE Press, 1995.
- www.hartnell.edu/faculty/awright/powerpoint/cardiovascular%20system.ppt -
- www.ieee.or.com/Archive/Welch_Allyn.pdf

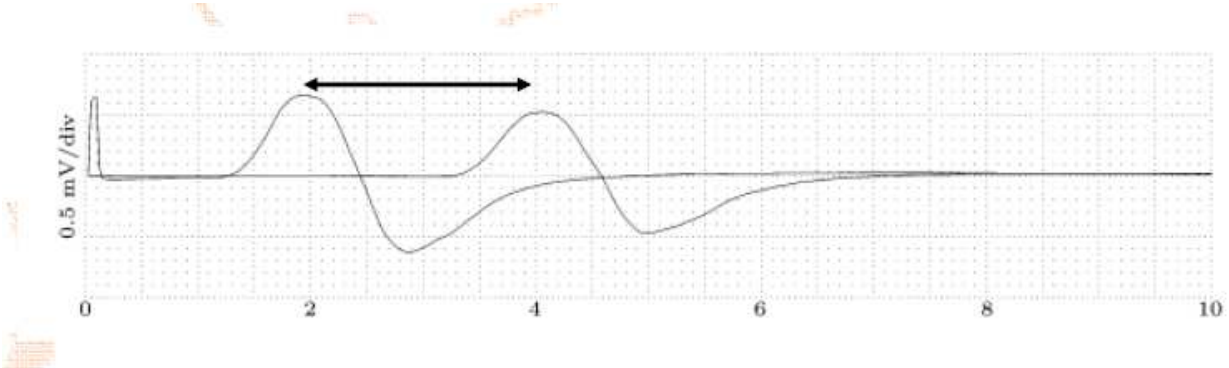
- Reference e-books.
- 1-Encyclopedia of Biomaterials and Biomedical engineering
- second edition, Volume 1
- Edited by
- gary e. Wnek, gary l. BoWlin

Electroneurogram - ENG

ENG is the response of a (peripheral) nerve cell when it is stimulated withan electrical shock.

Acquired using needle electrodes
Used to determine the conduction velocity of the nerve

• If the nerve does not respond quickly enough, or does not respond at all, it signifies a nerve injury.
• The conduction velocity is measured by placing two electrodes at close-by locations and recording the ENG at both locations. The temporal difference between the two ENG can then be used to obtain conduction velocity.

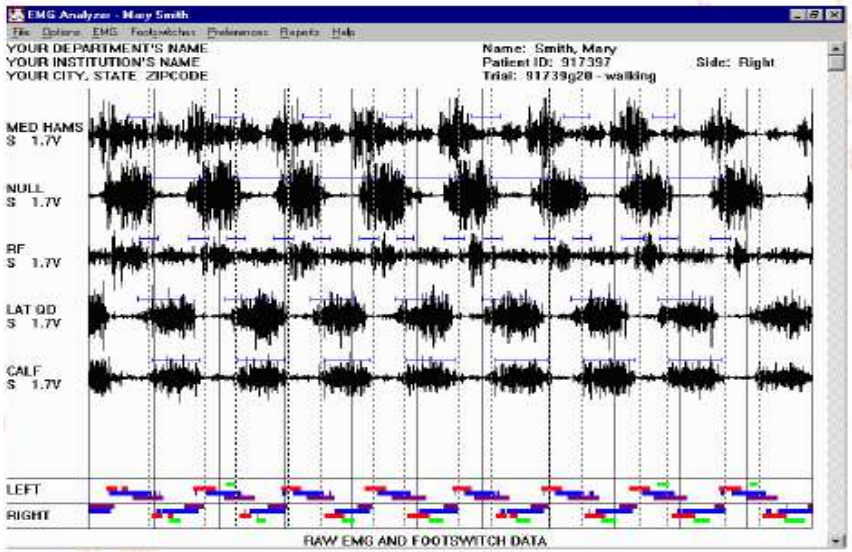


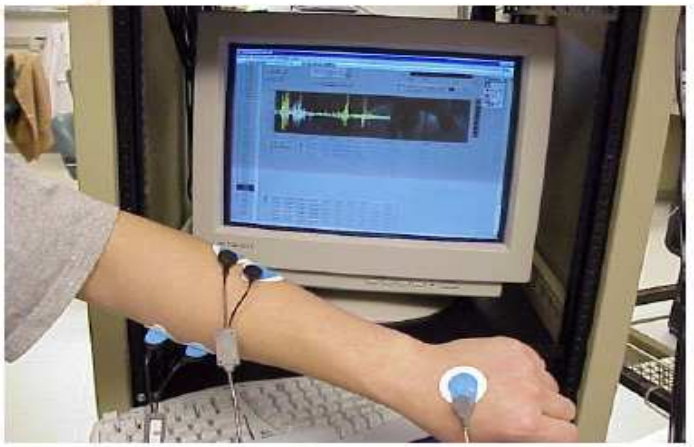
The Electromyogram -EMG

The EMG is the graphic representation of the electrical activity of the skeletal muscles – either during resting stage, or in response to stimulation

Unlike AP which is measured on the cellular level, the EMG is a surface signal obtained through surface and/or needle electrodes

• It is the collection / integration / amalgamation of millions of muscle APs asmeasured from the skin surface





http://www.pitt.edu/~zmli/handlab/image/EMG.JPG

Practical use…? Not always pleasant!

The EMG is used to determine whether a person's perceived muscle weakness is caused by a disease within the muscle or by a problem in a nerve supplying the muscle. This is an invasive test; it is performed by inserting needles into muscles and measuring their responsiveness to electrical stimulation. Risks may include pain during needle insertion, bleeding, or infection. Bleeding or infection occurs infrequently. The patient will feel electrical shocks in the muscles that are tested during the EMG. If the patient understands
the test and wants

A typical EMG lasts between 15 and 90 minutes. (Ouch!)

• The patient is positioned on an exam table with the muscles to be tested at rest.

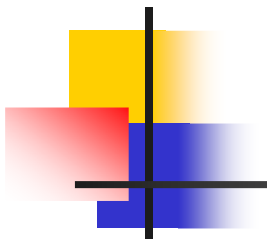
• An antiseptic is used to cleanse the skin at the planned needle insertion points and a metal plate
is positioned under the muscle(s) being tested.

• Several needle electrodes are then inserted through the skin and into the muscle.

• The muscle's electrical activity is measured at rest and with voluntary contraction.

• The electrical activity will be audible over an audio-amplifier. It is also visible on an oscilloscope
and recorded on graph paper.

• Following the test, the patient may take a mild analgesic and/or apply warm compresses to the
muscles for soreness. Needle insertion sites should be observed and the patient's primary health
care provider notified if bleeding, a hematoma, or signs of infection are noted.



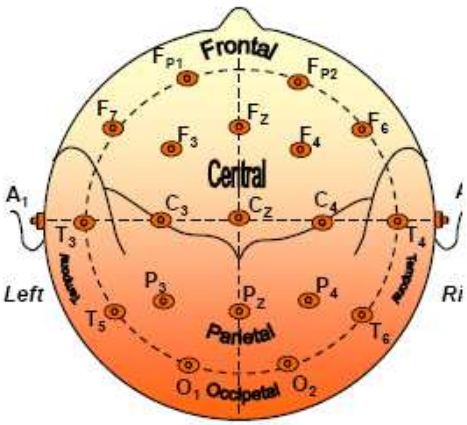
The Electroencephalogram
EEG

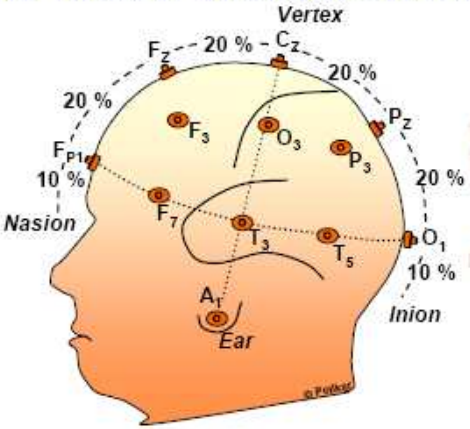
EEG is the graphical representation of the electrical activity of the brain

- Very commonly used to diagnose certain neurological disorders, such as epilepsy
- More recently, also investigated whether it can detect various forms of dementia or schizophrenia
- EEG is the specific recording obtained using the scalp electrodes from the surface of the skull
- During surgery, electrodes may also be placed directly on the cortex. The resulting signal is then **electrocorticogram (ECoG).**
- Just like ECG, EEG is also obtained using several different electrodes places on different regions of the head / brain

The Electroencephalogram
EEG

Traditionally, electrodes are placed at standard locations





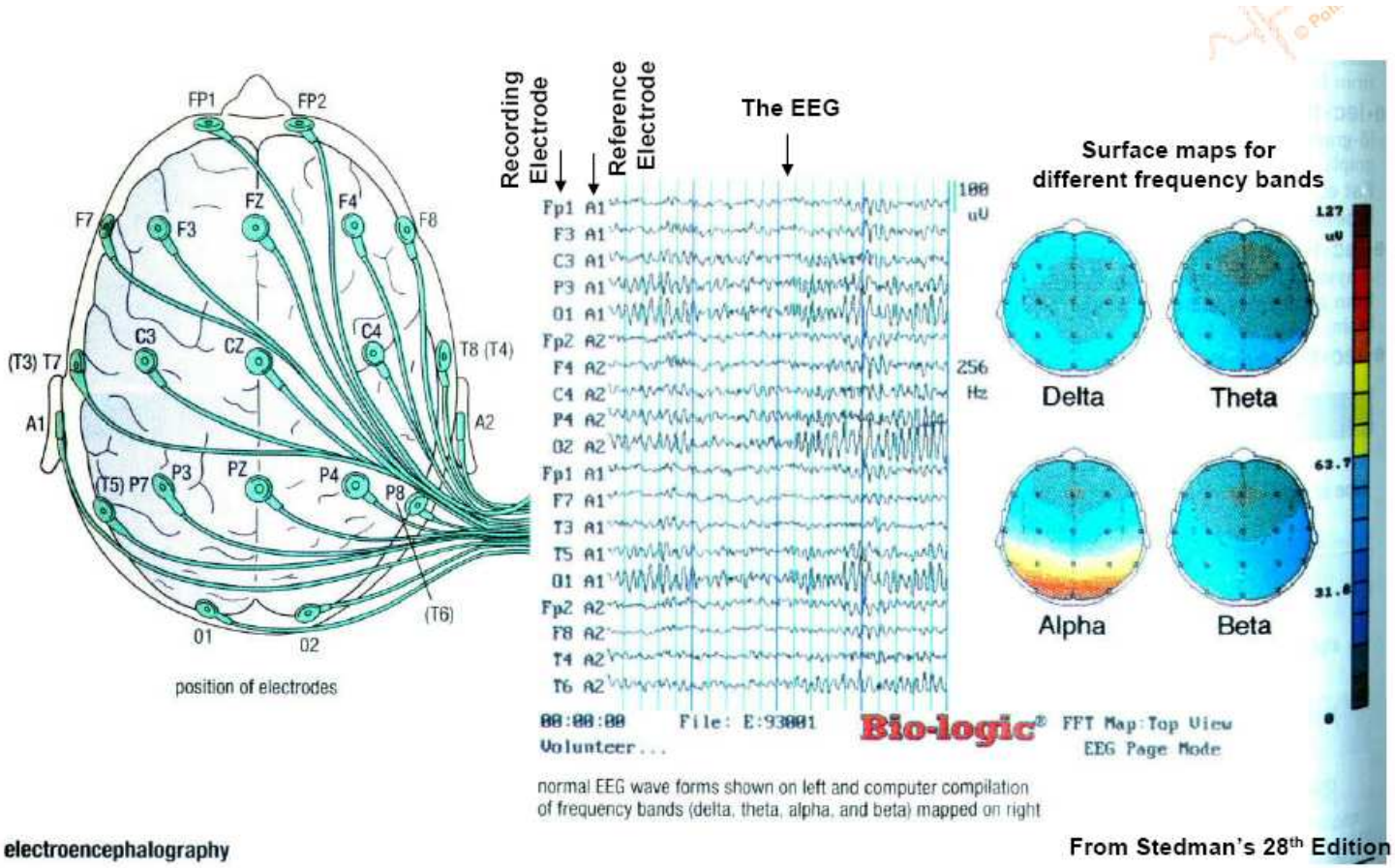
However, recently electrode-caps allowed additional (64-128) electrodes to be used.

ttp://www.shifz.org/race/eeg2.htm

http://ieng9.ucsd.edu/~phammon/

http://local.wasp.uwa.edu.au/~pbourke/other/eeg/

The Electroencephalogram
EEG



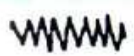
The EEG signals

EEG signals are of extremely small amplitude – typically in the μV range

Often analyzed in four frequency bands that are associated with certain activities:

- δ: 0.5 – 4 Hz
- θ: 4 – 8 Hz
- α: 8-13 Hz
- β: 13 - 30 Hz

electroencephalogram

type of wave	shape	frequency per sec.	amplitude in μV	physiologic variations of potential in waking EEG		in sleeping EEG
				adult	child	all ages
beta		14–30	5–50	frontal and precentral prominent, in clusters	seldom prominent	beta-activity ("spindles") sign of light sleep
alpha		8–13	20–120	predominant activity	predominant activity, age 5 and above	not a sign of sleep
theta		4–7	20–100	constant, not prominent	predominant activity, from 18 mos. to 5 yrs.	normal sign of sleep
delta		0.5–3	5–250	not prominent	predominant activity until 18 mos.	concomitant sign of deep sleep
gamma	—	31–60	–10	laws governing predominance and localization not fully known		

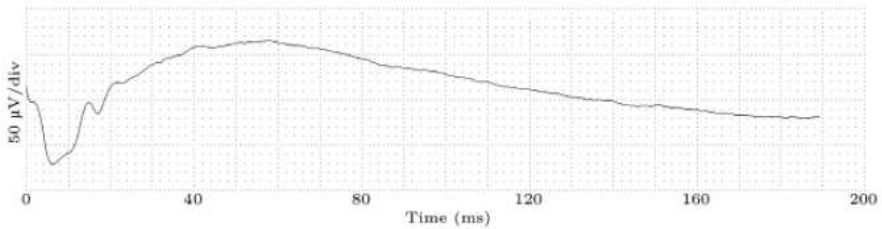
From Stedman's 28th Edition

Electroretinogram
ERG

The ERG is the record of the retinal action currents produced by the retina in response to a light stimulus.

It measures the electrical responses of the light-sensitive cells (such as rods and cones).

The stimuli are often a series of light flashes or rotating patterns
The ERG is recorded using contact lens electrode that the subject wears while watching the stimuli.



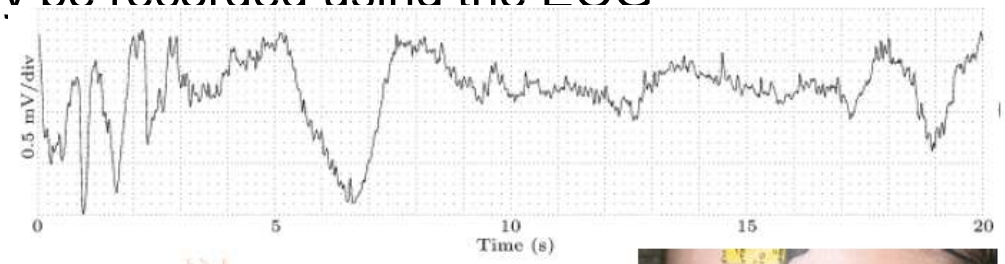
http://www.metrovision.fr/mv-electrodes-im01.gif

Electroretinogram
ERG

The EOG measures the resting potential of the retina. Unlike ERG it is not recorded in response to a stimulus.

The EOG is often used in recording the eye-movements (such as in VR applications, or as a reference in EEG applications to remove eye-blink artifacts)

EOG is also used in diagnosing certain sleep disorders, where the active REM can easily be recorded using the EOG



http://www.metrovision.fr/