Ethiopian TVET-System

# Basic Biomedical Equipment Servicing Level II

Based on May 2011 Occupational Standards

October, 2019

**Module Title: Prepare models to demonstrate human anatomy and physiology**

**TTLM Code: EEL BES2M08TTLM 0919v1**

## This module includes the following Learning Guides

**LG32: Understand basic normal structure and function of the human body**

**LG Code: EEL BES2 M08 LO1-LG-32**

**LG33: Describe the structure and function of the human body applying medical terms**

**LG Code: EEL BES2 M08 LO2-LG-33**

**LG34: Prepare models to demonstrate human anatomy and physiology**

**LG Code: EEL BES2 M08 LO3-LG-34**

**LG35: Identify the different types of physiological signals.**

**LG Code:** EEL BES2 M08 LO**3-LG-35**

| Instruction Sheet | LG32: Understand basic normal structure and function of the human body |
|---|---|

**This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:**

- Identifying resources needed
- Organizing Information regarding normal structure and function of the Human body coherently to ensure clear understanding
- Consulting appropriate personnel to ensure the programs for understanding basic normal structure and function of the human
- Identifying and detailing Materials necessary to complete the work in accordance with established procedures and checked against job requirements

**This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to:**

- Identify resources needed
- Organize Information regarding normal structure and function of the Human body coherently to ensure clear understanding
- Consult appropriate personnel to ensure the programs for understanding basic normal structure and function of the human
- Identify and detail Materials necessary to complete the work in accordance with established procedures and checked against job requirements

**Learning Instructions:**

**1.** Read the specific objectives of this Learning Guide.

2. Follow the instructions described below 3 to 4.

3. Read the information written in the information “Sheet 1, Sheet 2, Sheet 3 and Sheet 4” in page -6, 23,36 and 46 respectively.

4. Accomplish the “Self-check 1, Self-check t 2, Self-check 3 and Self-check 4” in page -22, 35, 46 and 60 respectively.


Federal TVET Agency

| Information Sheet-1 | Identifying resources needed |
|---|---|

## Resources needed in demonstrating human anatomy and physiology

### 1.1Respiratory belt transducer

The respiratory belt transducer is designed to measure changes in chest diameter resulting from breathing. The belt produces a linear voltage proportional to changes in length and connects directly to a pod (DIN) port on a power lab. It is primarily designed for use on humans but can also be used on small and large animals.

Figure1 Respiratory belt transducer

## 1.2 Cardio microphone

Accurately converts heart sounds (mechanical vibration) into electrical signals via an electric (condenser) microphone device

**Figure2 Cardio microphone**

## 1.3 Sphygmomanometers

Demonstrate clinical blood pressure measurements in a lecture tutorial or practical class with these Sphygmomanometers, each of which is coupled to a pressure transducer.

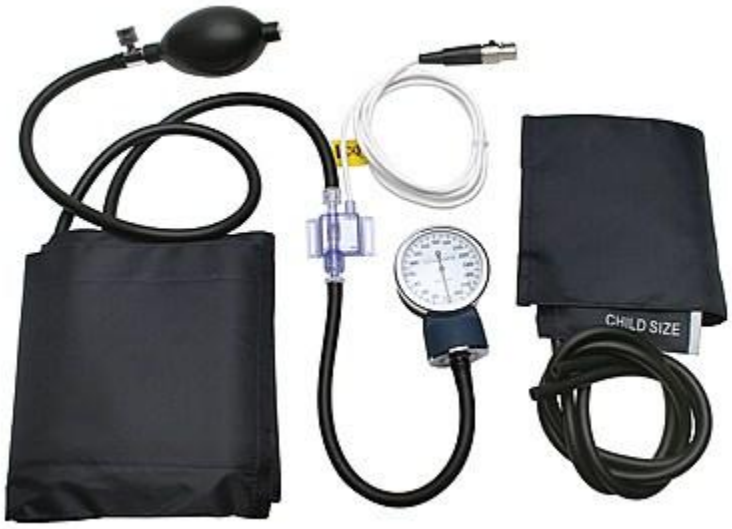



Figure3 Sphygmomanometers

### 1.4 Push button switches

Push button switches convert to any power lab via BNC or DIN input provides either a 1v output for triggering, timing or marker signals

Figure4 Push button switches

### 1.5 Tendon Hammers

Tendon Hammers available for connection via the BNC input channel or 8 pin din (pod) input channel of any power lab recording system, to provide triggering, timer or marker signals.

### 1.6 3D Printed Anatomical Models of Cadaver Specimens

3D printed anatomical models refer to models that are created in a 3-dimensional technology using 3D printers.

Australian scientists from Monash University created these models to allow doctors, both in practice and in training, to examine and learn about the body anatomy of humans without having to use the real cadavers in hospitals or medical training institutes. It is important to note that there are countries where real cadavers are illegal and as such, these models provide an alternative to addressing the ethical concerns for medical students in these countries.

The ground-breaking Monash 3D Printed Anatomy Series represents a unique and unrivalled collection of colour-augmented human anatomy 3D prints designed specifically for enhanced teaching and learning. This premium collection of highly accurate normal human anatomy models has been generated directly from either radiographic data or actual cadaveric specimens using advanced imaging techniques and state-of-the-art 3D printing technology. The Monash 3D Printed Anatomy Series provides a cost effective means to meet your specific educational and demonstration needs in a range of curricula from medicine, allied health sciences and biological sciences.

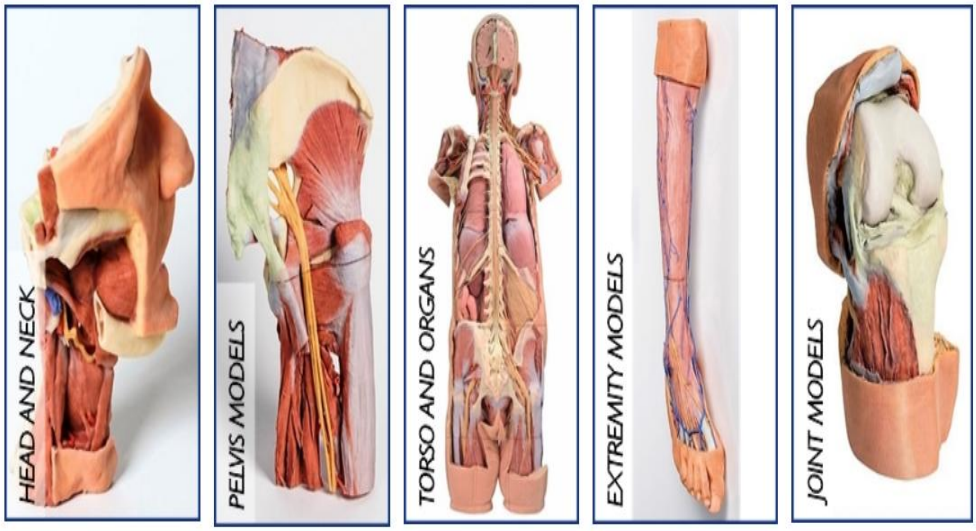



**Figure5: 3D Printed Anatomical Models of Cadaver Specimens**

**Who Are They Meant For?**

3D printed human replicas are especially meant for doctors in practice or in simpler terms, medical students. This means that they are used as realistic models for the purpose of illustrating the various human anatomical parts such as the organs, bones etc, without the need for real cadavers. Professors as well as teachers of medical colleges and universities also need to learn more about these models, given they are the ones who have to use them for real classroom demonstrations to their students.

**Why Do You Need Them?**

Over the years, there have been many ethical issues involved with the use of real human cadavers in medical practical lessons and in order to avoid the associated human rights concerns, or even legal implications, 3d printed human body parts come in handy in addressing these challenges. As already pointed out, the ethic dilemmas are so immense that certain counties went as far as prohibit the cadavers altogether. However, as no real human body parts are involved, this 3d printed human replicas serve as a compromise for the whole situation.

Additionally, these replicas are anatomically accurate and the fact that they are identical to the real specimens makes the whole illustrative process easier for students to learn.

Their availability is also not subjected to massive bureaucratic procedures, which means they can be made available over a short notice, as opposed to the real human cadavers. Needless to mention, they are also reasonably priced as opposed to their real cadaver counterparts. They are also reproducible, which means several identical prints may be used as a classroom set.

## 1.7 Skeleton Models

The skeletal system includes all of the bones and joints in the human body. The human skeleton has major functions as movement, protection, support, and endocrine regulation, production of blood cells and storage of ions. The skeleton system provides attachment points for the muscles, allowing the movements of the joints.

We are committed to provide you with a perfect range of anatomically correct skeleton models such as:

- Human Skeleton - high quality models for hospitals, schools, universities, and laboratories.
- Disarticulated Skeleton - great for any in depth study of the human skeleton and scientific anatomy studies.
- Animal Skeleton - there is no better way to study the anatomy of animal then with genuine animal skeletons.
- Bone Structure - the perfect way to teach and learn about the structure of the human bones.
- Kinesiology models - life-like positioning and motions of the head, spine, hand and foot, with natural flexibility.
- Life-size Skeleton - amazing replicas of the human skeleton, almost realistic weight for all of the bones.

https://www.gtsimulators.com/Skeleton-Model-Human-Skeleton-Models-s/22.htm

Figure 6 Human-Skeleton-Models

https://www.gtsimulators.com/3B-Scientific-Human-Skeleton-Model-Stan-p/a10.htm

## 1.8 Muscle Models

### 1.8.1 SOMSO Model of the Arm Muscles

Natural size can be separated into 24 parts. All muscles can be traced to their point of attachment (blue) and their origin (red) both singly and in relation to each other; On stand with green base.

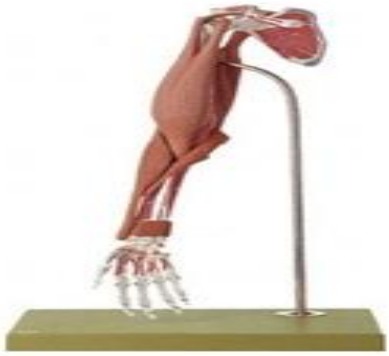
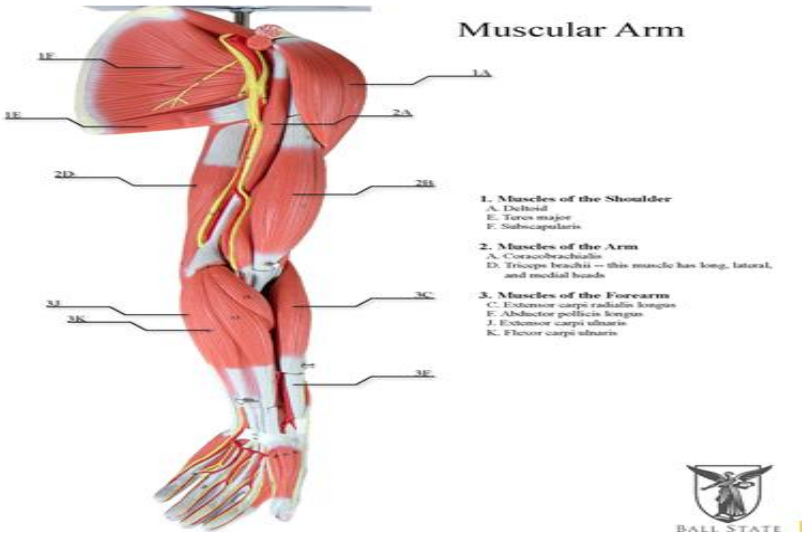


Figure6: SOMSO Model of the Arm Muscles

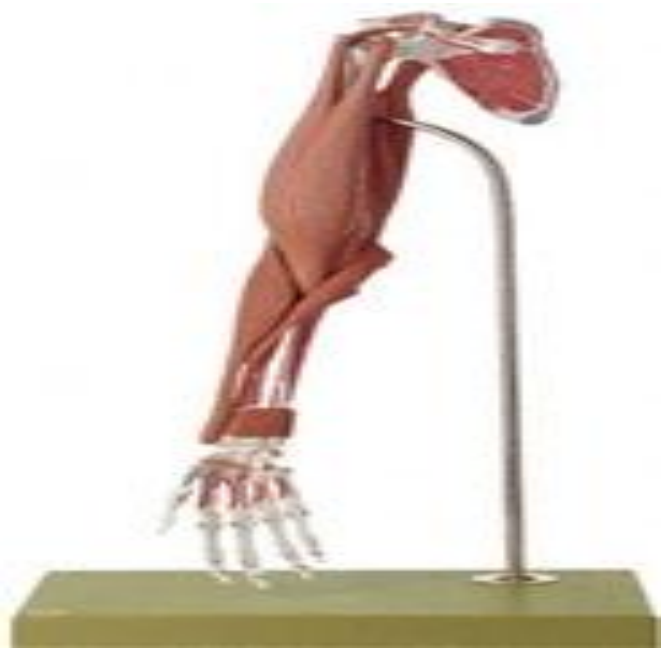
https://www.gtsimulators.com/SOMSO-Demonstration-Model-of-the-Arm-Muscles-p/qs55-3.htm




https://dmr.bsu.edu/digital/collection/AnatMod/id/211/

### 1.8.2 SOMSO Demonstration Model of the Arm Muscles

Life-size dimensions in SOMSO-Can be separated into 10 parts. The most important arm muscles can be assigned to their insertion and origin either individually or collectively. The muscle groups responsible for the bending and stretching movements and pronation and supination can be demonstrated. On a stand with a green base



https://www.gtsimulators.com/SOMSO-Demonstration-Model-of-the-Arm-Muscles-p/qs55-3.htm

### 1.8.3 Numbered Muscular Arm with Stand, 2/3 Life-Size

Human Muscular arm model - Model shows the muscles, tendons, blood vessels and nerves of the arm hand and shoulder. Five muscles can be removed to reveal structure down to the bone.

- Model comes with stand for display
- Made with durable plastic
- Comes with a identification sheet as each muscle is numbered.

**Dimensions and weight:**

- Weight (lb)3.7
- Length (in)22.0
- Width (in)8.0
- Height (in)4.5

https://www.gtsimulators.com/Model-of-Muscular-Arm-6-Parts-p/eam0276s.htm

### 1.9 Human Torso Models

We're one of the leading companies in supplying high quality human torso models at low prices. We focus on health care demands and we strive to provide the best products, training and customer care for our clients. Nowadays, you can find your torso model on sale and also most of them are free shipping. Our website makes it easy to place the order and our customer support representatives will help you with any trouble you may have. The models include male, female, mini and gender neutral designs. It will give you the most useful tool that you can get for your anatomy class for students and residents or to explain something to a patient. And now, you can get your torso models on sale! You can find convenient products like the Kyoto Kagaku Human Torso Anatomy Model,

with 700 parts and rigid plastic structure that makes it safe to use and hard to damage. It has both skeletal and muscle structure. It is waterproof and washable. it is indeed a deluxe model. Or you can also get the Classic Genderless Torso with Half Skull Head, a true quality educational tool. It is made of high quality, hand painted plastic that makes it easier to explain any biology class. All in all, it is the perfect opportunity to buy a great torso model that will help you on your educational needs.

**1.10 Life-size Muscle Torso Model, 27 Parts**

This muscle torso is designed to meet your high demands by showing the deep and superficial muscles in great anatomical detail. With the muscle torsos extraordinary accuracy and life size presence, this muscular masterpiece is a distinctive aid for anatomic demonstrations even in large lecture halls.

The following parts can be removed from the muscle torso for detailed studies of human anatomy and muscular system:

- Skull cap
- 6-part brain
- Eyeball with optic nerve
- Chest/abdominal wall
- 2-part larynx
- 2 lungs
- 2-part heart
- Diaphragm
- 2-part stomach
- Liver with gall bladder
- Complete intestinal tract with appendix
- Front half of kidney
- Half urinary bladder
- 4 muscles
- Complete intestinal tract with appendix

https://www.gtsimulators.com/Life-size-Muscle-Torso-Model-with-27-part-p/va16.htm

**1.11 Deluxe Dual-Sex Muscle-Torso Model, 31-part, Opened Neck & Back**

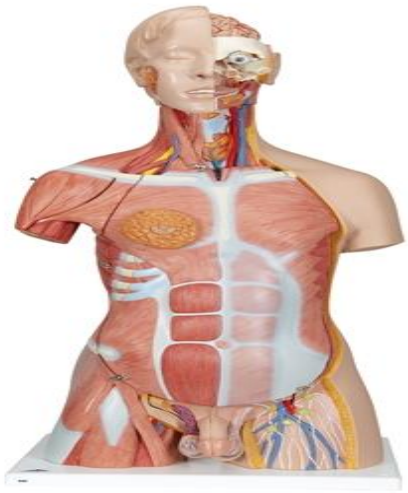
This deluxe human torso model is top notch in the field of anatomy. This unique torso depicts both the superficial and deep muscles, and the two main muscles, the deltoid and gluteus maximus can even be removed for closer studies. With this human torso model you can also study the vertebrae, the spinal cord, spinal nerves and vertebral arteries, exchange the male and female genital inserts, discover the internal structures of the brain and much more.

The following parts are removable from this remarkable torso:

- 6-part head
- Chest and abdominal wall with muscles
- 7th thoracic vertebra
- Female mammary gland
- Gluteus maximus and deltoid muscle
- 2 lungs
- 2-part heart
- 2-part stomach
- Liver with gall bladder
- 4-part intestinal tract
- Front half of kidney

- 3-part female genital insert with fetus
- 4-part male genital insert

This deluxe dual-sex torso is complete as a tool for human anatomy education with the 3B Torso Guide. All the organs in this human torso are hand painted for a quality product. This great human anatomy educational tool and makes learning the location of the human organs easy.



https://www.gtsimulators.com/Deluxe-Dual-Sex-Muscle-Torso-Model-31-part-p/b40.htm

https://www.youtube.com/watch?time_continue=9&v=Mij_jDI63PQ

### 1.12 Basic Know Body Teaching Torso Model

10 parts | 19 dissectible structures | 150 hand-numbered anatomical features

With basic anatomical details for introducing the functional systems of the human body, the life size Basic Know Body divides into the following parts:

- ✓ Eyeball
- ✓ One-piece brain half
- ✓ Left and right lung
- ✓ Heart (2 halves)
- ✓ Liver and gallbladder unit with segment of diaphragm
- ✓ One-piece stomach
- ✓ One-piece small and large intestine
- ✓ One-piece torso and head unit.

https://www.gtsimulators.com/basic-knowbody-teaching-anatomical-torso-model-p/dgt28.htm

## 1.13 Nervous System Models

For a better understanding and teaching of the nervous system anatomy, we have a wide selection of nervous system models available, including its physiological functions. At GT Simulators, we aim at delivering the best nervous system models for medical students. To understand the anatomical arrangement and structures of both the peripheral and central nervous system, we have designed our models in a suitable way. This reliefs you of the stress of having to go over the nervous system diagrams all the time. It also has an aspect of the real view of the system. This makes studying or teaching more lively and fun.

Most models are delivered in a baseboard and come in very many varieties. This enables you to choose based on your area of specialty and scope of understanding. Its schematic presentation enables you to acquire knowledge on the physiological functions of the nervous system also.


https://www.gtsimulators.com/Nervous-System-Models-Spinal-Cord-Models-s/20.htm

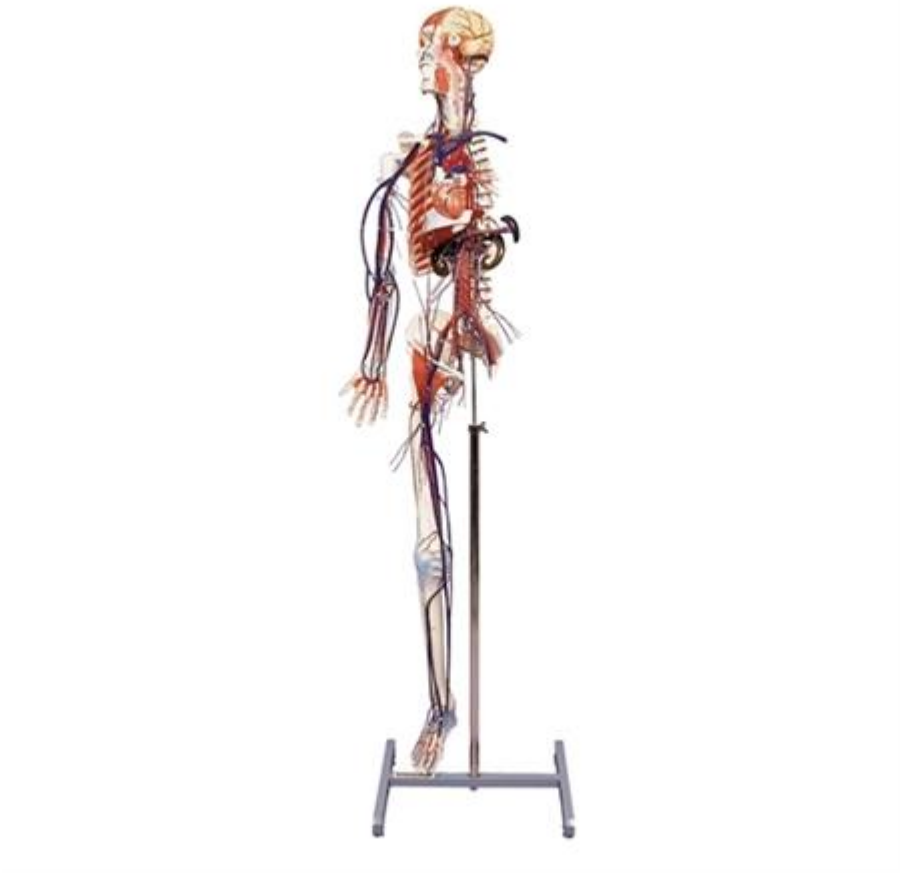
### 1.14 Skull Models

The Skull consists of two parts: A Cranial Part containing mainly the brain and sensory organs. And a Facial Part which contains the nasal, the oral cavity and the chewing apparatus. The cranial cavity is continuous with the vertebral canal which contains the spinal cord.

GT Simulators supplies a complete line of Skull Models including Human Skull Models, Anthropological Skull Models, Animal Skull Models and Fetal Skull Models


https://cdn3.volusion.com/nqpvm.detql/v/vspfiles/photos/categories/24.jpg?v-cache=1562918099

## 1.15 Full-Figure Circulatory System With Half Skeleton

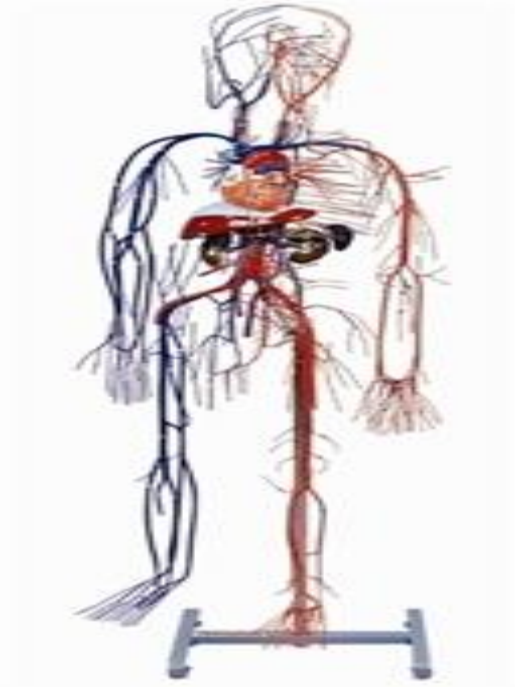


https://www.gtsimulators.com/Full-Figure-Circulatory-System-Model-p/kk-a62.htm

### 1.16 Full-Figure Circulatory System Model

This model is an excellent representation of the human vascular system. The 3/4-life-size model, sturdily constructed of hardened plastic-coated metal wire, is supported by a metal rod. This model is mounted on a metal stand.
Key card identifying the structures of the human vascular system
**Circulatory System Model Features:**

- ✓ Vessels - Arteries on the left side of body (Red) and Veins on the right side of Body (Blue)
- ✓ heart,
- ✓ liver,
- ✓ kidneys,
- ✓ and spleen

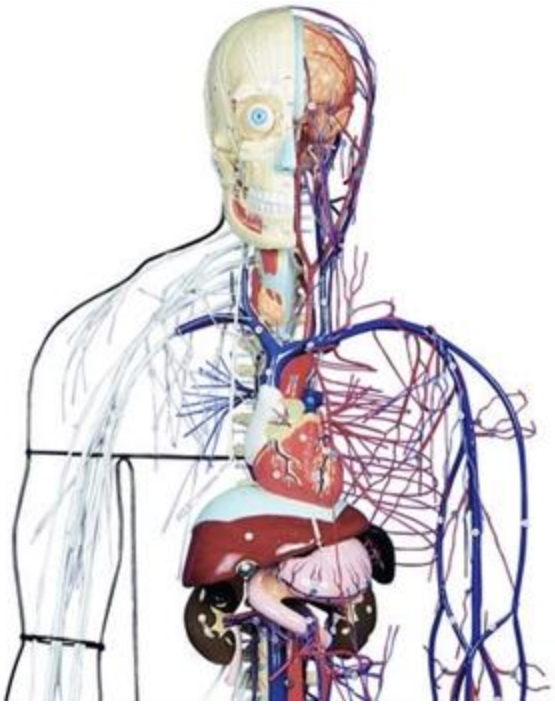


https://www.gtsimulators.com/Full-Figure-Circulatory-System-Model-p/kk-a61.htm

**1.17 Kyoto Kagaku Full-Figure Nervous and Circulatory System Model**
Three Models have been combined to make this advanced model. This unique model shows the Circulatory System on the left side and the Nervous System on the right side.

These two systems are combined to give a complete and convenient explanation to medical and nursing students. Internal organs, such as the heart, liver, pancreas, kidneys, and so on are combined with the brain, skull and spine in correct position and order.
Model is mounted on a metal stand.
Dimensions and Weight:

- ✓ Height: 135 cm.
- ✓ Weight: 22 Lbs

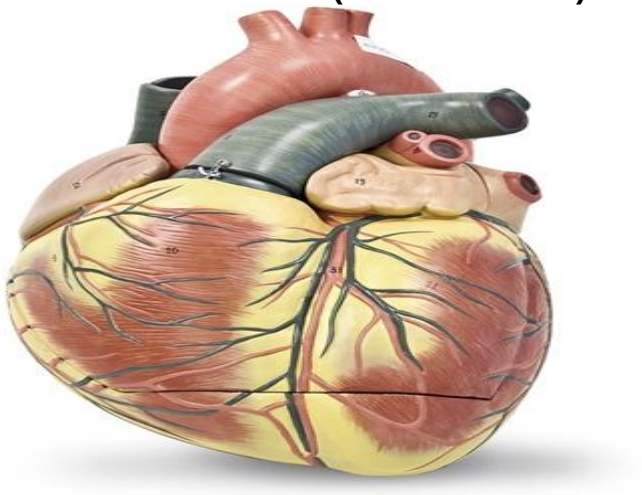


https://www.gtsimulators.com/Full-Figure-Nervous-and-Circulatory-System-Model-p/kk-a100.htm

**1.18 Jumbo Heart Model - 3 Parts**

**This colorful, durable, plastic jumbo heart model is excellent for patient education or elementary science classes. Dissectible into three parts showing anterior, posterior, and inferior views, along with details usually found only on more expensive models. Labeled diagram included.**

**Dimension: 9-1/2" x 9-1/2" x 11" (24 x 24 x 28 cm).**



https://www.gtsimulators.com/Jumbo-Heart-Model-3-Parts-p/la00108u.htm

### 1.19Brain Models

Here you can buy lifelike Human Brain Model at your disposal. GT Simulators provides the most realistic and life-size Anatomical Brain Models ideal for biology lessons. This is all so that you have the opportunity to get to know your way around the human brain. Haven't you ever wondered what the cerebellum looks like in real life? With our life size Human Brain Models, you get the chance to study all the parts of the human brain you want to know about in great detail.

Not only do these models are mounted on a base and modeled to exceptional to scientific accuracy. You will get to see the human brain in its truest possible form outside of the human skull. The models are highly suitable for biology lessons and not only make the learning process much more fun, but they also go a long way towards simplifying it. This is your chance to pull the human brain apart, and see just how everything really fits together


https://www.gtsimulators.com/Human-Brain-Models-s/6.htm

### 1.20 Anatomy of the Human Head and Neck

The Anatomy of the human head and Neck includes the brain, bones, muscles, blood vessels, nerves, glands, eyes, ears, nose, mouth, teeth, tongue, and throat. Eyes, ears, nose and mouth, with their related nerves, provides the special senses as Sight, Hearing, Balance, Smell and Taste.

GT Simulators provides a complete line of Head and Neck Models featuring the muscles, brain with arteries, blood vessels, nerves, skull including facial bones, cranium and cavity of the mouth.


https://www.gtsimulators.com/Head-Models-Neck-Models-Head-and-Neck-Models-s/14.htm

Eye Model

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Hand Anatomy Model

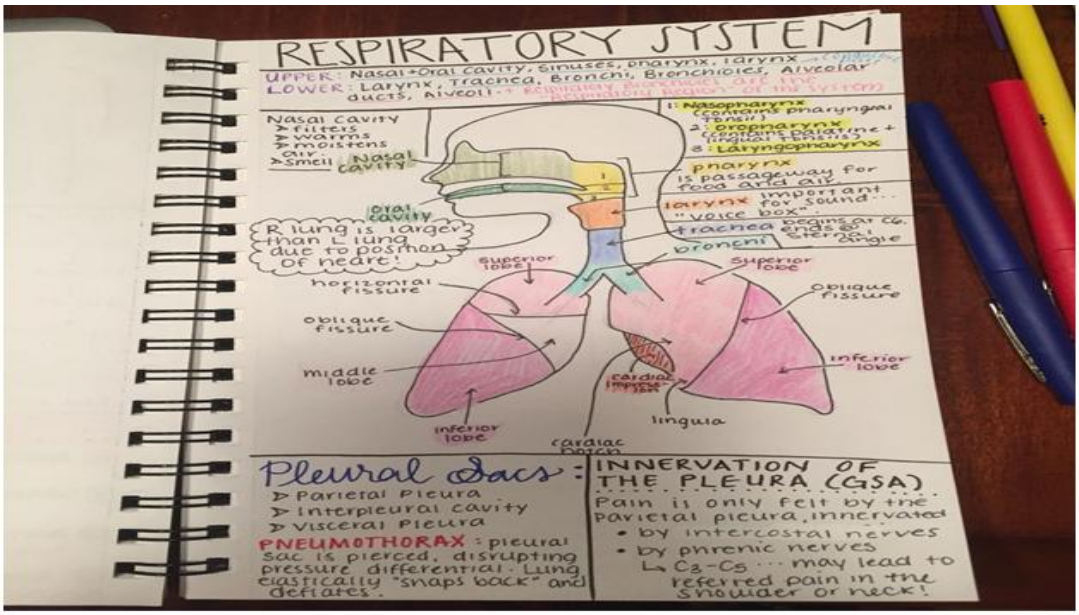
https://www.gtsimulators.com/Hand-and-Foot-Models-and-Extremities-s/13.htm

### 1.21 Anatomy charts

There are different charts that help the trainees to understand human anatomy and physiology in detail. Some of these charts are:

- ✓ Body system chart
- ✓ Cell charts
- ✓ Muscular charts
- ✓ Brain-neurological charts
- ✓ Skeletal charts
- ✓ Digestive system charts
- ✓ Heart and circulatory system charts
- ✓ Kidney charts
- ✓ Respiratory charts

**Respiratory system chart**




https://cdn3.volusion.com/nqpvm.detql/v/vspfiles/photos/categories/3.jpg?v-cache=1562918099

### 1.22 Anatomy and physiology simulator (Human Studio)

The most complete, scientifically accurate, interactive 3D body ever assembled.

- Male and female anatomy, in both basic (free) and professional grade detail
- Each system fully segmented, labeled and dissect able for easy configuration to meet any educational need

https://www.youtube.com/watch?v=zDrLMgYZcac

https://www.youtube.com/watch?v=vB3_0wq4lzA

| Self-Check -1 | Written Test |
|---|---|

**Directions:** Answer all the questions listed below. Use the Answer sheet provided in the next page:

**1.** _____is designed to measure changes in chest diameter resulting from breathing (2pt)

A. Cardio microphone B. Respiratory belt transducer C. Sphygmomanometer

D. All

**2.** _____is an instrument used to measure blood pressure in clinical demonstration(2pts)

A. Sphygmomanometer B. Cardio microphone C. Respiratory belt transducer D. None

***Note:*** **Satisfactory rating - 2points** **Unsatisfactory - below 2 points**

**Answer Sheet**

Score = _____

Rating: _____

Name: _____ Date: _____

**Short Answer Questions**

| Information Sheet-2 | **Organizing Information regarding normal structure and function of the Human body** |
|---|---|

## 2.1 Overview of Anatomy and Physiology

Human **anatomy** is the scientific study of the body's structures. Some of these structures are very small and can only be observed and analyzed with the assistance of

a microscope. Other larger structures can readily be seen, manipulated, measured, and weighed. The word “anatomy” comes from a Greek root that means “to cut apart.” Human anatomy was first studied by observing the exterior of the body and observing the wounds of soldiers and other injuries. Later, physicians were allowed to dissect bodies of the dead to augment their knowledge. When a body is dissected, its structures are cut apart in order to observe their physical attributes and their relationships to one another. Dissection is still used in medical schools, anatomy courses, and in pathology labs. In order to observe structures in living people, however, a number of imaging techniques have been developed. These techniques allow clinicians to visualize structures inside the living body such as a cancerous tumor or a fractured bone.

Anatomists take two general approaches to the study of the body’s structures: regional and systemic.

**Regional anatomy** is the study of the interrelationships of all of the structures in a specific body region, such as the abdomen. Studying regional anatomy helps us appreciate the interrelationships of body structures, such as how muscles, nerves, blood vessels, and other structures work together to serve a particular body region. **Systemic anatomy** is the study of the structures that make up a discrete body system that is, a group of structures that work together to perform a unique body function. For example, a systemic anatomical study of the muscular system would consider all of the skeletal muscles of the body.

Whereas anatomy is about structure, physiology is about function. Human **physiology** is the scientific study of the chemistry and physics of the structures of the body and the ways in which they work together to support the functions of life. Much of the study of physiology centers on the body’s tendency toward homeostasis. **Homeostasis** is the state of steady internal conditions maintained by living things. The study of physiology certainly includes observation, both with the naked eye and with microscopes, as well as manipulations and measurements. However, current advances in physiology usually depend on carefully designed laboratory experiments that reveal the functions of the many structures and chemical compounds that make up the human body.

Like anatomists, physiologists typically specialize in a particular branch of physiology. For example, neurophysiology is the study of the brain, spinal cord, and nerves and how these work together to perform functions as complex and diverse as vision, movement, and thinking. Physiologists may work from the organ level (exploring, for example, what different parts of the brain do) to the molecular level (such as exploring how an electrochemical signal travels along nerves).

Form is closely related to function in all living things. For example, the thin flap of your eyelid can snap down to clear away dust particles and almost instantaneously slide back up to allow you to see again. At the microscopic level, the arrangement and function of the nerves and muscles that serve the eyelid allow for its quick action and retreat. At a smaller level of analysis, the function of these nerves and muscles likewise relies on the interactions of specific molecules and ions. Even the three-dimensional structure of certain molecules is essential to their function.

## 2.2 Structural Organization of the Human Body

Before you begin to study the different structures and functions of the human body, it is helpful to consider its basic architecture; that is, how its smallest parts are assembled into larger structures. It is convenient to consider the structures of the body in terms of fundamental levels of organization that increase in complexity: subatomic particles, atoms, molecules, organelles, cells, tissues, organs, organ systems, organisms and biosphere (**Figure2.1**).

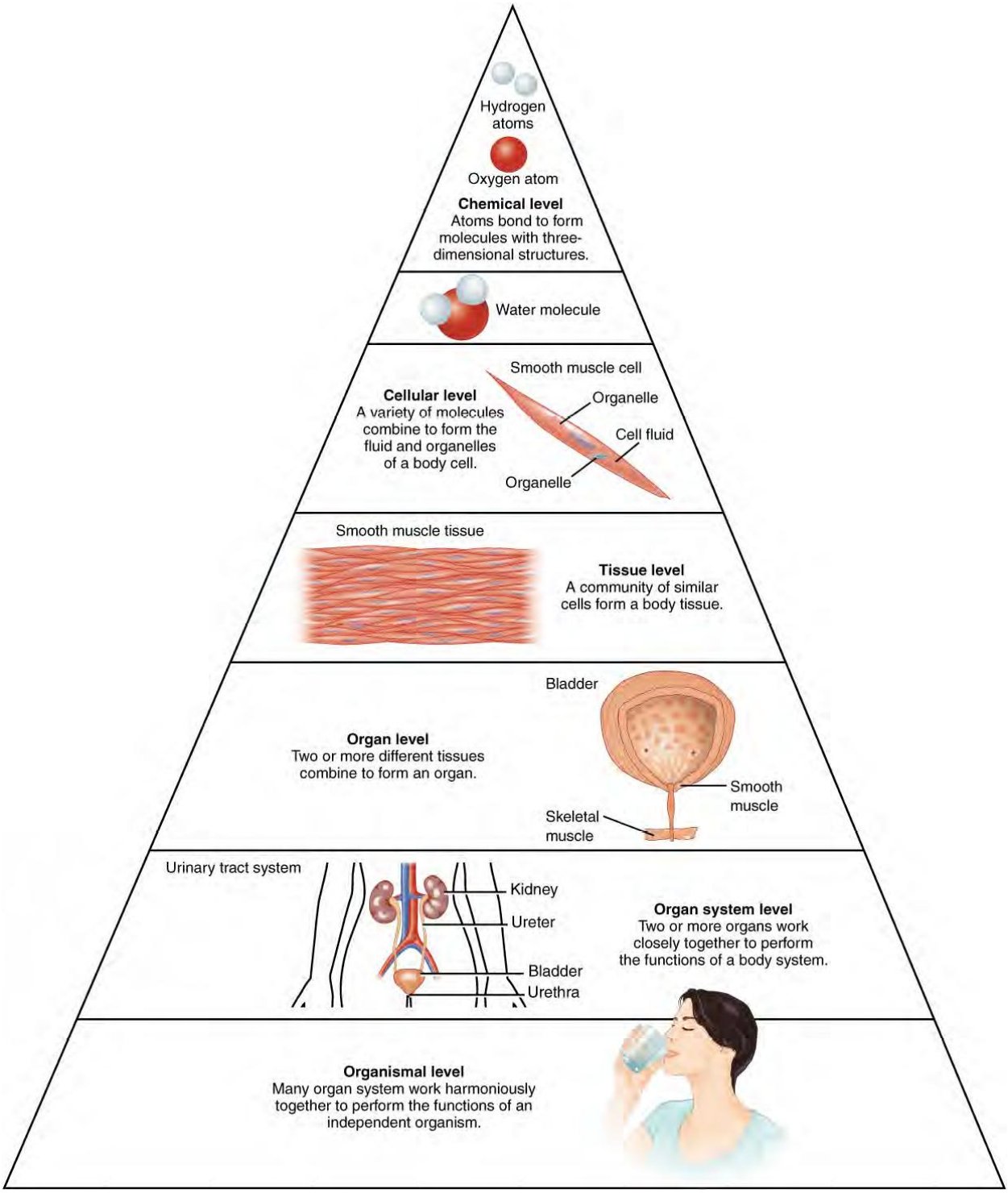



**Figure 2.1 Levels of Structural Organization of the Human Body**

The organization of the body often is discussed in terms of six distinct levels of increasing complexity, from the smallest chemical building blocks to a unique human organism.

### 2.3 The Levels of Organization

To study the chemical level of organization, scientists consider the simplest building blocks of matter: subatomic particles, atoms and molecules. All matter in the universe is composed of one or more unique pure substances called elements, familiar examples of which are hydrogen, oxygen, carbon, nitrogen, calcium, and iron. The smallest unit of any of these pure substances (elements) is an atom. Atoms are made up of subatomic particles such as the proton, electron and neutron.

Two or more atoms combine to form a molecule, such as the water molecules, proteins, and sugars found in living things.

Molecules are the chemical building blocks of all body structures.

A **cell** is the smallest independently functioning unit of a living organism. Even bacteria, which are extremely small, independently-living organisms, have a cellular structure. Each bacterium is a single cell. All living structures of human anatomy contain cells, and almost all functions of human physiology are performed in cells or are initiated by cells.

A human cell typically consists of flexible membranes that enclose cytoplasm, a water-based cellular fluid together with a variety of tiny functioning units called **organelles**. In humans, as in all organisms, cells perform all functions of life. A**t issue** is a group of many similar cells (though sometimes composed of a few related types) that work together to perform a specific function. An **organ** is an anatomically distinct structure of the body composed of two or more tissue types. Each organ performs one or more specific physiological functions. An **organ system** is a group of organs that work together to perform major functions or meet physiological needs of the body.

This learning guide covers eleven distinct organ systems in the human body (**Figure 2.2** and **Figure 2.3**). Assigning organs to organ systems can be imprecise since organs that “belong” to one system can also have functions integral to another system. In fact, most organs contribute to more than one system.

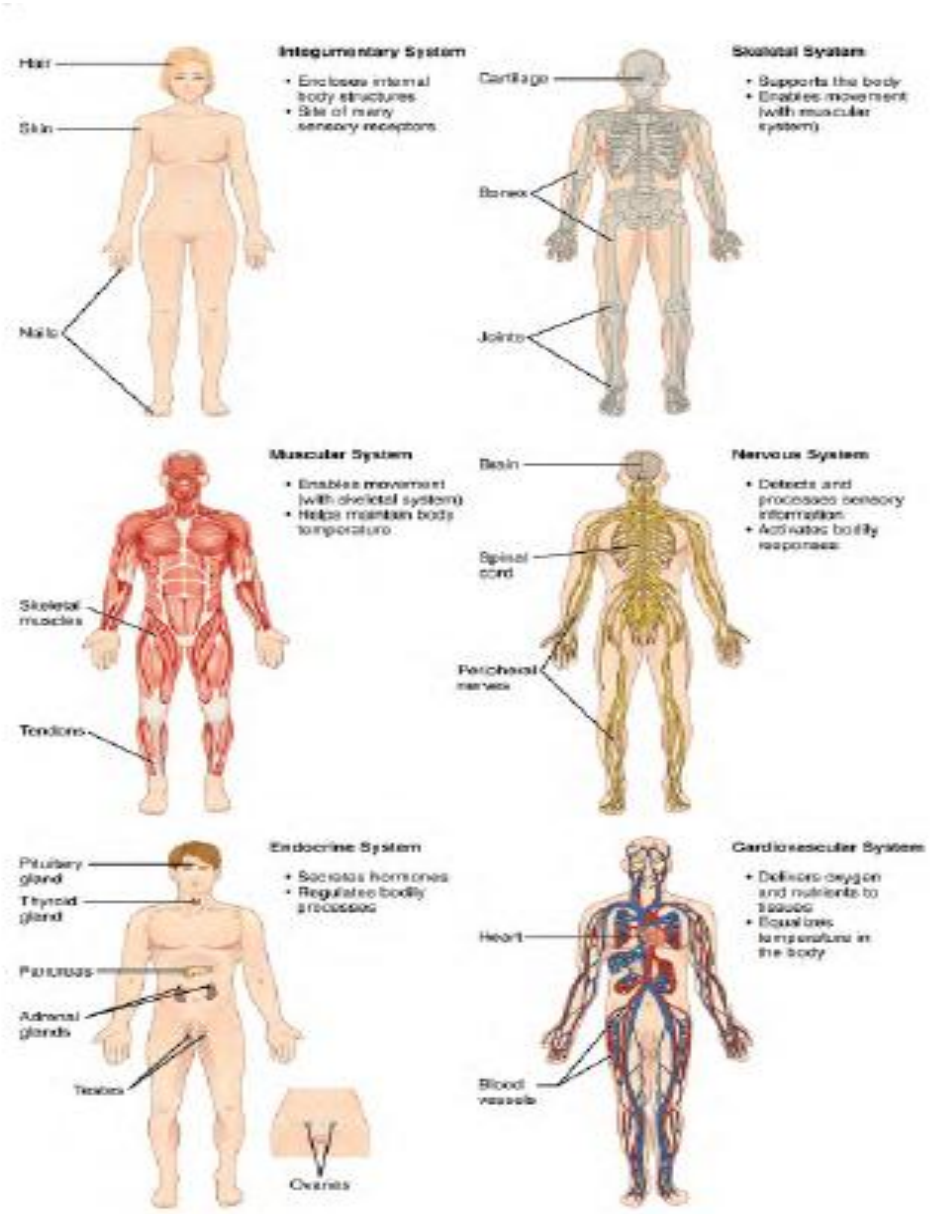

Integumentary System
• Encloses internal body structures
• Site of many sensory receptors
Hair
Skin
Nails
Skeletal System
• Supports the body
• Enables movement (with muscular system)
Cartilage
Bones
Joints
Muscular System
• Enables movement (with skeletal system)
• Helps maintain body temperature
Skeletal muscles
Tendons
Nervous System
• Detects and processes sensory information
• Activates bodily responses
Brain
Spinal cord
Peripheral nerves
Endocrine System
• Secretes hormones
• Regulates bodily processes
Pituitary gland
Thyroid gland
Pancreas
Adrenal glands
Testes
Ovaries
Cardiovascular System
• Delivers oxygen and nutrients to tissues
• Equalizes temperature in the body
Heart
Blood vessels

**Figure 2.2 Organ Systems of the Human Body** Organs that work together are grouped into organ systems.

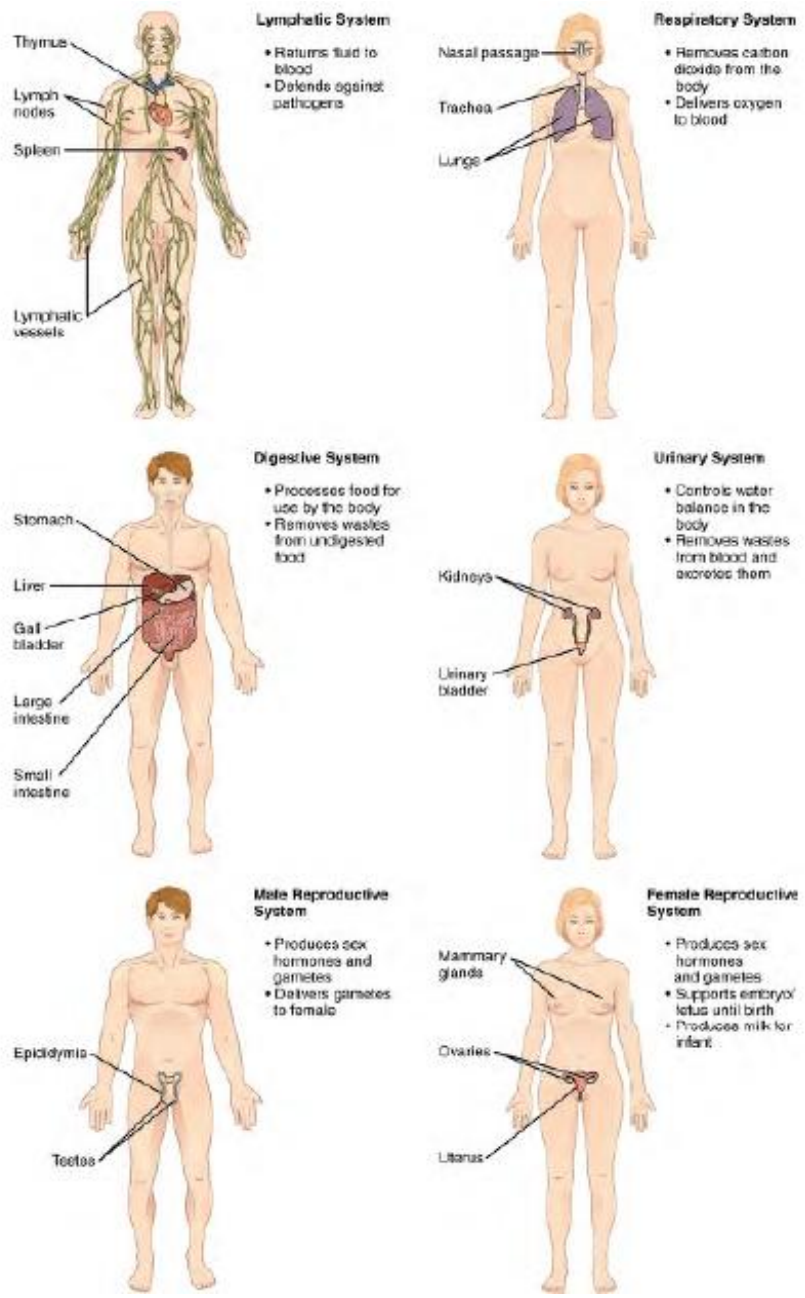



**Figure 2.3 Organ Systems of the Human Body (continued)** Organs that work together are grouped into organ systems.

The organism level is the highest level of organization. An **organism** is a living being that has a cellular structure and that can independently perform all physiologic functions necessary for life. In multicellular organisms, including humans, all cells, tissues, organs, and organ systems of the body work together to maintain the life and health of the organism.

The different organ systems each have different functions and therefore unique roles to perform in physiology. These many functions can be summarized in terms of a few that we might consider definitive of human life: organization, metabolism, responsiveness, movement, development, and reproduction.

## 2.4 Organization

A human body consists of trillions of cells organized in a way that maintains distinct internal compartments. These compartments keep body cells separated from external environmental threats and keep the cells moist and nourished. They also separate internal body fluids from the countless microorganisms that grow on body surfaces, including the lining of certain tracts, or passageways. The intestinal tract, for example, is home to even more bacteria cells than the total of all human cells in the body, yet these bacteria are outside the body and cannot be allowed to circulate freely inside the body.

Cells, for example, have a cell membrane (also referred to as the plasma membrane) that keeps the intracellular environment the fluids and organelles separate from the extracellular environment. Blood vessels keep blood inside a closed circulatory system, and nerves and muscles are wrapped in connective tissue sheaths that separate them from surrounding structures. In the chest and abdomen, a variety of internal membranes keep major organs such as the lungs, heart, and kidneys separate from others.

The body's largest organ system is the integumentary system, which includes the skin and its associated structures, such as hair and nails. The surface tissue of skin is a barrier that protects internal structures and fluids from potentially harmful microorganisms and other toxins.

## 2.5 The chemical level of organization

The smallest, most fundamental material components of the human body are basic chemical elements. In fact, chemicals called nucleotide bases are the foundation of the genetic code with the instructions on how to build and maintain the human body from

conception through old age. There are about three billion of these base pairs in human DNA.

Human chemistry includes organic molecules (carbon-based) and bio-chemicals (those produced by the body). Human chemistry also includes elements. In fact, life cannot exist without many of the elements that are part of the earth. All of the elements that contribute to chemical reactions, to the transformation of energy, and to electrical activity and muscle

Contraction elements that include phosphorus, carbon, sodium, and calcium, to name a few originated in stars.

These elements, in turn, can form both the inorganic and organic chemical compounds important to life, including, for example, water, glucose, and proteins.

### 2.6 Elements and Atoms: The Building Blocks of Matter

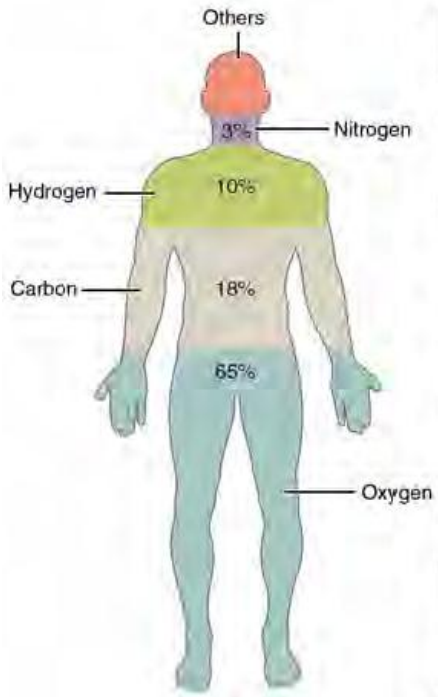
The substance of the universe from a grain of sand to a star is called **matter**. Scientists define matter as anything that occupies space and has mass. An object's mass and its weight are related concepts, but not quite the same. An object's mass is the amount of matter contained in the object, and the object's mass is the same whether that object is on Earth or in the zero-gravity environment of outer space. An object's weight, on the other hand, is its mass as affected by the pull of gravity.

Where gravity strongly pulls on an object's mass its weight is greater than it is where gravity is less strong. An object of a certain mass weighs less on the moon, for example, than it does on Earth because the gravity of the moon is less than that of Earth. In other words, weight is variable, and is influenced by gravity. A piece of cheese that weighs a pound on Earth weighs only a few ounces on the moon.

### 2.7 Elements and Compounds

All matter in the natural world is composed of one or more of the 92 fundamental substances called elements. An **element** is a pure substance that is distinguished from all other matter by the fact that it cannot be created or broken down by ordinary chemical means. While your body can assemble many of the chemical compounds needed for life from their constituent elements, it cannot make elements. They must come from the environment. A familiar example of an element that you must take in is calcium (Ca++). Calcium is essential to the human body; it is absorbed and used for a number of processes, including strengthening bones. When you consume dairy

products your digestive system breaks down the food into components small enough to cross into the bloodstream. Among these is calcium, which, because it is an element, cannot be broken down further. The elemental calcium in cheese, therefore, is the same as the calcium that forms your bones. Some other elements you might be familiar with are oxygen, sodium, and iron. The elements in the human body are shown in **Figure 2.4**, beginning with the most abundant: oxygen (O), carbon (C), hydrogen (H), and nitrogen (N). Each element's name can be replaced by a one- or two-letter symbol; you will become familiar with some of these during this course. All the elements in your body are derived from the foods you eat and the air you breathe.




| Element | Symbol | Percentage in Body |
|---|---|---|
| Oxygen | O | 65.0 |
| Carbon | C | 18.5 |
| Hydrogen | H | 9.5 |
| Nitrogen | N | 3.2 |
| Calcium | Ca | 1.5 |
| Phosphorus | P | 1.0 |
| Potassium | K | 0.4 |
| Sulfur | S | 0.3 |
| Sodium | Na | 0.2 |
| Chlorine | Cl | 0.2 |
| Magnesium | Mg | 0.1 |
| Trace elements include boron (B), chromium (Cr), cobalt (Co), copper (Cu), fluorine (F), iodine (I), iron (Fe), manganese (Mn), molybdenum (Mo), selenium (Se), silicon (Si), tin (Sn), vanadium (V), and zinc (Zn). | | less than 1.0 |

**Figure 2.4 Elements of the Human Body** the main elements that compose the human body are shown from most abundant to least abundant.

## 2.8 The cellular level of organization (the cell membrane)

Despite differences in structure and function, all living cells in multicellular organisms have a surrounding cell membrane.

### 2.8.1 Structure and composition of the cell membrane

The **cell membrane** is an extremely pliable structure composed primarily of back-to-back phospholipids (a "bilayer"). Cholesterol is also present, which contributes to the

fluidity of the membrane, and there are various proteins embedded within the membrane that have a variety of functions.

A single phospholipid molecule has a phosphate group on one end, called the “head,” and two side-by-side chains of fatty acids that make up the lipid tails (**Figure 2.5**). The phosphate group is negatively charged, making the head polar and hydrophilic—or “water loving.” A **hydrophilic** molecule (or region of a molecule) is one that is attracted to water. The phosphate heads are thus attracted to the water molecules of both the extracellular and intracellular environments. The lipidtails, on the other hand, are uncharged, or nonpolar, and are hydrophobic or “water fearing.” A **hydrophobic** molecule (or region of a molecule) repels and is repelled by water. Some lipid tails consist of saturated fatty acids and some contain unsaturated fatty acids. This combination adds to the fluidity of the tails that are constantly in motion. Phospholipids are thus amphipathic molecules. An **amphipathic** molecule is one that contains both a hydrophilic and a hydrophobic region. In fact, soap works to remove oil and grease stains because it has amphipathic properties. The hydrophilic portion can dissolve in water while the hydrophobic portion can trap grease in micelles that then can be washed away.

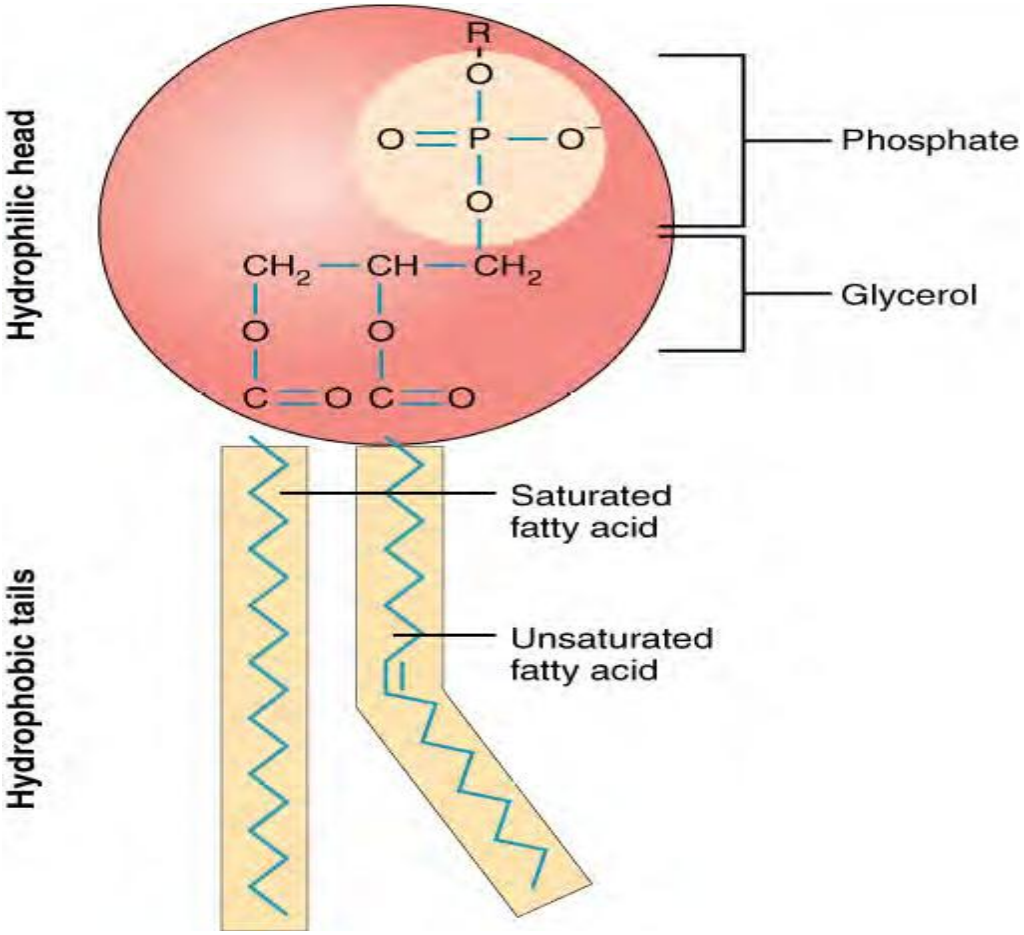



**Figure 2.5 Phospholipid Structure** A phospholipid molecule consists of a polar phosphate "head," which is hydrophilic and a non-polar lipid "tail," which is hydrophobic. Unsaturated fatty acids result in kinks in the hydrophobic tails.

## 2.9 The tissue level of organization

The body contains at least 200 distinct cell types. These cells contain essentially the same internal structures yet they vary enormously in shape and function. The different types of cells are not randomly distributed throughout the body; rather they occur in organized layers, a level of organization referred to as tissue.

The variety in shape reflects the many different roles that cells fulfill in your body. The human body starts as a single cell at fertilization. As this fertilized egg divides, it gives

rise to trillions of cells, each built from the same blueprint, but organizing into tissues and becoming irreversibly committed to a developmental pathway.

The term **tissue** is used to describe a group of cells found together in the body. The cells within a tissue share a common embryonic origin. Microscopic observation reveals that the cells in a tissue share morphological features and are arranged in an orderly pattern that achieves the tissue's functions. From the evolutionary perspective, tissues appear in more complex organisms. For example, multicellular protists, ancient eukaryotes, do not have cells organized into tissues.

Although there are many types of cells in the human body, they are organized into four broad categories of tissues: epithelial, connective, muscle, and nervous. Each of these categories is characterized by specific functions that contribute to the overall health and maintenance of the body. A disruption of the structure is a sign of injury or disease. Such changes can be detected through **histology**, the microscopic study of tissue appearance, organization, and function.

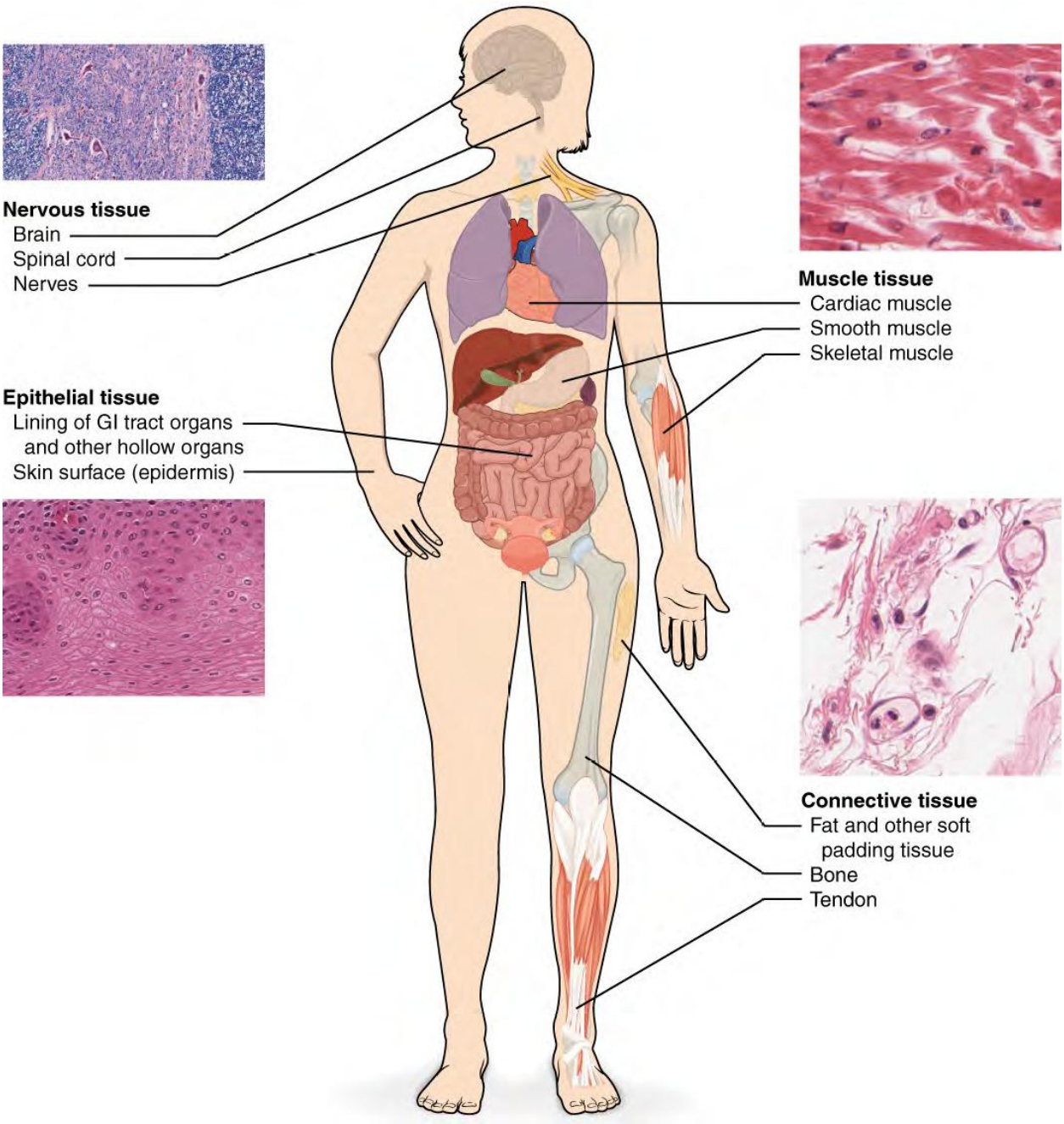



**Figure 2.6 Four Types of Tissue: Body** The four types of tissues are exemplified in nervous tissue, stratified squamous epithelial tissue, cardiac muscle tissue, and connective tissue in small intestine.

| Self-Check -2 | Written Test |
|---|---|

**Directions:** Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. Collection of similar tissues that perform a specific function is an_____(2pt)

   A. Organ B. Organelle C. Organism D. Organ system

2. The smallest independently functioning unit of an organism is a(n)_____(2pt)

   A. Cell B. Molecule C. Organ D. tissue

***Note:*** **Satisfactory rating - 5 points** **Unsatisfactory - below 5 points**

**Answer Sheet**

Score = _____

Rating: _____

Name: _____ Date: _____

**Short Answer Questions**

| Information Sheet-3 | Consulting appropriate personnel to ensure the programs for understanding basic normal structure and function of the human body |
|---|---|

## 3.1 Consulting with workers

This duty to consult is based on the recognition that worker input and participation improves decision-making about health and safety matters and assists in reducing work-related injuries and disease.

The broad definition of a 'worker' under the world health and safety(WHS) Act means that you must consult with your employees plus anyone else who carries out work for your business or undertaking. You must consult, so far as is reasonably practicable, with your contractors and sub-contractors and their employees, on-hire workers, volunteers and any other people who are working for you and who are directly affected by a health and safety matter.

Workers are entitled to take part in consultation arrangements and to be represented in relation to work health and safety by a health and safety representative who has been elected to represent their work group. If workers are represented by a health and safety representative, consultation must involve that representative.

### Why is consultation important

Consultation is a legal requirement and an essential part of managing health and safety risks.

A safe workplace is more easily achieved when everyone involved in the work communicates with each other to identify hazards and risks, talks about any health and safety concerns and works together to find solutions. This includes cooperation between the people who manage or control the work and those who carry out the work or who are affected by the work.

By drawing on the knowledge and experience of your workers, more informed decisions can be made about how the work should be carried out safely.

Effective health and safety consultation also has other benefits:

- Greater awareness and commitment – because workers who have been actively involved in how health and safety decisions are made will better understand the decisions.
- Positive working relationships – because understanding the views of others leads to greater co-operation and trust.

In situations where you share responsibility for health and safety with another person, the requirement to consult, co-operate and co-ordinate activities with other duty holders will help address any gaps in managing health and safety risks that often occur when:

- there is a lack of understanding of how the activities of each person may add to the hazards and risks to which others may be exposed
- duty holders assume that someone else is taking care of the health and safety matter
- The person who takes action is not the best person to do so.
- The outcome of consulting, co-operating and co-ordinating activities with other duty holders is that you each understand how your activities may impact on health and safety and that the actions you each take to control risks are complementary.

### 3.2 When to consult with workers

Many organisational decisions or actions have health and safety consequences for workers. For example, introducing new equipment into the workplace may affect the tasks your workers carry out, the timeframes for doing work, how they interact with each other and the environment in which they work.

#### 3.2.1 Managing risks

Consultation is required when identifying hazards, assessing risks and deciding on measures to control those risks.

In deciding how to control risks, you must consult with your workers who will be affected by this decision, either directly or through their health and safety representative. Their experience may help you identify hazards and choose practical and effective control measures.

Regularly walking around the workplace, talking to your workers and observing how things are done will also help you identify hazards. Conducting a survey of your workers can provide valuable information about work-related health issues such as workplace bullying, stress, as well as muscular aches and pains that can signal potential hazards.

Workers and their health and safety representatives may need access to information such as technical guidance about workplace hazards and risks (plant, equipment and substances). Information should not be withheld just because it is technical or may be difficult to understand.

The WHS Act requires that you allow any health and safety representative for a work group to have access to information you have relating to hazards (including associated risks) affecting workers in the work group and also any information about the health and safety of workers in the work group. This does not extend access to any personal or medical information concerning a worker without the worker's consent.

### 3.2.2 Making changes

You must consult your workers when planning to make changes that may affect their work health and safety, for example when:

- changing work systems such as shift work rosters, work procedures or the work environment
- developing a new product or planning a new project
- purchasing new or used equipment or using new substances
- Restructuring the business.

### 3.2.3 Developing procedures

A procedure sets out the steps to be followed for work activities. You must consult with affected workers when developing procedures for:

- resolving work health and safety issues
- consulting with workers on work health and safety
- monitoring workers' health and workplace conditions
- Providing information and training.

Procedures should be in writing to provide clarity and certainty at the workplace and assist in demonstrating compliance. They should clearly set out the role of health and safety representatives, and any other parties involved in the activity. The procedures should be easily accessible, for example by placing them on noticeboards and intranet sites.

If issue resolution procedures are agreed to, the WHS Regulations include minimum requirements including that these procedures are set out in writing and communicated to all workers to whom the procedure applies.

## 3.3 What is effective consultation?

Consultation is a two-way process between you and your workers where you:

- ✓ talk to each other about health and safety matters
- ✓ listen to their concerns and raise your concerns

- ✓ seek and share views and information, and
- ✓ Consider what your workers say before you make decisions.

Management commitment and open communication between managers and workers is important in achieving effective consultation. Your workers are more likely to engage in consultation when their knowledge and ideas are actively sought and any concerns about health and safety are taken seriously.

- ✓ Consultation does not mean telling your workers about a health and safety decision or action after it has been taken. Workers should be encouraged to:
- ✓ ask questions about health and safety
- ✓ raise concerns and report problems
- ✓ make safety recommendations
- ✓ Be part of the problem solving process.

While consultation may not result in agreement, this should be the objective as it will make it more likely that the decisions are effective and will be actively supported

### 3.3.1 Sharing information

You must share relevant information with workers and their health and safety representatives about matters that may affect their health and safety. This information should be provided early on so that workers and health and safety representatives have enough time to consider the matters, discuss them and then provide feedback to you.

You should make available all the information that you have relating to the health and safety matter to enable informed and constructive discussions. This information may include:

- ✓ health and safety policies and procedures
- ✓ technical guidance about hazards, risks and risk control measures
- ✓ hazard reports and risk assessments
- ✓ proposed changes to the workplace, systems of work, plant or substances
- ✓ Data on incidents, illnesses or injuries (in a way that protects the confidentiality of personal information).

The information should be presented in a way that can be easily understood by your workers and take into account literacy needs and the cultural or linguistically diverse backgrounds of your workers.

Young workers and those with limited English may be less likely to question health and safety practices or speak up if they are unsure. They may find it easier to communicate through a health and safety representative, an interpreter or worker representative.

Information should also be simplified and presented in different ways, such as using diagrams, to make it easier to understand.

Meeting face-to-face is usually the most effective way of communicating, although that may not always be possible or preferable. Information can also be shared in other ways, including:

- ✓ by telephone or email
- ✓ Featuring current health and safety news and information on intranet sites or noticeboards.

Information should be updated and attention drawn to new material so that people who do not regularly check it will know what is happening in their workplace.

### 3.3.2 Providing reasonable opportunities to express views and contribute

Giving your workers a reasonable opportunity to express their views and contribute to health and safety decisions may involve:

- ✓ providing a suitable time during work hours for consultation with workers
- ✓ allowing opinions about health and safety to be regularly discussed and considered during workplace meetings
- ✓ Providing workers with different ways to provide feedback, for example using email, setting up an intranet health and safety page or a suggestion box.

How long the consultation processes takes will depend on the complexity of the health and safety matter, how many people are being consulted, the accessibility of workers and the methods of consultation. A simple issue affecting only a small number of workers can probably be dealt with in a few hours or days through regular channels of communication. A complex technical matter, or consulting a large workforce, may require more time.

## 3.4 How to consult with workers

Consultation with workers can be undertaken in various ways. It does not need to be a formal process and can be as simple as talking to them regularly and considering their views when making health and safety decisions.

Consultation can also be undertaken through health and safety representatives and health and safety committees. However, the WHS Act does not require the establishment of these consultation mechanisms, unless:

- ✓ in relation to a health and safety representative – a request is made by a worker
- ✓ In relation to a health and safety committee – a request is made by 5 or more workers or a health and safety representative.

### 3.4.1 What kind of consultation is best for your workplace?

Consultation arrangements should take into account the size of the business, the way work is arranged and what suits your workers. Many workplaces will already have ways to consult on health and safety that suit their needs. These arrangements can continue if they are consistent with the requirements of the WHS Act and workers have been consulted about them.

To determine how best to consult, you should first discuss with your workers issues such as:

- ✓ the duty to consult and the purpose of consultation
- ✓ the range of work and associated health and safety issues at the workplace
- ✓ the various ways for consultation to occur, including your workers' right to elect health and safety representatives
- ✓ Your workers' ideas about the most effective way to consult.

You should work out methods that:

- ✓ meet your duty to consult
- ✓ ensure all workers can participate in consultation including any shift workers or mobile workers
- ✓ Will best integrate with the way your business manages health and safety.

### 3.4.2 Agreeing on consultation procedures

Agreeing on procedures for consultation with workers can save time and confusion about how and when consultation must occur. The agreed consultation procedures should clarify key responsibilities of people in the workplace and clearly state when consultation is necessary.

Before consultation procedures can be agreed, you must genuinely consult about the proposed procedures with all affected workers, including any health and safety representatives for the relevant workers.

If procedures for consultation are agreed, they must be consistent with the requirements of the WHS Act and the consultation must be conducted in accordance with those procedures. For example, the procedures must include sharing of information, allowing workers a reasonable opportunity to express their views and cannot remove the powers of any health and safety representatives or the functions of any health and safety committee established for the workplace.

Agreed consultation procedures are likely to be most effective if they include:

- ✓ the matters that require consultation
- ✓ who will be consulted
- ✓ the ways consultation will occur, for example, through regular meetings, tool-box talks or health and safety representatives

- ✓ how information will be shared with workers and health and safety representatives
- ✓ what opportunities will be provided for workers and health and safety representatives to give their views on proposed matters
- ✓ how feedback will be given to workers and health and safety representatives
- ✓ how consultation will occur with any workers who have special language and literacy needs
- ✓ Timeframes for reviewing the procedures.

### 3.4.3 Consulting using health and safety representatives and committees

#### Health and safety representatives

A worker may ask you for the election of a health and safety representative to represent them on work health and safety matters. If a worker makes this request, work groups must be established to facilitate the election. The process requires you and your workers to negotiate and agree on the formation of work groups.

**Health and safety committees**

A health and safety committee brings together workers and management to assist in the development and review of health and safety policies and procedures for the workplace.

## 3.5 How to consult, co-operative and co-ordinate activities with other duty holders

People often assume that someone else is going to take action for health and safety, perhaps because that other person is more directly involved in the activity. This may be more likely where there are numerous people involved in the work. This can mean that nobody takes the necessary action.

Each person conducting a business or undertaking must ensure, so far as is reasonably practicable, the elimination or minimization of risks to health and safety. This includes ensuring, for example, that safe plant is used, that there are adequate welfare facilities for workers and that training is provided to workers.

You must ensure these requirements are met even if others may also have the duty to do so.
You may ensure the outcomes by not necessarily taking the required action yourself, but making sure that another person is doing so.

Talking to, and co-operating and co-coordinating activities with others who are involved in the work or things associated with the work will make the control of risks more likely and assist each duty holder comply with their duty. It can also mean that health and safety measures are more efficiently undertaken.

For example, you may not need to provide toilet facilities for your workers if they are already available, but you need to check that those facilities are in good working order, clean and accessible for your workers. Consultation, co-operation and co-ordination between you and the person providing those facilities will help you ensure that the necessary steps are being taken
so that you can meet your duty.

What is reasonably practicable in relation to consulting, co-operating and co-coordinating activities with other duty holders will depend on the circumstances, including the nature of the work and
the extent of interaction. For example, two contractors working together may engage in direct discussions and planning as part of their everyday work, whereas the owner of a large shopping Centre may need formal mechanisms with the retail businesses, such as written agreements and consultative committees.

### 3.6 Who must consult, co-operate and co-ordinate and with whom

The first step is to identify who the other duty holders are that you need to consult, co-operate and co-ordinate activities with. The duty requires each person with a health and safety duty to consult, co-operate and co-ordinate activities with each other person who has a duty over the same matter.

Examples of who may need to be involved in consultation, co-operation and co-ordination of activities are as follows:

- Various contractors who are involved in the same work at the same time at a workplace will need to consult, co-operate and co-ordinate activities with each other as they may each affect the health or safety of their own workers or the workers of other business operators or other people at or near the workplace.
- An installer of plant at a workplace and the person with management or control of the workplace should consult, co-operate and co-ordinate activities with each other in relation
  to when, where and how the plant is to be installed to control any health and safety risks.
- A landlord or managing agent should consult, co-operate and co-ordinate activities with the tenant (for example, in relation to emergency plans and procedures) or with a contractor carrying out maintenance or repair work.
- Each of the business operators involved in the supply and logistics chain (the consignor and consignee, the operator of a warehouse, the trucking company and any sub-contracted drivers) should consult, co-operate and co-ordinate activities with each other on the timing and process for the collection and delivery of the goods.

- A franchisor and franchisee should consult, co-operate and co-ordinate activities with each other when determining how the franchise arrangements are to operate and any requirements that the franchisor may impose on the franchisee relating to work health and safety.

3.7 **When must you consult, co-operate and co-ordinate with others?**

Consultation should commence during the planning of the work, to ensure that health and safety measures are identified and implemented from the start. A need for further consultation may arise when circumstances change over the period of the work, including the work environment and the people involved in the work. Co-operation and co-ordination with other duty holders should be an ongoing process throughout the time in which you are involved in the same work and share the same duty.

**3.8 What is meant by consultation with other duty holders?**

The objective of consultation is to make sure everyone associated with the work has a shared understanding of what the risks are, which workers are affected and how the risks will be controlled. The exchange of information will allow the duty holders to work together to plan and manage health and safety.

The consultation should include:

- what each will be doing, how, when and where and what plant or substances may be used
- who has control or influence over aspects of the work or the environment in which the work is being undertaken
- ways in which the activities of each duty holder may affect the work environment
- ways in which the activities of each duty holder may affect what others do
- identifying the workers that are or will be involved in the activity and who else may be affected by the activity
- what procedures or arrangements may be in place for the consultation and representation of workers, and for issue resolution
- what information may be needed by another duty holder for health and safety purposes
- what each knows about the hazards and risks associated with their activity
- whether the activities of others may introduce or increase hazards or risks
- what each will be providing for health and safety, particularly for controlling risks
- What further consultation or communication may be required to monitor health and safety or to identify any changes in the work or environment

### 3.9 What is meant by co-operation?

What is required for co-operation should have been identified in the consultation process.

Co-operation may involve implementing arrangements in accordance with any agreements reached during consultation with the other duty holder and involve not acting in a way that may compromise what they are doing for health and safety.

Co-operation also means that, if you are approached by other duty holders wanting to consult with you on a health and safety matter, you should:

- not obstruct communication
- Respond to reasonable requests from other duty holders to assist them in meeting their duty.

### 3.10 What is meant by co-ordination?

The co-ordination of activities requires duty holders to work together so that each person can meet their duty of care effectively without leaving any gaps in health and safety protection. You should plan and organize activities together with the other duty holders.

This will include making sure that the measures you each put in place work effectively together to control the risks. You should:

- identify when and how each control measure is to be implemented
- Ensure control measures complement each other.

Co-ordination of activities may include the scheduling of work activities so that each duty holder carries out their work separately. It may require work to be arranged in a way that will allow
for necessary precautions to be in place or pre-conditions met before particular work is done.

Where work is not effectively co-ordinated, the parties should consult further to determine what should be changed.

| Self-Check -3 | Written Test |
|---|---|

**Directions:** Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. Which one of the following is **not** the benefit of effective consultation?(3pts)
   A. Increases awareness and commitment
   B. Positive working relationships enhanced
   C. Exposes lack of understanding

D. none

2. Consultation is one way process (3pts)

A. True B. False

***Note:*** **Satisfactory rating - 3 points** **Unsatisfactory - below 3 points**

**Answer Sheet**

Score = _____

Rating: _____

Name: _____ Date: _____

**Short Answer Questions**

| Information Sheet-4 | Identifying and detailing Materials necessary to complete the work |
|---|---|

## 4.1 Identifying and detailing Materials necessary to complete the work

Since the title talk about the materials according to the work performed, the materials are listed after the explanation of each task/activities as model.

### Skin

Let's face it; the world is a tough place. It is nice to have a flexible, self-repairing, multi-sensory suit of armor that shields you from the elements and protects your vital organs from microbial invaders and physical harm. Many people are surprised to learn that skin is an organ. In fact, it is the human body's largest organ.

Specialized cells known as melanocytes produce melanin, the chemical pigment that gives skin its color. People with light colored skin and dark colored skin have the same number of melanocytes. The only difference between them is the activity level of melanin production. Melanin helps to protect the body from the harmful effects of UV light from the sun.

**Introducing the activity**

When we say something is hot or cold, we are usually thinking in terms of its comparison to something else. Boiling water isn't very hot compared with molten steel, for instance. We sometimes get a glass of water from the cold-water tap and complain about the water being warm, but if we were to take a shower in water of the same temperature we would probably consider it very cold. This activity is designed to point out that our reactions to temperatures are relative.

We frequently judge something to be hot or cold relative to the temperature of the skin. The lukewarm water used in this activity should be such that it feels neither hot nor cold to the skin.

**Materials** (per pair of students)

1. Three pans or bowls
2. Hot, lukewarm, and cold water
3. Blindfold

**Skeletal system**

If you have ever seen an X-ray taken by a doctor, you probably realize that everyone has a skeleton made up of many bones. In fact, the average adult has about 206 of them over half of them in your hands and feet. Your skeleton gives your body structure like the girders of a building. The bones of your skeleton also protect your internal organs, such as your heart, brain and lungs.

Many people think that the skull is one big piece of bone, but in truth it is composed of **30 different bones.**

Follow these tips if you want to have strong and healthy bones:

• Protect your skull bones and the brain inside by wearing a helmet whenever you bike, skateboard or roller skate. Also, wear appropriate gear such as elbow and kneepads to give you extra protection if you fall.

• Strengthen your skeleton by getting plenty of calcium through drinking milk and eating other foods high in calcium. Check out the nutritional labels on the foods you eat to see which are highest in calcium.

Joints, made up of ligaments and cartilage, link one bone to another. Joints that do not move are known as fixed joints and can be found connecting the sides and front of the skull. Moving joints allow for a wide range of motions depending on their purpose. Our elbows and knees are examples of hinge joints while our shoulders and hips allow for motion in many different directions.

**Introducing the (work) activity**

The skeletal system of the human body is made up of bones. These bones create the body's shape and protect internal, delicate body parts. An adult person has about 206

bones in his/her body. The number of bones in a person's body varies due to the discrepancies in the number of little bones in the hands and feet.

## Materials (per group of trainees)

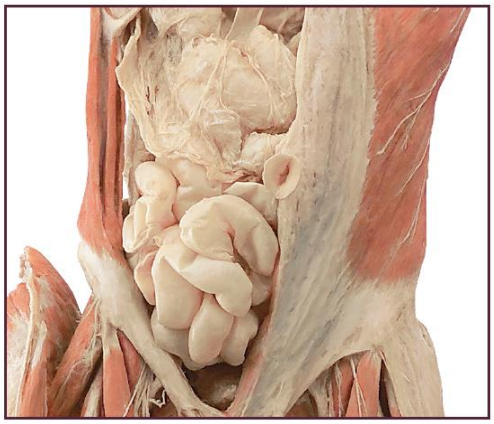
- 6 sheets of 8 ½" x 11" papers
- 1 roll tape
- 2 paper plates
- 1 measuring cup
- 20 weights (small blocks)

**Muscular system**

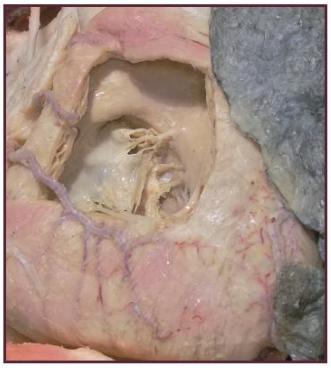
If all 600 muscles in your body pulled in one direction, you could lift around 25 tons. But lifting things is just one of the jobs our muscles help us do. Muscles pump blood through our body, allow us to smile or frown, and help us to run and jump. The muscular system is made up of three types of muscles:

**Smooth muscles:** Muscles that work automatically, without conscious thought, are involuntary or smooth muscles. Smooth muscles are made up of smooth muscular tissue. They control the involuntary movements of the internal organs (i.e. blood vessels, bronchi, digestive tract, and uterus). The smooth muscles found in our digestive system help us digest by squeezing food from the esophagus to the rectum using the process called peristalsis.

Smooth muscles are capable of staying contracted for long periods of time.



One of the locations smooth muscle can be found is the gastrointestinal tract

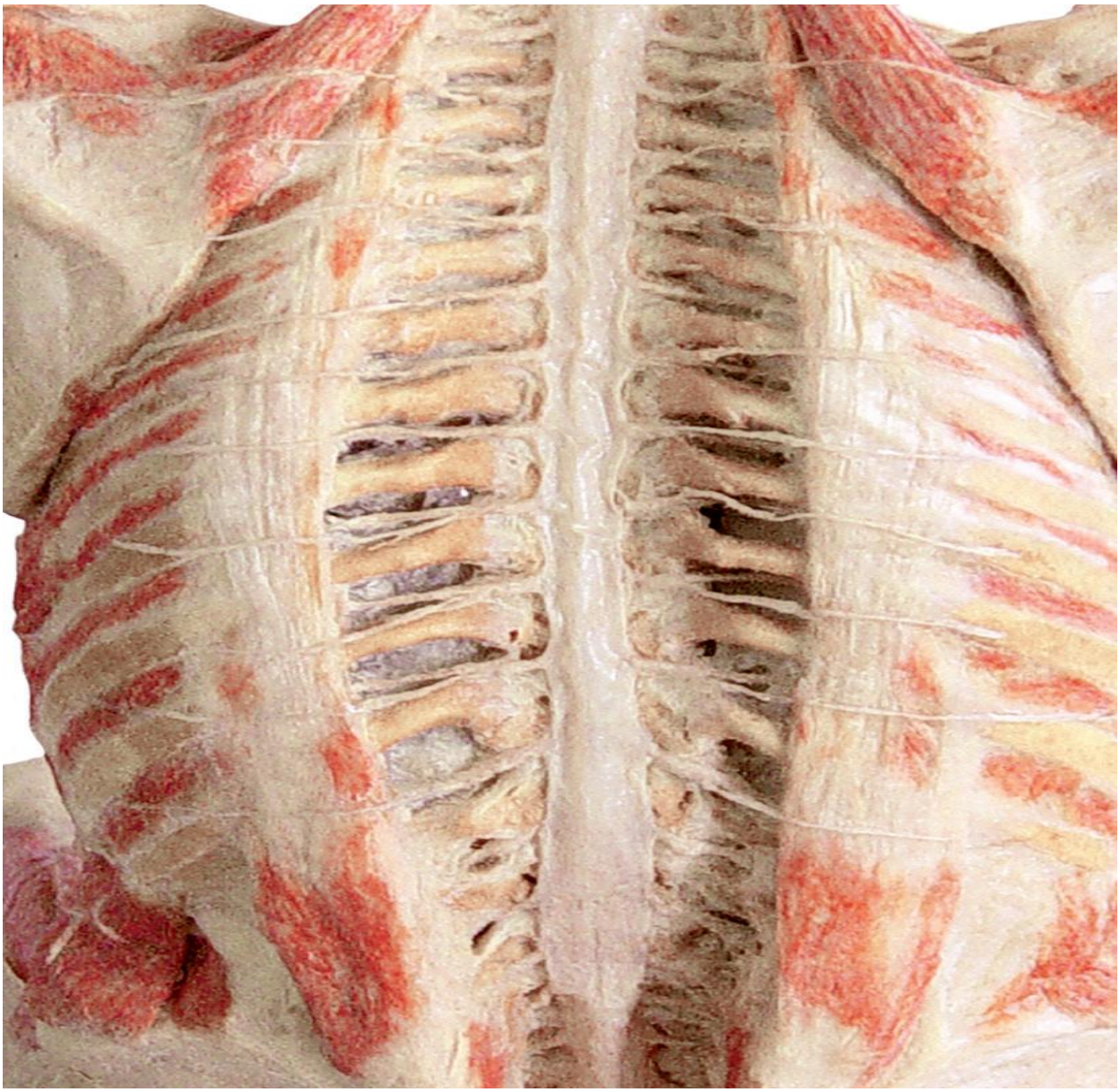


**Cardiac muscle in the ventricular wall**

**Cardiac muscles:** Our hearts are made of cardiac muscle designed to squeeze blood to all the systems of our body through blood vessels. The cardiac muscle is made up of cardiac fibers laid into spiral bundles. Each cell can contract rhythmically. The entire tissue contracts in a coordinated fashion due to a particular anatomical element from which, “waves” of contraction emanate. These waves spread to the heart, regulating its beat. The cardiac muscle is able to sustain strong and continuous contractions without getting tired.

**Skeletal muscles:** Skeletal muscles, the muscles most people identify with, are voluntary muscles that we control. They make up the musculoskeletal system.

Skeletal muscles are made up of striated muscle tissue. They insert into your bones. Skeletal muscles are able to contract with great strength, but they tire easily.



Spinal cord exposed

**Muscle contraction.** The act of lifting an object is not a simple process. When we use our muscles for physical movement, we call upon our skeletal muscles. Skeletal muscles contract when the brain sends signals in the form of “action potentials” through the nervous system.

The place where the nerve and muscle meet is called the neuromuscular junction. An electrical signal crosses this junction and triggers the flow of calcium ions causing the myofilaments, fibers made from protein, to slide across one another. When this

happens, the sarcomere, a thick filament system that gives cardiac and skeletal muscles their striped appearance, shortens and force is generated.
Billions of sarcomeres shortening cause a contraction of the entire muscle fiber. An energy supply of ATP (adenosine triphosphate), the body's primary energy unit, ensures continued muscle contraction.

**Activity (work) Muscle Stamina**

**Introducing the activity**

Explain to trainees that muscles help the body move.
Muscles require food, water and oxygen to do this work. You use muscles every day to do things like breathe, walk, eat and digest your food. Muscles that are used on a regular basis become stronger and can work for longer periods of time without becoming fatigued. They develop increased stamina.
These muscles become larger and their blood vessels become wider. A muscle exercised strenuously for a prolonged period of time may lose its ability to contract, a condition called fatigue.
Muscle fibers contract many times per second.
Sometimes your body cannot supply food, water, and oxygen fast enough for your muscles. You begin to breathe harder and your heart beats faster trying to meet the needs. Your body is able to make a little muscle energy without oxygen.
When this happens, lactic acid is produced and collects in the muscles. As the lactic acid increases, it becomes harder for the muscles to contract.
Eventually, the muscles get tired and refuse to work until they have had time to rest. Your body needs oxygen to get rid of the lactic acid in your muscles.
Your heart will continue to beat fast and you will continue to breathe deeply until this need is met.

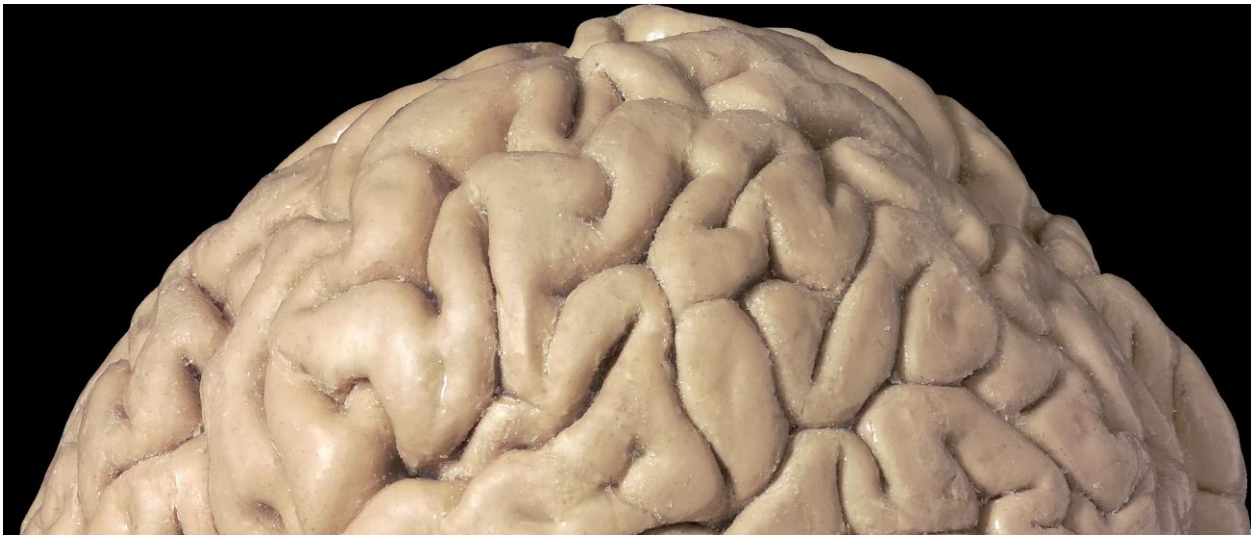
**Materials (per pair of trainees)**

- ✓ **1 stopwatch**
- ✓ **1 spring clothespin**
- ✓ **notebook for recording data**
- ✓ **2 sheets large graph paper**

# Nervous system

Let's say you are walking in a dark room when suddenly you see something move in the corner. Your eyes send that information to your brain, which reacts to possible "danger" by sending impulses to prepare the body for action. Your heart might beat faster as your muscles are prepared to retreat or protect yourself. This is an example of the "fight or flight" response and represents one of the ways our nervous system looks after our survival.

The nervous system is like the Internet of the human body. It gathers stores and transfers information to control systems throughout the body. The nervous system is designed to prepare and adapt your body to a wide variety of situations and environments.



Your nervous system is divided into the central nervous system (the brain and spinal cord) and the peripheral nervous system (the nerves that move information into the arms and hands and to the legs and feet).

The autonomic system innervates our organs, things that we do not even think about, like our heart, kidneys or our digestive system. The somatic system is made up of motor fibers and sensory fibers.

**Activity (work) :Spinal Reflexes**

**Introducing the activity**

Reflexes are rapid, involuntary responses to stimuli which are mediated over simple nerve pathways called reflex arcs. Involuntary reflexes are very fast, traveling in milliseconds. The patellar reflex is a true spinal reflex. It involves only neurons in the body and spinal cord and completely bypasses the brain. The patellar reflex is a normal, healthy reflex that involves the contraction of the quadriceps and extension of the leg when the patellar tendon is tapped.

**materials (per pair of trainees)**

• 1 lab stool or chair

• 1 reflex mallet (if not available, try to use the outside edge of your hand)

**Circulatory system**

Your circulatory system is like the highway system of your body. Vital nutrients and oxygen are transported in the blood flowing through your arteries.

The deoxygenated blood and waste are transported through veins. You have about 5 quarts of blood traveling continuously throughout your body. Blood is made up of plasma, a liquid, and the following three types of cells:

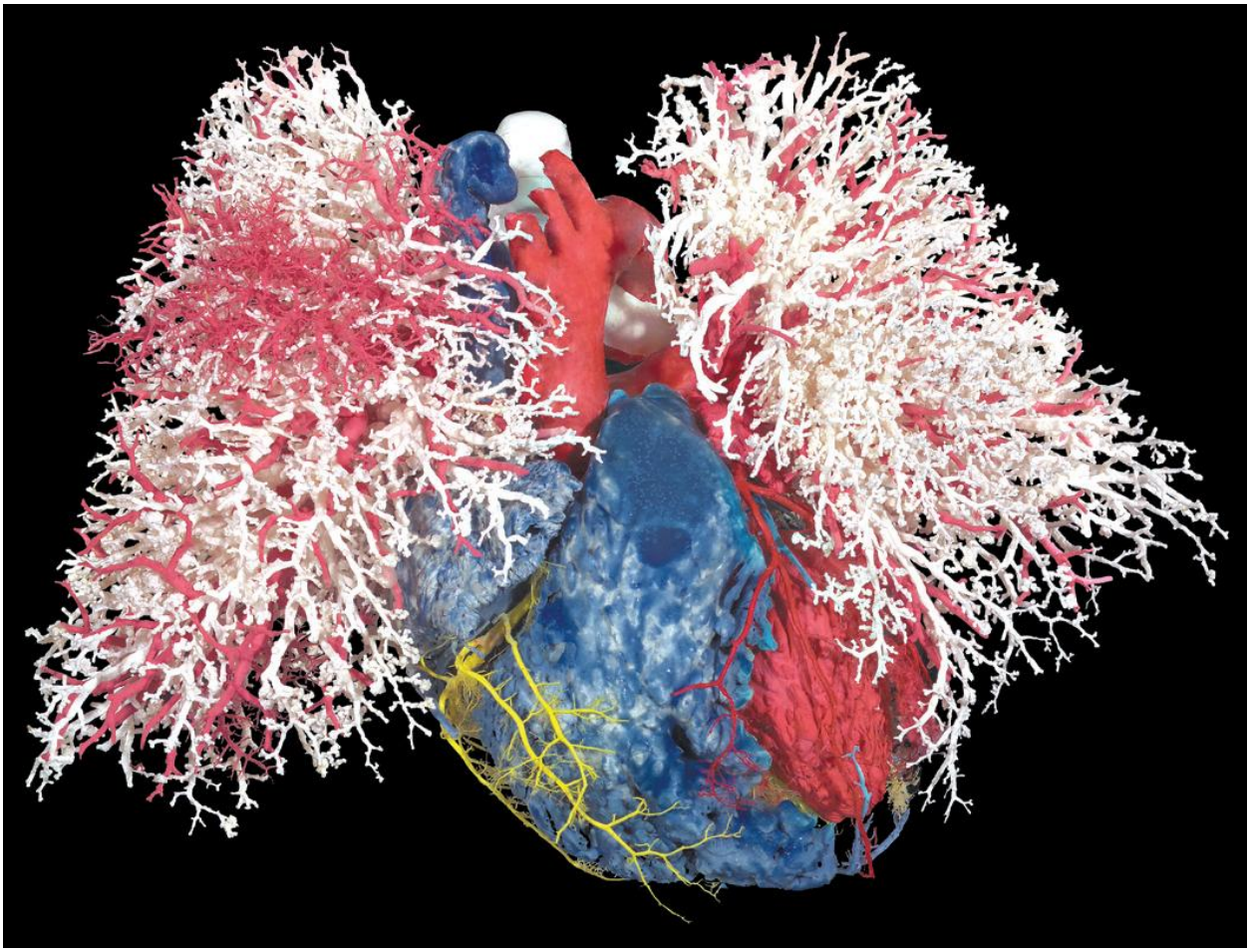
• Red cells, or erythrocytes, carry oxygen for delivery to all of your cells.

• White cells, or leukocytes, function as body police by fighting off bacteria and viruses.

• Platelets, or thrombocytes, are tiny pieces of cells that plug up injured blood vessels and start the clotting process when you get a cut.

Blood cells are created from the stem cells found in the red marrow of the skull, ribs, sternum, spine and pelvis. These stem cells divide and multiply to make various blood cells.

The primary organ of the circulatory system the heart pumps oxygenated blood out through the arteries to all parts of the body. Because the heart is a double pump with four chambers, it also pumps the deoxygenated blood to the lungs to be oxygenated again.



Veins and arteries of the heart

## Activity:Straight from the Heart

**Materials** (per pair of trainees)

**Heart Model**

• One-half pear cut lengthwise
• Two 6 inch pieces of surgical tubing
• 1 plastic spoon
• 1 small knife
• “heart” vocabulary per student

**Vibration Observation**

• Small amount of modeling clay
• 1 match

**Stethoscope Model**

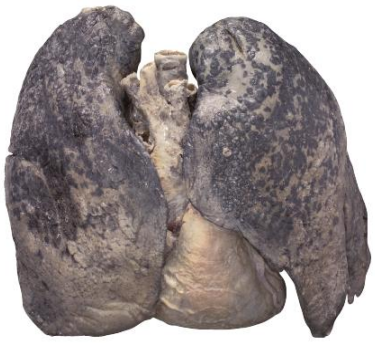
• One 3 feet piece of surgical tubing
• 2 funnel per model
• Small amount of modeling clay

## Respiratory system

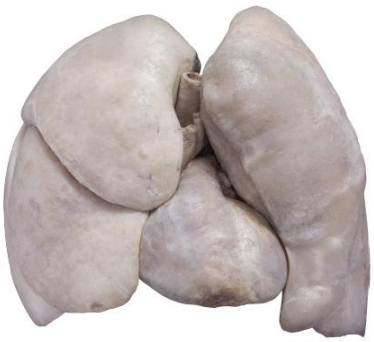
You don’t think about your breathing throughout the day, do you? You might, however, be more aware of your breathing after you finish exercising or running up stairs! Your lungs, the star of your respiratory system, allow you to take air in from your environment and extract the vital oxygen that is transported to all the cells in your body. Once finished with the air, your diaphragm, the muscle that works to inhale and exhale, expels carbon dioxide and other waste out into the environment.

Your lungs are made up of branches of tubes called bronchioles. Each bronchiole is about the same thickness as a hair. At the end of the bronchioles are microscopic air sacs known as alveoli. Alveoli take the oxygen molecules in the air and pass them to the red blood cells to deliver oxygen to the rest of the body.

Although it is up to your lungs to ventilate your body, it is up to *you* to keep harmful chemical fumes and cigarette smoke from damaging your lungs.



Smoker's lungs



Healthy lungs

## Activity: understand the anatomy and physiology of the human lung.

### Introducing the activity

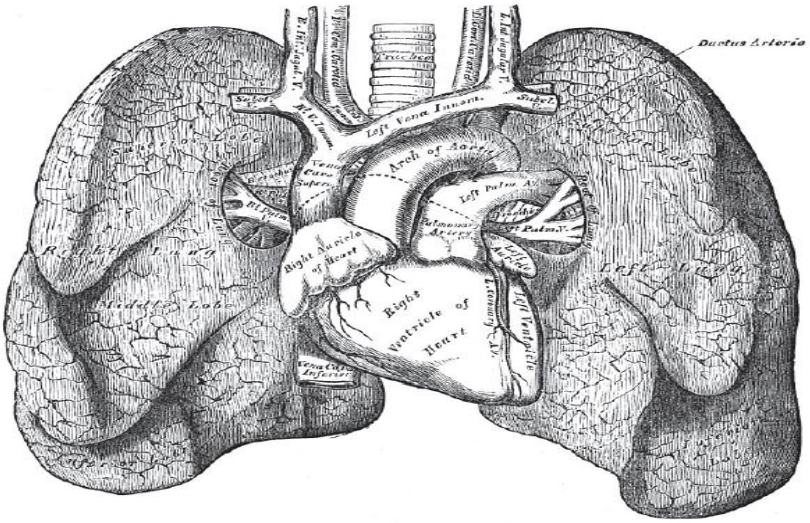
We breathe about 15 times a minute and are not even aware of it. A newborn breathes up to 70 times per minute. Breathing expels carbon dioxide, a toxic bi-product of cellular metabolism, and substitutes it with oxygen. Oxygen is necessary to conduct all the chemical reactions that allow us to get energy from food.

The respiratory system plays the main role in this important process and closely collaborates with the circulatory system to collect carbon dioxide from the body, bring it to the lungs and discharge it outside the body. In addition, the respiratory system distributes oxygen collected inside the lungs to the entire body. It also plays an important role in the process of speech, thanks to a series of specialized structures inside the pathways.

The activity below will provide students with a better understanding of lung anatomy and physiology.

**Materials (per pair of trainees)**

- **1 pair of scissors**
- **6" of surgical tubing**
- **3 good-sized balloons**
- **Two rubber bands**
- **Large lump of modeling clay**
- **1 clear plastic one-liter bottle**
- **1 three-way hose connector (available at the hardware store)**




**Digestive system**

We base our decision on what to eat largely on taste preferences and nutritional habits. Let's follow what happens to our food from the minute we put it into our mouth to the time it comes out the other end.

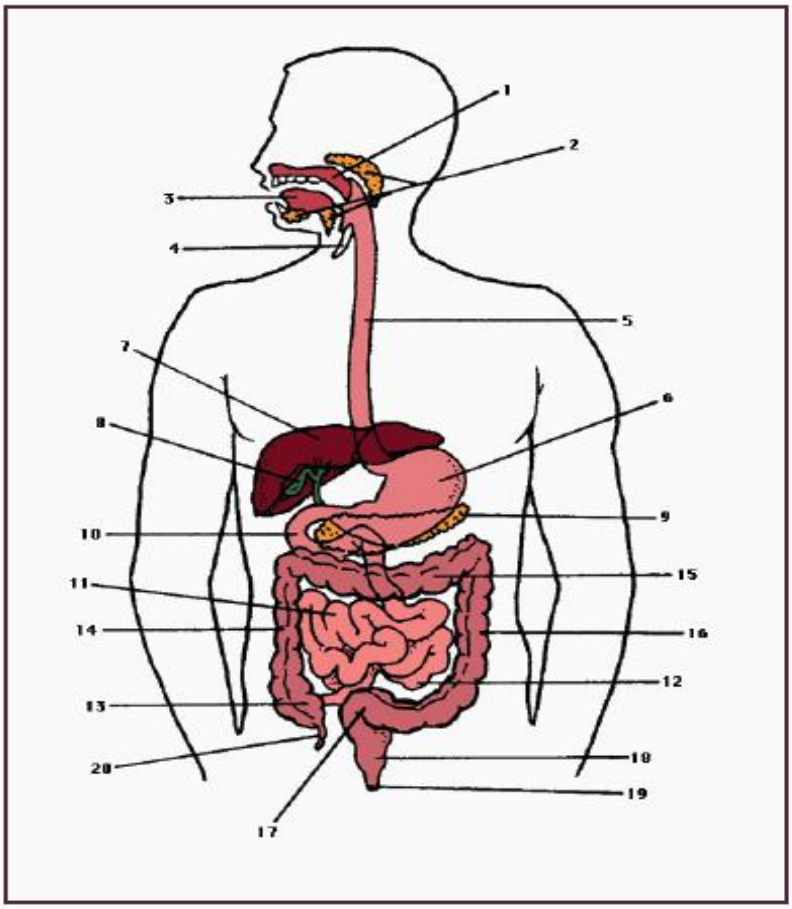
1. You put food into your mouth. Teeth prepare the food by chewing larger pieces into smaller, easier to swallow ones. Enzymes are added to get a start on breaking down foods chemically.
2. Once your food is chewed, it is pushed into the esophagus and squeezed down using a muscular action called peristalsis.
3. Food arriving in the stomach is subjected to highly acidic gastric juices that digest food and kill bacteria. Although the stomach churns and mixes the food, the stomach also acts as a storage compartment slowly changing the food into a gray, oatmeal-like mush known as chime and passing it into the small intestine.
4. As the chime enters the small intestine, it is mixed with green bile and other digestive juices to help with the absorption of minerals, vitamins, carbohydrates, proteins, and fats. This 26-foot long tube absorbs most of the nutrition from the food we eat.

Once the chyme makes it through the small intestine, its nutrients have already been stripped and transported to other organs. The fluid remains of the food have their water absorbed by the large intestine.

6. The final step. The nutrient and water remains of the food are stored in the rectum until there is enough to be defecated as feces.

**Digestion:** 1 palate, 2 salivary glands, 3 tongue, 4 epiglottis, 5 esophagus, 6 stomach, 7 liver, 8 gallbladder, 9 pancreas, 10 duodenum, 11 jejunum,
12 ileum (10, 11, and 12 comprise the small intestine),

13 cecum, 14 ascending colon, 15 transverse colon, 16 descending colon, 17 sigmoid flexure, 18 rectum (13–18 comprise the large intestine), 19 anus, 20 vermiform appendix




**Activity:** how bile fluid in the intestines emulsifies oils and fats.

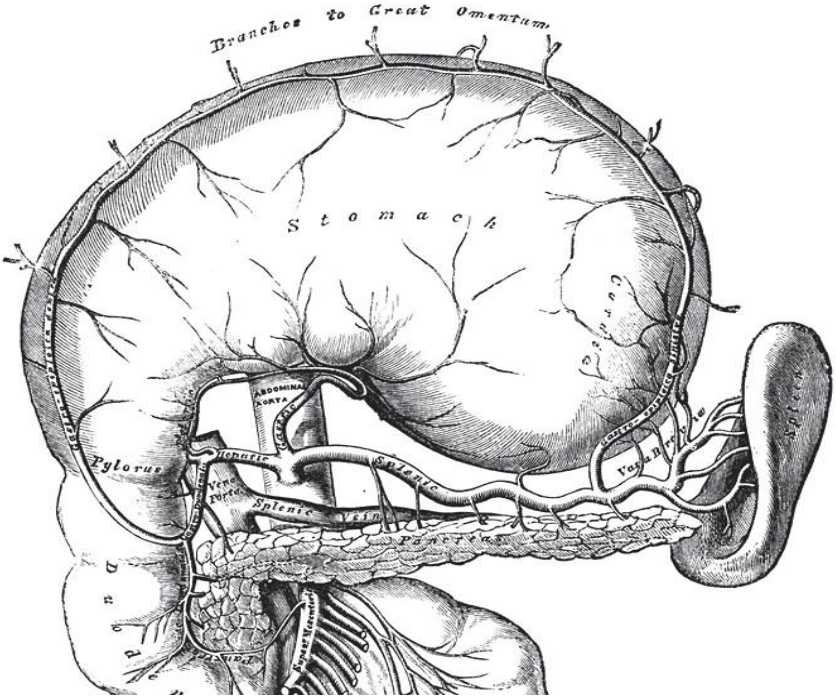
**Introducing the activity**

Explain to students that it is necessary for the body to emulsify fats to separate them and expose them to more enzymes. In this exercise, the dishwashing liquid represents the bile fluid.

Our digestive system works to break down food into fats, proteins, and starch molecules that can then be absorbed by our body. Once absorbed, these molecules must be transported via the blood stream to all parts of the body where they serve as fuel.

Food is broken down using the following two methods: (1) hydrolytic, which takes place in the presence of water and (2) enzymatic, where food is broken down using enzymes. These two processes, along with the physical actions of chewing, stomach churning,

absorption by the microvilli in the intestine and transportation of nutrients via the bloodstream, make up the digestive system.




**Materials** (per group of students)
- 2 clear plastic cups
- Warm water
- Dishwashing liquid
- cooking oil
- 1 tablespoon
- 1 teaspoon

**Urinary system**

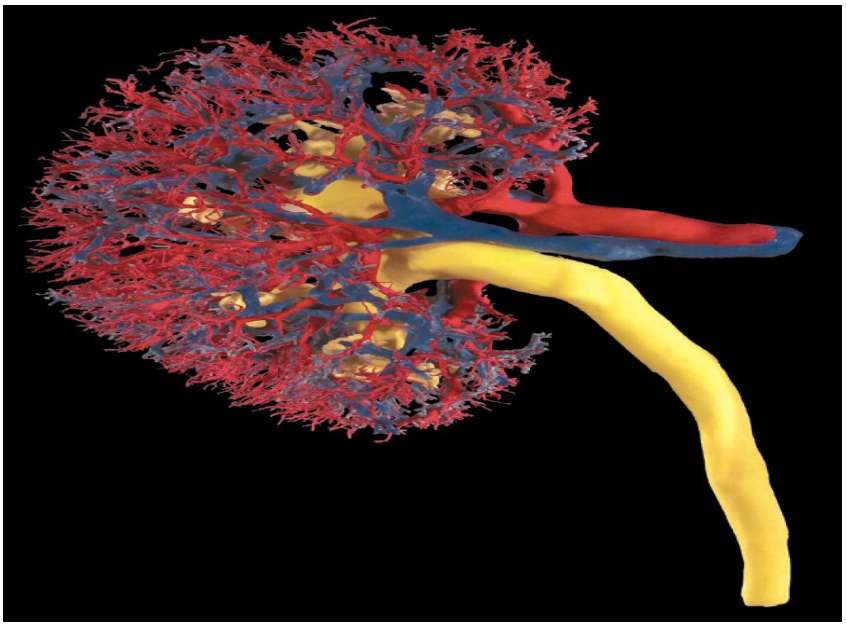
The chore of taking out the trash is a dirty job, but someone has to do it. Luckily, we have the urinary system dedicated to removing discarded waste from every cell and system of your body.

Although defecation releases feces as the final step of digestion, only our body's urinary system "cleans up" after metabolic or chemical processes in the form of urine.

Urea, the body's main waste product excreted by cells into the bloodstream, has to be removed because it is toxic. Traveling through the bloodstream, urea is filtered out from the blood by the kidneys. Your kidneys, located just below the ribs in the lower back, produce urine by combining the urea with other metabolic waste, salts, ions, and excess water.

The urine is transported via tube-like ureters to the bladder acting like a storage tank. When enough urine has filled the bladder, the brain sends an impulse telling the

sphincter to relax (open) and the detrusor muscle to contract allowing the urine to flow from the bladder and down the urethra in the process known as micturition or urination.



Veins and arteries of the kidney

Activity: identify the structures and functions of the urinary system by building a model containing the kidney, ureters, bladder and blood vessels.

**Introducing the activity**

The urinary system includes the kidneys, bladder, ureter and blood vessels. These organs control the amount of water and salts that are absorbed back into the blood and what is taken out as waste. The urinary system also acts as a filtering mechanism for the blood.

**Materials** (trainees)

- One large marshmallow = the bladder
- Glue
- Three kidney beans = the kidneys
- 2 drinking straws = the urethra
- 1 pair of scissors
- 3 spaghetti pieces = the ureters
- 2 pieces of red yarn = the arteries
- 2 pieces of blue yarn = represents the veins
- 1 sheet of construction paper (8 ½" x 11")

| Self-Check -4 | Written Test |
|---|---|

**Directions:** Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. What is the longest organ in the digestive system?(2pts)

E. Esophagus B. Appendix C. Large intestine D. small intestine

2. What "extra" piece attached to the large intestine serves no discernible purpose and can be removed?(2pts)

A. Spleen B. Appendix C. Duodenum D. Gall bladder

3. What is the connection between the respiratory and circulatory system?(2pts)

A. Oxygen from the respiratory system is absorbed into the blood stream

B. the blood carries the oxygen to every organ in the body

C. Both A and B

D. None

***Note:*** **Satisfactory rating - 5 points** **Unsatisfactory - below 5 points**

**Answer Sheet**

Score = _____

Rating: _____

Name: _____ Date: _____

**Short** **Answer** **Questions**

| Instruction Sheet | LG33: Describe the structure and function of the human body applying medical terms |
|---|---|

**This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:**

- Ascertaining and detailing Normal function of human body structure and associated parts in accordance with requirements.
- Selecting and organizing Information selected and organized correctly.
- Identify and organize technique and approached for descriptions of human body.

**This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to:**

- Ascertain and detail Normal function of human body structure and associated parts in accordance with requirements.
- Select and organize Information selected and organized correctly.
- Identify and organize technique and approached for descriptions of human body.

**Learning Instructions:**

**1.** Read the specific objectives of this Learning Guide.

2. Follow the instructions described below 3 to 6.

3. Read the information written in the information “Sheet 1, Sheet 2, Sheet 3 and Sheet 4”,In page -3, 20 and 31 respectively.

4. Accomplish the “Self-check 1, Self-check t 2 and Self-check 3” in page -18, 30 and 35 respectively.

5. If you earned a satisfactory evaluation from the “Self-check” proceed to “Operation Sheet 1” in page -36.

6. Do the “LAP test” in page – 37 (if you are ready).

| Information Sheet-1 | Ascertaining and Detailing Normal function of human body structure and associated parts |
|---|---|

## 2.1 Ascertaining and Detailing Normal function of human body structure and associated parts

Functional organization of the human body

The Internal Environment

Physiology is the study of function in living matter; it attempts to explain the physical and chemical factors that are responsible for the origin, development, and progression of life. In human physiology we attempt to explain the events (chemical and electrical) that occur in the body which allow us to exist under a wide variety of conditions.

**Cells as the basic living unit of the body**- The basic living unit of the body is the cell. Organs and tissues are actually assemblies of many different cells. They are held together by supporting structures (tissue, bone, etc.) and work to provide a uniform or greater purpose. Each type of cell is specially adapted to perform its specific function. For instance, the red blood cells are specifically designed to carry oxygen from the lungs to the tissues in the body.

Even though cells may have difference, in some basic ways they are alike. For example:

a) Cells are built with cell walls, which is like a skin that separates the fluid inside the cell separate from the fluid outside the cell. These walls are not solid; they have pores which allow substances (like nutrients) to pass in and waste products to escape out.

b) Each cell requires nutrition (food) to stay alive; they use almost the same types of nutrients to sustain life; the methods of changing these nutrients into energy is the same; and, almost all cells have the ability to reproduce.

Cells are automatons (they work automatically) that are capable of living, growing, and providing their special functions so long as the body provides the proper amounts of oxygen, glucose (sugar), electrolytes (electrically charged elements), amino acids, and fatty substances.

FLUID- Over half of the human body is fluid. There is the fluid which is inside the cells and that is called intracellular fluid; and, there is the fluid which is outside of the cells and that is called the extra cellular fluid.

Intracellular fluid is much the same from one cell to the other but is different from extra cellular fluid in that it contains larger amounts of minerals such as potassium, magnesium, and phosphate ions. Ions are particles that have an electronic charge to them; the charge may be positive (+) or negative (-). Bicarbonate ions. In addition, the extra cellular fluid carries nutrients (oxygen, glucose, fatty acids, and amino acids) the cells and carries waste (carbon dioxide and excretory products) away from the cells. The extra cellular fluid is in constant motion throughout the body and in its motion into and out of the cells. Therefore, all cells live in essentially the same environment.
The chemical difference between the intracellular fluid and extra cellular fluid establishes a concentration and electronic charge difference which works to move nutrients into the cell, waste out, and in brain cells facilitates communications.
A group of cells may organize into tissue, which means they are connected and work together to perform a similar function. Tissues may be organized into an organ (Latin: organum, "instrument, or tool"). An organ is a group of tissues that perform a specific function or group of functions. Frequently the tissue is specific for that organ's function—heart muscle tissue is different from brain or liver tissue, for example.

THE MAJOR SYSTEMS- The body has a number of systems of organs established to carry out the tasks essential to the functioning and survival of the body. For the most part, it is important for these systems to operate in harmony with each other. This harmony is sometimes called homeostasis. The term *homeostasis* is used by physiologists to mean the *maintenance of steady, consistent conditions* (usually referring to the body's internal environment). Essentially all the organs and tissues of the body function to help maintain homeostasis (a stable, internal condition). For example, the lungs provide new oxygen and eliminate old carbon dioxide at rates that are consistent with the body's needs.

**The Fluid Transport System**- Extra cellular fluid is transported to all parts of the body in two different stages:

The first stage is the movement of blood around the body via the circulatory system. Essential to this stage is the action of the heart. The heart is actually two separate pumps, one which propels blood through the lungs and the other which propels blood throughout the rest of the body (blood usually moves through the entire body system an

average of once every minute when a person is at rest and 5 times each minute when the person is extremely active). Blood pumped through the lungs is essential to picking up oxygen for transport to other parts of the body.

The second stage involves the movement of blood in and out of the cells of the body. Blood and fluids going into cell areas, usually move from larger “pipes”—the veins and arteries into smaller ones called capillaries. The materials that enter the cell is determined by a number of factors including the size of the material, the porosity (how big are the “doors into” the cell) of the cell membrane, the ionic charge (like how magnets are charged) of the material, and the electrolytic balance in the cell fluids.

**The Respiratory Syste**m- Each time the blood passes through the body it also flows through the lungs where it picks up oxygen. Oxygen diffuses (passes) through the membranes of the lung and into the blood in the same way that water, nutrients, and waste products move to and from cells and the blood.

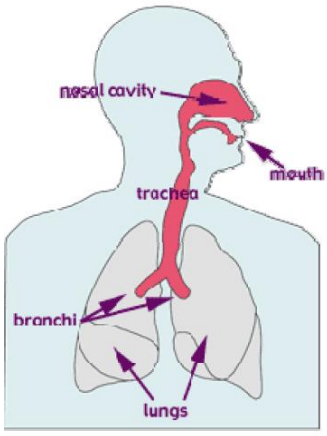



Figure1.1 **The Fluid Transport System**

**The Digestive System**- The human digestive system is a complex series of organs and glands that processes food. In order to use the food we eat, our body has to break the food down into smaller molecules that it can process; it also has to excrete waste.

Most of the digestive organs (like the stomach and intestines) are tube-like and contain the food as it makes its way through the body. The digestive system is essentially a long, twisting tube that runs from the mouth to the anus, plus a few other organs (like the liver and pancreas) that produce or store digestive chemicals.

An important route for blood is through the walls of the gastrointestinal (GI) organs especially the small intestine. Blood’s job here is to pick up and transport the various dissolved nutrients, including carbohydrates, fatty acids, and amino acids for use by the

body. Because not all substances absorbed from the gastrointestinal tract can be used in their composition is changed so they are in more useable forms.

**The Digestive Process**: **The Mouth (the start of the process):** The digestive process begins in the mouth. Food is partly broken down by the process of chewing and by the chemical action of salivary enzymes (these enzymes are produced by the salivary glands and break down starches into smaller molecules).

**The esophagus (The way to the stomach):** After being chewed and swallowed, the food enters the esophagus. The esophagus is a long tube that runs from the mouth to the stomach. It uses rhythmic, wave-like muscle movements (called peristalsis) to force food from the throat into the stomach. This muscle movement gives us the ability to eat or drink even when we're upside-down.

**In the stomach** - The stomach is a large, sack-like organ that churns the food and bathes it in a very strong acid (gastric acid).

**Small intestine** (finer processing area)- After being in the stomach, food enters the duodenum, the first part of the small intestine. It then enters the final part of the small intestine. In the small intestine, bile (produced in the liver and stored in the gall bladder), pancreatic enzymes, and other digestive enzymes produced by the inner wall of the small intestine help in the breakdown of food.

**Large intestine** (a final squeeze for nutrients)- After passing through the small intestine, food passes into the large intestine. In the large intestine, some of the water and electrolytes (chemicals like sodium) are removed from the food. Many bacteria like microbes in the large intestine help in the digestion process. Food then travels upward in the ascending colon. The food travels across the abdomen in the transverse colon, goes back down the other side of the body in the descending colon, and then through the sigmoid colon.

**The end of the process** – From the small intestine, food that has not been digested (and some water) travels to the large intestine through a valve that prevents food from returning to the small intestine. By the time food reaches the large intestine, the work of absorbing nutrients is nearly finished. The large intestine's main function is to remove water from the undigested matter and form solid waste that can be excreted.

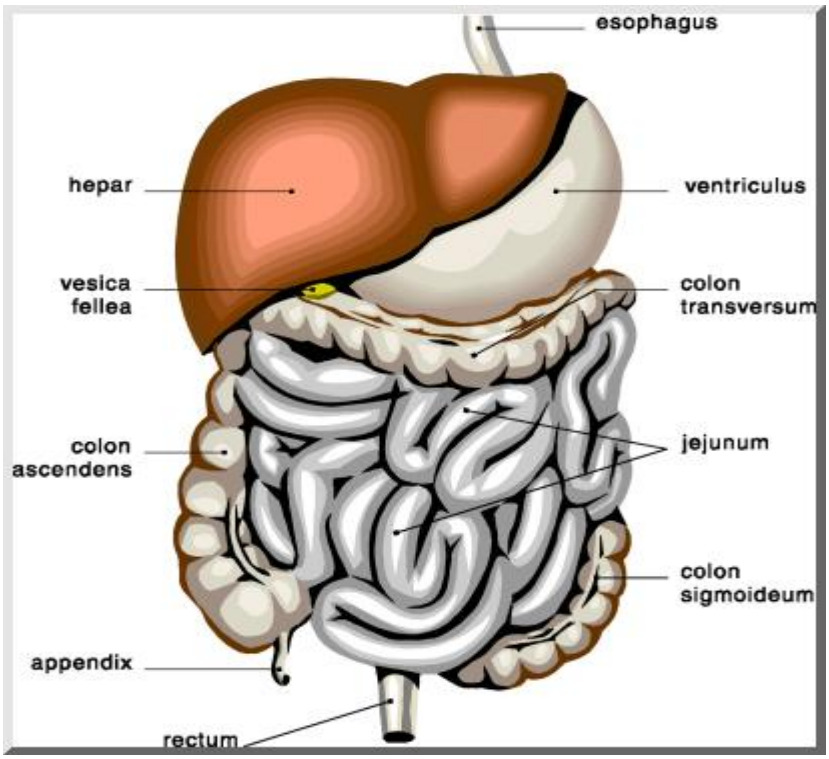


Figure1.2 **The Digestive System**

The **liver** (located under the ribcage in the right upper part of the abdomen), the **gallbladder** (hidden just below the liver), and the **pancreas** (beneath the stomach) are not part of the GI system, but these organs are still important for healthy digestion.

The pancreas produces enzymes that help digest proteins, fats, and carbohydrates. It also makes a substance that neutralizes stomach acid. The liver produces **bile**, which helps the body absorb fat. Bile is stored in the gallbladder until it is needed. These enzymes and bile travel through special channels (called ducts) directly into the small intestine, where they help to break down food.

The liver also plays a major role in the handling and processing of nutrients. These nutrients are carried to the liver in the blood from the small intestine.

D. **the Musculoskeletal System- getting** the body to move to the right place at the right time is extremely important to survival. Without this system, the ability to get food and escape enemies would be greatly, if not fatally, hindered.

**E. The Endocrine (hormone) System**- Located in the body are eight major endocrine or hormone producing glands. Hormones are transported in the extra cellular fluids to all parts of the body to help regulate functioning. For instance, thyroid hormone increases the rate of almost all chemical reactions in all cells. In this way thyroid hormone helps to set the tempo of bodily activities. Likewise:

Insulin controls glucose (sugar) metabolism
Adrenal hormones control many stress reactions in the body
Testosterone and estrogen influence sexual drive

Whereas the nervous system generally regulates **"faster"** activities of the body, the hormone system regulates mainly the **slowly reacting** metabolic functions.

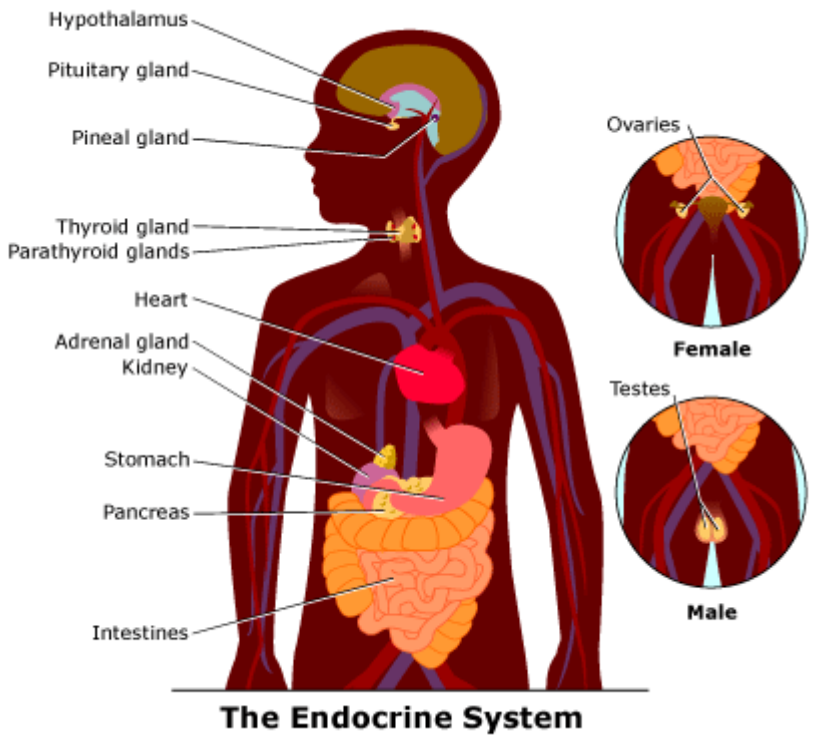



Figure1.3 The endocrine system

The foundations of the endocrine system are the hormones and glands. As the body's chemical messengers, **hormones** transfer information and instructions from one set of cells to another. Although many different hormones circulate throughout the bloodstream, each one affects only the cells that are genetically programmed to receive and respond to its message. Hormone levels can be influenced by factors such as stress, infection, and changes in the balance of fluid and minerals in blood.

A **gland** is a group of cells that produces and secretes, or gives off, chemicals. A gland selects and removes materials from the blood, processes them, and secretes the finished chemical product for use somewhere in the body. **Endocrine glands** release

more than 20 major hormones directly into the bloodstream where they can be transported to cells in other parts of the body.

**F. The "Waste Removal" System**- Some other systems like the respiratory and GI systems play key roles in the removal of waste from the body. At the same time that blood picks up oxygen in the lungs, carbon dioxide is released from the blood so it can be eliminated as breath (Carbon dioxide is the most common "end product" of metabolism).

A key organ in the waste removal system is the kidney (or kidneys, because we have two). Passage of blood through the kidneys removes most of the waste and excess water and electrolytes from the body. The kidneys perform their function by first filtering large quantities of plasma (part of the blood which contains high amounts of proteins) substances that are needed by the body (glucose, amino acids, necessary water and electrolytes) are reabsorbed into the blood. The remaining elements pass through the renal (kidney) tubes into the urine.

**The Nervous System**- The nervous system can be divided into several connected systems that function together. The Central Nervous System and the Peripheral Nervous System.

I. the **Central Nervous System** (CNS) is comprised of the brain and the spinal cord. The average adult human brain weighs approximately 3 pounds. The brain contains about 100 billion **nerve cells (neurons)** and trillions of "support cells" called **glia**. The **spinal cord** is the collection of bones (back bone) that houses the spinal cord.

**The Brain**- The brain is involved in everything you do, how you think, how you feel, how you act, and how well you get along with other people. When your brain works right, you work right; when your brain doesn't work right, it is very hard to do your best. There are things which hurt our brains, such as injuries, pollution (such as taking drugs), poor nutrition, and excessive stress.

Basic Organization of the Brain- In general terms, the brain can be separated into *three main systems:*

**Old Brain**- represented by the upper spinal chord to the hypothalamus. Primary functions include system arousal level, hormonal control of many basic body survival functions (digestion, breathing, temperature regulation, blood pressure), and a communications network.

**Limbic System** (middle-aged brain)- represented by areas that focus on pleasure-reward and emotions. This part of the brain is also important as an integrator of sensory

information received to the body and a processor of that information, selecting what is important to pay attention to and take action toward.

**Cortex** (new-aged brain)- representing areas important in reasoning, higher level decision making, planning, organizing and sequencing behavior.

All of these tasks are coordinated, controlled and regulated by an organ that is about the size of a small head of cauliflower

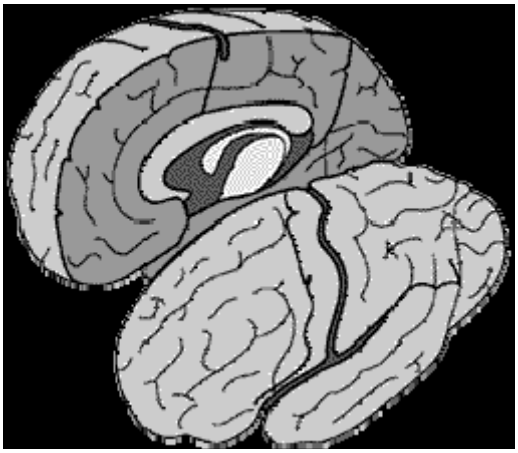


**Figure1.4 The "Waste Removal" System**

From a top view, notice how the brain is divided into two halves, called hemispheres. Each hemisphere communicates with the other through the corpus callosum, a bundle of nerve fibers.

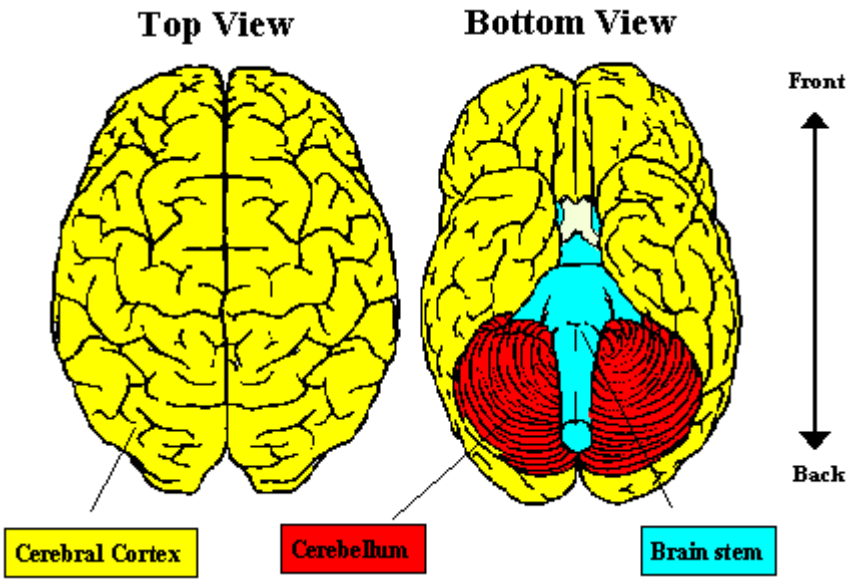


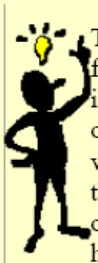

**Figure1.5 top view and bottom view**

# Brain Structures

**Cerebral Cortex**

Functions:

- Thought
- Voluntary movement
- Language
- Reasoning
- Perception

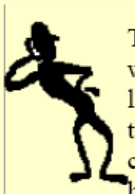


The word "cortex" comes from the Latin word for "bark" (of a tree). This is because the cortex is a sheet of tissue that makes up the outer layer of the brain. The thickness of the cerebral cortex varies from 2 to 6 mm. The right and left sides of the cerebral cortex are connected by a thick band of nerve fibers called the "corpus callosum." In higher mammals such as humans, the cerebral cortex looks like it has many bumps and grooves. A bump or bulge on the cortex is called a gyrus (the plural of the word gyrus is "gyri") and a groove is called a sulcus (the plural of the word sulcus is "sulci"). Lower mammals, such as rats and mice, have very few gyri and sulci.

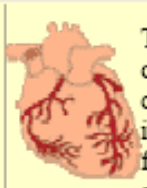
**Cerebellum**

Functions:

- Movement
- Balance
- Posture



The word "cerebellum" comes from the Latin word for "little brain." The cerebellum is located behind the brain stem. In some ways, the cerebellum is similar to the cerebral cortex: the cerebellum is divided into hemispheres and has a cortex that surrounds these hemispheres.

| | |
|---|---|
| **Brain stem**<br>Functions:<br>• Breathing<br>• Heart Rate<br>• Blood Pressure |  The brain stem is a general term for the area of the brain between the thalamus and spinal cord. Structures within the brain stem include the medulla, pons, tectum, reticular formation and tegmentum. Some of these areas are responsible for the most basic functions of life such as breathing, heart rate and blood pressure. |
| **Hypothalamus**<br>Functions:<br>• Body Temperature<br>• Emotions<br>• Hunger<br>• Thirst<br>• Circadian Rhythms |  The hypothalamus is composed of several different areas and is located at the base of the brain. Although it is the size of only a pea (about 1/300 of the total brain weight), the hypothalamus is responsible for some very important functions. One important function of the hypothalamus is the control of body temperature. The hypothalamus acts as a "thermostat" by sensing changes in body temperature and then sending signals to adjust the temperature. For example, if you are too hot, the hypothalamus detects this and then sends a signal to expand the capillaries in your skin. This causes blood to be cooled faster. The hypothalamus also controls the pituitary. |
| **Thalamus**<br>Functions:<br>• Sensory processing<br>• Movement |  The thalamus receives sensory information and relays this information to the cerebral cortex. The cerebral cortex also sends information to the thalamus which then transmits this information to other areas of the brain and spinal cord. |
| **Limbic System**<br>Functions:<br>• Emotions | The limbic system (or the limbic areas) is a group of structures that includes the amygdala, the hippocampus, basal ganglia, ventral tegmental area, and cingulate. These areas are important for controlling the emotional response to a given situation. The hippocampus is also important for memory. |

| | |
|---|---|
| **Hippocampus**<br>Functions:<br>• Learning<br>• Memory |  The hippocampus is one part of the limbic system that is important for memory and learning. |
| **Basal Ganglia**<br>Functions:<br>• Movement |  The basal ganglia are a group of structures, including the globus pallidus, caudate nucleus, subthalamic nucleus, putamen and substantia nigra, that are important in coordinating movement. |
| **Midbrain**<br>Functions:<br>• Vision<br>• Audition<br>• Eye Movement<br>• Body Movement |  The midbrain includes structures such as the superior and inferior colliculi and red nucleus. There are several other areas also in the midbrain. |

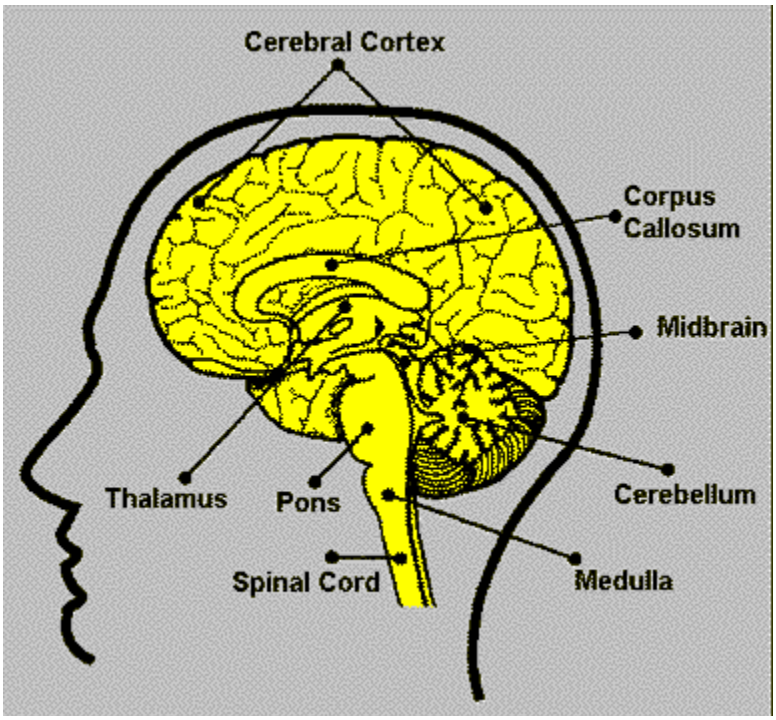



**Figure1.6 brain parts**

The brain is "wired" with a network of structural neural connections. These connections are not “hard-wired” like in a computer. With some limits, the brains nerve cells (neurons) are able to flexibly change connectivity as the individual’s activity demands. This neural flexibility is called plasticity. In much of the brain, the connections are made between neurons that connect the sensory inputs and motor outputs with centers in the various lobes of the cortex. There are also connections between these cortical centers and other parts of the brain.

II. **Spinal Cord-** The spinal cord is a primary pathway for sensory information

The spinal cord allows for sensory information than auditory or visual to flow from the body to the brain and for the responses from the brain to transmit back to the body. The spinal cord is also a primary pathway for the *autonomic nervous system.* The autonomic nervous system is that portion of the nervous system that controls visceral functions of the body. This system helps to control arterial pressure, gastrointestinal motility and secretion, urinary output, sweating, body temperature, and many other activities. The autonomic impulses are transmitted to the body through two major subdivisions called the sympathetic and parasympathetic systems.

Sympathetic- Sometimes called the “fight or flight” response, it is the readiness response of the body, mediated by a neurohormone (messenger) called acetylcholine (nerves that work with acetylcholine are called, cholinergic).

Parsympathetic- Called the “feed or breed” response, it is the relaxation response of the body, mediated by the neurohormone called norepinephrine (nerves that work with norepinephrine are called, adrenergic).

Organizing and orchestrating many of the body’s activities are literally thousands of control systems. Some of these control systems work to control intracellular functions; others operate within the organs to control functions of the individual parts of the organs; others operate throughout the entire body to control the interrelationships between different organs. Some examples include:

The respiratory control system regulates the concentration of carbon dioxide in the extra cellular fluids and stimulates breathing;

The liver and pancreas regulate the concentration of glucose in the extra cellular fluids;

The kidneys regulate the concentrations of important ions like sodium and potassium in the extra cellular fluids.

Autonomic Effects on Various Organs of the Body

**III. Nerve Cells-**Part of the nervous system is in the brain. The basic unit of the nervous system is the nerve cell, or neuron. Neurons transmit information. Within the body, the nerves branch out like telephone wires from an exchange. They run to every part of the body, from the bottom of the feet to the top of the head and from just below the skin to the inner organs.

Neurons are found in the central nervous system, which includes your brain and spinal cord, and the peripheral nervous system, which includes all the nerves that reach your body's extremities. Neurons can be divided into three different categories:

Sensory (or afferent) neurons carry messages to the brain and spinal cord.

Motor (or efferent) neurons carry messages away from the brain and spinal cord. They tell muscles to contract or relax and to activate glands.

Interneurons send messages between nerve cells within the brain, spinal cord, and the periphery.

**Neuron Structure**

Your brain is made of approximately 100-billion nerve cells, called **neurons**. Neurons have the amazing ability to gather and transmit electrochemical signals -- they are something like the gates and wires in a computer. Neurons vary greatly in size and shape. The longest neurons are those that extend down the leg as part of the sciatic nerve. The average nerve running from the base of the spine to the tip of a toe is about 3 feet long, but many other axons are only a fraction of an inch in length. Even though the sizes of neurons vary, all nerve cells have a similar structure.

Neurons have three basic parts:

• **Cell body** - This main part has all of the necessary components of the cell, such as the nucleus (contains DNA), endoplasmic reticulum and ribosomes (for building proteins) and mitochondria (for making energy). If the cell body dies, the neuron dies.

• **Axon** - This long, cable-like projection of the cell carries the electrochemical message (**nerve impulse** or **action potential**) along the length of the cell.

- Depending upon the type of neuron, axons can be covered with a thin layer of **myelin**, like an insulated electrical wire. Myelin is made of fat, and it helps to speed transmission of a nerve impulse down a long axon. Myelinated (fat coated) neurons are usually found in the peripheral nerves (they are sensory and motor neurons), while non-myelinated neurons are found in the brain and spinal cord.

**Dendrites** or **nerve endings** - These small, branch-like projections of the cell make connections to other cells and allow the neuron to talk with other cells or get information from the environment. Dendrites can be located on one or both ends of the cell.

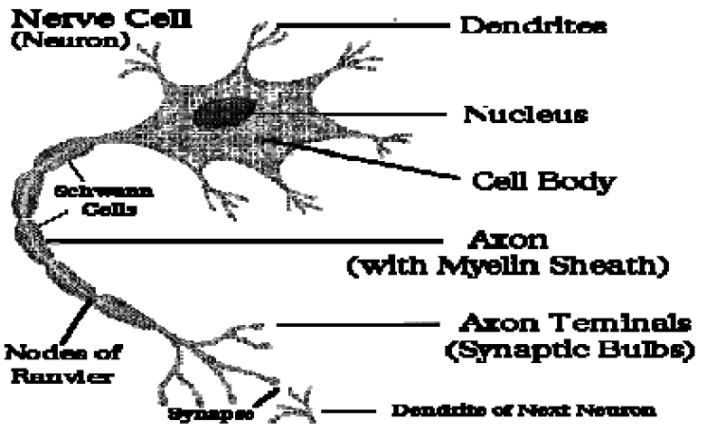



Figure1.7 neuron part

Basic Neuron Types

Neurons come in many sizes. For example, a single sensory neuron from your fingertip has an axon that extends the length of your arm, while neurons within the brain may extend only a few millimeters. Neurons have different shapes depending on what they do. **Motor neurons** that control muscle contractions have a cell body on one end, a long axon in the middle and dendrites on the other end; **sensory neurons** have dendrites on both ends, connected by a long axon with a cell body in the middle.

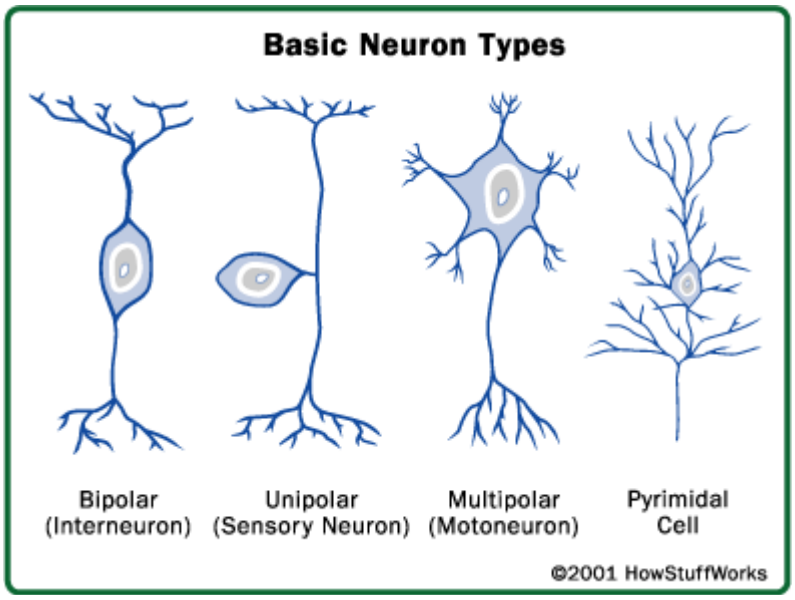



**Figure1.8 basic neuron types**

Neurons also vary with respect to their functions:

**Sensory neurons** carry signals from the outer parts of your body (periphery) into the central nervous system.

**Motor neurons** (motoneurons) carry signals from the central nervous system to the outer parts (muscles, skin, glands) of your body.

**Receptors** sense the environment (chemicals, light, sound, touch) and encode this information into electrochemical messages that are transmitted by sensory neurons.

**Interneurons** connect various neurons within the brain and spinal cord.

The simplest type of neural pathway is a **monosynaptic** (single connection) **reflex pathway**, like the knee-jerk reflex. When the doctor taps the the right spot on your knee with a rubber hammer, receptors send a signal into the spinal cord through a sensory neuron. The sensory neuron passes the message to a motor neuron that controls your leg muscles. Nerve impulses travel down the motor neuron and stimulate the appropriate leg muscle to contract. The response is a muscular jerk that happens quickly and does not involve your brain. Humans have lots of hard-wired reflexes like

this, but as tasks become more complex, the pathway "circuitry" gets more complicated and the brain gets involved.
Fundamentals

| Self-Check -1 | Written Test |
|---|---|

**Directions:** Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. What makes bones lighter and distributes force over a wide surface area?

a. Marrow b. Spongy bone tissue c. Compact bone tissue d. cartilage

**2. Examples of a ball and socket joint are your _____.**

a. Shoulder and hip b. Neck and spine c. Elbow and knee d. Toe and finger

3. The muscular system is attached to which other system with tendons and ligaments throughout the body?

a. Respiratory b. Circulatory c. Urinary d. Skeletal

4. **What are the names of the types of muscle tissue?**

a. Voluntary and involuntary b. Cardiac, smooth, and skeletal
c. Motor, core, and dynamic d. Supinator and pronator

5. What protects the spinal cord?

a. Vagus nerve b. Medulla oblongata and cerebellum

c. Skull and vertebral column d. Meninges and vertebrae

6. The function of the cerebellum is to control _____.

a. equilibrium and muscular movement

b. vital body functions, such as breathing and digestion

c. connections between the right and left hemispheres

d. All of the above

**7. What prevents blood from flowing backwards?**
a. Veins have valves
b. The dorsal venous arches
c. Lymphocytes
d. Ventricles

**8. What large organ is also the second heaviest organ of the body?**
a. Stomach
b. Lungs
c. Brain
d. Liver

9. What are the parts of the urinary system?

a. Ovary, uterine tubes, and kidneys

b. Small intestine, kidneys, and urethra

c. Ureter, bladder, and prostate

d. Kidney, ureters, and bladder

***Note:*** **Satisfactory rating - 5 points Unsatisfactory - below 5 points**

**Answer Sheet**

| |
|---|
| Score = _____ |
| Rating: _____ |

Name: _____ Date: _____

**Short Answer Questions**

| | |
|---|---|
| **Information Sheet-2** | **Selecting and organizing Information correctly** |

## 2.1 **Health communication**

Health communication is a rich, exciting, and relevant area of study that investigates and elucidates the many ways that human and mediated communication dramatically influences the outcomes of health-care and health-promotion efforts. While health

communication is a relatively young area of communication inquiry and education, research and writing on this topic has grown tremendously since the early 1980s, generating increasing numbers of important research findings and publications. A major reason for the tremendous growth and development of inquiry related to health communication is the importance of this research area for addressing complex and challenging healthcare demands in society and guiding the promotion of public health.

Communication is at the very center of healthcare and health-promotion efforts. To gather relevant diagnostic information from health-care consumers, doctors, nurses, and other health-care providers depend on their ability to communicate effectively by asking pertinent questions, interpreting responses, and probing for more detailed information. Consumers depend on their own ability to communicate with health-care providers when seeking help, identifying health problems, interpreting health-care recommendations and treatment strategies, and negotiating their way through the often complex modern health-care systems. At the broader system-wide level, communication is the primary mechanism that professionals have for engendering cooperation and coordination. In a large hospital, for example, the efforts of physicians, nurses, pharmacists, laboratory technicians, therapists, and administrative personnel must be carefully coordinated in order to accomplish treatment goals.

Similarly, communication is an important element of health-promotion efforts (i.e., campaigns designed to influence public health knowledge, attitudes, and behaviors in order to help reduce health risks and encourage the adoption of healthy behaviors and lifestyles). The campaigners must be able to communicate successfully with their intended audiences if the important messages about relevant health risks and appropriate health-preserving behaviors are going to be heeded. In health-promotion efforts, care must be taken to craft messages that are appropriate and compelling for the target audiences and to guarantee that the messages are delivered to these audiences through the most effective communication channels possible. The effectiveness of communication in virtually all health-care and health-promotion activities is directly related to the potency of the health outcomes achieved, and in many cases these outcomes can mean life or death for health-care consumers.

### 2.2 Health Communication as an Important Area of Study

A large and developing body of scholarly research in the area of health communication powerfully illustrates the centrality of communication processes in achieving important

health-care and health-promotion goals. For example, Gary Kreps and Dan O'Hair (1995) have reported a series of studies showing the influences of communication strategies and programs (introduced at individual, dyadic, group, organizational, and societal levels) on health knowledge, behaviors, and outcomes. Similarly, a study by Sheldon Greenfield, Sherrie Kaplan, and John Ware (1985) has clearly demonstrated the positive influences of increased patient-provider communicative involvement in directing health-care treatment in achieving desired health outcomes. In addition, James Dearing and his colleagues (1996) have illustrated the positive influences of social marketing and diffusion-based communication campaign strategies in encouraging at-risk populations to adopt important health-risk-prevention behaviors. Large-scale longitudinal (multi-year) communication intervention programs, such as the Stanford Five City Heart Health Program and the Minnesota Heart Health Communication Program also demonstrate the positive influences of these campaigns on promoting adoption of lifestyle changes to prevent cardiovascular disease and reducing gaps in public health knowledge. There is great potential for the use of strategic programs in the area of health communication to provide health-care consumers and providers with needed health information and to help address important public health needs.

In response to the growing body of health communication research and intervention work, there is increasing recognition within the academic world and throughout the health-care delivery system that health communication is a most important and relevant area of inquiry for addressing salient health-care and health-promotion issues.

Health communication issues are increasingly a primary topic of large-scale funded research programs sponsored by numerous major foundations, health-care corporations, and government agencies. It is especially common for these organizations to fund the development and implementation of important campaigns for promoting public health and preventing the spread of serious health threats. Increased funding for research has spurred tremendous growth in inquiry, education, and publication in the area of health communication. Similarly, scholarly divisions and interest groups related to health communication have been established in many social scientific professional societies. For example, almost all of the communication discipline's professional associations, such as the International Communication Association, the National Communication Association, the American Public Health Association, and several regional communication societies, have interest groups or divisions devoted to health communication. In addition, there is strong interest in health communication by medical, nursing, pharmacy, and other allied health professions. Health communication is closely

aligned with other areas of social inquiry such as health administration, health psychology, medical sociology, and health anthropology. Well-attended scholarly conferences presenting state-of-the-art research and intervention programs for health communication are held on a regular basis, both in the United States and internationally. Indeed, increasing numbers of theses and dissertations written by graduate students concern health communication, and courses in health communication have become standard fare in many undergraduate and graduate communication and public health educational programs across the United States and around the world.

There is no doubt that education and research in the area of health communication is achieving a higher level of disciplinary maturation than ever before—generating stronger scholarly interest, support, and productivity. However, the powerful, complex, and widespread influences of communication on health care and health promotion demand careful examination, leading to the systematic study of health communication. There is still much to be learned about health communication, and there are many areas where knowledge of health communication can be applied to enhancing the quality of public health. As scholarly inquiry in this area grows, new and exciting areas of examination have developed.

### 2.3 Need for Relevant Health Information

Health information is the primary commodity of health communication. Consumers of health care depend on the quality of the health information that they can access to make important health-care choices. There are many different sources of health information available today. In addition to gathering health information directly from their health-care providers, consumers can consult their public libraries (or, if available, a local university or medical library) that have access to reference books, journals, and computerized sources, such as the National Library of Medicine's Medline database. There is a large and growing list of health information services available to consumers via the Internet, which has rapidly become an extremely powerful source of health information for both consumers and health-care providers. However, the sheer number of information sources and the incredible volume of health information that is available today can sometimes overload and confuse consumers.

Consumers can obtain information about specific health-care issues from advocacy groups (e.g., the Alzheimer's Association, the American Cancer Society, and the American Heart Association), health-care delivery centers (e.g., hospitals, clinics, and health maintenance organizations), and research organizations (e.g., the World Health

Organization, the Centers for Disease Control and Prevention, and the National Institutes of Health). Government health agencies typically provide excellent, up-to-date information on most serious diseases. For example the National Cancer Institute operates a toll-free telephone information system, the Cancer Information Service, which can be accessed from anywhere in the United States at 1-800-4-CANCER. The hotline operators try to answer any questions about cancer, and they provide referral and treatment information when it is needed. The operators can also have searches conducted on the Physician Data Query database in order to access the latest information about cancer treatment and clinical research that is being conducted.

### 2.4 Health Communication and Health Informatics

One area of tremendous growth in the study of health communication is the way in which computer-based technologies can be used to process and disseminate relevant health information. The dawn of the information-oriented society has spawned a communication revolution in modern health care that has changed the way health care is delivered. Quality health care is closely tied to the widespread availability of health information. Unprecedented levels of health information are now available to both consumers and health-care providers via a broad range of new and more traditional communication channels (e.g., the Internet, interactive CD-ROM programs, television, and different print media).

The use of new communication technologies to process and disseminate health information has spawned an exciting new area of inquiry, health informatics. Health informatics involves the study of computer-based dissemination of information. As information technologies advance, there are a variety of new computer-based tools and media for disseminating and accessing health information. There are also new mechanisms (based on advances in areas such as artificial intelligence and decision sciences) for manipulating, interpreting, and applying health information. Health informatics scholars are interested in studying the ways computer-based information systems can be used to

1. disseminate relevant information to key audiences,
2. increase public knowledge about important health-care treatment and risk prevention issues,
3. promote the adoption of healthy behaviors and lifestyles by the public,
4. facilitate adoption of the best treatment modalities and technologies by health-care providers,

5. encourage collaboration and multidisciplinary consultation in health-care treatment,
6. facilitate, when relevant, patient entry into appropriate clinical trials (controlled scientific studies of new and promising treatment modalities, usually conducted at major medical centers),
7. Enhance social support and psychosocial adaptation for health-care consumers and their caregivers.

The widespread availability of relevant and accurate health information offers the great promise of demystifying many of the complexities and uncertainties of health care and the health-care system for consumers, shedding light on health-care processes and treatment strategies that were once only the domain of health-care professionals. Access to relevant and timely health information can help consumers participate fully in health-care decision-making and encourage greater cooperation and collaboration between health-care providers and consumers than ever before. This health information revolution can also help healthcare professionals access state-of-the-art prevention, diagnostic, and treatment information and, through easy contact with other providers, engage in multidisciplinary consultation with other health professionals in coordinating health-care services. New communication technologies have also helped promote increasing use of telemedicine (i.e., health-care services delivered via interactive communication channels such as computer, video, and teleconferencing technologies) to assist consumers in remote and isolated geographic locations. However, on the negative side, this information revolution has also led to a general overload of available health information that is of limited quality and that inevitably serves to confuse and misdirect-health care consumers and providers, thereby decreasing the quality of health-care choices that are made. Scholars of health communication have an opportunity to help promote public health by focusing on the role of information in the modern health-care system. Research on health communication can help to sort out the ways in which communication can most profitably inform consumers and providers about relevant health issues, identify the best ways to develop and present high-quality health information to key audiences, and encourage effective collaborative decision-making in modern health-care efforts.

### 2.5 Major Levels and Areas of Inquiry

There are many important areas of health communication education and inquiry that range from the intrapersonal study of health beliefs and attitudes to the mass-mediated dissemination of health information within and across societies. A good framework for

describing the primary levels of the analysis of health communication differentiates between intrapersonal, interpersonal, group, organizational, and societal levels of inquiry. The ability of scholars to examine the influences of communication on health outcomes at multiple levels of interaction occurring within a broad range of social settings clearly illustrates the power and pertinence of inquiry into health communication, yet it also illustrates the complexity of this area of inquiry.

Intrapersonal health communication inquiry examines the internal mental and psychological processes that influence health care, such as the health beliefs, attitudes, and values that predispose health-care behaviors and decisions. Scholars focusing on these intrapersonal issues in health communication often benefit from adopting a psychological frame of reference to their inquiry, examining the ways in which health communicators process information, create meanings, and craft messages. There has been excellent progress in integrating health communication and health psychology scholarship, and there should be further opportunities for collaboration between these interrelated areas of inquiry. Some of the issues scholars might examine from an intrapersonal perspective include the development of unique health beliefs within different cultural groups that influence the health behaviors of individual members of these cultures, the ways in which certain health-related attitudes and values might predispose certain target audiences toward accepting or rejecting advice provided in campaigns for health promotion, and the emotional effects of specific health threats (e.g., breast cancer) and treatment strategies (e.g., radical mastectomy) on healthcare consumers. The intrapersonal perspective on health communication provides unique insights into the personal orientations, expectations, and predispositions held by the different participants in the health-care system and enables health communicators to adjust their messages to these particular psychological variables.

Interpersonal health communication inquiry examines relational influences on health outcomes, focusing on the study of provider-consumer relationships, dyadic (face-to-face) provision of health education, therapeutic interaction, and the exchange of relevant information in health-care interviews. This provocative area of inquiry focuses on the development of cooperative relationships between mutually dependent participants in the modern health-care system, such as the study of provider-patient relations, inter-professional relations among health-care providers, and multicultural relations within the health-care system. Relationship development is a complex social process that develops incrementally as relational partners exchange messages and gets to know one another. The stronger the interpersonal relationships that health-care participants can develop with one another, the more likely they are to develop trust in

one another, share relevant health information, and work cooperatively during challenging, complex, and sometimes even tense situations.

Relationship development is very important to health-care delivery, from the point of view of both the provider and the consumer. Health-care providers need to encourage their patients to trust them, provide them with full information about symptoms and past health behaviors, listen carefully to instructions and to provide informed consent explanations (in which health-care providers are legally required to explain the costs and benefits of alternative treatments and identify the relative implications of the treatment strategies that are recommended), and to follow carefully the treatment protocols that are prescribed for them. Health-care consumers depend on relationship development to gain the trust and concern of their providers, to gather full information from providers about treatment options, and to encourage providers to allow them to participate actively in making important treatment decisions.

The interpersonal perspective has been a dominant area of health communication inquiry over the years, focusing directly on important healthcare delivery issues. It is a complex area of study, with many different personal, psychological, cultural, linguistic, and nonverbal variables at play. Care must be taken when studying interpersonal aspects of health communication to address fairly the important cultural, political, and power issues that underlie interpersonal relations in the delivery of health care.

Group health communication inquiry examines the role communication performs in the interdependent coordination of members of collectives (e.g., health-care teams, support groups, ethics committees, and families) as the group members share relevant health information in making important health-care decisions. Healthcare teams are comprised of specialists from different professional backgrounds (e.g., medicine, pharmacy, nursing, therapy) who work together to help plan and implement complex treatment strategies for the same patient. As specialization of services and technologies continues to increase, there is a growing dependence on health-care teams in the delivery of modern health care, as well as growing interdependence among the different members of these health-care teams. However, due to differences in professional knowledge, specialization, and orientation toward the consumer's health care, it is common for differences of opinion to emerge between members of healthcare teams. These differences of opinion, while sometimes uncomfortable for team members to deal with, can be very useful, because they highlight different aspects of health care that all members of a team may not have been aware of. By sharing such information, the team can make more informed choices about treatment strategies. It is important, though, for

team members to be willing to accept points of view that are different from their own and to use group communication effectively to work through conflict and make good health-care decisions.

There are many difficult ethical issues concerning quality of care, access to care, consumer dignity, and end-of-life issues that have led to the widespread use of ethics committees in healthcare systems to ensure that fair and moral choices are made in health care. (These committees also help guard health-care systems from legal problems and litigation claims.) Ethics committees are often comprised of different health-care professionals, religious leaders, bio-ethicists, health-care administrators, lawyers, and concerned lay individuals (often representing the consumer or a consumer advocacy group). These individuals meet to communicate about complex ethical choices that often have to made in health-care systems, such as who among many applicants should get access to specialized, yet limited, treatment equipment and resources (e.g., organ transplants). Group communication among the members of these ethics committees is the primary process by which ethical decisions are reached.

The growing complexities of modern healthcare delivery, with new diagnostic tools and sophisticated treatment technologies and strategies, demand greater input from groups of individuals to make difficult and challenging health-care decisions. Interdependent health-care providers, administrators, and consumers must learn how to share relevant information and coordinate efforts in group settings. Because communication performs such important functions in group coordination and information exchange, a communication perspective is particularly appropriate for the study of health-care teams, ethics committees, and other decision-making groups.

Organizational health communication inquiry examines the use of communication to coordinate interdependent groups, mobilize different specialists, and share relevant health information within complex health-care delivery systems to enable effective multidisciplinary provision of health care and prevention of relevant health risks. With the rise of managed care, the delivery of health-care services has become increasingly controlled by financial and bureaucratic concerns. There is growing frustration among many consumers about the quality of care they receive and their ability to participate actively in making important healthcare decisions. There are many important opportunities for scholars in the area of health communication to examine ways to promote greater receptivity, flexibility, and sensitivity toward consumers within the increasingly complex and highly regulated modern health-care system.

Communication between different interdependent departments in health-care systems is crucial for coordinating health-care efforts. For example, in-patients receiving treatment in hospitals are housed within specific hospital wards, yet they are often sent to different departments (e.g., radiology, surgery, therapy) for treatment. It is important for these departments to share information about the consumers they serve, to keep track of the consumers' needs and activities as they move through the hospital, and to coordinate the care of these patients. Organizational communication tracks the ways these departments share information, coordinate activities, and adapt to each other as they share the accomplishment of organizational goals.

Societal health communication inquiry examines cultural influences on health care and the generation, dissemination, and utilization of health information communicated via diverse media to the broad range of professional and lay audiences in society that influence health education, promotion, and health-care practices. Social marketing has been widely adopted by communication scholars as an important strategic framework for designing sophisticated campaigns of health promotion. In the past, research focusing on societal inquiry was conducted primarily by communication scholars who specialized in media studies and examined the ways that various media can deliver messages on health promotion and risk prevention to targeted audiences. However, as efforts at health promotion have become more and more sophisticated, using multiple message strategies and delivery systems, there are increasing opportunities for greater participation by communication scholars (and others) with expertise in analyzing the intrapersonal, interpersonal, group, and organizational levels of health communication.

### 2.6 Health Communication Channels

Inquiry into health communication also involves examination of many communication channels. Face-to-face communication between providers and consumers, members of health-care teams, and support group members are the focus of many studies. A broad range of both personal communication media (e.g., telephone, mail, fax, e-mail) and mass communication media (e.g., radio, television, film, billboards) are also the focus of much research. More and more, the new communication technologies that have developed have been examined as important media for health communication. These new media, especially the interactive computer technologies and the Internet, have become increasingly important sources for relevant health information and support for many consumers and health-care providers. For this reason, they will be a most promising topic for future research.

## 2.7 Settings for Health Communication

The settings for the study of health communication are quite diverse and include the wide range of settings where health information is generated and exchanged, such as homes, offices, schools, clinics, and hospitals. Scholars of health communication must be aware of the widespread nature of health communication so they can design and conduct studies in many diverse field settings. Research has examined such diverse issues as the role of interpersonal communication in developing cooperative provider-consumer relationships, the role of comforting communication in providing social support to those who are troubled, the effects of various media and presentation strategies on the dissemination of health information to those who need such information, the use of communication to coordinate the activities of interdependent health-care providers, and the use of communication for administering complex health-care systems. Since the study of health communication encompasses such a broad range of media, channels, levels, and settings, it is a convergent research area that benefits from the work of scholars representing multiple research traditions, disciplines, methodologies, and theoretical perspectives. Indeed, health communication is a "trans disciplinary" area of inquiry, attracting researchers who represent multiple related social scientific, humanist, and technical disciplines and conduct research that focuses on a diverse set of health issues in a broad range of health-care settings.

| Self-Check -2 | Written Test |
|---|---|

**Directions:** Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. Which of the following is not an element of communication channel?
   A. Internet B. television C. Printing media D. none
2. Which one of the following is not true about computer based information?
   A. Increase public knowledge
   B. Promote the knowledge of anatomy and physiology
   C. Encourage single disciplinary than multidisciplinary
   D. All

***Note:*** **Satisfactory rating - 5 points** **Unsatisfactory - below 5 points**

**Answer Sheet**

Score = _____

Rating: _____

Name: _____ Date: _____

**Short Answer Questions**

| | |
|---|---|
| **Information Sheet-3** | **Identify and organize technique and approached for descriptions of human body.** |

## 2.3 Identify and organize technique and approached for descriptions of human body.

There are five different ways of organizing information (approaching)

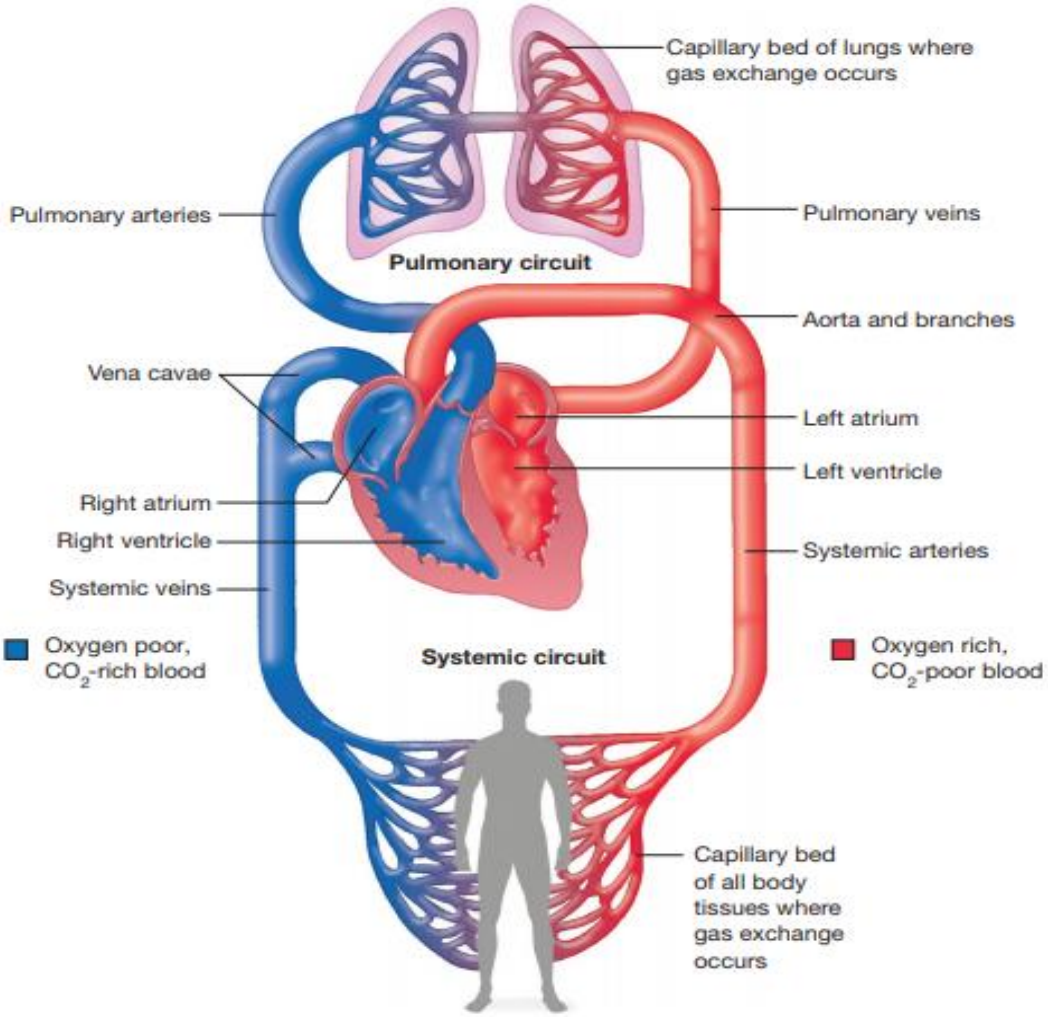
1. Organized by location (diagram)
2. Organized by location(map)
3. Organized by alphabet
4. Organized by time(chorological order)
5. Organized by category

   Among the above ways of information gathering ways the most important to describe human anatomy and physiology organizing by location (diagram) is suitable.

   Accordingly only some of the human anatomy and physiology illustrated

1. The cardiovascular (CV) system(the circulatory system)

The cardiovascular (CV) system, also called the circulatory system, maintains the distribution of blood throughout the body and is composed of the heart and the blood vessels arteries, capillaries, and veins. The circulatory system is composed of two parts: the pulmonary circulation and the systemic circulation. The pulmonary circulation, between the heart and lungs, transports deoxygenated blood to the lungs to get oxygen, and then back to the heart. The systemic circulation carries oxygenated blood away from the heart to the tissues and cells, and then back to the heart (see Figure 2-1 ■). In this way, all the body's cells receive blood and oxygen.




■ Figure 2-1 A schematic of the circulatory system illustrating the pulmonary circulation picking up oxygen from the lungs and the systemic circulation delivering oxygen to the body

## 2. Heart

The heart, a muscular pump made up of cardiac muscle fibers, could be considered a muscle rather than an organ. It has four chambers, or cavities, and beats an average of 60–100 beats per minute (bpm) or about 100,000 times in one day. Each time the cardiac muscle contracts, blood is ejected from the heart and pushed throughout the body within the blood vessels. The heart is located in the mediastinum in the center of

the chest cavity; however, it is not exactly centered; more of the heart is on the left side of the mediastinum than the right (see Figure 2-2 ■). At about the size of a fist and shaped like an upside-down pear, the heart lies directly behind the sternum. The tip of the heart at the lower edge is called the apex.

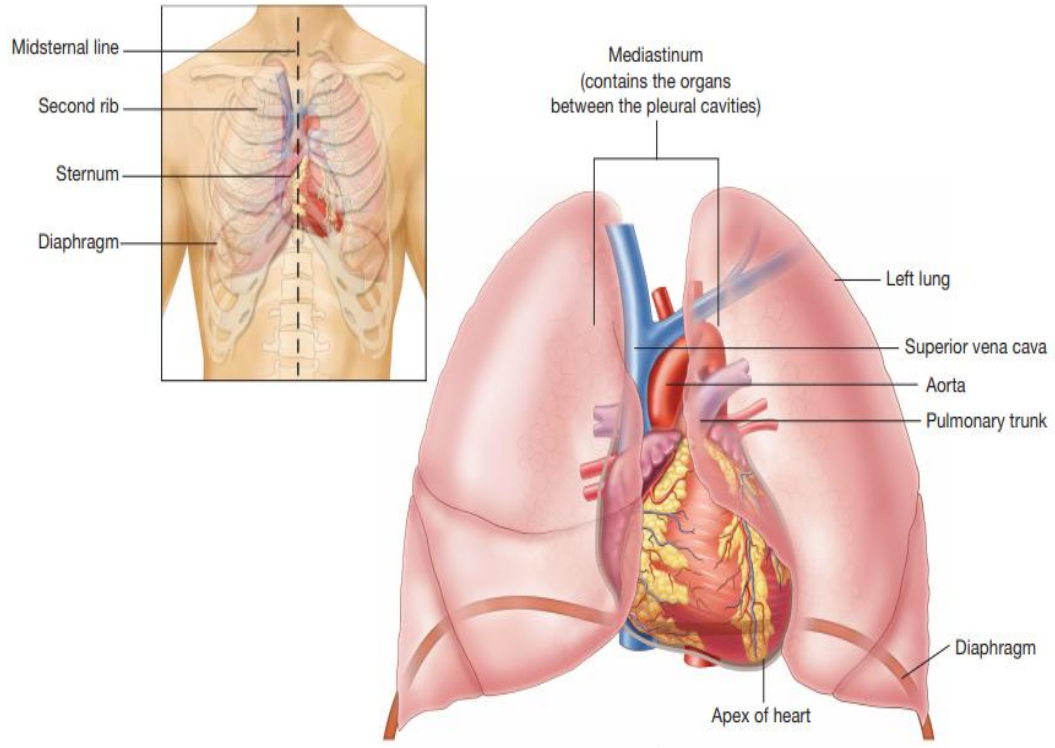



Figure 2-2 Location of the heart within the mediastinum of the thoracic cavity

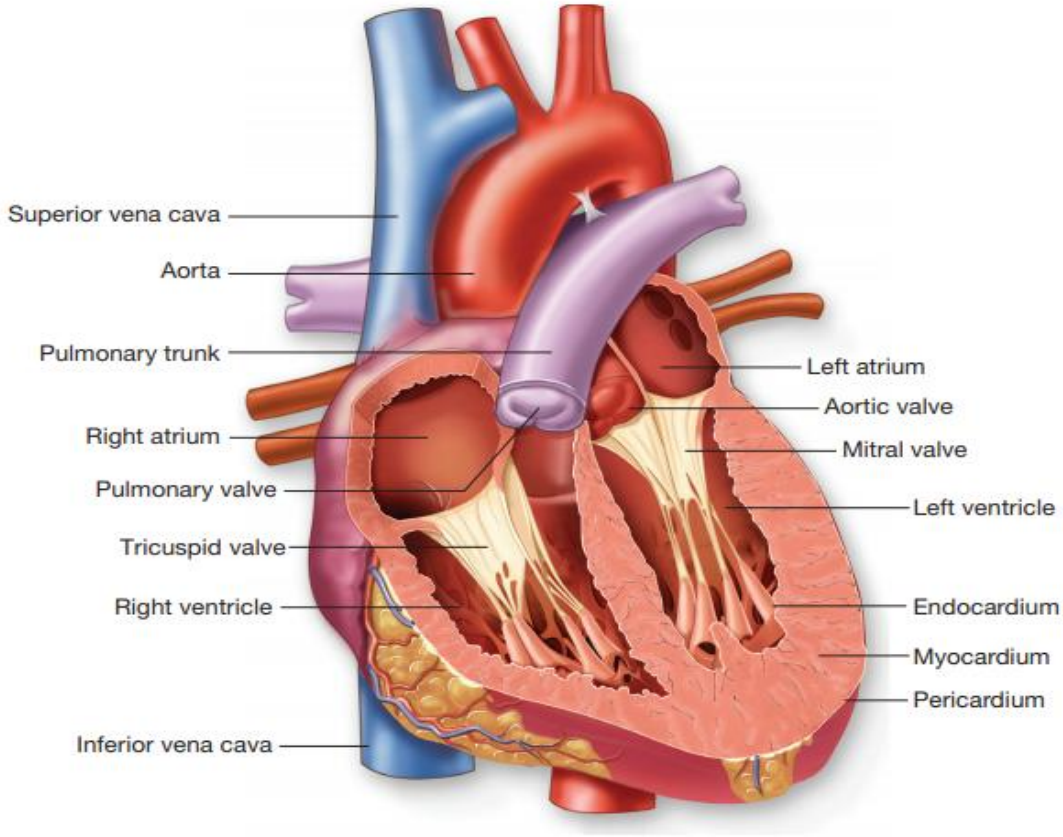
Heart layers

The wall of the heart is quite thick and is composed of three layers (see Figure 2-3 ■):

1. The endocardium is the inner layer of the heart lining the heart chambers. It is a very smooth, thin layer that serves to reduce friction as the blood passes through the heart chambers.

2. The myocardium is the thick, muscular middle layer of the heart. Contraction of this muscle layer develops the pressure required to pump blood through the blood vessels.
3. The epicardium is the outer layer of the heart. The heart is enclosed within a double-layered pleural sac, called the pericardium. The epicardium is the visceral pericardium,

or inner layer of the sac. The outer layer of the sac is the parietal pericardium. Fluid between the two layers of the sac reduces friction as the heart beats.




■ Figure 2-3 Internal view of the heart illustrating the heart chambers, heart layers, and major blood vessels associated with the heart.

Generally some can put or illustrate all human anatomy and physiology by diagram whenever needed.

| Self-Check -3 | Written Test |
|---|---|

**Directions:** Answer all the questions listed below. Use the Answer sheet provided in the next page:

**1.** Most blood enters the ventricle during_____

A. atrial B. atrial diastole

C. ventricular systole D. Isovolumic contraction

2. The first heart sound represents which portion of the cardiac cycle

A. atrial B. ventricular systole C. closing of the atrioventricular valves

D. Closing of the semilunar valve

***Note:*** **Satisfactory rating - 5 points** **Unsatisfactory - below 5 points**

**Answer Sheet**

Score = _____

Rating: _____

Name: _____ Date: _____

**Short Answer Questions**

| Operation Sheet 1 | **Procedure of Describing the structure and function of the human body applying medical terms** |
|---|---|

2.3 Identify and organize technique and approached for descriptions of human body;

**Steps 1-** prepare working by applying OHS

**Step 2-** List out orderly all resources and models of human body

**Step 3-** Identify all structures of human body

**Step 4-** List all the parts existing in a specific structure one by one

**Step 5-** describe all the organizational structures and their respective parts in detail

| | |
|---|---|
| **LAP Test** | **Practically Describing the structure and function of the human body applying medical terms** |

Name: _____ Date: _____

Time started: _____ Time finished: _____

**Instructions:** Given necessary templates, tools and materials you are required to perform the following tasks within 2 hours.

**Task 1: Describe the structure and function of the human body applying medical terms**

| Instruction Sheet | LG34: Prepare models to demonstrate human anatomy and physiology |
|---|---|

**This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:**

- **Planning and preparing OH&S policies and procedures** to be followed and work sequence is in accordance with **requirements**
- Preparing Appropriate models
- Analyzing Different structure of human bodies
- analyzing Human body systems

**This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to:**

- **Plan and prepare OH&S policies and procedures** to be followed and work sequence is in accordance with **requirements**
- Prepare Appropriate models
- Analyze Different structure of human bodies
- analyze Human body systems

**Learning Instructions:**

**1.** Read the specific objectives of this Learning Guide.

2. Follow the instructions described below 3 to 6.

3. Read the information written in the information “Sheet 1, Sheet 2, Sheet 3 and Sheet 4” in page -3, 14,25 and 65 respectively.

4. Accomplish the “Self-check 1, Self-check t 2, Self-check 3 and Self-check 4” in page -13, 24, 64 and 75 respectively.

| | |
|---|---|
| **Information Sheet-1** | **Planning and preparing OH&S policies and procedures to be followed** |

## 3.1 OHS guidelines and PPE

### Personal Protective Equipment (PPE) Selection

- **The Personal Protective Equipment (PPE)** Selection Policy Guideline provides guidance in the identification of personal protective equipment and examples of personal protective equipment that may be available, selected and used.
- The Work Health and Safety Act (SA) 2012, its regulation and associated codes of practice place a duty of care on all workers to take reasonable care to protect their own health and safety while at work. This may include the need for using personal protective equipment (PPE) and clothing when undertaking a hazardous task.

**Principles PPE**

Personal Protective Equipment is any device or clothing worn by a worker to control the level of risk that cannot be controlled or eliminated by providing protection / shield between the hazard and the worker when exposed to :

- dangerous goods, hazardous chemicals, infectious substances including blood and bodily fluids(BBF)
- dust, fumes or particles
- radiation (ionizing and non-ionizing), ultraviolet or solar radiation
- noise
- moving objects such as vehicles, trolleys and forklifts
- flying objects when using machinery with moving parts
- Environmental factors , for example, high and low temperature

- PPE must be used for additional protection when other risk control measures do not provide sufficient exposure control.
- PPE is one of the least effective methods of controlling risk to work health and safety , as per the hierarchy of control, and must be used :
- When there are no other practical risk control measures available or when identified through a dynamic risk assessment, for example:

- **Gloves** - for all contact with blood and or body fluids.
- **Double glove** - application in operating theatres and procedural areas.
- **Eye protection**- use of a face shield when undertaking any procedure where a splash of fluid may occur
- **Gowns** - use when undertaking any procedure where a splash of blood or body fluid may occur
- **Respiratory Masks:** A correctly fitted P2 (N95) respiratory mask must be used for all known or suspected 'airborne' respiratory diseases such as Tuberculosis, Measles, Chicken Pox and during aerosol generating procedures such as bronchoscopy and pulmonary function testing.
- **Surgical Masks** must be worn for all patients exhibiting signs and symptoms of confirmed or suspected respiratory disease (droplet) such as: Influenza, Pertussis, Meningococcal infection and Respiratory Syncutial virus (RSV).

**The use of PPE and Infection Prevention**

The use of PPE must be routine practice for all workers when there is a risk of exposure to blood (including dried blood), all other body substances, secretions and excretion's (excluding sweat), regardless of whether they contain visible blood i.e. standard precautions.

The Work Health and Safety Regulations, 2012 (SA) states that it is the responsibility of each

Healthcare worker (HCW) to be familiar with and comply with these protective measures at all times when there is an identified risk of exposure to BBF.

PPE in this context refers to a variety of barriers, used alone or in combination, to reduce the risk of acquiring and transmitting potentially infectious microorganisms by:

- protecting skin, eyes, mouth, respiratory system and clothing of staff from potentially infectious excretions and secretions
- Preventing contamination of skin and clothing by microorganisms present in the environment.
- Selection of PPE should be based on the risk of transmission of potentially infectious microorganisms to the healthcare worker from:

  Exposure to blood and body substances during an activity (standard precautions) contamination from infectious microorganisms via the contact, droplet or airborne route. (Transmission-based precautions) When a disease agent is unknown, a symptom-based approach will reduce the risk of transmission to the HCW and to other patients. For example, if a patient presents with vomiting or diarrhea or respiratory symptoms (coughing, sneezing and fever) then the appropriate precautions should be implemented immediately, rather than waiting for a definitive diagnosis.
- Routine use of PPE, especially gloves, should not be encouraged in a patient care environment if there is no risk of a BBF exposure.
- PPE items used as part of standard and transmission-based precautions include: aprons, gowns gloves, respiratory, face and eye protection.

Further information regarding the use of standard and transmission based precautions can be Detail

Identifying the need for PPE

The identification of the need for Personal Protective Equipment (PPE) is determined through the following process:

- Identification of the hazard / task /activity
- Risk Assessment of hazard / task /activity
- Development of risk control measures through the Hierarchy of Risk Control (Elimination,
- Substitution, Engineering Controls, Administrative Controls, PPE)
- Identification of PPE required to minimize / reduce risk Selection, purchase and accessibility of PPE

**Training in the use of PPE Inspection, Cleaning and Maintenance of PPE**

Where PPE is in use, routine inspection, cleaning and maintenance is required.

- The wearer is required to inspect PPE prior to use, for signs of penetration or other damage due to impact, rough treatment or unauthorized alterations which may reduce the degree of safety originally provided.
- Regularly check respiratory devices (every time before and after use), to ensure that filters / cartridges or air supply are in place and replaced as necessary. This is to ensure that the equipment is ready for use at all times.
- Clean/decontaminate all re-useable PPE in accordance with the manufactures instructions. However, in the absence of such instruction the item can be washed thoroughly in detergent and warm water using a soft cloth, then rinsed and dried.
- Avoid using any cleaning agents that are likely to scratch surfaces, particularly the lenses of eye protection equipment.
- Store PPE in clean, sealed containers, such as plastic tubs with lids. This prevents continual exposure to air or other particulates or other environmental factors, for example, prolonged exposure to direct sunlight that may compromise the effectiveness of the equipment (including filter / cartridges).
- Ensure that the PPE is kept clean in between usage.
- Remove damaged PPE from use, and take to the supervisor to arrange for replacement equipment.

**Details of Types of Personal Protective Equipment**

- Hand Protection (gloves)
- Eye Protection (goggles, safety glasses, face shields)
- Face Protection and infection prevention (eye wear, face shield, surgical masks)
- Hearing Protection (ear plugs, ear muffs)
- Respiratory Protection (respirators, face masks, cartridge filters )

- Surgical Masks
- Particulate Filters
- Disposal N95 or P2 Masks
- Respiratory Protection with Powered Air Purified Respirator (PAPR)
- Laser Safety
- Skin Integrity and Protection (sunscreen, alcohol gel)
- Protective Clothing (high visibility garments, thermal wear, overalls, aprons, lead aprons, reflective vests, impervious long-sleeve gowns )
- Footwear (enclosed shoes, safety boots )
- Head Protection (hard hats, helmets, sun hats, bike helmet)
- Falls Protection (safety harness)

### Hand Protection

Workers must be educated in the correct manner to clean hands and preserve hand skin integrity.

Gloves must be worn for protection from hazards such as:

- ✓ Infectious agents
- ✓ Abrasion
- ✓ Chemicals
- ✓ Sharp Objects
- ✓ Radiation
- ✓ Hot or Cold Materials

The type of glove will vary, dependant on the nature of the task and a range should be available to accommodate individual worker needs. There are some conditions where gloves are not permitted

(e.g. some machinery operation)

For gloves to be used with chemicals consult the relevant chemical's Safety Data Sheet

(SDS) for advice on the type of glove to use

- Hands must be cleaned with soap and water or alcohol gel before and after glove use
- Moisturizing lotion should be made available and should be applied as required
- Consideration should be given to the need for a glove lining or inner glove or moisture /barrier cream where prolonged use of waterproof gloves is envisaged.

Note: Some workers may develop an allergic reaction to latex gloves. Recommendations to avoid reactions include:

- The provision of reduced protein and powder free gloves
- Ensure good housekeeping to reduce latex build up
- Advise workers to wash hands thoroughly after removing latex gloves.

**Examples of hand protection**

**Fig. Examples are provided for illustration only**

**Gloves and infection prevention**

- Gloves can protect both patients and HCW from exposure to potentially infectious microorganisms that may be carried on the hands. As part of standard precautions they are used to prevent contamination of HCW hands when:

- anticipating direct contact with blood or body substances, mucous membranes, non-intact skin and other potentially infectious material

- handling or touching visibly soiled or potentially contaminated patient-care equipment
- there is potential exposure to toxic drugs during administration
- there is exposure to chemicals during the cleaning process

Key considerations in glove selection will include potential exposure to BBF and the potential contact with non-intact skin, mucous membranes or sterile sites.

- Types of materials:

Non-sterile single use medical gloves are available in a variety of materials and consist of the following:

- natural rubber latex (NRL)
- NRL alternative - synthetic alternative to latex e.g. nitrile
- Vinyl gloves - do not provide optimal protection against BBF and are not recommended for patient care.
- Polythene gloves - are not suitable for clinical use and are generally used for food handling, preparation and serving.
- Single use disposable sterile gloves are worn when there is contact with sterile instruments or normally sterile parts of the body.
- Reusable utility gloves are indicated for non-patient care activities such as cleaning of contaminated equipment or surfaces, general cleaning duties and instrument cleaning in sterilizing services departments.

**Recommendations:**

- Gloves must be worn as a single-use item for each invasive procedure, contact with non-intact skin, mucous membranes or sterile site and if the activity has been assessed as being an exposure risk to blood, body substances, secretions and excretions.
- Gloves must be removed and hand hygiene performed before leaving a patient's room or area.
- Single use disposable gloves must be changed:

- between episodes of care for different patients
- between each episode of clinical care on the same patient to prevent cross-contamination of body sites e.g. mouth care followed by wound care when the integrity of the glove has been compromised i.e. ripped , torn
- Single use disposable sterile gloves must be worn during: contact with sterile sites procedures requiring aseptic technique where key parts and / or sites are touched directly (i.e. when a non-touch technique cannot be achieved)

**Glove risk assessment**

**Removing and disposing of gloves**

- When removing gloves, care should be taken not to contaminate the hands. After gloves have been removed hand hygiene is to be performed as per the SA Health Hand Hygiene Guideline.
- Single use gloves must not be washed or alcohol-based hand rub applied for subsequent reuse.
- Gloves should be disposed of and then discarded into a designated container for waste to contain the contamination.

## Eye Protection

- Goggles and safety glasses prevent injury to eyes. Face shields and visors prevent injury to eyes, nose and mouth from dust, flying particles, chemicals/substances, radiation (visible and invisible) and potentially infectious blood or body fluids
- Workers must wear protective eyewear for any procedure where they may be exposed to these situations, or where stated in the safe work procedure
- Eye protection must comply with relevant standards, and provide the level of protection required e.g. arc welding / cutting, infection control procedures
- Normal prescription glasses DO NOT provide adequate protection. Workers requiring reading
- Glasses should seek additional eye protection equipment which does not interfere with the worker's vision, yet provides an appropriate barrier to hazards.

Personnel who wear contact lenses, and work with chemical substances, should be aware of the following potential hazards:

- Contact lenses may adhere to the eye
- Contact lenses may absorb chemicals and concentrate them on the surface of the eye
- Contact lenses may interfere with emergency flushing procedures by trapping fumes or solids
- If a worker is unconscious following an injury, rescue personnel may be unaware the contact lenses are in place.
- Refer to the Chemical SDS for safety information regarding wearing of contact lenses.

Examples of eye protection:



**Face Protection and Infection Prevention**

The mucous membranes of the nose, mouth and eyes and non-intact skin are portals of entry for infectious microorganisms. Face and eye protection reduces the risk of exposure of healthcare workers to splashes or sprays of blood, body substances, secretions or excretions.

Equipment includes:

- Protective eyewear – are generally fog resistant goggles that can be single use or reusable and provide protection from splashes, sprays from multiple angles. These are required in addition to personal glasses and contact lenses as personal eyewear are not considered adequate eye protection
- Face shield – single use or reusable face shields may be used in addition to surgical masks, as an alternative to protective eyewear. A face shield can

provide protection to other parts of the face as well as the eyes. Face shields extending from chin to crown provide better face and eye protection from splashes and sprays

- Surgical masks – are loose fitting, single use items that cover the nose and mouth.

They are used to keep splashes or sprays from reaching the mouth and nose of the person wearing them. They also provide some protection from exposure to respiratory secretions. Surgical masks should be of a fluid resistant material when used for patient care. Considerations when using a surgical mask must include:

- changing the mask when it becomes soiled or wet
- never reapplying when it has been removed
- not left dangling around the neck
- avoid touching the front of the mask while wearing it
- safe removal i.e. using ear loops or ties to remove, avoiding touching the front of the mask
- hand hygiene before and after removal

P2 / N95 respirators (masks) - are medical devices designed to protect the wearer from infectious microorganisms transmitted via the airborne route or during aerosol generating procedures.

**Removal and safe disposal of face and eye protection**

The front of a mask, protective eyewear or face shield is considered to be contaminated.

Removal of a face shield, protective eyewear and surgical mask can be safely performed after gloves have been removed and hand hygiene has been performed.

Single-use face and eye protection should be disposed of by discarding into a designated container for waste to contain the contamination. Re-usable eyewear or face shields require cleaning with detergent and water and / or disinfectant immediately after use.

## Hearing Protection

In areas of identified high noise hazard (e.g. workshops) ensure that 'hearing protection must be worn' signs are in place and are complied with Types of hearing protection include: a variety of disposal and re-useable ear plugs, ear muffs or ear canal caps. The selection made will be based on the outcome of a risk assessment in relation

| Self-Check -1 | Written Test |
|---|---|

**Directions:** Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. _____must be used for all known or suspected 'airborne'

   A. Surgical masks B. gowns C. respiratory mask D. Gloves

2. Gloves must be worn for protection from hazards of

   A. Chemicals B. Radiation C. Hot materials D. All

***Note:*** **Satisfactory rating - 3 points** **Unsatisfactory - below 3 points**

**Answer Sheet**

Score = _____

Rating: _____

Name: _____ Date: _____

**Short Answer Questions**

| | |
|---|---|
| **Information Sheet-2** | **preparing appropriate models of human anatomy and Physiology** |

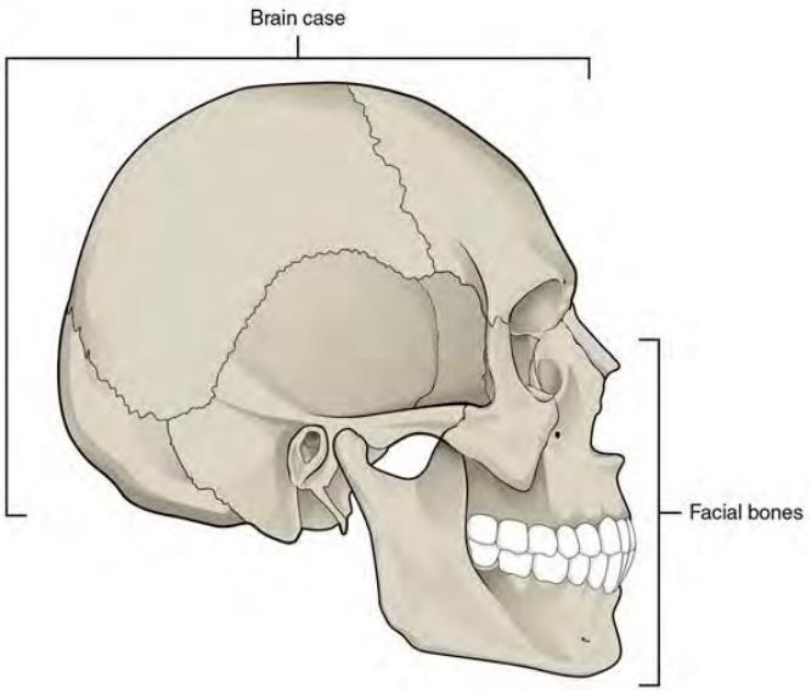
## 2.1 The Axial Skeleton

The skeleton is subdivided into two major divisions the axial and appendicular. The axial skeleton forms the vertical, central axis of the body and includes all bones of the head, neck, chest, and back it serves to protect the brain, spinal cord, heart, and lungs. It also serves as the attachment site for muscles that move the head, neck, and back, and for muscles that act across the shoulder and hip joints to move their corresponding limbs. The axial skeleton of the adult consists of 80 bones, including the skull, the vertebral column, and the thoracic cage. The skull is formed by 22 bones. Also associated with the head are an additional seven bones, including the hyoid bone and the ear ossicles

(three small bones found in each middle ear). The vertebral column consists of 24 bones, each called a vertebra, plus the sacrum and coccyx. The thoracic cage includes the 12 pairs of ribs, and the sternum, the flattened bone of the anterior chest.

### 2.2 The Skull

The cranium (skull) is the skeletal structure of the head that supports the face and protects the brain. It is subdivided into the facial bones and the brain case, or cranial vault. The facial bones underlie the facial structures, form the nasal cavity, enclose the eyeballs, and support the teeth of the upper and lower jaws. The rounded brain case surrounds and protects the brain and houses the middle and inner ear structures. In the adult, the skull consists of 22 individual bones, 21 of which are immobile and united into a single unit. The 22nd bone is the mandible (lower jaw), which is the only moveable bone of the skull.

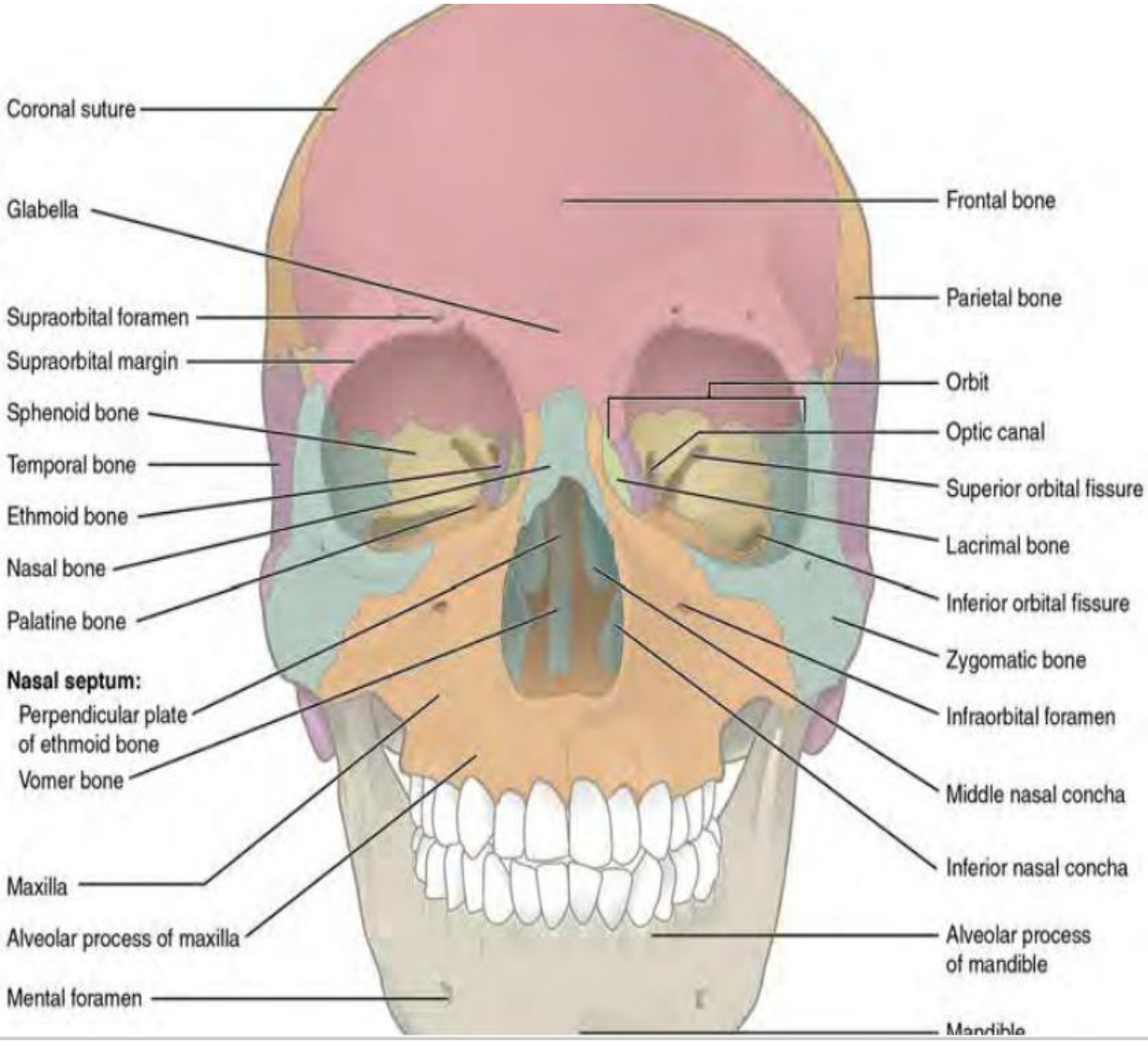



### 2.3 Anterior View of Skull

The anterior skull consists of the facial bones and provides the bony support for the eyes and structures of the face. This view of the skull is dominated by the openings of

the orbits and the nasal cavity. Also seen are the upper and lower jaws, with their respective teeth.

The orbit is the bony socket that houses the eyeball and muscles that move the eyeball or open the upper eyelid. The upper margin of the anterior orbit is the supraorbital margin. Located near the midpoint of the supraorbital margin is a small opening called the supraorbital foramen. This provides for passage of a sensory nerve to the skin of the forehead. Below the orbit is the infraorbital foramen, which is the point of emergence for a sensory nerve that supplies the anterior face below the orbit.



Inside the nasal area of the skull, the nasal cavity is divided into halves by the nasal septum. The upper portion of the nasal septum is formed by the perpendicular plate of the ethmoid bone and the lower portion is the vomer bone. Each side of the nasal cavity is triangular in shape, with a broad inferior space that narrows superiorly. When looking into the nasal cavity from the front of the skull, two bony plates are seen projecting from each lateral wall. The larger of these is the inferior nasal concha, an independent bone of the skull. Located just above the inferior concha is the middle nasal concha, which is part of the ethmoid bone. A third bony plate, also part of the ethmoid bone, is the superior nasal concha. It is much smaller and out of sight, above the middle concha. The superior nasal concha is located just lateral to the perpendicular plate, in the upper nasal cavity.

### 2.4 Lateral View of Skull

A view of the lateral skull is dominated by the large, rounded brain case above and the upper and lower jaws with their teeth below. Separating these areas is the bridge of bone called the zygomatic arch. The zygomatic arch is the bony arch on the side of skull that spans from the area of the cheek to just above the ear canal. It is formed by the junction of two bony processes: a short anterior component, the temporal process of the zygomatic bone (the cheekbone) and a longer posterior portion, the zygomatic process of the temporal bone, extending forward from the temporal bone. Thus the temporal process (anteriorly) and the zygomatic process (posteriorly) join together, like the two ends of a drawbridge, to form the zygomatic arch. One of the major muscles that pulls the mandible upward during biting and chewing arises from the zygomatic arch.

On the lateral side of the brain case, above the level of the zygomatic arch, is a shallow space called the temporal fossa. Below the level of the zygomatic arch and deep to the vertical portion of the mandible is another space called the infratemporal fossa. Both the temporal fossa and infratemporal fossa contain muscles that act on the mandible during chewing.

### 2.5 Bones of the Brain Case

The brain case consists of eight bones. These include the paired parietal and temporal bones, plus the unpaired frontal, occipital, sphenoid, and ethmoid bones.

### 2.6 Parietal Bone

The parietal bone forms most of the upper lateral side of the skull These are paired bones, with the right and left parietal bones joining together at the top of the skull. Each

parietal bone is also bounded anteriorly by the frontal bone, inferiorly by the temporal bone, and posteriorly by the occipital bone.

### 2.7 Temporal Bone

The temporal bone forms the lower lateral side of the skull. Common wisdom has it that the temporal bone (temporal = “time”) is so named because this area of the head (the temple) is where hair typically first turns gray, indicating the passage of time.

The temporal bone is subdivided into several regions. The flattened, upper portion is the squamous portion of the temporal bone. Below this area and projecting anteriorly is the zygomatic process of the temporal bone, which forms the posterior portion of the zygomatic arch. Posteriorly is the mastoid portion of the temporal bone. Projecting inferiorly from this region is a large prominence, the mastoid process, which serves as a muscle attachment site. The mastoid process can easily be felt on the side of the head just behind your earlobe. On the interior of the skull, the petrous portion of each temporal bone forms the prominent, diagonally oriented petrous ridge in the floor of the cranial cavity. Located inside each petrous ridge are small cavities that house the structures of the middle and inner ears**.**

### 2.8 Occipital Bone

The occipital bone is the single bone that forms the posterior skull and posterior base of the cranial cavity. On its outside surface, at the posterior midline, is a small protrusion called the external occipital protuberance, which serves as an attachment site for a ligament of the posterior neck. Lateral to either side of this bump is a superior nuchal line (nuchal = “nape” or “posterior neck”). The nuchal lines represent the most superior point at which muscles of the neck attach to the skull, with only the scalp covering the skull above these lines. On the base of the skull, the occipital bone contains the large opening of the foramen magnum The sphenoid bone is a single, complex bone of the central skull (Figure 7.10). It serves as a “keystone” bone, because it joins with almost every other bone of the skull. The sphenoid forms much of the base of the central skull and also extends laterally to contribute to the sides of the skull. Inside the cranial cavity, the right and left lesser wings of the sphenoid bone, which resemble the wings of a flying bird, form the lip of a prominent ridge that marks the boundary between the anterior and middle cranial fossae. The sella turcica (“Turkish saddle”) is located at the midline of the middle cranial fossa. This bony region of the sphenoid bone is named for its resemblance to the horse saddles used by the Ottoman Turks, with a high back and a tall front. The rounded depression in the floor of the sella turcica is the hypophyseal

(pituitary) fossa, which houses the pea-sized pituitary (hypophyseal) gland. The greater wings of the sphenoid bone extend laterally to either side away from the sella turcica, where they form the anterior floor of the middle cranial fossa. The greater wing is best seen on the outside of the lateral skull, where it forms a rectangular area immediately anterior to the squamous portion of the temporal bone. On the inferior aspect of the skull, each half of the sphenoid bone forms two thin, vertically oriented bony plates. These are the medial pterygoid plate and lateral pterygoid plate (pterygoid = “wing-shaped”). The right and left medial pterygoid plates form the posterior, lateral walls of the nasal cavity. The somewhat larger lateral pterygoid plates serve as attachment sites for chewing muscles that fill the infratemporal space and act on the mandible

## 2.9 Ethmoid Bone

Which allows for passage of the spinal cord as it exits the skull. On either side of the foramen magnum is an oval-shaped occipital condyle. These condyles form joints with the first cervical vertebra and thus support the skull on top of the vertebral column.

## 2.10 Sphenoid Bone

The ethmoid bone is a single, midline bone that forms the roof and lateral walls of the upper nasal cavity, the upper portion of the nasal septum, and contributes to the medial wall of the orbit. On the interior of the skull, the ethmoid also forms a portion of the floor of the anterior cranial cavity. Within the nasal cavity, the perpendicular plate of the ethmoid bone forms the upper portion of the nasal septum. The ethmoid bone also forms the lateral walls of the upper nasal cavity. Extending from each lateral wall are the superior nasal concha and middle nasal concha, which are thin, curved projections that extend into the nasal cavity.

In the cranial cavity, the ethmoid bone forms a small area at the midline in the floor of the anterior cranial fossa. This region also forms the narrow roof of the underlying nasal cavity. This portion of the ethmoid bone consists of two parts, the crista galli and cribriform plates. The crista galli (“rooster’s comb or crest”) is a small upward bony projection located at the midline. It functions as an anterior attachment point for one of the covering layers of the brain. To either side of the crista galli is the cribriform plate (cribrum = “sieve”), a small, flattened area with numerous small openings termed olfactory foramina. Small nerve branches from the olfactory areas of the nasal cavity pass through these openings to enter the brain.

The lateral portions of the ethmoid bone are located between the orbit and upper nasal cavity, and thus form the lateral nasal cavity wall and a portion of the medial orbit wall.

Located inside this portion of the ethmoid bone are several small, air-filled spaces that are part of the paranasal sinus system of the skull.

### 2.11 Appendicular skeleton

### 2.11.1The Pectoral Girdle

The pectoral girdle, consisting of the clavicle and the scapula, attaches each upper limb to the axial skeleton. The clavicle is an anterior bone whose sternal end articulates with the manubrium of the sternum at the sternoclavicular joint. The sternal end is also anchored to the first rib by the costoclavicular ligament. The acromial end of the clavicle articulates with the acromion of the scapula at the acromioclavicular joint. This end is also anchored to the coracoid process of the scapula by the coracoclavicular ligament, which provides indirect support for the acromioclavicular joint. The clavicle supports the scapula, transmits the weight and forces from the upper limb to the body trunk, and protects the underlying nerves and blood vessels.

The scapula lies on the posterior aspect of the pectoral girdle. It mediates the attachment of the upper limb to the clavicle, and contributes to the formation of the glenohumeral (shoulder) joint. This triangular bone has three sides called the medial, lateral, and superior borders. The suprascapular notch is located on the superior border. The scapula also has three corners, two of which are the superior and inferior angles. The third corner is occupied by the glenoid cavity. Posteriorly, the spine separates the supraspinous and infraspinous fossae, and then extends laterally as the acromion. The subscapular fossa is located on the anterior surface of the scapula. The coracoid process projects anteriorly, passing inferior to the lateral end of the clavicle.

### 2.11.2 Bones of the Upper Limb

Each upper limb is divided into three regions and contains a total of 30 bones. The upper arm is the region located between the shoulder and elbow joints. This area contains the humerus. The proximal humerus consists of the head, which articulates with the scapula at the glenohumeral joint, the greater and lesser tubercles separated by the intertubercular (bicipital) groove, and the anatomical and surgical necks. The humeral shaft has the roughened area of the deltoid tuberosity on its lateral side. The distal humerus is flattened, forming a lateral supracondylar ridge that terminates at the small lateral epicondyle. The medial side of the distal humerus has the large, medial epicondyle. The articulating surfaces of the distal humerus consist of the trochlea medially and the capitulum laterally. Depressions on the humerus that accommodate

the forearm bones during bending (flexing) and straightening (extending) of the elbow include the coronoid fossa, the radial fossa, and the olecranon fossa.

The forearm is the region of the upper limb located between the elbow and wrist joints. This region contains two bones, the ulna medially and the radius on the lateral (thumb) side. The elbow joint is formed by the articulation between the trochlea of the humerus and the trochlear notch of the ulna, plus the articulation between the capitulum of the humerus and the head of the radius. The proximal radioulnar joint is the articulation between the head of the radius and the radial notch of the ulna. The proximal ulna also has the olecranon process, forming an expanded posterior region, and the coronoid process and ulnar tuberosity on its anterior aspect. On the proximal radius, the narrowed region below the head is the neck; distal to this is the radial tuberosity. The shaft portions of both the ulna and radius have an interosseous border, whereas the distal ends of each bone have a pointed styloid process. The distal radioulnar joint is found between the head of the ulna and the ulnar notch of the radius. The distal end of the radius articulates with the proximal carpal bones, but the ulna does not.

The base of the hand is formed by eight carpal bones. The carpal bones are united into two rows of bones. The proximal row contains (from lateral to medial) the scaphoid, lunate, triquetrum, and pisiform bones. The scaphoid, lunate, and triquetrum bones contribute to the formation of the radiocarpal joint. The distal row of carpal bones contains (from medial to lateral) the hamate, capitate, trapezoid, and trapezium bones (“So Long To Pinky, Here Comes The Thumb”). The anterior hamate has a prominent bony hook. The proximal and distal carpal rows articulate with each other at the midcarpal joint. The carpal bones, together with the flexor retinaculum, also form the carpal tunnel of the wrist.

The five metacarpal bones form the palm of the hand. The metacarpal bones are numbered 1–5, starting with the thumb side. The first metacarpal bone is freely mobile, but the other bones are united as a group. The digits are also numbered 1–5, with the thumb being number 1. The fingers and thumb contain a total of 14 phalanges (phalanx bones). The thumb contains a proximal and a distal phalanx, whereas the remaining digits each contain proximal, middle, and distal phalanges.

### 2.11.3 **The Pelvic Girdle and Pelvis**

The pelvic girdle, consisting of a hip bone, serves to attach a lower limb to the axial skeleton. The hip bone articulates posteriorly at the sacroiliac joint with the sacrum, which is part of the axial skeleton. The right and left hip bones converge anteriorly and

articulate with each other at the pubic symphysis. The combination of the hip bone, the sacrum, and the coccyx forms the pelvis. The pelvis has a pronounced anterior tilt. The primary function of the pelvis is to support the upper body and transfer body weight to the lower limbs. It also serves as the site of attachment for multiple muscles. The hip bone consists of three regions: the ilium, ischium, and pubis. The ilium forms the large, fan-like region of the hip bone. The superior margin of this area is the iliac crest. Located at either end of the iliac crest are the anterior superior and posterior superior iliac spines. Inferior to these are the anterior inferior and posterior inferior iliac spines. The auricular surface of the ilium articulates with the sacrum to form the sacroiliac joint. The medial surface of the upper ilium forms the iliac fossa, with the arcuate line marking the inferior limit of this area. The posterior margin of the ilium has the large greater sciatic notch. The posterolateral portion of the hip bone is the ischium. It has the expanded ischial tuberosity, which supports body weight when sitting. The ischial ramus projects anteriorly and superiorly. The posterior margin of the ischium has the shallow lesser sciatic notch and the ischial spine, which separates the greater and lesser sciatic notches. The pubis forms the anterior portion of the hip bone. The body of the pubis articulates with the pubis of the opposite hip bone at the pubic symphysis. The superior margin of the pubic body has the pubic tubercle. The pubis is joined to the ilium by the superior pubic ramus, the superior surface of which forms the pectineal line. The inferior pubic ramus projects inferiorly and laterally. The pubic arch is formed by the pubic symphysis, the bodies of the adjacent pubic bones, and the two inferior pubic rami. The inferior pubic ramus joins the ischial ramus to form the ischiopubic ramus. The subpubic angle is formed by the medial convergence of the right and left ischiopubic rami. The lateral side of the hip bone has the cup-like acetabulum, which is part of the hip joint. The large anterior opening is the obturator foramen. The sacroiliac joint is supported by the anterior and posterior sacroiliac ligaments. The sacrum is also joined to the hip bone by the sacrospinous ligament, which attaches to the ischial spine, and the sacrotuberous ligament, which attaches to the ischial tuberosity. The sacrospinous and sacrotuberous ligaments contribute to the formation of the greater and lesser sciatic foramina.

The broad space of the upper pelvis is the greater pelvis, and the narrow, inferior space is the lesser pelvis. These areas are separated by the pelvic brim (pelvic inlet). The inferior opening of the pelvis is the pelvic outlet. Compared to the male, the female pelvis is wider to accommodate childbirth, has a larger subpubic angle, and a broader greater sciatic notch.

### 2.11.4 Bones of the Lower Limb

The lower limb is divided into three regions. These are the thigh, located between the hip and knee joints; the leg, located between the knee and ankle joints; and distal to the ankle, the foot. There are 30 bones in each lower limb. These are the femur, patella, tibia, fibula, seven tarsal bones, five metatarsal bones, and 14 phalanges. The femur is the single bone of the thigh. Its rounded head articulates with the acetabulum of the hip bone to form the hip joint. The head has the fovea capitis for attachment of the ligament of the head of the femur. The narrow neck joins inferiorly with the greater and lesser trochanters. Passing between these bony expansions are the intertrochanteric line on the anterior femur and the larger intertrochanteric crest on the posterior femur. On the posterior shaft of the femur is the gluteal tuberosity proximally and the linea aspera in the mid-shaft region. The expanded distal end consists of three articulating surfaces: the medial and lateral condyles, and the patellar surface. The outside margins of the condyles are the medial and lateral epicondyles. The adductor tubercle is on the superior aspect of the medial epicondyle. The patella is a sesamoid bone located within a muscle tendon. It articulates with the patellar surface on the anterior side of the distal femur, thereby protecting the muscle tendon from rubbing against the femur.

The leg contains the large tibia on the medial side and the slender fibula on the lateral side. The tibia bears the weight of the body, whereas the fibula does not bear weight. The interosseous border of each bone is the attachment site for the interosseous membrane of the leg, the connective tissue sheet that unites the tibia and fibula.

The proximal tibia consists of the expanded medial and lateral condyles, which articulate with the medial and lateral condyles of the femur to form the knee joint. Between the tibial condyles is the intercondylar eminence. On the anterior side of the proximal tibia is the tibial tuberosity, which is continuous inferiorly with the anterior border of the tibia. On the posterior side, the proximal tibia has the curved soleal line. The bony expansion on the medial side of the distal tibia is the medial malleolus. The groove on the lateral side of the distal tibia is the fibular notch. The head of the fibula forms the proximal end and articulates with the underside of the lateral condyle of the tibia. The distal fibula articulates with the fibular notch of the tibia. The expanded distal end of the fibula is the lateral malleolus.

The posterior foot is formed by the seven tarsal bones. The talus articulates superiorly with the distal tibia, the medial malleolus of the tibia, and the lateral malleolus of the fibula to form the ankle joint. The talus articulates inferiorly with the calcaneus bone. The sustentaculum tali of the calcaneus help to support the talus. Anterior to the talus is the navicular bone, and anterior to this are the medial, intermediate, and lateral cuneiform bones. The cuboid bone is anterior to the calcaneus.

The five metatarsal bones form the anterior foot. The bases of these bones articulate with the cuboid or cuneiform bones. The metatarsal heads, at their distal ends, articulate with the proximal phalanges of the toes. The big toe (toe number 1) has proximal and distal phalanx bones. The remaining toes have proximal, middle, and distal phalanges.

| Self-Check -2 | Written Test |
|---|---|

**Directions:** Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. The skull is formed from _____bones

A. 10 B. 100 C. 22 D. 33

2. The vertebral column consists of _____bones
A. 25 B. 24 C. 48 D. 50

***Note:*** **Satisfactory rating - 3 points** **Unsatisfactory - below 3 points**

**Answer Sheet**

Score = _____

Rating: _____

Name: _____ Date: _____

**Short Answer Questions**

| **Information Sheet-3** | **Analyzing Different structure of human bodies** |
|---|---|

**3.1 Nervous system**

Considering the anatomical regions of the nervous system, there are specific names for the structures within each division. A localized collection of neuron cell bodies is

referred to as a nucleus in the CNS and as a ganglion in the PNS. A bundle of axons is referred to as a tract in the CNS and as a nerve in the PNS. Whereas nuclei and ganglia are specifically in the central or peripheral divisions, axons can cross the boundary between the two. A single axon can be part of a nerve and a tract. The name for that specific structure depends on its location.

Nervous tissue can also be described as gray matter and white matter on the basis of its appearance in unstained tissue.

These descriptions are more often used in the CNS. Gray matter is where nuclei are found and white matter is where tracts are found. In the PNS, ganglia are basically gray matter and nerves are white matter.

The nervous system can also be divided on the basis of how it controls the body. The somatic nervous system (SNS) is responsible for functions that result in moving skeletal muscles. Any sensory or integrative functions that result in the movement of skeletal muscle would be considered somatic. The autonomic nervous system (ANS) is responsible for functions that affect cardiac or smooth muscle tissue, or that cause glands to produce their secretions. Autonomic functions are distributed between central and peripheral regions of the nervous system. The sensations that lead to autonomic functions can be the same sensations that are part of initiating somatic responses. Somatic and autonomic integrative functions may overlap as well.

A special division of the nervous system is the enteric nervous system, which is responsible for controlling the digestive organs. Parts of the autonomic nervous system overlap with the enteric nervous system. The enteric nervous system is exclusively found in the periphery because it is the nervous tissue in the organs of the digestive system.

### 3.1.1 Primary Vesicles

As the anterior end of the neural tube starts to develop into the brain, it undergoes a couple of enlargements; the result is the production of sac-like vesicles. Similar to a child's balloon animal, the long, straight neural tube begins to take on a new shape. Three vesicles form at the first stage, which are called **primary vesicles**. These vesicles are given names that are based on Greek words, the main root word being *enkephalon*, which means "brain" (en- = "inside"; kephalon = "head").

The prefix to each generally corresponds to its position along the length of the developing nervous system.

The **prosencephalon** (pros- = "in front") is the forward-most vesicle, and the term can be loosely translated to mean **forebrain**. The **mesencephalon** (mes- = "middle") is the next vesicle, which can be called the **midbrain**. The third vesicle at this stage is the **rhombencephalon**. The first part of this word is also the root of the word rhombus,

which is a geometrical figure with four sides of equal length (a square is a rhombus with 90° angles). Whereas prosencephalon and mesencephalon translate into the English words forebrain and midbrain, there is not a word for “four-sided-figure-brain.” However, the third vesicle can be called the **hindbrain**. One way of thinking about how the brain is arranged is to use these three regions forebrain, midbrain, and hindbrain which are based on the primary vesicle stage of development (**Figure 3.1a**).

### 3.1.2 Secondary Vesicles

The brain continues to develop, and the vesicles differentiate further (see **Figure 3.1b**). The three primary vesicles become five **secondary vesicles**. The prosencephalon enlarges into two new vesicles called the **telencephalon** and the **diencephalon**. The telecephalon will become the cerebrum. The diencephalon gives rise to several adult structures; two that will be important are the thalamus and the hypothalamus. In the embryonic diencephalon, a structure known as the eye cup develops, which will eventually become the retina, the nervous tissue of the eye called the retina. This is a rare example of nervous tissue developing as part of the CNS structures in the embryo, but becoming a peripheral structure in the fully formed nervous system.

The mesencephalon does not differentiate into any finer divisions. The midbrain is an established region of the brain at the primary vesicle stage of development and remains that way. The rest of the brain develops around it and constitutes a large percentage of the mass of the brain. Dividing the brain into forebrain, midbrain, and hindbrain is useful in considering its developmental pattern, but the midbrain is a small proportion of the entire brain, relatively speaking.

The rhombencephalon develops into the **metencephalon** and **myelencephalon**. The metencephalon corresponds to the adult structure known as the pons and also gives rise to the cerebellum. The cerebellum (from the Latin meaning “little brain”) accounts for about 10 percent of the mass of the brain and is an important structure in itself. The most significant connection between the cerebellum and the rest of the brain is at the pons, because the pons and cerebellum develop out of the same vesicle. The myelencephalon corresponds to the adult structure known as the medulla oblongata. The structures that come from the mesencephalon and rhombencephalon, except for the cerebellum, are collectively considered the **brain stem**, which specifically includes the midbrain, pons, and medulla.

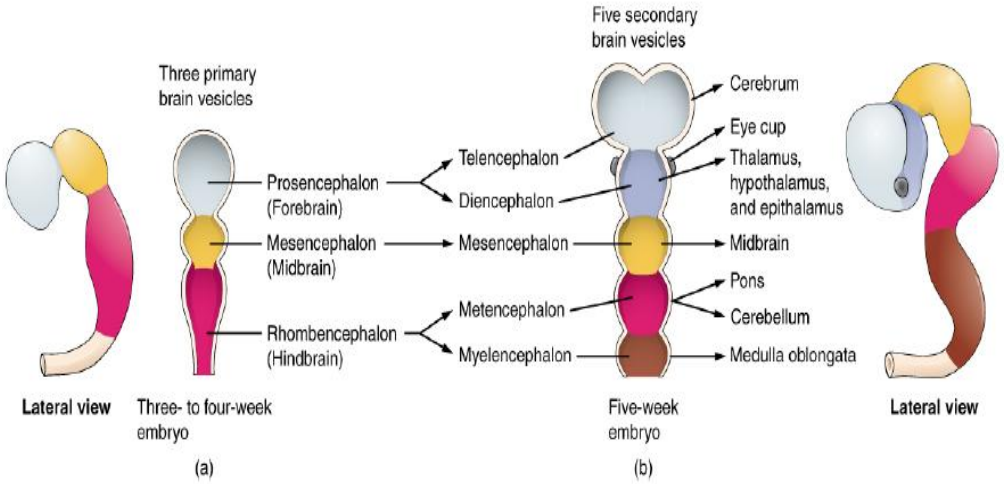



**Figure 3.1Primary and Secondary Vesicle Stages of Development**

### 3.1.3 Subcortical structures

Beneath the cerebral cortex are sets of nuclei known as **subcortical nuclei** that augment cortical processes. The nuclei of the basal forebrain serve as the primary location for acetylcholine production, which modulates the overall activity of the cortex, possibly leading to greater attention to sensory stimuli. Alzheimer's disease is associated with a loss of neurons in the basal forebrain. The **hippocampus** and **amygdala** are medial-lobe structures that, along with the adjacent cortex, are involved in long-term memory formation and emotional responses. The basal nuclei are a set of nuclei in the cerebrum responsible for comparing cortical processing with the general state of activity in the nervous system to influence the likelihood of movement taking place. For example, while a student is sitting in a classroom listening to a lecture, the basal nuclei will keep the urge to jump up and scream from actually happening. (The basal nuclei are also referred to as the basal ganglia, although that is potentially confusing because the term ganglia is typically used for peripheral structures.)

The major structures of the basal nuclei that control movement are the **caudate**, **putamen**, and **globus pallidus**, which are located deep in the cerebrum. The caudate is a long nucleus that follows the basic C-shape of the cerebrum from the frontal lobe, through the parietal and occipital lobes, into the temporal lobe. The putamen is mostly deep in the anterior regions of the frontal and parietal lobes. Together, the caudate and putamen are called the **striatum**. The globus pallidus is a layered nucleus that lies just medial to the putamen; they are called the lenticular nuclei because they look like curved pieces fitting together like lenses. The globus pallidus has two subdivisions, the

external and internal segments, which are lateral and medial, respectively. These nuclei are depicted in a frontal section of the brain in **Figure 3.2**.

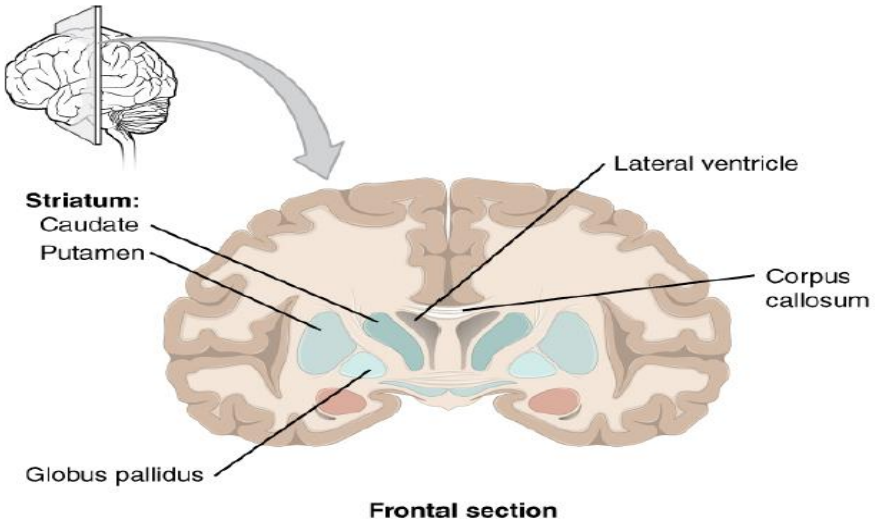



**Figure 3.2 Frontal Sections of Cerebral Cortex and Basal Nuclei**

### 3.1.4 The Spinal Cord

The description of the CNS is concentrated on the structures of the brain, but the spinal cord is another major organ of the system. Whereas the brain develops out of expansions of the neural tube into primary and then secondary vesicles, the spinal cord maintains the tube structure and is only specialized into certain regions. As the spinal cord continues to develop in the newborn, anatomical features mark its surface. The anterior midline is marked by the **anterior median fissure**, and the posterior midline is marked by the **posterior median sulcus**. Axons enter the posterior side through the **dorsal (posterior) nerve root**, which marks the **posterolateral sulcus** on either side. The axons emerging from the anterior side do so through the **ventral (anterior) nerve root**. Note that it is common to see the terms dorsal (dorsal = “back”) and ventral (ventral = “belly”) used interchangeably with posterior and anterior, particularly in reference to nerves and the structures of the spinal cord. You should learn to be comfortable with both.

On the whole, the posterior regions are responsible for sensory functions and the anterior regions are associated with motor functions. This comes from the initial development of the spinal cord, which is divided into the **basal plate** and the **alar plate**. The basal plate is closest to the ventral midline of the neural tube, which will become the anterior face of the spinal cord and gives rise to motor neurons. The alar plate is on the dorsal side of the neural tube and gives rise to neurons that will receive sensory input from the periphery.

The length of the spinal cord is divided into regions that correspond to the regions of the vertebral column. The name of a spinal cord region corresponds to the level at which spinal nerves pass through the intervertebral foramina. Immediately adjacent to the brain stem is the cervical region, followed by the thoracic, then the lumbar, and finally the sacral region. The spinal cord is not the full length of the vertebral column because the spinal cord does not grow significantly longer after the first or second year, but the skeleton continues to grow. The nerves that emerge from the spinal cord pass through the intervertebral formina at the respective levels. As the vertebral column grows, these nerves grow with it and result in a long bundle of nerves that resembles a horse's tail and is named the **cauda equina**. The sacral spinal cord is at the level of the upper lumbar vertebral bones. The spinal nerves extend from their various levels to the proper level of the vertebral column.

### Gray Horns

In cross-section, the gray matter of the spinal cord has the appearance of an ink-blot test, with the spread of the gray matter on one side replicated on the other a shape reminiscent of a bulbous capital "H." As shown in **Figure 3.3**, the gray matter is subdivided into regions that are referred to as horns. The **posterior horn** is responsible for sensory processing.

The **anterior horn** sends out motor signals to the skeletal muscles. The **lateral horn**, which is only found in the thoracic, upper lumbar, and sacral regions, is the central component of the sympathetic division of the autonomic nervous system.

Some of the largest neurons of the spinal cord are the multipolar motor neurons in the anterior horn. The fibers that cause contraction of skeletal muscles are the axons of these neurons. The motor neuron that causes contraction of the big toe, for example, is located in the sacral spinal cord. The axon that has to reach all the way to the belly of that muscle may be a meter in length.

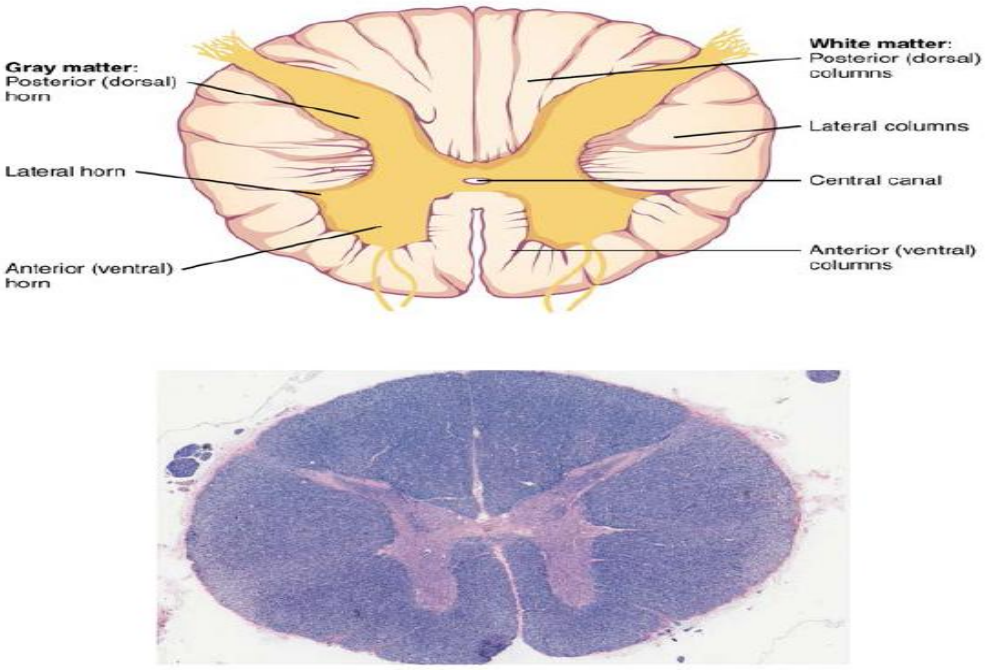



**Figure 3.3 Cross-section of Spinal Cord**

### 3.2 Structures of the Endocrine System

The endocrine system consists of cells, tissues, and organs that secrete hormones as a primary or secondary function.

The **endocrine gland** is the major player in this system. The primary function of these ductless glands is to secrete their hormones directly into the surrounding fluid. The interstitial fluid and the blood vessels then transport the hormones throughout the body. The endocrine system includes the pituitary, thyroid, parathyroid, adrenal, and pineal glands (**Figure 3.4**). Some of these glands have both endocrine and non-endocrine functions. For example, the pancreas contains cells that function in digestion as well as cells that secrete the hormones insulin and glucagon, which regulate blood glucose levels.

The hypothalamus, thymus, heart, kidneys, stomach, small intestine, liver, skin, female ovaries, and male testes are other organs that contain cells with endocrine function. Moreover, adipose tissue has long been known to produce hormones, and recent research has revealed that even bone tissue has endocrine functions.

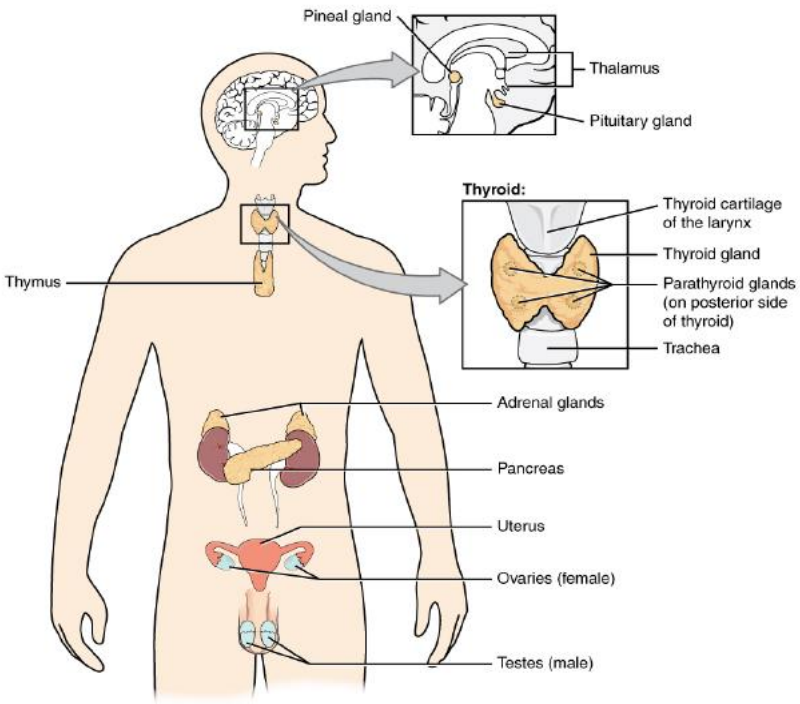



**Figure 3.4Endocrine System**

### 3.2.1 The Parathyroid Glands

The **parathyroid glands** are tiny, round structures usually found embedded in the posterior surface of the thyroid gland (**Figure 3.5**). A thick connective tissue capsule separates the glands from the thyroid tissue. Most people have four parathyroid glands, but occasionally there are more in tissues of the neck or chest. The function of one type of parathyroid cells, the oxyphil cells, is not clear. The primary functional cells of the parathyroid glands are the chief cells. These epithelial cells produce and secrete the **parathyroid hormone (PTH)**, the major hormone involved in the regulation of blood calcium levels.

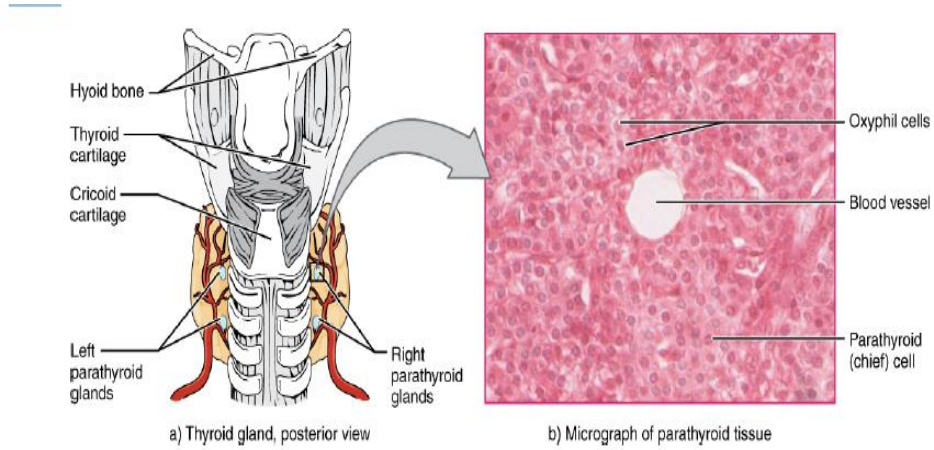



**Figure 3.5 Parathyroid Glands**

### 3.2.2 Development and Aging of the Endocrine System

The endocrine system arises from all three embryonic germ layers. The endocrine glands that produce the steroid hormones, such as the gonads and adrenal cortex, arise from the mesoderm. In contrast, endocrine glands that arise from the endoderm and ectoderm produce the amine, peptide, and protein hormones. The pituitary gland arises from two distinct areas of the ectoderm: the anterior pituitary gland arises from the oral ectoderm, whereas the posterior pituitary gland arises from the neural ectoderm at the base of the hypothalamus. The pineal gland also arises from the ectoderm. The two structures of the adrenal glands arise from two different germ layers: the adrenal cortex from the mesoderm and the adrenal medulla from ectoderm neural cells. The endoderm gives rise to the thyroid and parathyroid glands, as well as the pancreas and the thymus.

As the body ages, changes occur that affect the endocrine system, sometimes altering the production, secretion, and catabolism of hormones. For example, the structure of the anterior pituitary gland changes as vascularization decreases and the connective tissue content increases with increasing age. This restructuring affects the gland's hormone production. For example, the amount of human growth hormone that is produced declines with age, resulting in the reduced muscle mass commonly observed in the elderly.

The adrenal glands also undergo changes as the body ages; as fibrous tissue increases, the production of cortisol and aldosterone decreases. Interestingly, the production and secretion of epinephrine and norepinephrine remain normal throughout the aging process.

A well-known example of the aging process affecting an endocrine gland is menopause and the decline of ovarian function. With increasing age, the ovaries decrease in both

size and weight and become progressively less sensitive to gonadotropins. This gradually causes a decrease in estrogen and progesterone levels, leading to menopause and the inability to reproduce. Low levels of estrogens and progesterone are also associated with some disease states, such as osteoporosis, atherosclerosis, and hyperlipidemia, or abnormal blood lipid levels.

Testosterone levels also decline with age, a condition called andropause (or viropause); however, this decline is much less dramatic than the decline of estrogens in women, and much more gradual, rarely affecting sperm production until very old age. Although this means that males maintain their ability to father children for decades longer than females, the quantity, quality, and motility of their sperm is often reduced.

As the body ages, the thyroid gland produces less of the thyroid hormones, causing a gradual decrease in the basal metabolic rate. The lower metabolic rate reduces the production of body heat and increases levels of body fat. Parathyroid hormones, on the other hand, increase with age. This may be because of reduced dietary calcium levels, causing a compensatory increase in parathyroid hormone. However, increased parathyroid hormone levels combined with decreased levels of calcitonin (and estrogens in women) can lead to osteoporosis as PTH stimulates demineralization of bones to increase blood calcium levels.

### 3.2.3 The Pituitary Gland and Hypothalamus

The hypothalamus–pituitary complex is located in the diencephalon of the brain. The hypothalamus and the pituitary gland are connected by a structure called the infundibulum, which contains vasculature and nerve axons. The pituitary gland is divided into two distinct structures with different embryonic origins. The posterior lobe houses the axon terminals of hypothalamic neurons. It stores and releases into the bloodstream two hypothalamic hormones: oxytocin and antidiuretic hormone (ADH). The anterior lobe is connected to the hypothalamus by vasculature in the infundibulum and produces and secretes six hormones. Their secretion is regulated, however, by releasing and inhibiting hormones from the hypothalamus.

The six anterior pituitary hormones are: growth hormone (GH), thyroid-stimulating hormone (TSH), adrenocorticotropic hormone (ACTH), follicle-stimulating hormone (FSH), luteinizing hormone (LH), and prolactin (PRL).

## 3.3 The cardiovascular system: the heart

### 3.3.1 Location of the Heart

The human heart is located within the thoracic cavity, medially between the lungs in the space known as the mediastinum.

**Figure 3.6** shows the position of the heart within the thoracic cavity. Within the mediastinum, the heart is separated from the other mediastinal structures by a tough membrane known as the pericardium, or pericardial sac, and sits in its own space called

the **pericardial cavity**. The dorsal surface of the heart lies near the bodies of the vertebrae, and its anterior surface sits deep to the sternum and costal cartilages. The great veins, the superior and inferior venae cavae, and the great arteries, the aorta and pulmonary trunk, are attached to the superior surface of the heart, called the base. The base of the heart is located at the level of the third costal cartilage, as seen in **Figure 3.6**. The inferior tip of the heart, the apex, lies just to the left of the sternum between the junction of the fourth and fifth ribs near their articulation with the costal cartilages. The right side of the heart is deflected anteriorly, and the left side is deflected posteriorly. It is important to remember the position and orientation of the heart when placing a stethoscope on the chest of a patient and listening for heart sounds, and also when looking at images taken from a midsagittal perspective. The slight deviation of the apex to the left is reflected in a depression in the medial surface of the inferior lobe of the left lung, called the **cardiac notch**.

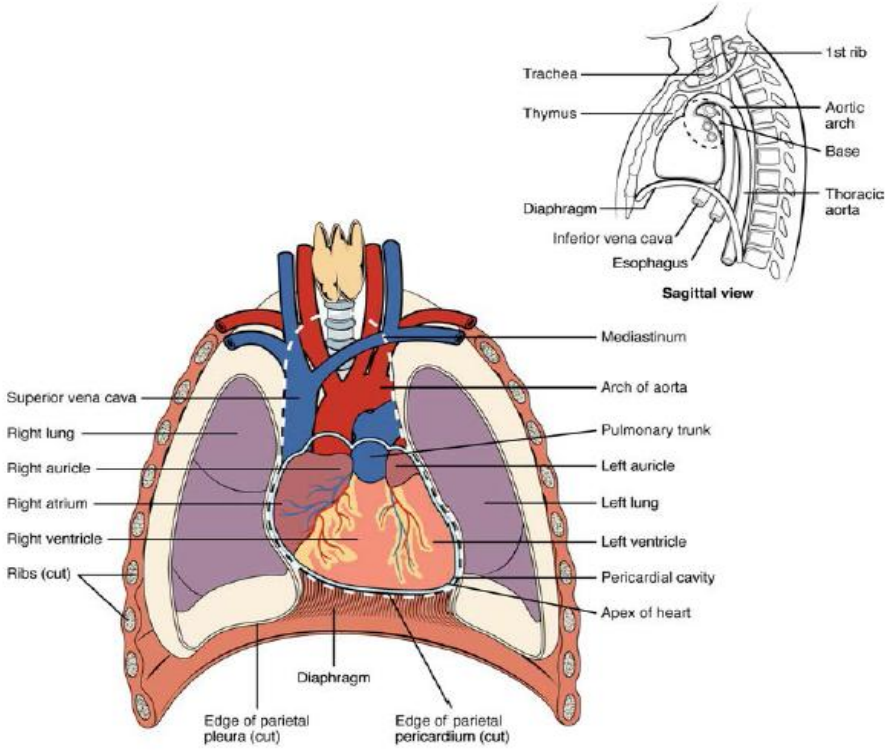



**Figure 3.6 Position of the Heart in the Thorax**

### 3.3.2 Surface Features of the Heart

Inside the pericardium, the surface features of the heart are visible, including the four chambers. There is a superficial leaflike extension of the atria near the superior surface of the heart, one on each side, called an **auricle** a name that means “ear like” because its shape resembles the external ear of a human (**Figure 3.7**). Auricles are relatively

thin-walled structures that can fill with blood and empty into the atria or upper chambers of the heart. You may also hear them referred to as atrial appendages. Also prominent is a series of fat-filled grooves, each of which is known as a **sulcus** (plural = sulci), along the superior surfaces of the heart. Major coronary blood vessels are located in these sulci. The deep **coronary sulcus** is located between the atria and ventricles. Located between the left and right ventricles are two additional sulci that are not as deep as the coronary sulcus. The **anterior interventricular sulcus** is visible on the anterior surface of the heart, whereas the **posterior interventricular sulcus** is visible on the posterior surface of the heart. **Figure 3.7** illustrates anterior and posterior views of the surface of the heart.

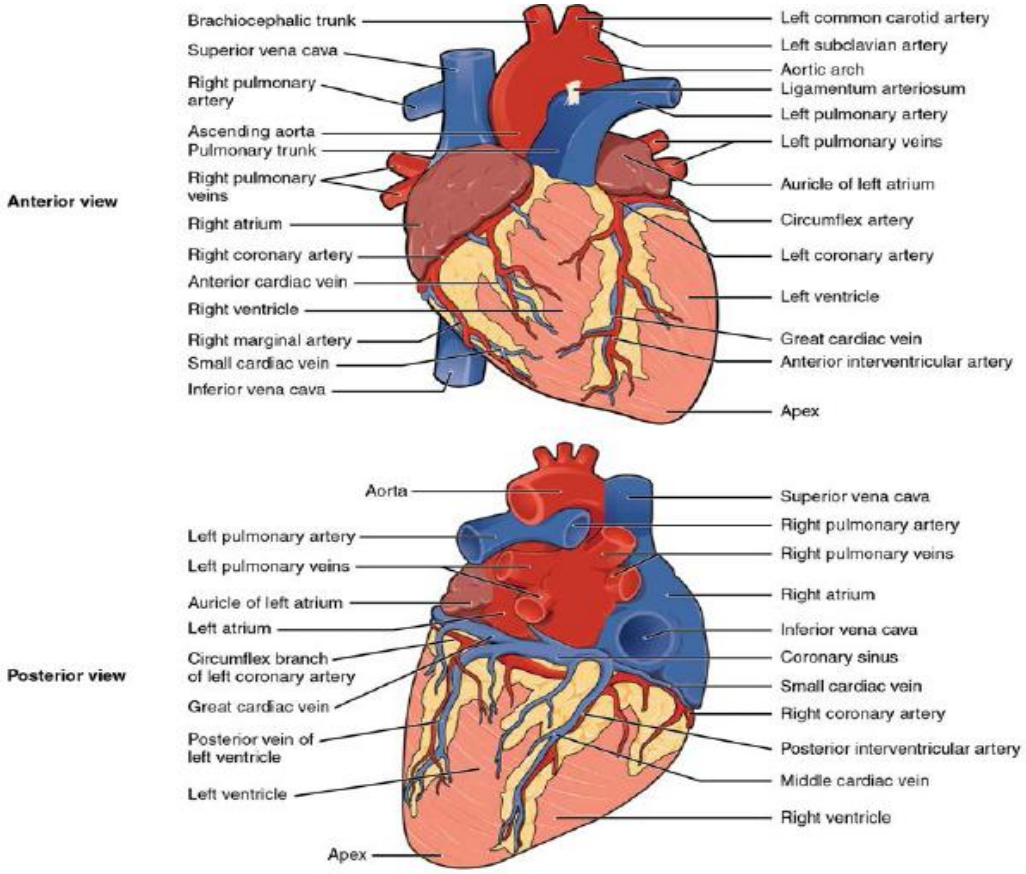



**Figure 3.7 External Anatomy of the Heart**

### 3.3.3 Septa of the Heart

The word septum is derived from the Latin for “something that encloses;” in this case, a **septum** (plural = septa) refers to a wall or partition that divides the heart into chambers. The septa are physical extensions of the myocardium lined with endocardium. Located

between the two atria is the **interatrial septum**. Normally in an adult heart, the interatrial septum bears an oval-shaped depression known as the **fossa ovalis**, a remnant of an opening in the fetal heart known as the **foramen ovale**. The foramen ovale allowed blood in the fetal heart to pass directly from the right atrium to the left atrium, allowing some blood to bypass the pulmonary circuit. Within seconds after birth, a flap of tissue known as the **septum primum** that previously acted as a valve closes the foramen ovale and establishes the typical cardiac circulation pattern.

Between the two ventricles is a second septum known as the **interventricular septum**. Unlike the interatrial septum, the interventricular septum is normally intact after its formation during fetal development. It is substantially thicker than the interatrial septum, since the ventricles generate far greater pressure when they contract.

The septum between the atria and ventricles is known as the **atrioventricular septum**. It is marked by the presence of four openings that allow blood to move from the atria into the ventricles and from the ventricles into the pulmonary trunk and aorta. Located in each of these openings between the atria and ventricles is a **valve**, a specialized structure that ensures one-way flow of blood. The valves between the atria and ventricles are known generically as **atrioventricular valves**. The valves at the openings that lead to the pulmonary trunk and aorta are known generically as **semilunar valves**.

The interventricular septum is visible in **Figure 3.8**. In this figure, the atrioventricular septum has been removed to better show the bicupid and tricuspid valves; the interatrial septum is not visible, since its location is covered by the aorta and pulmonary trunk. Since these openings and valves structurally weaken the atrioventricular septum, the remaining tissue is heavily reinforced with dense connective tissue called the **cardiac skeleton**, or skeleton of the heart. It includes four rings that surround the openings between the atria and ventricles, and the openings to the pulmonary trunk and aorta, and serve as the point of attachment for the heart valves. The cardiac skeleton also provides an important boundary in the heart electrical conduction system.

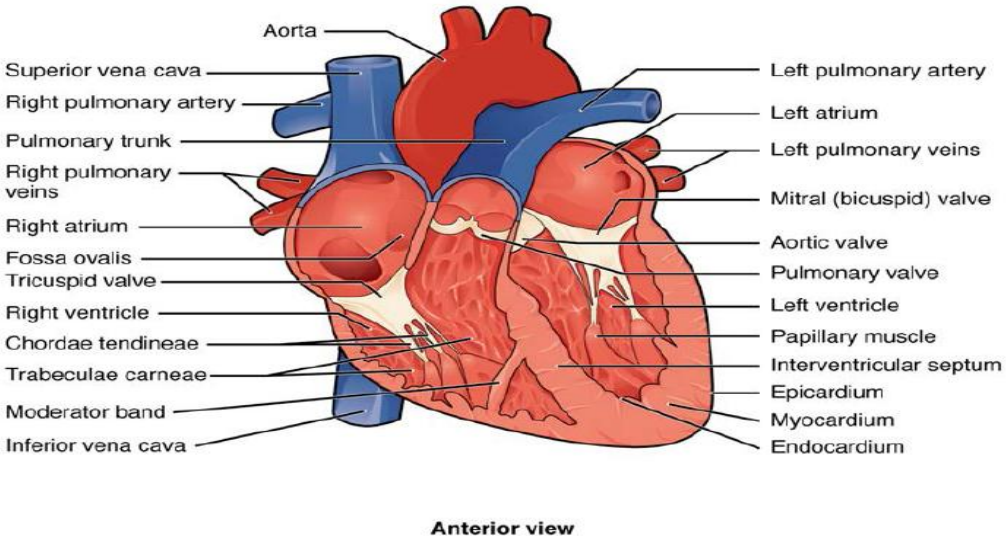



**Figure 3.8 Internal Structures of the Heart**

### 3.3.4 Right Atrium

The right atrium serves as the receiving chamber for blood returning to the heart from the systemic circulation. The two major systemic veins, the superior and inferior venae cavae, and the large coronary vein called the **coronary sinus** that drains the heart myocardium empty into the right atrium. The superior vena cava drains blood from regions superior to the diaphragm: the head, neck, upper limbs, and the thoracic region. It empties into the superior and posterior portions of the right atrium. The inferior vena cava drains blood from areas inferior to the diaphragm: the lower limbs and abdominopelvic region of the body. It, too, empties into the posterior portion of the atria, but inferior to the opening of the superior vena cava.

Immediately superior and slightly medial to the opening of the inferior vena cava on the posterior surface of the atrium is the opening of the coronary sinus. This thin-walled vessel drains most of the coronary veins that return systemic blood from the heart. The majority of the internal heart structures discussed in this and subsequent sections are illustrated in **Figure3.9**.

While the bulk of the internal surface of the right atrium is smooth, the depression of the fossa ovalis is medial, and the anterior surface demonstrates prominent ridges of muscle called the **pectinate muscles**. The right auricle also has pectinate muscles. The left atrium does not have pectinate muscles except in the auricle.

The atria receive venous blood on a nearly continuous basis, preventing venous flow from stopping while the ventricles are contracting. While most ventricular filling occurs while the atria are relaxed, they do demonstrate a contractile phase and actively pump

blood into the ventricles just prior to ventricular contraction. The opening between the atrium and ventricle is guarded by the tricuspid valve.

### 3.3.5 Right Ventricle

The right ventricle receives blood from the right atrium through the tricuspid valve. Each flap of the valve is attached to strong strands of connective tissue, the **chordae tendineae**, literally “tendinous cords,” or sometimes more poetically referred to as “heart strings.” There are several chordae tendineae associated with each of the flaps. They are composed of approximately 80 percent collagenous fibers with the remainder consisting of elastic fibers and endothelium. They connect each of the flaps to a **papillary muscle** that extends from the inferior ventricular surface. There are three papillary muscles in the right ventricle, called the anterior, posterior, and septal muscles, which correspond to the three sections of the valves.

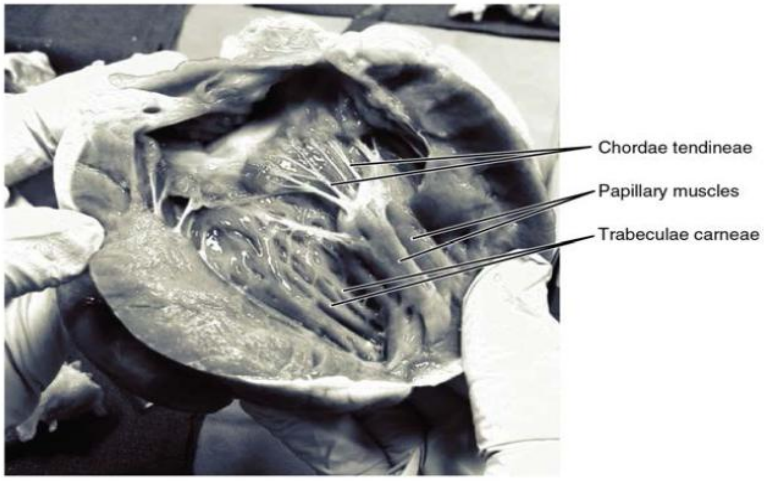



**Figure 3.10 Chordae Tendineae and Papillary Muscles**

### 3.3.6 Heart Valve Structure and Function

A transverse section through the heart slightly above the level of the atrioventricular septum reveals all four heart valves along the same plane (**Figure 3.11**). The valves ensure unidirectional blood flow through the heart. Between the right atrium and the right ventricle is the **right atrioventricular valve**, or **tricuspid valve**. It typically consists of three flaps, or leaflets, made of endocardium reinforced with additional connective tissue. The flaps are connected by chordae tendineae to the papillary muscles, which control the opening and closing of the valves.

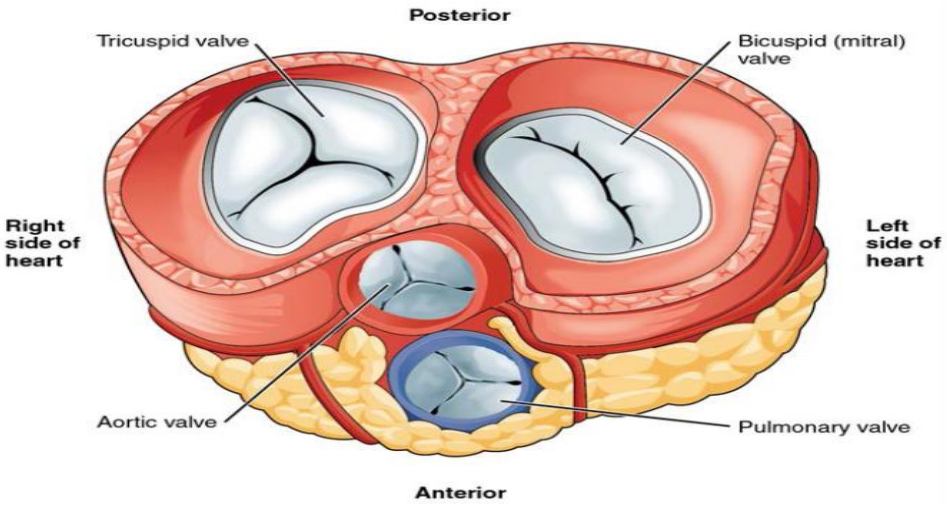



**Figure 3.11 Heart Valves**

Emerging from the right ventricle at the base of the pulmonary trunk is the pulmonary semilunar valve, or the **pulmonary valve**; it is also known as the pulmonic valve or the right semilunar valve. The pulmonary valve is comprised of three small flaps of endothelium reinforced with connective tissue. When the ventricle relaxes, the pressure differential causes blood to flow back into the ventricle from the pulmonary trunk. This flow of blood fills the pocket-like flaps of the pulmonary valve, causing the valve to close and producing an audible sound. Unlike the atrioventricular valves, there are no papillary muscles or chordae tendineae associated with the pulmonary valve.

Located at the opening between the left atrium and left ventricle is the **mitral valve**, also called the **bicuspid valve** or the **left atrioventricular valve**. Structurally, this valve consists of two cusps, known as the anterior medial cusp and the posterior medial cusp, compared to the three cusps of the tricuspid valve. In a clinical setting, the valve is referred to as the mitral valve, rather than the bicuspid valve. The two cusps of the mitral valve are attached by chordae tendineae to two papillary muscles that project from the wall of the ventricle.

At the base of the aorta is the aortic semilunar valve, or the **aortic valve**, which prevents backflow from the aorta. It normally is composed of three flaps. When the ventricle relaxes and blood attempts to flow back into the ventricle from the aorta, blood will fill the cusps of the valve, causing it to close and producing an audible sound.

In **Figure 3.12a**, the two atrioventricular valves are open and the two semilunar valves are closed. This occurs when both atria and ventricles are relaxed and when the atria contract to pump blood into the ventricles. **Figure 3.12b** shows a frontal view. Although only the left side of the heart is illustrated, the process is virtually identical on the right.

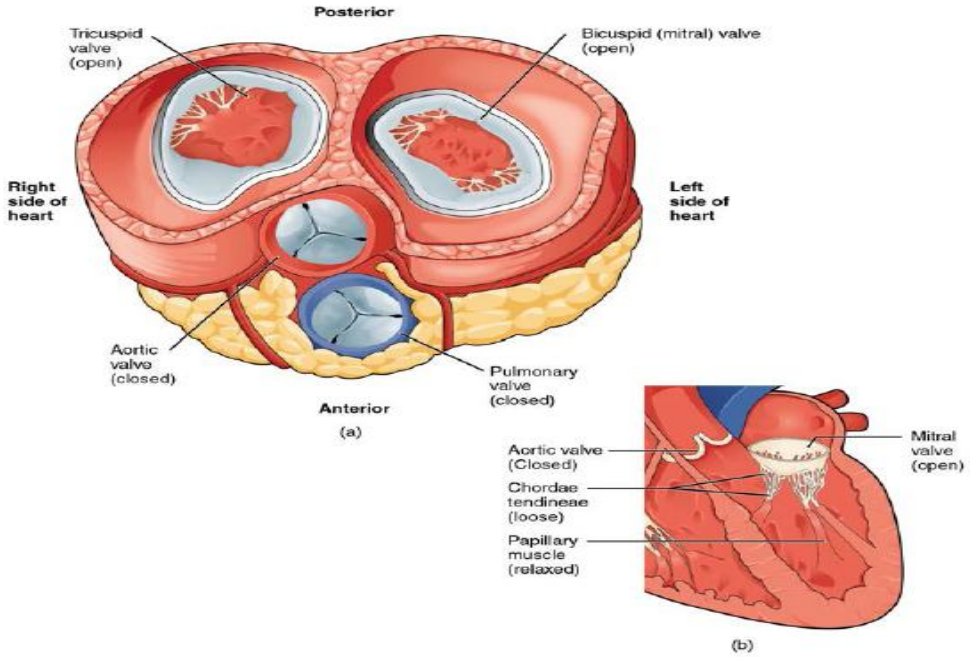



**Figure 3.12 Blood Flow from the Left Atrium to the Left Ventricle**

### 3.3.7 Structure of Cardiac Muscle

Compared to the giant cylinders of skeletal muscle, cardiac muscle cells, or cardiomyocytes, are considerably shorter with much smaller diameters. Cardiac muscle also demonstrates striations, the alternating pattern of dark A bands and light I bands attributed to the precise arrangement of the myofilaments and fibrils that are organized in sarcomeres along the length of the cell (**Figure 3.13a**). These contractile elements are virtually identical to skeletal muscle. T (transverse) tubules penetrate from the surface plasma membrane, the sarcolemma, to the interior of the cell, allowing the electrical impulse to reach the interior. The T tubules are only found at the Z discs, whereas in skeletal muscle, they are found at the junction of the A and I bands. Therefore, there are one-half as many T tubules in cardiac muscle as in skeletal muscle. In addition, the sarcoplasmic reticulum stores few calcium ions, so most of the calcium ions must come from outside the cells. The result is a slower onset of contraction. Mitochondria are plentiful, providing energy for the contractions of the heart. Typically, cardiomyocytes have a single, central nucleus, but two or more nuclei may be found in some cells.

Cardiac muscle cells branch freely. A junction between two adjoining cells is marked by a critical structure called an **intercalated disc**, which helps support the synchronized contraction of the muscle (**Figure 3.13b**). The sarcolemmas from adjacent cells bind together at the intercalated discs. They consist of desmosomes, specialized linking

proteoglycans, tight junctions, and large numbers of gap junctions that allow the passage of ions between the cells and help to synchronize the contraction (**Figure 3.13c**). Intercellular connective tissue also helps to bind the cells together. The importance of strongly binding these cells together is necessitated by the forces exerted by contraction.

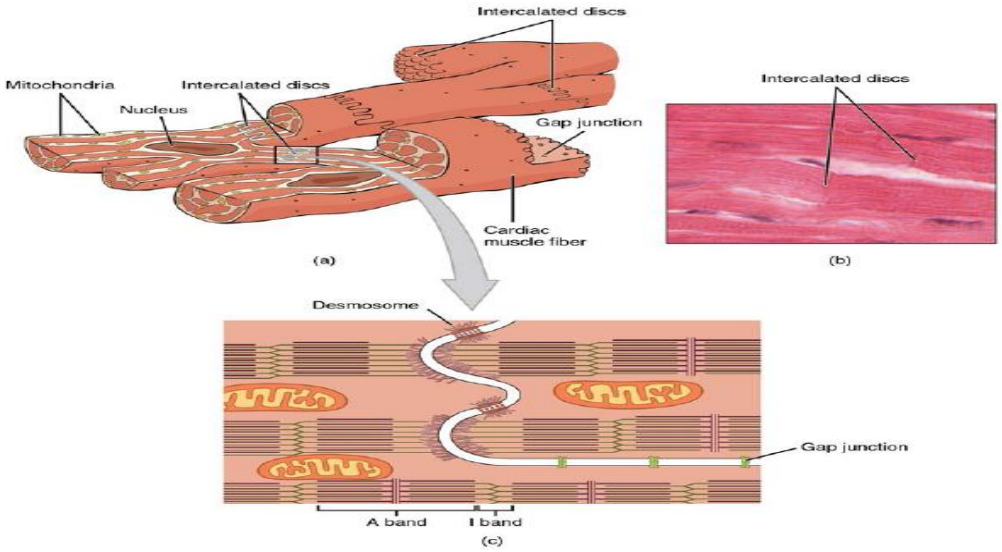



**Figure 3.13 Cardiac Muscle**

### 3.4 Organs and Structures of the Respiratory System

The major organs of the respiratory system function primarily to provide oxygen to body tissues for cellular respiration, remove the waste product carbon dioxide, and help to maintain acid-base balance. Portions of the respiratory system are also used for non-vital functions, such as sensing odors, speech production, and for straining, such as during childbirth or coughing (**Figure 3.13**).

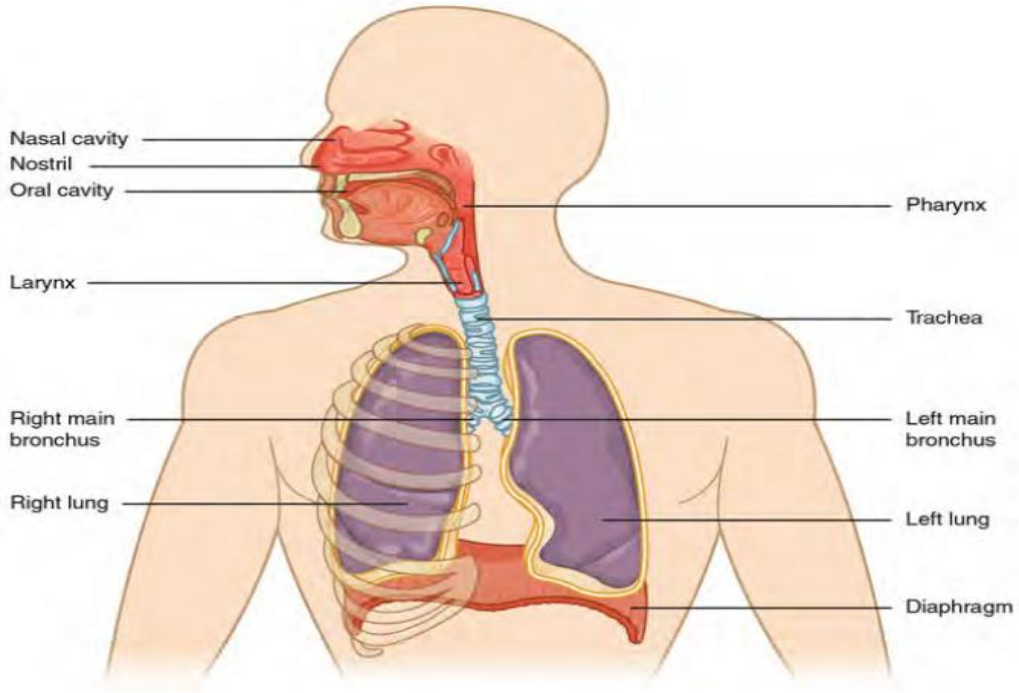



**Figure 3.13 Major Respiratory Structures**

Functionally, the respiratory system can be divided into a conducting zone and a respiratory zone. The **conducting zone** of the respiratory system includes the organs and structures not directly involved in gas exchange. The gas exchange occurs in the **respiratory zone**.

### 3.4.1 Conducting Zone

The major functions of the conducting zone are to provide a route for incoming and outgoing air, remove debris and pathogens from the incoming air, and warm and humidify the incoming air. Several structures within the conducting zone perform other functions as well. The epithelium of the nasal passages, for example, is essential to sensing odors, and the bronchial epithelium that lines the lungs can metabolize some airborne carcinogens.

### 3.4.2 The Nose and its Adjacent Structures

The major entrance and exit for the respiratory system is through the nose. When discussing the nose, it is helpful to divide it into two major sections: the external nose, and the nasal cavity or internal nose.

The **external nose** consists of the surface and skeletal structures that result in the outward appearance of the nose and contribute to its numerous functions (**Figure 3.14**). The **root** is the region of the nose located between the eyebrows. The **bridge** is the part

of the nose that connects the root to the rest of the nose. The **dorsum nasi** is the length of the nose.

The **apex** is the tip of the nose. On either side of the apex, the nostrils are formed by the alae (singular = ala). An **ala** is a cartilaginous structure that forms the lateral side of each **naris** (plural = nares), or nostril opening. The **philtrum** is the concave surface that connects the apex of the nose to the upper lip.

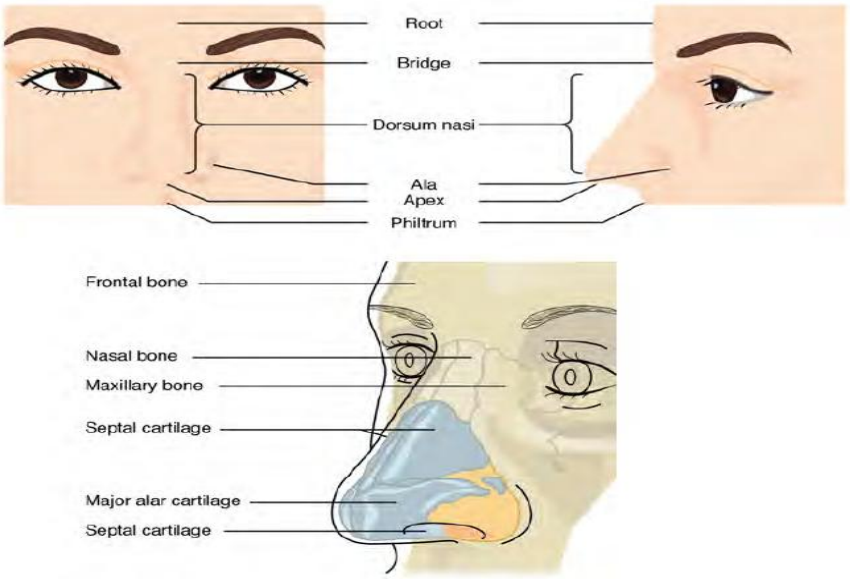



**Figure 3.14 Nose**

### 3.4.3 Pharynx

The **pharynx** is a tube formed by skeletal muscle and lined by mucous membrane that is continuous with that of the nasal cavities (see **Figure 3.15**). The pharynx is divided into three major regions: the nasopharynx, the oropharynx, and the laryngopharynx (**Figure 3.16**).

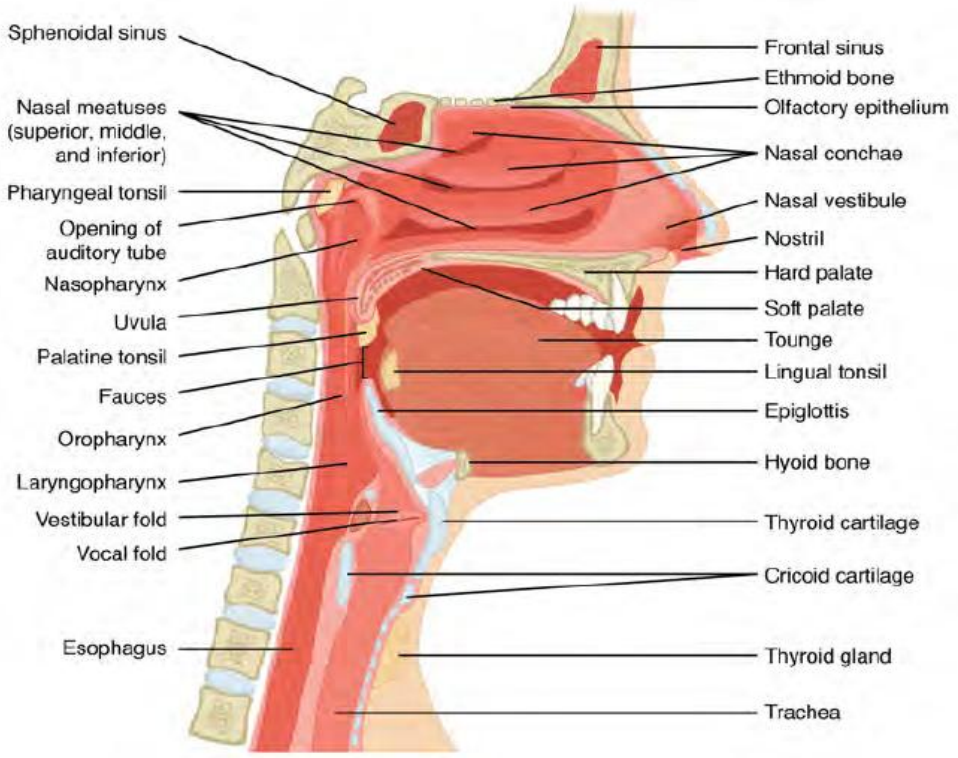



**Figure 3.15 Upper Airway**

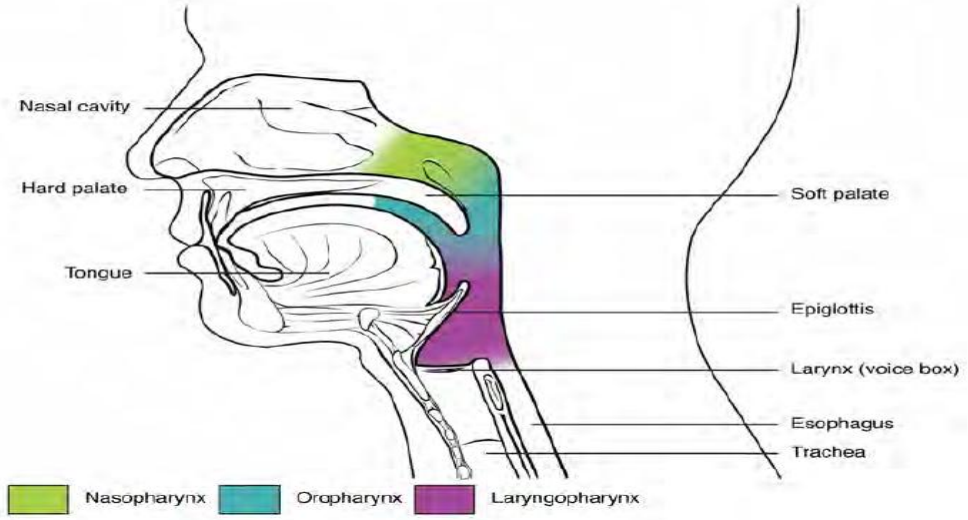



**Figure 3.6 Divisions of the Pharynx:** The pharynx is divided into three regions: the nasopharynx, the oropharynx, and the laryngopharynx.

The **nasopharynx** is flanked by the conchae of the nasal cavity, and it serves only as an airway. At the top of the nasopharynx are the pharyngeal tonsils. A **pharyngeal tonsil**, also called an adenoid, is an aggregate of lymphoid reticular tissue similar to a lymph node that lies at the superior portion of the nasopharynx. The function of the pharyngeal tonsil is not well understood, but it contains a rich supply of lymphocytes and is covered with ciliated epithelium that traps and destroys invading pathogens that enter during inhalation. The pharyngeal tonsils are large in children, but interestingly, tend to regress with age and may even disappear. The uvula is a small bulbous, teardrop-shaped structure located at the apex of the soft palate. Both the uvula and soft palate move like a pendulum during swallowing, swinging upward to close off the nasopharynx to prevent ingested materials from entering the nasal cavity. In addition, auditory (Eustachian) tubes that connect to each middle ear cavity open into the nasopharynx. This connection is why colds often lead to ear infections.

The **oropharynx** is a passageway for both air and food. The oropharynx is bordered superiorly by the nasopharynx and anteriorly by the oral cavity. The **fauces** is the opening at the connection between the oral cavity and the oropharynx. As the nasopharynx becomes the oropharynx, the epithelium changes from pseudostratified ciliated columnar epithelium to stratified squamous epithelium. The oropharynx contains two distinct sets of tonsils, the palatine and lingual tonsils. A **palatine tonsil** is one of a pair of structures located laterally in the oropharynx in the area of the fauces. The **lingual tonsil** is located at the base of the tongue. Similar to the pharyngeal tonsil, the palatine and lingual tonsils are composed of lymphoid tissue, and trap and destroy pathogens entering the body through the oral or nasal cavities.

The **laryngopharynx** is inferior to the oropharynx and posterior to the larynx. It continues the route for ingested material and air until its inferior end, where the digestive and respiratory systems diverge. The stratified squamous epithelium of the oropharynx is continuous with the laryngopharynx. Anteriorly, the laryngopharynx opens into the larynx, whereas posteriorly, it enters the esophagus.

### 3.4.4 Larynx

The **larynx** is a cartilaginous structure inferior to the laryngopharynx that connects the pharynx to the trachea and helps regulate the volume of air that enters and leaves the lungs (**Figure 3.17**). The structure of the larynx is formed by several pieces of cartilage. Three large cartilage pieces the thyroid cartilage (anterior), epiglottis (superior), and cricoid cartilage (inferior) form the major structure of the larynx. The **thyroid cartilage** is the largest piece of cartilage that makes up the larynx. The thyroid cartilage consists of the **laryngeal prominence**, or “Adam’s apple,” which tends to be more prominent in males. The thick **cricoid cartilage** forms a ring, with a wide posterior region and a

thinner anterior region. Three smaller, paired cartilages the arytenoids, corniculates, and cuneiforms attach to the epiglottis and the vocal cords and muscle that help move the vocal cords to produce speech.

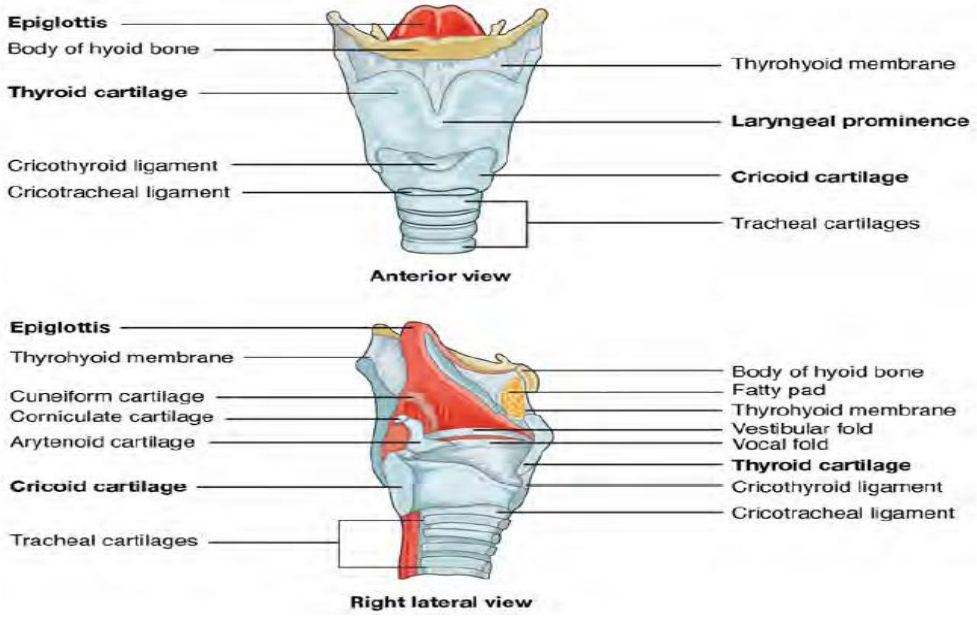



**Figure 3.17 Larynx** The larynx extends from the laryngopharynx and the hyoid bone to the trachea.

### 3.4.5 Trachea

The trachea (windpipe) extends from the larynx toward the lungs (**Figure 3.18a**). The **trachea** is formed by 16 to 20 stacked, C-shaped pieces of hyaline cartilage that are connected by dense connective tissue. The **trachealis muscle** and elastic connective tissue together form the **fibroelastic membrane**, a flexible membrane that closes the posterior surface of the trachea, connecting the C-shaped cartilages. The fibroelastic membrane allows the trachea to stretch and expand slightly during inhalation and exhalation, whereas the rings of cartilage provide structural support and prevent the trachea from collapsing. In addition, the trachealis muscle can be contracted to force air through the trachea during exhalation. The trachea is lined with pseudostratified ciliated columnar epithelium, which is continuous with the larynx. The esophagus borders the trachea posteriorly.

### 3.4.6 Bronchial Tree

The trachea branches into the right and left primary **bronchi** at the carina. These bronchi are also lined by pseudostratified ciliated columnar epithelium containing mucus-producing goblet cells (**Figure 3.18b** ). The carina is a raised structure that contains specialized nervous tissue that induces violent coughing if a foreign body, such as food, is present. Rings of cartilage, similar to those of the trachea, support the structure of the bronchi and prevent their collapse. The primary bronchi enter the lungs

at the hilum, a concave region where blood vessels, lymphatic vessels, and nerves also enter the lungs.

The bronchi continue to branch into bronchial a tree. A **bronchial tree** (or respiratory tree) is the collective term used for these multiple-branched bronchi. The main function of the bronchi, like other conducting zone structures, is to provide a passageway for air to move into and out of each lung. In addition, the mucous membrane traps debris and pathogens.

A **bronchiole** branches from the tertiary bronchi. Bronchioles, which are about 1 mm in diameter, further branch until they become the tiny terminal bronchioles, which lead to the structures of gas exchange. There are more than 1000 terminal bronchioles in each lung. The muscular walls of the bronchioles do not contain cartilage like those of the bronchi. This muscular wall can change the size of the tubing to increase or decrease airflow through the tube.

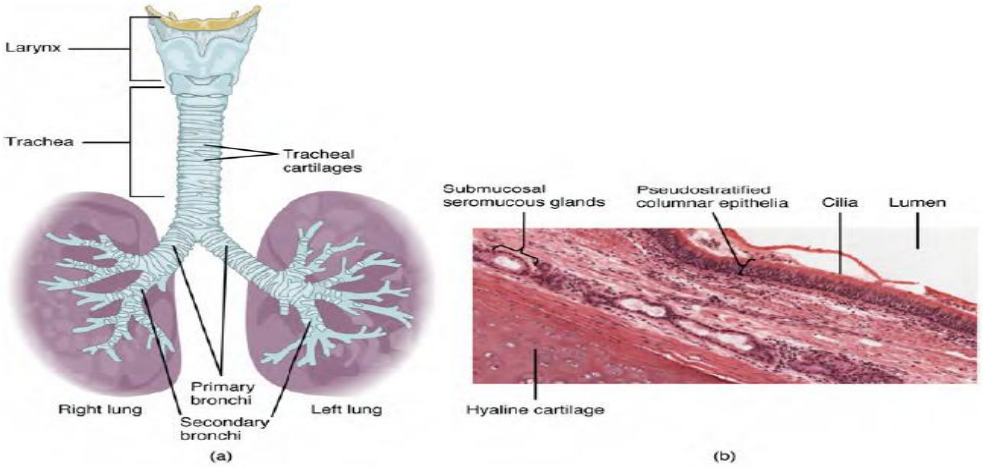



**Figure 3.18 Trachea** (a) The tracheal tube is formed by stacked, C-shaped pieces of hyaline cartilage. (b) The layer visible in this cross-section of tracheal wall tissue between the hyaline cartilage and the lumen of the trachea is themucosa, which is composed of pseudostratified ciliated columnar epithelium that contains goblet cells. LM × 1220. (Micrograph provided by the Regents of University of Michigan Medical School © 2012)

### 3.4.7 Respiratory Zone

In contrast to the conducting zone, the respiratory zone includes structures that are directly involved in gas exchange.

The respiratory zone begins where the terminal bronchioles join a **respiratory bronchiole**, the smallest type of bronchiole (**Figure 3.19**), which then leads to an alveolar duct, opening into a cluster of alveoli.

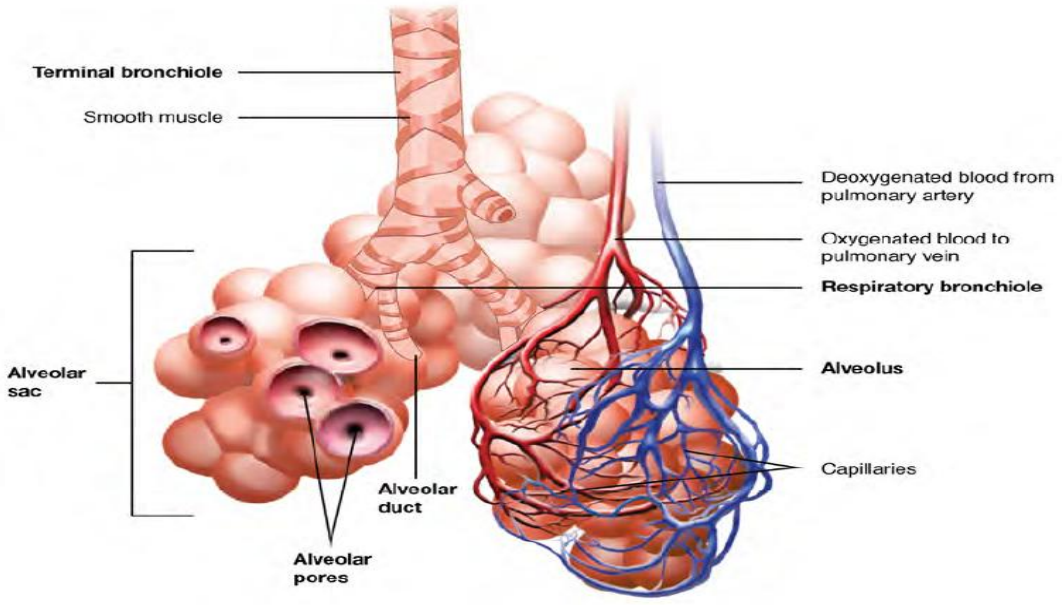



**Figure 3.19 Respiratory Zone** Bronchioles lead to alveolar sacs in the respiratory zone, where gas exchange occurs.

### 3.4.8 Alveoli

An **alveolar duct** is a tube composed of smooth muscle and connective tissue, which opens into a cluster of alveoli. An **alveolus** is one of the many small, grape-like sacs that are attached to the alveolar ducts.

An **alveolar sac** is a cluster of many individual alveoli that are responsible for gas exchange. An alveolus is approximately 200 μm in diameter with elastic walls that allow the alveolus to stretch during air intake, which greatly increases the surface area available for gas exchange. Alveoli are connected to their neighbors by **alveolar pores**, which help maintain equal air pressure throughout the alveoli and lung (**Figure 3.20**).

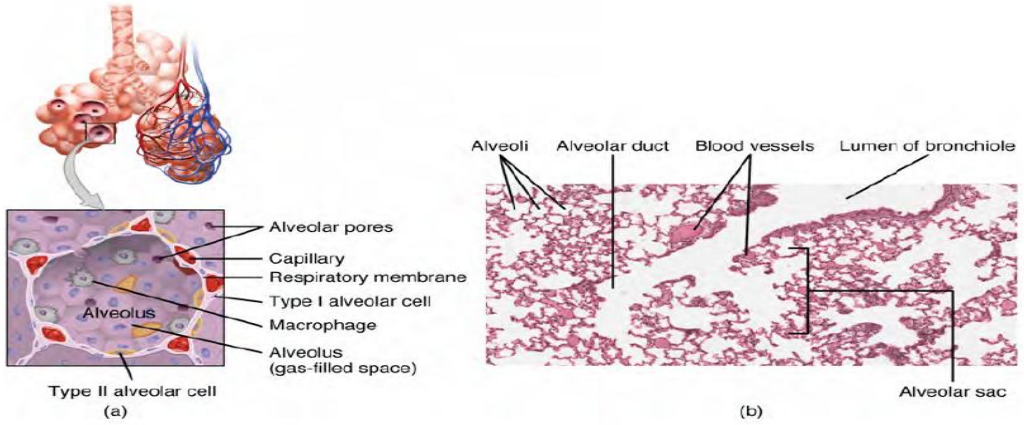



**Figure 3.20 Structures of the Respiratory Zone** (a) The alveolus is responsible for gas exchange. (b) A micrograph shows the alveolar structures within lung tissue. LM × 178. (Micrograph provided by the Regents ofUniversity of Michigan Medical School © 2012)

### 3.4.9 The Lungs

A major organ of the respiratory system, each **lung** houses structures of both the conducting and respiratory zones. The main function of the lungs is to perform the exchange of oxygen and carbon dioxide with air from the atmosphere. To this end, the lungs exchange respiratory gases across a very large epithelial surface area about 70 square meters that is highly permeable to gases.

### 3.4.10 Blood Supply

The major function of the lungs is to perform gas exchange, which requires blood from the pulmonary circulation. This blood supply contains deoxygenated blood and travels to the lungs where erythrocytes, also known as red blood cells, pick up oxygen to be transported to tissues throughout the body. The **pulmonary artery** is an artery that arises from the pulmonary trunk and carries deoxygenated, arterial blood to the alveoli. The pulmonary artery branches multiple times as it follows the bronchi, and each branch becomes progressively smaller in diameter. One arteriole and an accompanying venule supply and drain one pulmonary lobule. As they near the alveoli, the pulmonary arteries become the pulmonary capillary network. The pulmonary capillary network consists of tiny vessels with very thin walls that lack smooth muscle fibers. The capillaries branch and follow the bronchioles and structure of the alveoli. It is at this point that the capillary wall meets the alveolar wall, creating the respiratory membrane. Once the blood is oxygenated, it drains from the alveoli by way of multiple pulmonary veins, which exit the lungs through the **hilum**.

### 3.4.11 Gas Exchange

Gas exchange occurs at two sites in the body: in the lungs, where oxygen is picked up and carbon dioxide is released at the respiratory membrane, and at the tissues, where oxygen is released and carbon dioxide is picked up. External respiration is the

exchange of gases with the external environment, and occurs in the alveoli of the lungs. Internal respiration is the exchange of gases with the internal environment, and occurs in the tissues. The actual exchange of gases occurs due to simple diffusion. Energy is not required to move oxygen or carbon dioxide across membranes. Instead, these gases follow pressure gradients that allow them to diffuse. The anatomy of the lung maximizes the diffusion of gases: The respiratory membrane is highly permeable to gases; the respiratory and blood capillary membranes are very thin; and there is a large surface area throughout the lungs.

### 3.4.12 External Respiration

The pulmonary artery carries deoxygenated blood into the lungs from the heart, where it branches and eventually becomes the capillary network composed of pulmonary capillaries. These pulmonary capillaries create the respiratory membrane with the alveoli (**Figure 3.21**). As the blood is pumped through this capillary network, gas exchange occurs. Although a small amount of the oxygen is able to dissolve directly into plasma from the alveoli, most of the oxygen is picked up by erythrocytes (red blood cells) and binds to a protein called hemoglobin, a process described later in this chapter. Oxygenated hemoglobin is red, causing the overall appearance of bright red oxygenated blood, which returns to the heart through the pulmonary veins. Carbon dioxide is released in the opposite direction of oxygen, from the blood to the alveoli.

**External respiration** occurs as a function of partial pressure differences in oxygen and carbon dioxide between the alveoli and the blood in the pulmonary capillaries.

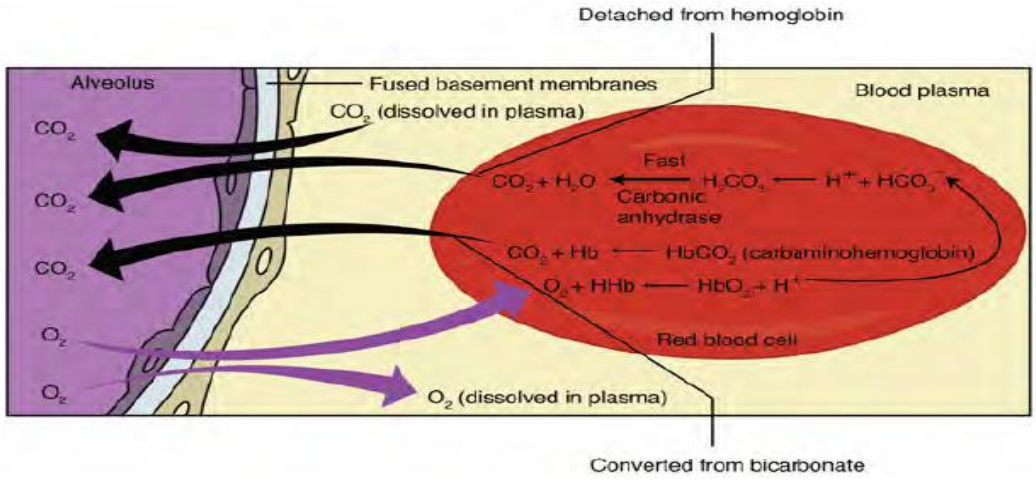



**Figure 3.21 External Respiration** In external respiration, oxygen diffuses across the respiratory membrane from the alveolus to the capillary, whereas carbon dioxide diffuses out of the capillary into the alveolus.

### 3.4.13 Internal Respiration

**Internal respiration** is gas exchange that occurs at the level of body tissues (**Figure 3.22**). Similar to external respiration, internal respiration also occurs as simple diffusion

due to a partial pressure gradient. However, the partial pressure gradients are opposite of those present at the respiratory membrane. The partial pressure of oxygen in tissues is low, about 40 mm Hg, because oxygen is continuously used for cellular respiration. In contrast, the partial pressure of oxygen in the blood is about 100 mm Hg. This creates a pressure gradient that causes oxygen to dissociate from hemoglobin, diffuse out of the blood, cross the interstitial space, and enter the tissue. Hemoglobin that has little oxygen bound to it loses much of its brightness, so that blood returning to the heart is more burgundy in color.

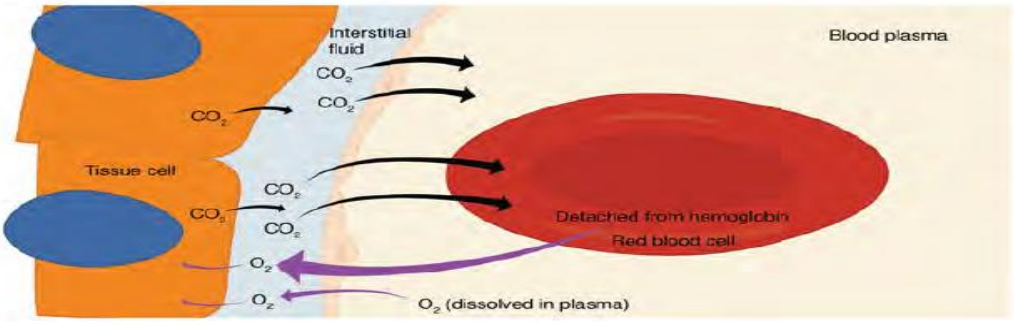



**Figure 3.22 Internal Respiration** Oxygen diffuses out of the capillary and into cells, whereas carbon dioxide diffuses out of cells and into the capillary.

### 3.4. 14 Function of Hemoglobin

Hemoglobin is composed of subunits, a protein structure that is referred to as a quaternary structure. Each of the four subunits that make up hemoglobin is arranged in a ring-like fashion, with an iron atom covalently bound to the heme in the center of each subunit. Binding of the first oxygen molecule causes a conformational change in hemoglobin that allows the second molecule of oxygen to bind more readily. As each molecule of oxygen is bound, it further facilitates the binding of the next molecule, until all four heme sites are occupied by oxygen. The opposite occurs as well: After the first oxygen molecule dissociates and is “dropped off” at the tissues, the next oxygen molecule dissociates more readily. When all four heme sites are occupied, the hemoglobin is said to be saturated. When one to three heme sites are occupied, the hemoglobin is said to be partially saturated. Therefore, when considering the blood as a whole, the percent of the available heme units that are bound to oxygen at a given time is called hemoglobin saturation. Hemoglobin saturation of 100 percent means that every heme unit in all of the erythrocytes of the body is bound to oxygen. In a healthy individual with normal hemoglobin levels, hemoglobin saturation generally ranges from 95 percent to 99 percent.

## 3.5 THE DIGESTIVE SYSTEM

### 3.5.1 The Mouth, Pharynx, and Esophagus

## The Mouth

The cheeks, tongue, and palate frame the mouth, which is also called the **oral cavity** (or buccal cavity). The structures of the mouth are illustrated in **Figure 3.24**.

At the entrance to the mouth are the lips, or **labia** (singular = labium). Their outer covering is skin, which transitions to a mucous membrane in the mouth proper. Lips are very vascular with a thin layer of keratin; hence, the reason they are "red."

They have a huge representation on the cerebral cortex, which probably explains the human fascination with kissing! The lips cover the orbicularis oris muscle, which regulates what comes in and goes out of the mouth. The **labial frenulum** is a midline fold of mucous membrane that attaches the inner surface of each lip to the gum. The cheeks make up the oral cavity's sidewalls. While their outer covering is skin, their inner covering is mucous membrane. This membrane is made up of non-keratinized, stratified squamous epithelium. Between the skin and mucous membranes are connective tissue and buccinator muscles. The next time you eat some food, notice how the buccinator muscles in your cheeks and the orbicularis oris muscle in your lips contract, helping you keep the food from falling out of your mouth. Additionally, notice how these muscles work when you are speaking.

The pocket-like part of the mouth that is framed on the inside by the gums and teeth, and on the outside by the cheeks and lips is called the **oral vestibule**. Moving farther into the mouth, the opening between the oral cavity and throat (oropharynx) is called the **fauces** (like the kitchen "faucet"). The main open area of the mouth, or oral cavity proper, runs from the gums and teeth to the fauces.

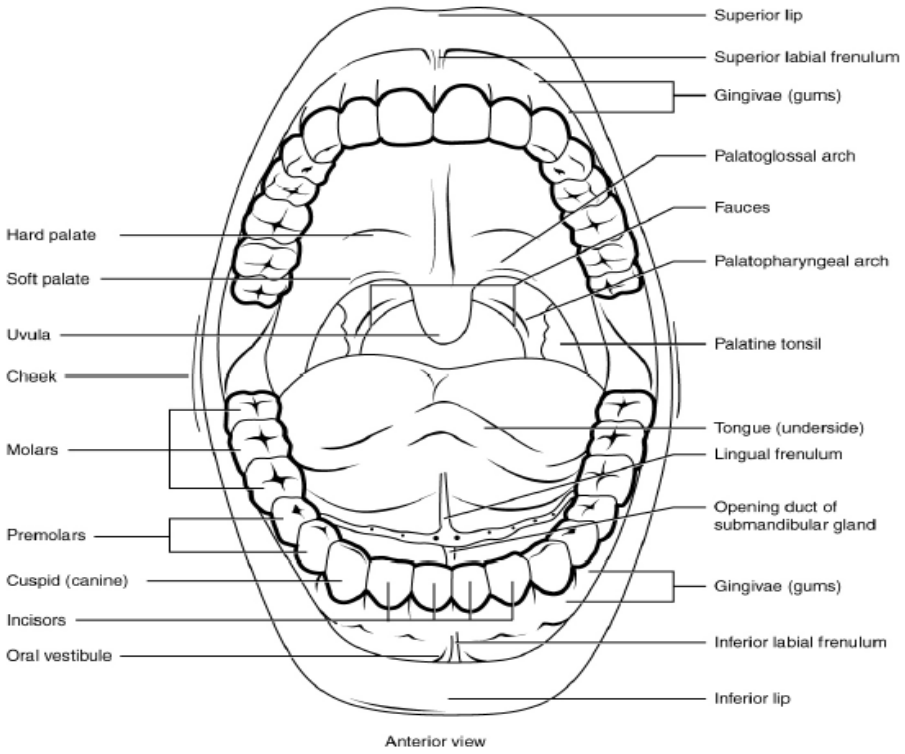



**Figure3.25 Mouth** The mouth includes the lips, tongue, palate, gums, and teeth.

## Anatomy of a Tooth

The teeth are secured in the alveolar processes (sockets) of the maxilla and the mandible. **Gingivae** (commonly called the gums) are soft tissues that line the alveolar processes and surround the necks of the teeth. Teeth are also held in their sockets by a connective tissue called the periodontal ligament.

The two main parts of a tooth are the **crown**, which is the portion projecting above the gum line, and the **root**, which is embedded within the maxilla and mandible. Both parts contain an inner **pulp cavity**, containing loose connective tissue through which run nerves and blood vessels. The region of the pulp cavity that runs through the root of the tooth is called the root canal. Surrounding the pulp cavity is **dentin**, a bone-like tissue. In the root of each tooth, the dentin is covered by an even harder bone-like layer called **cementum**. In the crown of each tooth, the dentin is covered by an outer layer of **enamel**, the hardest substance in the body (**Figure 3.26**).

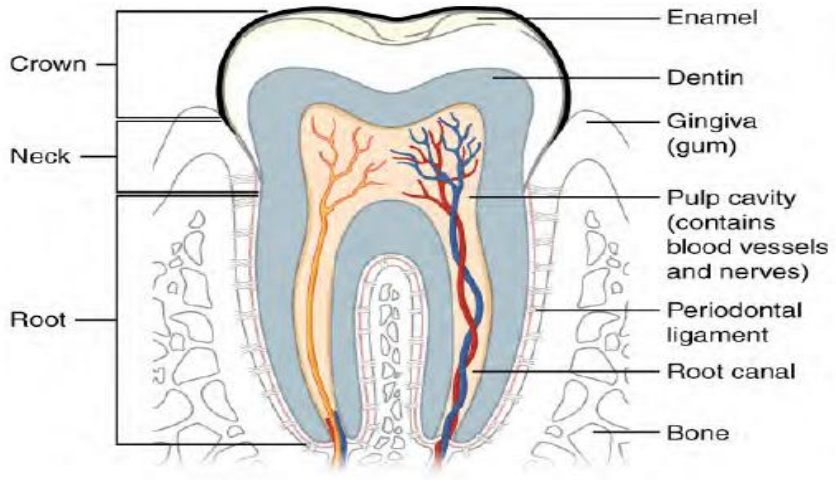



**Figure 3.26The Structure of the Tooth** This longitudinal section through a molar in its alveolar socket shows the relationships between enamel, dentin, and pulp.

### 3.5.2 Structure of stomach

There are four main regions in the **stomach**: the cardia, fundus, body, and pylorus (**Figure 3.27**). The **cardia** (or cardiac region) is the point where the esophagus connects to the stomach and through which food passes into the stomach. Located inferior to the diaphragm, above and to the left of the cardia, is the dome-shaped **fundus**. Below the fundus is the **body**, the main part of the stomach. The funnel-shaped **pylorus** connects the stomach to the duodenum. The wider end of the funnel, the **pyloric antrum**, connects to the body of the stomach. The narrower end is called the **pyloric canal**, which connects to the duodenum. The smooth muscle **pyloric sphincter** is located at this latter point of connection and controls stomach emptying. In the absence of food, the stomach deflates inward, and its mucosa and submucosa fall into a large fold called a **ruga**.

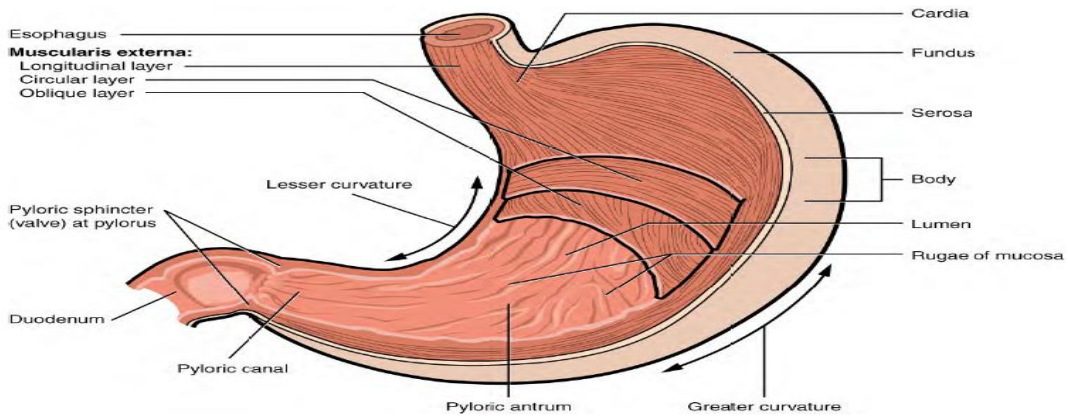



**Figure3.27 Stomach** The stomach has four major regions: the cardia, fundus, body, and pylorus.

### 3.5.3 The Small Intestine Structure

The coiled tube of the small intestine is subdivided into three regions. From proximal (at the stomach) to distal, these are the duodenum, jejunum, and ileum (**Figure 3.28**).

The shortest region is the 25.4-cm (10-in) **duodenum**, which begins at the pyloric sphincter. Just past the pyloric sphincter, it bends posteriorly behind the peritoneum, becoming retroperitoneal, and then makes a C-shaped curve around the head of the pancreas before ascending anteriorly again to return to the peritoneal cavity and join the jejunum. The duodenum can therefore be subdivided into four segments: the superior, descending, horizontal, and ascending duodenum.

Of particular interest is the **hepatopancreatic ampulla** (ampulla of Vater). Located in the duodenal wall, the ampulla marks the transition from the anterior portion of the alimentary canal to the mid-region, and is where the bile duct (through which bile passes from the liver) and the **main pancreatic duct** (through which pancreatic juice passes from the pancreas) join. This ampulla opens into the duodenum at a tiny volcano-shaped structure called the **major duodenal papilla**. The

**hepatopancreatic sphincter** (sphincter of Oddi) regulates the flow of both bile and pancreatic juice from the ampulla into the duodenum.

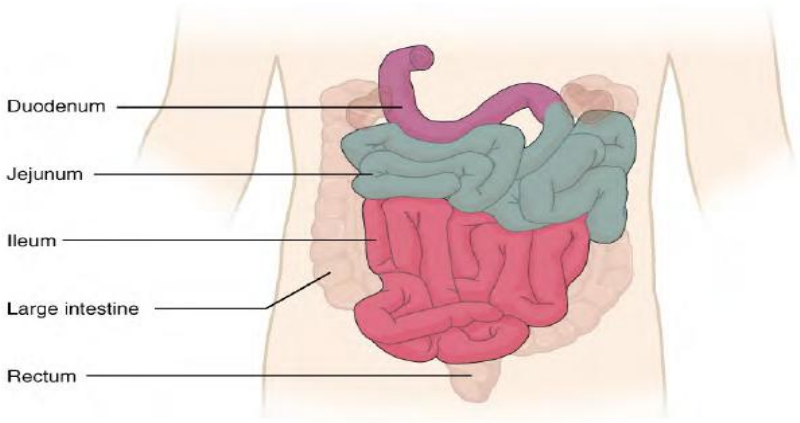



**Figure 3.28 Small Intestine** The three regions of the small intestine are the duodenum, jejunum, and ileum.

### 3.5.4 The Large Intestine structure

The large intestine runs from the appendix to the anus. It frames the small intestine on three sides. Despite its being about one-half as long as the small intestine, it is called large because it is more than twice the diameter of the small intestine, about 3 inches.

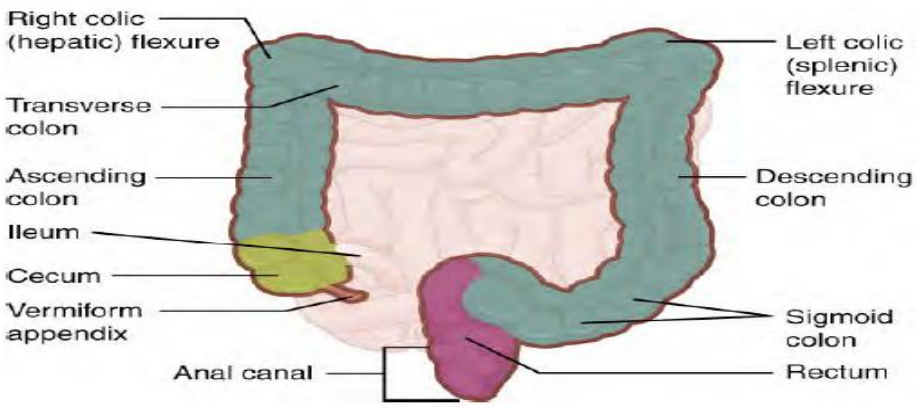


**Figure 3.29 Large Intestine** The large intestine includes the cecum, colon, and rectum.

### *Cecum*

The first part of the large intestine is the **cecum**, a sac-like structure that is suspended inferior to the ileocecal valve. It is about 6 cm (2.4 in) long, receives the contents of the ileum, and continues the absorption of water and salts. The **appendix** (or vermiform appendix) is a winding tube that attaches to the cecum. Although the 7.6-cm (3-in) long appendix contains lymphoid tissue, suggesting an immunologic function, this organ is generally considered vestigial. However, at least one recent report postulates a survival advantage conferred by the appendix: In diarrheal illness, the appendix may serve as a bacterial reservoir to repopulate the enteric bacteria for those surviving the initial phases of the illness. Moreover, its twisted anatomy provides a haven for the accumulation and multiplication of enteric bacteria. The **meso appendix**, the mesentery of the appendix, tethers it to the mesentery of the ileum.

### *Colon*

The cecum blends seamlessly with the **colon**. Upon entering the colon, the food residue first travels up the **ascending colon** on the right side of the abdomen. At the inferior surface of the liver, the colon bends to form the **right colic flexure** (hepatic flexure) and becomes the **transverse colon**. The region defined as hindgut begins with the last third of the transverse colon and continues on. Food residue passing through the transverse colon travels across to the left side of the abdomen, where the colon angles sharply immediately inferior to the spleen, at the **left colic flexure** (splenic flexure). From there, food residue passes through the **descending colon**, which runs down the left side of the posterior abdominal wall.

## 3.6 THE URINARY SYSTEM

Urine is a fluid of variable composition that requires specialized structures to remove it from the body safely and efficiently. Blood is filtered, and the filtrate is transformed into urine at a relatively constant rate throughout the day. This processed liquid is stored until a convenient time for excretion. All structures involved in the transport and storage of the urine are large enough to be visible to the naked eye. This transport and storage system not only stores the waste, but it protects the tissues from damage due to the wide range of pH and osmolarity of the urine, prevents infection by foreign organisms, and for the male, provides reproductive functions.

### Urethra

The **urethra** transports urine from the bladder to the outside of the body for disposal. The urethra is the only urologic organ that shows any significant anatomic difference between males and females; all other urine transport structures are identical (**Figure 3.30**).

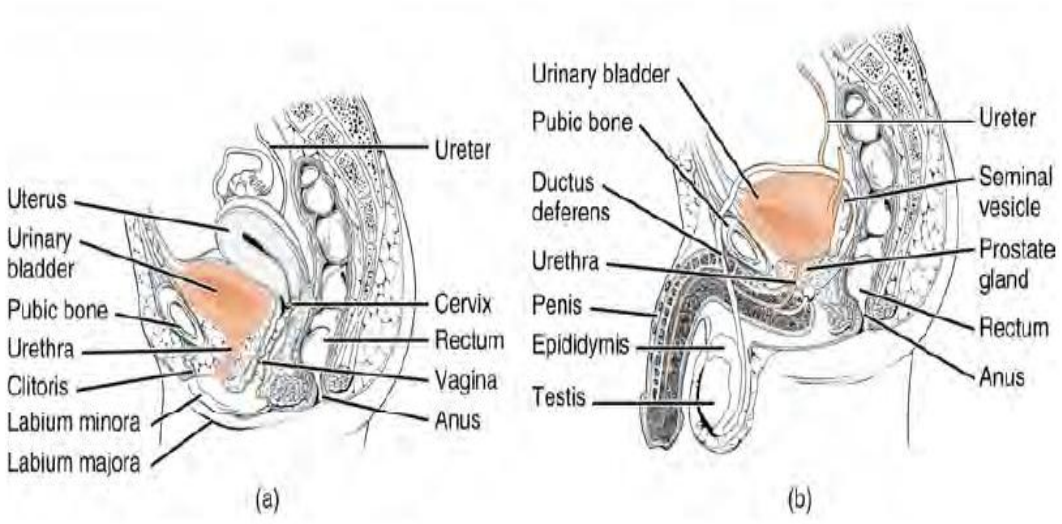



**Figure 3.30 Female and Male Urethras** The urethra transports urine from the bladder to the outside of the body. This image shows (a) a female urethra and (b) a male urethra.

### 3.6.1 External Anatomy of kidney

The left kidney is located at about the T12 to L3 vertebrae, whereas the right is lower due to slight displacement by the liver.

Upper portions of the kidneys are somewhat protected by the eleventh and twelfth ribs (**Figure 3.31**). Each kidney weighs about 125–175 g in males and 115–155 g in females. They are about 11–14 cm in length, 6 cm wide, and 4 cm thick, and are directly covered by a fibrous capsule composed of dense, irregular connective tissue that helps to hold their shape and protect them. This capsule is covered by a shock-absorbing layer of adipose tissue called the **renal fat pad**, which in turn is encompassed by a tough renal fascia. The fascia and, to a lesser extent, the overlying peritoneum serve to firmly anchor the kidneys to the posterior abdominal wall in a retroperitoneal position.

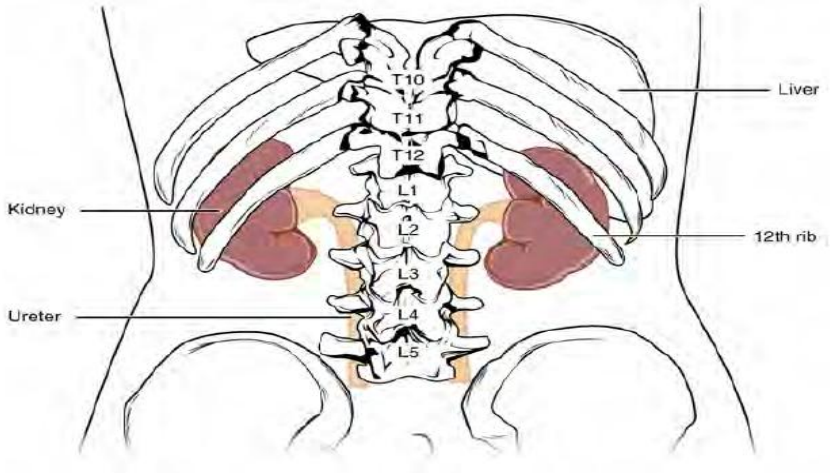



**Figure 3.31 Kidneys** The kidneys are slightly protected by the ribs and are surrounded by fat for protection (not shown).

### 3.6.2 Internal Anatomy of kidney

A frontal section through the kidney reveals an outer region called the **renal cortex** and an inner region called the **medulla** (**Figure 3.32**). The **renal columns** are connective tissue extensions that radiate downward from the cortex through the medulla to separate the most characteristic features of the medulla, the **renal pyramids** and **renal papillae**. The papillae are bundles of collecting ducts that transport urine made by nephrons to the **calyces** of the kidney for excretion. The renal columns also serve to divide the kidney into 6–8 lobes and provide a supportive framework for vessels that enter and exit the cortex. The pyramids and renal columns taken together constitute the kidney lobes.

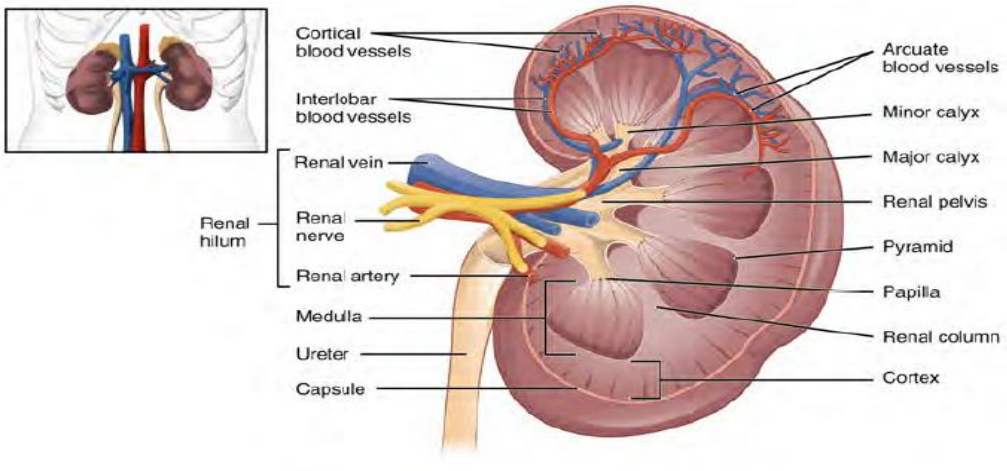



**Figure 3.32 Left Kidney**

### Renal Hilum

The **renal hilum** is the entry and exit site for structures servicing the kidneys: vessels, nerves, lymphatics, and ureters. The medial-facing hila are tucked into the sweeping convex outline of the cortex. Emerging from the hilum is the renal pelvis, which is formed from the major and minor calyxes in the kidney. The smooth muscle in the renal pelvis funnels urine via peristalsis into the ureter. The renal arteries form directly from the descending aorta, whereas the renal veins return cleansed blood directly to the inferior vena cava. The artery, vein, and renal pelvis are arranged in an anterior-to-posterior order.

## 3.7 THE REPRODUCTIVE SYSTEM

### 3.7.1 Anatomy and Physiology of the Male Reproductive System

Unique for its role in human reproduction, a **gamete** is a specialized sex cell carrying 23 chromosomes one half the number in body cells. At fertilization, the chromosomes in one male gamete, called a **sperm** (or spermatozoon), combine with the chromosomes in one female gamete, called an oocyte. The function of the male reproductive system (**Figure 3.33**) is to produce sperm and transfer them to the female reproductive tract. The paired testes are a crucial component in this process, as they produce both sperm and androgens, the hormones that support male reproductive physiology. In humans, the most important male androgen is testosterone. Several accessory organs and ducts aid the process of sperm maturation and transport the sperm and other seminal components to the penis, which delivers sperm to the female reproductive tract.

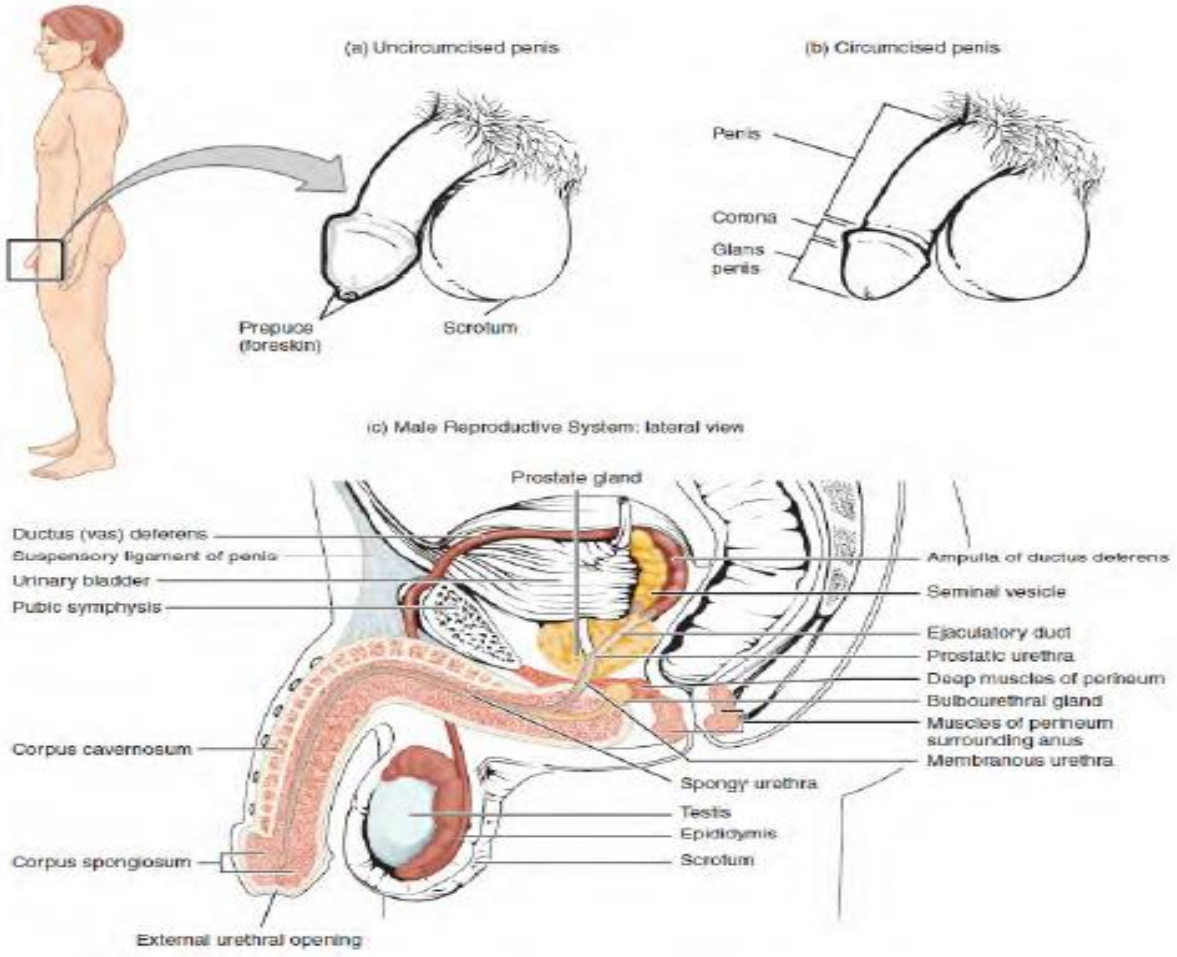


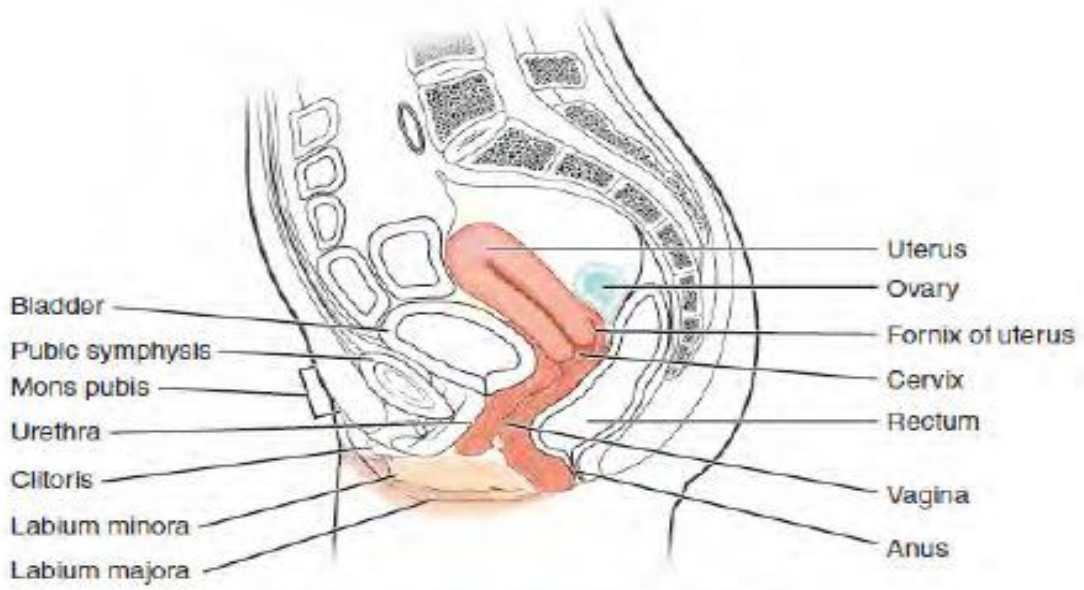

**Figure 3.33 Male Reproductive System** The structures of the male reproductive system include the testes, the epididymides, the penis, and the ducts and glands that produce and carry semen. Sperm exit the scrotum through the ductus deferens, which is bundled in the spermatic cord. The seminal vesicles and prostate gland add fluids to the sperm to create semen.

### 3.7.2 Anatomy and Physiology of the Female Reproductive System

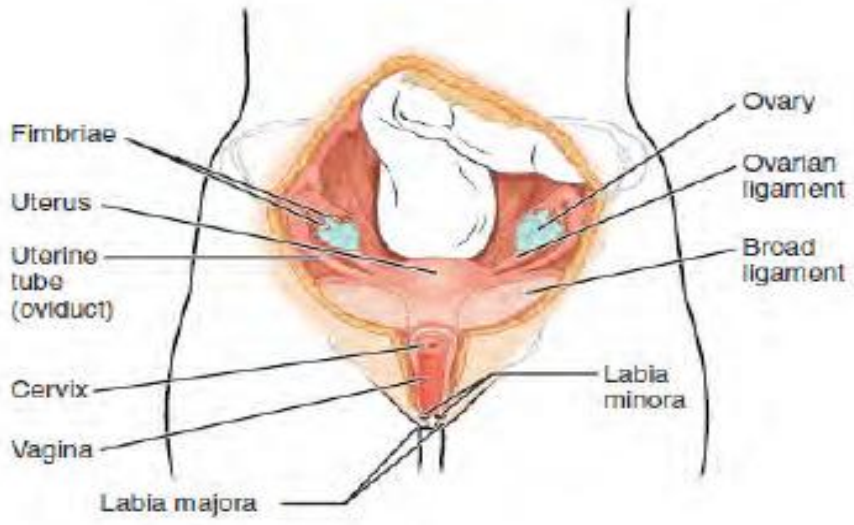
The female reproductive system functions to produce gametes and reproductive hormones, just like the male reproductive system; however, it also has the additional task of supporting the developing fetus and delivering it to the outside world.

Unlike its male counterpart, the female reproductive system is located primarily inside the pelvic cavity (**Figure 3.34**).

Recall that the ovaries are the female gonads. The gamete they produce is called an **oocyte**.




(a) Human female reproductive system: lateral view




(b) Human female reproductive system: anterior view

**Figure 3.34 Female Reproductive System** The major organs of the female reproductive system are located inside the pelvic cavity.

## 3.7.3 External Female Genitals

The external female reproductive structures are referred to collectively as the **vulva** (**Figure 3.35**). The **mons pubis** is a pad of fat that is located at the anterior, over the pubic bone. After puberty, it becomes covered in pubic hair. The **labia majora** (labia = “lips”; majora = “larger”) are folds of hair-covered skin that begin just posterior to the mons pubis. The thinner and more pigmented **labia minora** (labia = “lips”; minora = “smaller”) extend medial to the labia majora. Although they naturally vary in shape and size from woman to woman, the labia minora serve to protect the female urethra and the entrance to the female reproductive tract.

The superior, anterior portions of the labia minora come together to encircle the **clitoris** (or glans clitoris), an organ that originates from the same cells as the glans penis and has abundant nerves that make it important in sexual sensation and orgasm. The **hymen** is a thin membrane that sometimes partially covers the entrance to the vagina. An intact hymen cannot be used as an indication of “virginity”; even at birth, this is only a partial membrane, as menstrual fluid and other secretions must be able to exit the body, regardless of penile–vaginal intercourse. The vaginal opening is located between the opening of the urethra and the anus. It is flanked by outlets to the **Bartholin’s glands** (or greater vestibular glands).

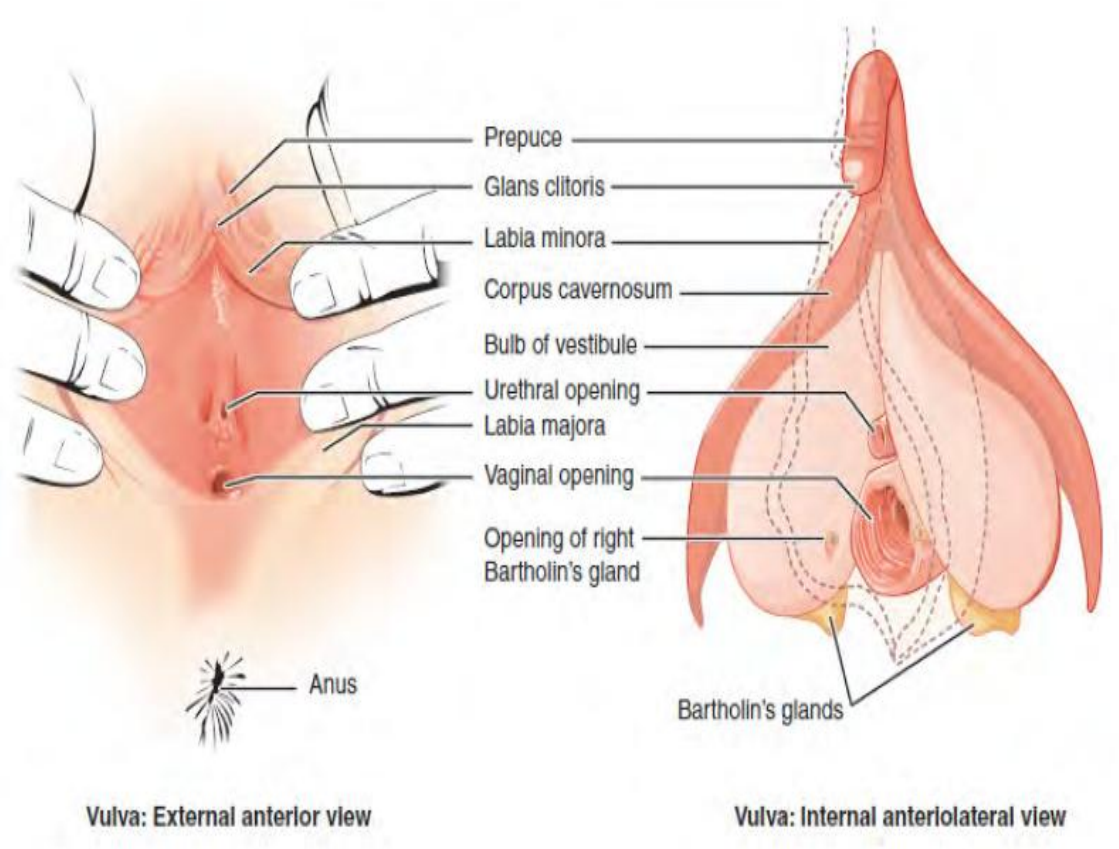



**Figure 3.35 The Vulva** The external female genitalia are referred to collectively as the vulva.

### 3.7.4 The Uterine Tubes

The **uterine tubes** (also called fallopian tubes or oviducts) serve as the conduit of the oocyte from the ovary to the uterus
(**Figure 3.36**). Each of the two uterine tubes is close to, but not directly connected to, the ovary and divided into sections.

The **isthmus** is the narrow medial end of each uterine tube that is connected to the uterus. The wide distal **infundibulum** flares out with slender, finger-like projections called **fimbriae**. The middle region of the tube, called the **ampulla**, is where fertilization often occurs. The uterine tubes also have three layers: an outer serosa, a middle smooth muscle layer, and an inner mucosal layer. In addition to its mucus-secreting cells, the inner mucosa contains ciliated cells that beat in the direction of the uterus, producing a current that will be critical to move the oocyte.

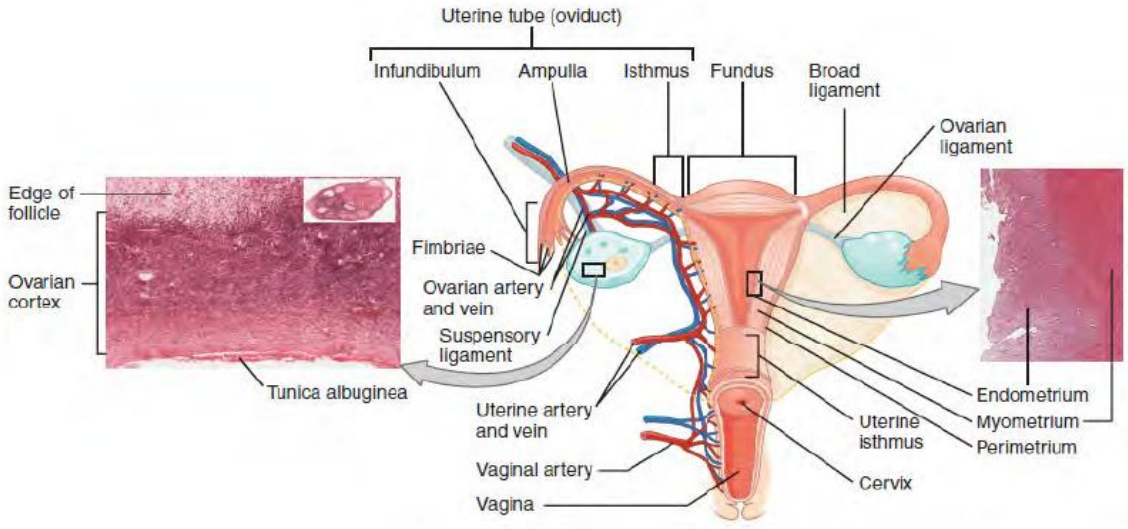



**Figure 3.36 Ovaries, Uterine Tubes, and Uterus** This anterior view shows the relationship of the ovaries, uterine tubes (oviducts), and uterus. Sperm enter through the vagina, and fertilization of an ovulated oocyte usually occurs in the distal uterine tube. From left to right, LM × 400, LM × 20. (Micrographs provided by the Regents of University of Michigan Medical School © 2012)

## 3.8 BONE TISSUE AND THE SKELETAL SYSTEM

### 3.8.1 The Functions of the Skeletal System

**Bone**, or **osseous tissue**, is a hard, dense connective tissue that forms most of the adult skeleton, the support structure of the body. In the areas of the skeleton where bones move (for example, the ribcage and joints), **cartilage**, a semi-rigid form of connective tissue, provides flexibility and smooth surfaces for movement.

#### Gross Anatomy of Bone

The structure of a long bone allows for the best visualization of all of the parts of a bone (**Figure 3.37**). A long bone has two parts: the **diaphysis** and the **epiphysis**. The diaphysis is the tubular shaft that runs between the proximal and distal ends of the bone. The hollow region in the diaphysis is called the **medullary cavity**, which is filled with yellow marrow. The walls of the diaphysis are composed of dense and hard **compact bone**.

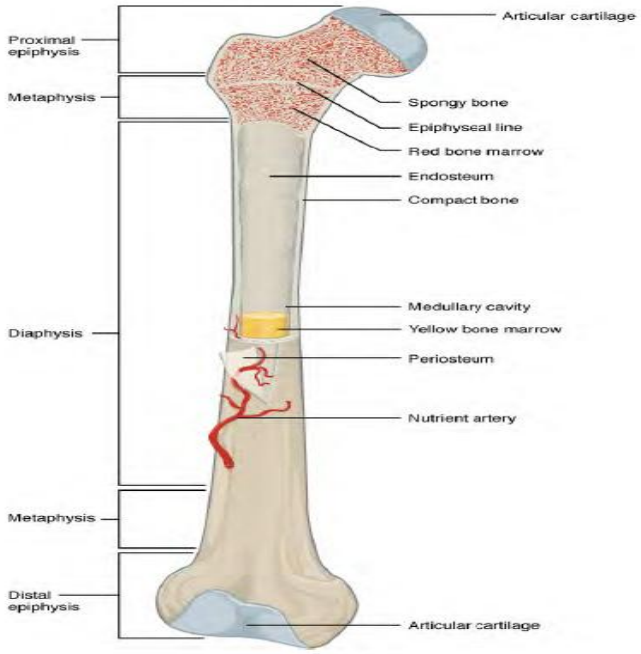



**Figure 3.37 Anatomy of a Long Bone** A typical long bone shows the gross anatomical characteristics of bone.

The wider section at each end of the bone is called the epiphysis (plural = epiphyses), which is filled with spongy bone.

Red marrow fills the spaces in the spongy bone. Each epiphysis meets the diaphysis at the metaphysis, the narrow area that contains the **epiphyseal plate** (growth plate), a layer of hyaline (transparent) cartilage in a growing bone. When the bone stops growing in early adulthood (approximately 18–21 years), the cartilage is replaced by osseous tissue and the epiphyseal plate becomes an epiphyseal line.

The medullary cavity has a delicate membranous lining called the **endosteum** (end- = “inside”; oste- = “bone”), where bone growth, repair, and remodeling occur. The outer surface of the bone is covered with a fibrous membrane called the **periosteum** (peri- = “around” or “surrounding”). The periosteum contains blood vessels, nerves, and lymphatic vessels that nourish compact bone. Tendons and ligaments also attach to bones at the periosteum. The periosteum covers the entire outer surface except where the epiphyses meet other bones to form joints (**Figure 3.38**). In this region, the epiphyses are covered with **articular cartilage**, a thin layer of cartilage that reduces friction and acts as ashock absorber.

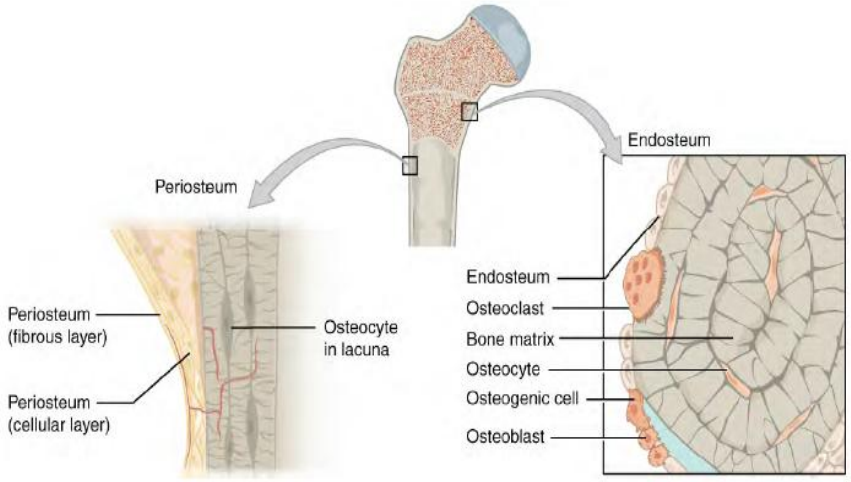



**Figure 3.38 Periosteum and Endosteum** The periosteum forms the outer surface of bone, and the endosteum lines the medullary cavity.

### 3.8.2 Bone Cells and Tissue

Bone contains a relatively small number of cells entrenched in a matrix of collagen fibers that provide a surface for inorganic salt crystals to adhere. These salt crystals form when calcium phosphate and calcium carbonate combine to create hydroxyapatite, which incorporates other inorganic salts like magnesium hydroxide, fluoride, and sulfate as it crystallizes, or calcifies, on the collagen fibers. The hydroxyapatite crystals give bones their hardness and strength, while the collagen fibers give them flexibility so that they are not brittle.

Although bone cells compose a small amount of the bone volume, they are crucial to the function of bones. Four types of cells are found within bone tissue: osteoblasts, osteocytes, osteogenic cells, and osteoclasts (**Figure 3.39**).

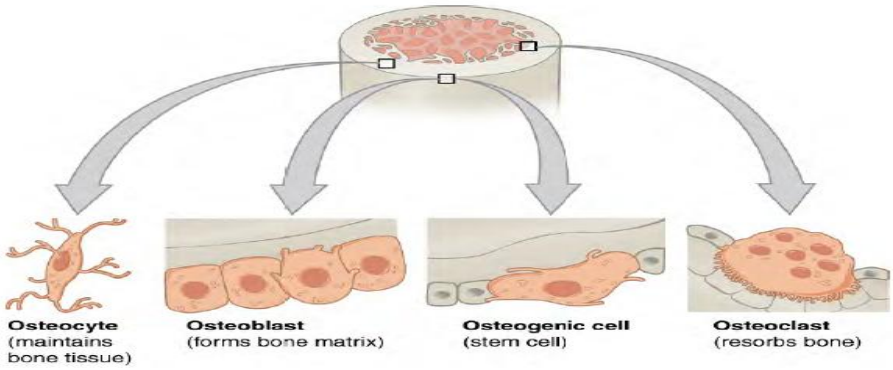



**Figure 3.39 Bone Cells**

| Self-Check -3 | Written Test |
|---|---|

**Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:**

1. What region of the spinal cord contains motor neurons that direct the movement of skeletal muscles?
A. anterior horn B. posterior horn C. lateral horn D. alar plate
2. Brodmann's areas map different regions of the _____ to particular functions.
a. cerebellum b. cerebral cortex c. basal forebrain d. corpus callosum
3. The pulmonary trunk and aorta are derived from which primitive heart structure?
a. bulbus cordis b. primitive ventricle
c. sinus venosus d. truncus arteriosus
4. Which of the following anatomical structures is *not* part of the conducting zone?
a. pharynx b. nasal cavity c. alveoli d. bronchi

***Note:*** **Satisfactory rating - 3 points** **Unsatisfactory - below 3 points**

**Answer Sheet**

Score = _____

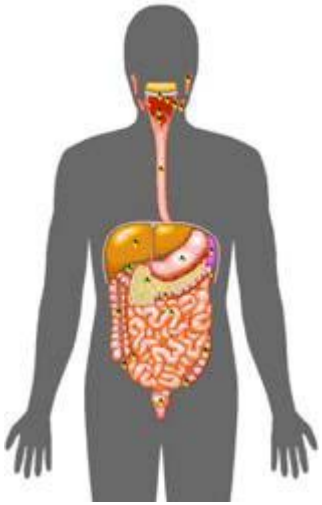
Rating: _____

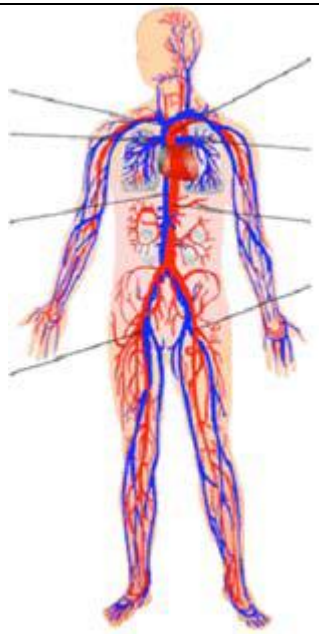
**Name:** _____ **Date:** _____

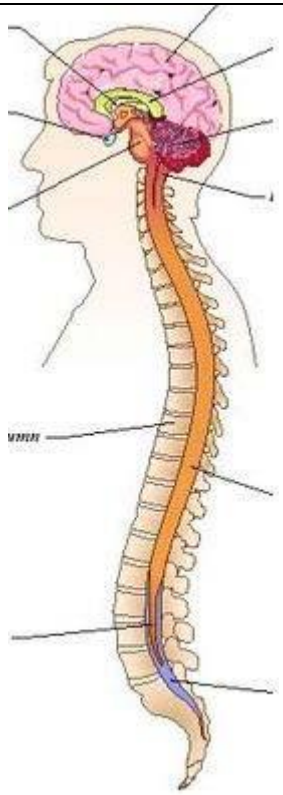
**Short Answer Questions**

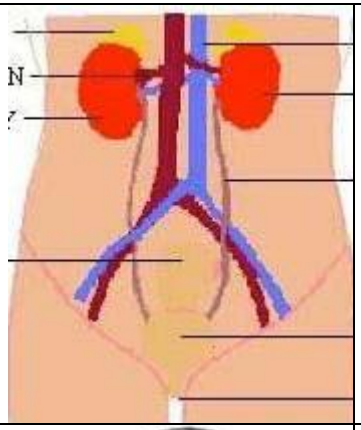
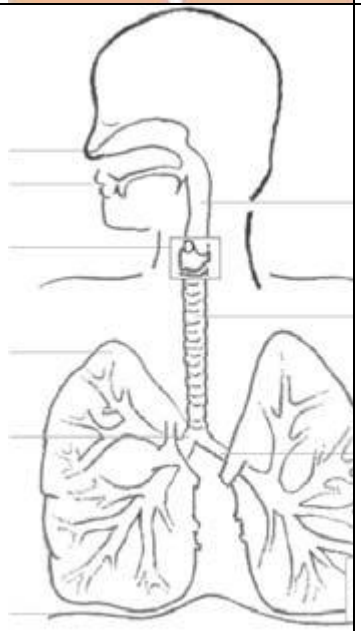
| Information Sheet-4 | Analyzing Human body Systems |
|---|---|

## 3.4 Analyzing Human body Systems

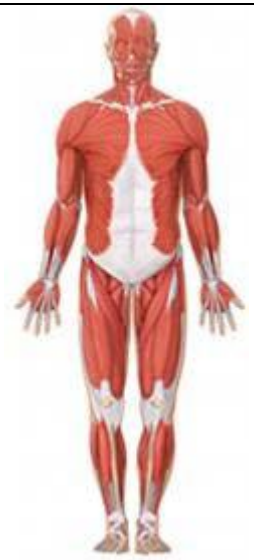
| System | Function | Diagram | Major Organs | Interactions- Working with Other Systems |
|---|---|---|---|---|
| Digestive | 1. take in food (ingestion)<br>2. digest food into smaller molecules and absorb nutrients<br>3. remove Undigestable food from body (feces) |  | Mouth, esophagus, Stomach, Sm. Intestine, Lg. intestine, rectum, anus Salivary glands, pancreas, liver, gall bladder | 1. w/circulatory – absorb & deliver the digested nutrients to the cells<br>2. w/muscular – control the contractions of many of the digestive organs to pass food along<br>3.w/nervous – hypothalamus maintains homeostasis by triggering appetite (stomach growling), digest. |

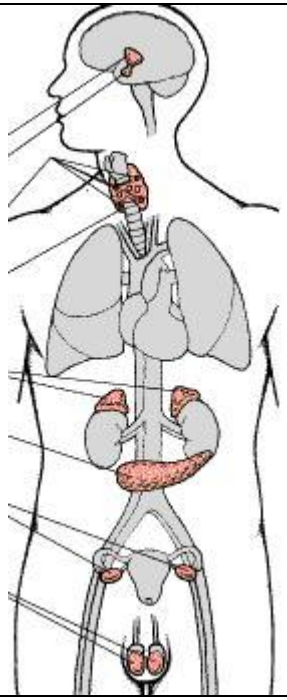
| | | | | |
|---|---|---|---|---|
| Circulatory | Transport materials to and from cells |  | Heart<br>Veins<br>Arteries<br>Capillaries<br>Red blood cells | 1. w/respiratory – deliver O2 from lungs to cells and drop off CO2 from cells to lungs<br>2. w/digestive – absorb and deliver digested nutrients to cells<br>3. w/excretory – kidneys filter cellular waste out of blood for removal<br>4. w/lymphatic – both transport things to and from cells<br>5. w/immune –<br><br>transports WBCs throughout body to fight disease<br>6. w/nervous – brain controls heartbeat<br>7. w/endocrine – trans. hormones |

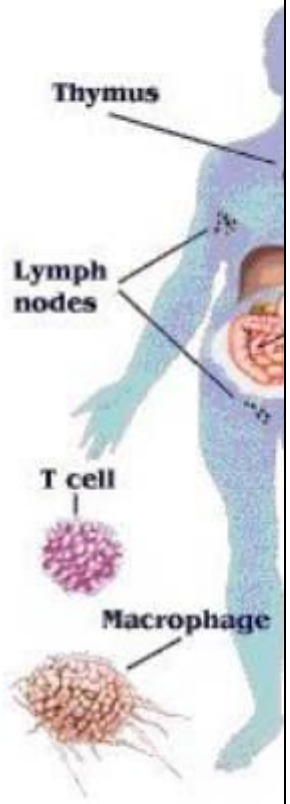
| | | | | |
|---|---|---|---|---|
| Nervous | 1. gathers and interprets information<br>2. responds to information<br>3. helps maintain homeostasis |  | Brain<br>Spinal cord<br>Nerves<br>Nerve cells = neurons<br>hypothalamus | Controls all other systems<br>Hypothalamus – maintains homeostasis by working<br>with all systems |

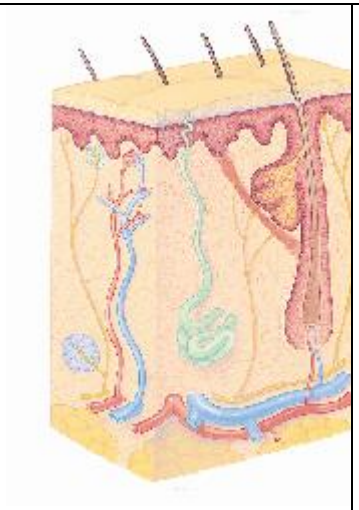
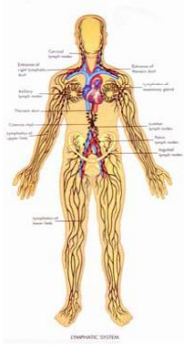
| | | | | |
|---|---|---|---|---|
| Excretory | removes waste products from cellular metabolism (urea, water, CO2)<br>2. filters blood |  | Kidneys<br>Ureters<br>Bladder<br>Urethra<br>Lungs<br>Skin – sweat glands<br>Liver (produces urea) | 1. w/circulatory – filters waste out of blood<br>2. w/lungs – removes excretory waste<br>3. w/integumentary – removes excretory waste |
| Respiratory | Takes in oxygen and removes carbon dioxide and water |  | Nose<br>Trachea<br>Bronchi<br>Bronchioles<br>Alveoli<br>lungs | 1. w/circulatory – takes in O2 for delivery to cells and removes CO2 brought from cells<br>2. w/excretory – removes excretory waste<br>3. w/nervous – controls breathing<br>4. w/muscular – diaphragm controls breathing |

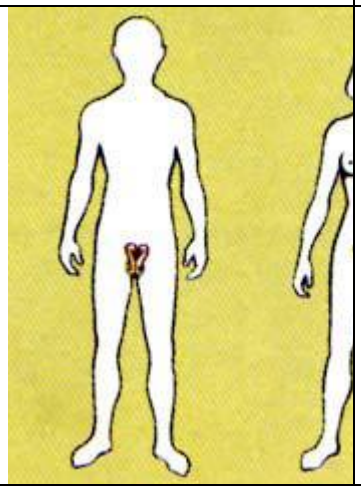
| | | | | |
|---|---|---|---|---|
| Skeletal | 1. protects organs<br>2. provides shape, support<br>3. stores materials (fats, minerals)<br>4. produces blood cells<br>5. allows movement |  | Bones<br>Cartilage<br>ligaments | 1. w/muscular – allow movement<br>2. w/circulatory – produce blood cells<br>3. w/immune – produce white blood cells<br>4. w/circulatory and respiratory – protects it's organs |

| | | | | |
|---|---|---|---|---|
| Muscular | Allows for movement by contracting |  | Cardiac muscle<br>Smooth muscle<br>Skeletal muscle<br>tendons | 1. w/skeletal – allow movement<br>2. w/digestive – allow organs to contract to push<br>food through<br>3. w/respiratory – diaphragm controls breathing<br>4. w/circulatory – controls<br>pumping of blood (heart)<br>5. w/nervous – controls all<br>muscle contractions |

| | | | | |
|---|---|---|---|---|
| Endocrine | Regulates body activities using hormones. Slow response, long lasting |  | Glands<br>*Hypothalamus<br>*Pituitary<br>*Thyroid<br>*Thymus<br>*Adrenal<br>*Pancreas<br>*Ovaries<br>*Testes<br>Glands produce Hormones | 1. w/circulatory – transports hormones to target organs<br>2. w/nervous – maintain homeostasis, hormone release<br>3. w/reproductive – controlled by hormones<br>4. w/skeletal – controls growth of bones |

| | | | | |
|---|---|---|---|---|
| Immune | Fights off foreign invaders in the body |  | White Blood Cells<br>*T cells<br>*B cells<br>-produce antibodies<br>*Macrophages<br>Skin | 1. w/circulatory – transports WBCs to fight invaders<br>2. w/lymphatic – has lots<br>of WBCs to fight invaders, spleen filters bacteria/viruses out of blood<br>3. w/skeletal – WBCs made in bone marrow<br>4. w/integumentary – prevents invaders from getting in |

| | | | | |
|---|---|---|---|---|
| Integumentary | 1. barrier against Infection (1st line of defense)<br>2. helps regulate body temp.<br>3. removes excretory waste (urea, water)<br>4. protects against sun's UV rays<br>5. produces vitamin D |  | SKIN<br>*Epidermis<br>*Dermis<br>- sweat gland<br>- sebaceous gland (oil)<br>- hair follicle<br>- blood vessels<br>- nerves | 1. w/excretory – removes cellular waste<br>2. w/nervous – controls body temperature (sweating, goose bumps)<br>3. w/immune – prevents pathogens from entering |
| Lymphatic | stores and carries WBC's that fight disease<br>2. collects excess fluid and returns it to blood (2nd circulatory system- |  | Lymph (liquid part of blood – plasma, when it's in lymph vessels)<br>Lymph Vessels<br>Lymph Nodes<br>Contain WBCs | 1. w/immune – holds lots of WBCs to fight pathogens<br>2. w/circulatory – to transport materials to and from cells |

| | | | | |
|---|---|---|---|---|
| | reaches places other one can't – between cells) | | | |
| Reproductive | Allows organisms to reproduce which prevents their species from becoming extinct. |  | Ovaries<br>*produce eggs<br>Testes<br>*produce sperm | 1. w/endocrine – controls production of sex cells<br>2. w/muscular – uterus contracts to give birth – controlled by hormones |

| Self-Check -4 | Written Test |
|---|---|

**Directions:** Answer all the questions listed below. Use the Answer sheet provided in the next page:

| **A** | **B** |
|---|---|
| 1. Regulates body activities | A. Skeletal |
| 2. Allows for movement | B. Nervous |
| 3. Protects organ | C. Muscular |
| 4. Takes $o_2$ and removes $Co_2$ | D. respiratory |
| 5. Gathers and interprets information | E. Endocrine |

***Note:*** **Satisfactory rating - 3 points** **Unsatisfactory - below 3 points**

**Answer Sheet**

Score = _____

Rating: _____

Name: _____ Date: _____

**Short Answer Questions**

| Instruction Sheet | LG35: Identify the different types of physiological signals |
|---|---|

**This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:**

- Identifying Different types of Bio-potential signals
- Describing Measurement techniques of bio-potential signals
- Measuring Bio-potential signals

**This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to:**

- Identify Different types of Bio-potential signals
- Describe Measurement techniques of bio-potential signals
- Measure Bio-potential signals

**Learning Instructions:**

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 6.
3. Read the information written in the information “Sheet 1, Sheet 2 and Sheet 3”.in page -3, 6 and 70 respectively.
4. Accomplish the “Self-check 1, Self-check t 2 and Self-check 3” in page -21, 69 and 75 respectively.
5. If you earned a satisfactory evaluation from the “Self-check” proceed to “Operation Sheet 1” in page -76.
6. Do the “LAP test” in page – 77 (if you are ready).

| Information Sheet-1 | Identify Different types of Bio-potential signals |
|---|---|

## 4.1 Identify Different types of Bio-potential signals

### 4.1.1 Introduction to Bio-potential signals

A signal is the function of one or several variables that carries useful information. A signal is said to be biological if it is recorded from a living system and conveys information about the state or behavior of that system. For example, the temperature record of a patient, the voltage record by an electrode placed on the scalp, and the spatial pattern of X-ray absorption obtained from a CT scan are biological signals.

### 4.1.2 **Origin of Biomedical Signals**

Human body is made up of a number of systems e.g- respiratory, cardiovascular, nervous system, etc. Each of these systems is made up of several subsystems that carry on many physiological processes. Each physiological process is associated with certain types of signals referred as Biomedical signals that reflect their nature and activities. Different types of biomedical signals are:

- Biochemical signals e.g. hormones, neurotransmitters
- Bioelectrical signals e.g. potentials, currents
- Biomechanical signals e.g. pressure, temperature

Bioelectric signals are specific types of biomedical signals which are obtained by electrodes that record the variations in electrical potential generated by physiological processes. Examples of bioelectric signals are:

- Electrocardiogram (ECG)
- Electroencephalogram (EEG)
- Electromyogram (EMG)
- Electrooculogram (EOG) among others.

Observing these signals and comparing them to their known norms, any disease / disorder is often detected. When such measurements are observed over a period of time, a one dimensional time-series is obtained which is called a physiological signal. For example, when a person is suffering from a heart problem it means that there are some changes in his electrocardiogram (ECG) or changes in blood pressure. Another example is a Neurological disorder (such as epilepsy) where there are changes in the patient's electroencephalogram (EEG).

### 4.1.3 Commonly Used Biomedical Signals

The signals which are commonly used are:

- The electromyogram (EMG): It is the electrical activity of the muscle cells.
- The electrocardiogram (ECG): It is the electrical activity of the heart /cardiac cells.
- The electroencephalogram (EEG): It is the electrical activity of the brain.
- The electrogastogram (EGG): It is the electrical activity of the stomach.
- The phonocardiogram (PCG): It is the audio recording of the heart's mechanical activity.
- The carotid pulse (CP): It is the pressure of the carotid artery.
- The electoretinogram (ERG): It is the electrical activity of the retinal cells.
- The electrooculogram (EOG): It is the electrical activity of the eye muscles.

The bio-signals of electric origin are made up from integration of many action potentials. The action potential itself is the electric potential which is generated by a single cell when it is mechanically, electrically or chemically stimulated.

### 4.1. 4 The Action Potential

The action potential is referred as the mother of all the biological signals. The action potential (AP) is the electrical signal that accompanies the mechanical contraction of a single cell when stimulated by an electrical current (neural or external). It is caused by the flow of sodium ($Na^+$), potassium ($K^+$), chloride ($Cl^-$) and other ion across the cell membrane. The action potential is the basic component of all bioelectrical signals. It provides information on the nature of physiological activity at the single-cell level. Recording an action potential requires the isolation of a single cell, and microelectrodes with tips of the order of a few micrometers to stimulate the cell and record the response.

The biomedical signals which are generated due to the action potential are ECG, EEG and EMG signals. Co-ordinated electrical events and a specialized conduction system intrinsic and unique to the heart play a major role in the rhythmic contractile activity of the heart. The SA node is the basic, natural cardiac pacemaker that triggers its own train of action

potentials. The action potential of the SA node propagates through the rest of the heart, causing a particular pattern of excitation and contraction, Figure 4.1. The sequence of events and wave in a cardiac cycle is as follows:

The conduction system of the heart is controlled by two nodes known as sinus node (sinusatrial or SA node) and atrioventricular node (AV node).

- The SA node is located in the right atrium at the superior vena cava.
- The SA nodal cells are self-excitatory known as pacemaker cells.
- Pacemaker cells generate an action potential at the rate about 70 per minute. The action potential then propagates from SA node throughout the atria but cannot propagate directly across the boundary between atria and ventricles.
- The AV node is located at the boundary of atria and ventricles. In the normal heart, the AV node provides the propagating path of action potential from atria to ventricles.
- From AV node, the action potential propagate to the ventricles through a specialized conduction system known as 'Bundle of His' which named after German physician, Wilhelm His, Jr. 1893-1934.
- This bundle separates into two: left and right bundle branches. These two branches are then ramifying into purkinje fibers of ventricles.

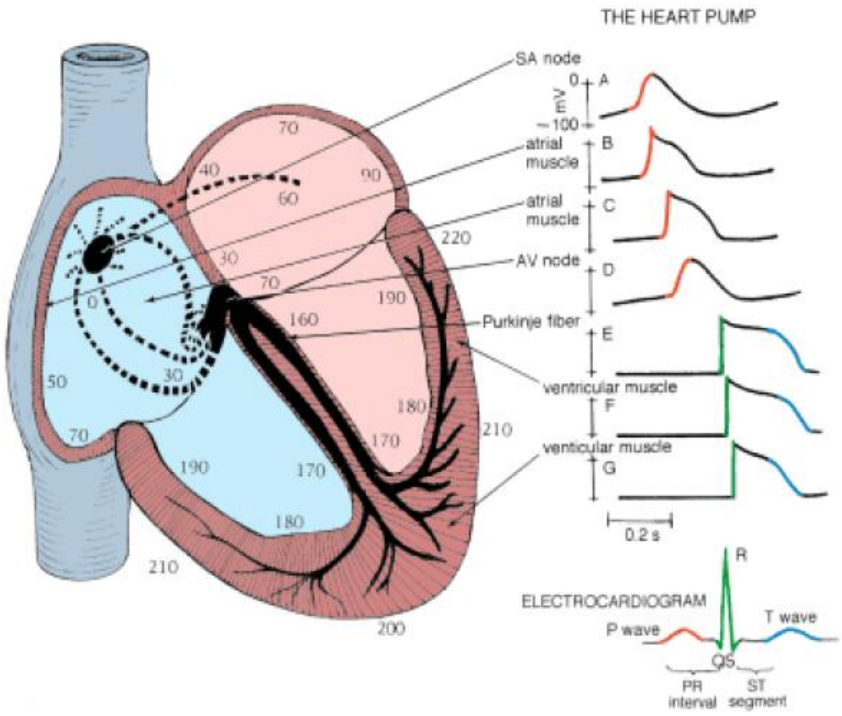



Figure 4.1: The waveform of action potential at different location of the heart

### 4.1. 5. The Electrocardiogram (ECG)

ECG is the graphical recording of the electrical activity of the heart. It is the combination of many Action Potentials from different regions of the heart that makes up the ECG. The electrical surface electrocardiograph (ECG) signal is generated by the heart's muscle and measured on the skin surface of the body. It has a great importance in diagnosis and monitoring of the heart's condition therefore it is the most commonly used signal used for the analysis. The ECG can be measured as a multi- or single- channel signal, depending on the application. During regular measurement of standard clinical ECG, 12 different leads (channels) are recorded from the body surface (skin) of a resting patient.

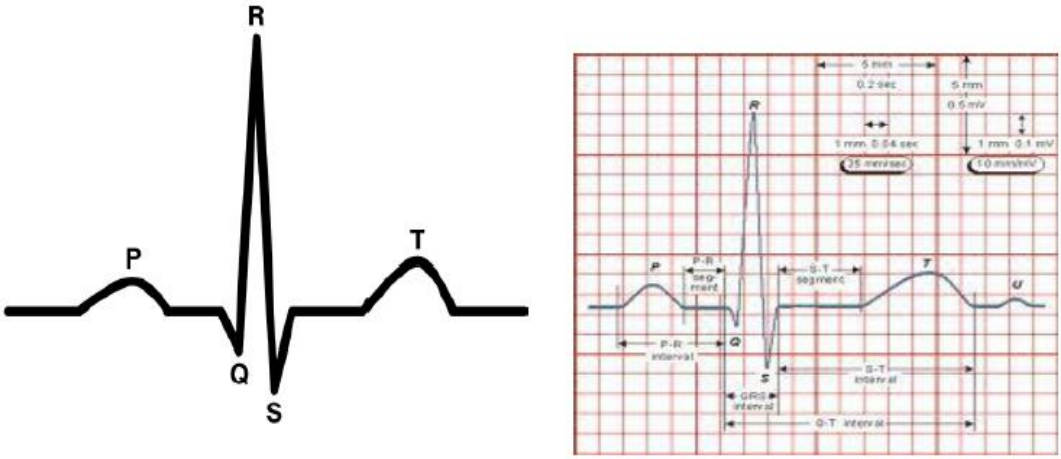



Figure 4.2: The ECG Waveform

General waveform generated is as shown in Figure 4.2 which is labeled as:

- **P wave**: Atrial depolarization
- **QRS complex**: Ventricular depolarization
- **T wave**: Ventricular repolarization
- **U wave**: Repolarization of the Purkinje fibers
- **Baseline**: The polarized state

The following waves and time intervals describe some important characteristics of the ECG signal; for example,

**R-R interval**. The R-R interval, measured between two successive R waves, represents the length of a complete cardiac cycle. It is the fundamental rhythm quantity and is used to characterize different arrhythmias as well as to study the variability of the heart rate.

**QRS-complex**. The QRS-complex reflects the contraction of the right and left ventricles. In a normal heart, the QRS complex lasts for about 70–110msec and is a sharp bi- or tri-phasic wave. The first negative deflection of the QRS complex is the Q-wave, and the first positive is the R-wave, while the negative deflection subsequent to the R-wave is the S-wave. Although the QRS-complex might have less than three individual waves, it is nevertheless called QRS complex. The morphology of the QRS-complex is highly variable and depends on the origin of the heart beat: the duration of the QRS-complex may extend up to 250msec in an abnormally working heart, and it is sometimes composed of more than three waves. The QRS-complex has an amplitude sometimes reaching 2–3mV; it is the largest amplitude of the ECG signal. Due to the steep slopes, the QRS-complex contains frequencies that are considerably higher than frequencies from other ECG waves. Its frequencies are mostly concentrated in the interval 10–50Hz.

**P-wave**. The P-wave reflects the sequential contraction of the left and the right atria. Mostly, the P-wave has positive polarity and smooth monophasic morphology. Its amplitude normally stays below 300 μV, and its duration is less than 120msec. The spectral characteristic of a normal P-wave is usually considered to be low-frequency, below 10–15Hz, but certain advanced signal processing techniques that produce very noise-reduced ECG signals have revealed, that much higher frequency components might exist in a P-wave, especially in some abnormal working-conditions of a heart. Often it is hard to determine the time instants that define the onset and the end of a P-wave because of its low amplitude and smoothness. Consequently, the analysis of individual P-waves is not done in ECG signals having considerable noise.

**T-wave.** The T-wave reflects ventricular relaxation and extends about 300msec after the QRS-complex. The position of the T-wave strongly depends on the heart rate; it becomes narrower and closer to the QRS-complex at high rates. The T-wave is smooth and has an amplitude in the range of 100–300 μV. Its frequency content is similar to that of the P-wave, with an even stronger low-frequency content.

**PQ-Interval.** The PQ-interval is the time interval from the onset of atrial activation to the onset of ventricular activation. The length of the PQ-interval is only weakly dependent on the heart rate.

**QT-Interval.** The QT-interval is the time interval from the onset of the ventricular activation to the completion of ventricular recovery. This interval is normally dependent on the heart rate; it becomes shorter at more rapid rates.

**ECG signal acquisition:** In clinical practice, the standard 12-channel ECG is obtained using four limb leads and chest leads in six positions as shown in Figure 4.3. The right leg is used to place the reference electrode. The left arm, right arm, and left leg are used to get leads I,

II, and III. A combined reference known as *Wilson's central terminal* is formed by combining the left arm, right arm, and left leg leads, and is used as the reference for chest leads. The *augmented* limb leads known as aVR, aVL, and aVF (aV for the augmented lead, R for the right arm, L for the left arm, and F for the left foot) are obtained by using the exploring electrode on the limb indicated by the lead name, with the reference being Wilson' central terminal without the exploring limb lead [197][198].

### 4.1.5.1 Recording of ECG

**The Standard 12-Lead ECG**

- The ECG signal is recorded in three different electrode positions.
- Standard Limb Leads I, II, III (Bipolar Limb Leads)
- Unipolar limb leads (Augmented Limb Leads)
- Unipolar chest leads. a. Standard Limb Leads – I, II, III
- Each lead gives different reading.
- Twelve reading is obtained where 3 from the standard leads, 3 from the unipolar leads and 6 from the chest lead.

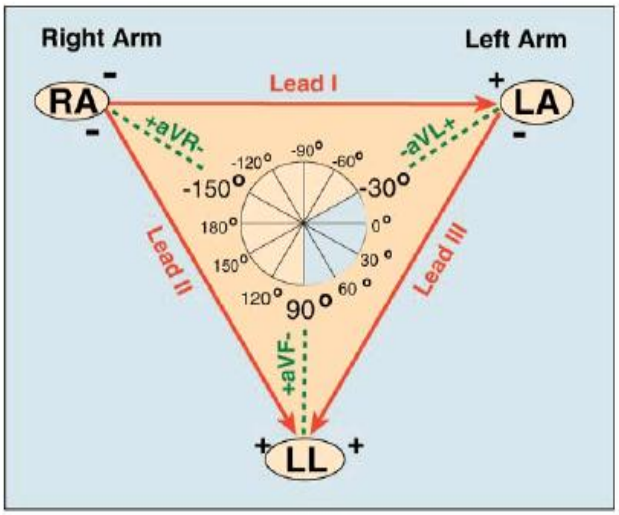



Figure 4.3: The standard 12-Lead ECG

**Bipolar Limb Leads:**

**Standard Limb Leads I, II, III**

The electrode I, II and III is attached to the left arm, right arm and the leg. Each of these leads measures voltage between two points on the body.

- **Lead I**: Measures the voltage between the left arm and right arm in which the left arm is the positive pole. Most useful for seeing electrical activity moving in a horizontal direction.
- **Lead II**: Connects the right arm to the leg, and therefore electricity moving down and leftward.
- **Lead III**: Measure the voltage potential between the left arm and the leg, thus monitors electricity moving down and rightward with the ECG regarded as the positive pole.

**4.1. 6. The Electroencephalogram (EEG)**

Electroencephalography is a medical imaging technique that reads scalp electrical activity generated by brain structures. The EEG (popularly known as *brain waves)* represents the electrical activity of the brain of an alternating type recorded from the scalp surface after being picked up by metal electrodes and conductive media. The EEG measured directly from the cortical surface is called electrocortiogram while when using depth probes it is called electrogram. Thus electroencephalographic reading is a completely non-invasive procedure that can be applied repeatedly to patients, normal adults, and children with virtually no risk or limitation.

When brain cells (neurons) are activated, local current flows are produced. EEG measures mostly the currents that flow during synaptic excitations of the dendrites of many pyramidal neurons in the cerebral cortex. Differences of electrical potentials are caused by summed postsynaptic graded potentials from pyramidal cells that create electrical dipoles between soma (body of neuron) and apical dendrites (neural branches). Brain electrical current consists mostly of Na+, K+, Ca++, and Cl- ions that are pumped through channels in neuron membranes in the direction governed by membrane potential. Only large populations of active neurons can generate electrical activity recordable on the head surface. Between electrode and neuronal layers current penetrates through skin, skull and several other layers. Weak electrical signals detected by the scalp electrodes are massively amplified, and then displayed on paper or stored to computer memory. Due to capability to reflect both the normal and abnormal electrical activity of the brain, EEG has been found to be a very powerful tool in the field of neurology and clinical neurophysiology.

A few important aspects of the organization of the brain are as follows: The main parts of the brain are the cerebrum, the cerebellum, the brain stem (including the midbrain, pons medulla, and the reticular formation), and the thalamus (between the midbrain and the hemispheres). The cerebrum obtains centres for movement initiation, conscious awareness of sensation, complex analysis, and expression of emotions and behavior. It is divided into two hemispheres, separated by a longitudinal fissure across which there is a large connective band of fibers known as the corpus callosum.. The outer surface of the cerebral hemi spheres, known as the cerebral cortex, is composed of neuron (grey

matter) in convoluted patterns, and separated into region by fissure (sulci). The cortex is a dominant part of the central nervous system. Beneath the cortex lie nerve fibers that lead to other part of the brain and the body (white matter). Cortical potentials are generated due to excitatory and inhibitory post-synaptic potentials developed by cell bodies and dendrites of pyramidal neurons. The cerebellum coordinates voluntary movements of muscles and balance maintaining. The brain stem controls respiration, heart regulation, biorythms, neurohormone and hormone secretion, etc. The highest influence to EEG comes from electric activity of cerebral cortex due to its surface position. Physiological control processes, thought processes, and external stimuli generate signals in the corresponding parts of the brain that may be recorded at the scalp using surface electrodes.

### 4.1. 6.1 Brain Waves Classification

Electroencephalogram (EEG) has been long utilized to diagnose different disorders of the nervous system such as epilepsy, classifying stages of sleep in patients, seizures and brain damage. EEG is the electrical activity recorded from the scalp surface, which is picked up by conductive media and electrodes. EEG recordings and the electrical activities collected on the surface of scalp can explain the physiological activities of the brain. Since the non-stationary of the EEG records, it becomes necessary to track the transient changes of the EEG signals to have a further understanding of the different brain functions and their information processing.

The frequency and energy content of EEG signals may contain helpful information about the nature of diseases affecting the brain. For obtaining basic brain patterns of individuals, subjects are instructed to close their eyes and relax. Brain patterns form wave shapes that are commonly sinusoidal. Usually, they are measured from peak to peak and normally range from 0.5 to 100 μV in amplitude, which is about 100 times lower than ECG signals. By means of Fourier transform power spectrum from the raw EEG signal is derived. In power spectrum contribution of sine waves with different frequencies are visible. Although the spectrum is continuous, ranging from 0 Hz up to one half of sampling frequency, the brain state of the individual may make certain frequencies more dominant. The frequency range of the EEG has a fuzzy lower and upper limit, but the most important frequencies from the physiological viewpoint lie in the range of 0.1 to 30 Hz. The standard EEG clinical bands are the delta, theta, alpha, and beta bands. EEG signals with frequencies greater than 30 Hz are called gamma waves. The commonly used terms for EEG frequency bands whose sample is shown in Figure 2.4.

• Delta (δ): $0.5 \leq f < 4$ *Hz;*
• Theta (θ): $4 \leq f < 8$ *Hz;*
• Alpha (α): $8 \leq f \leq 13$ *Hz:* and
Beta (β): $f > 13$ *Hz.*

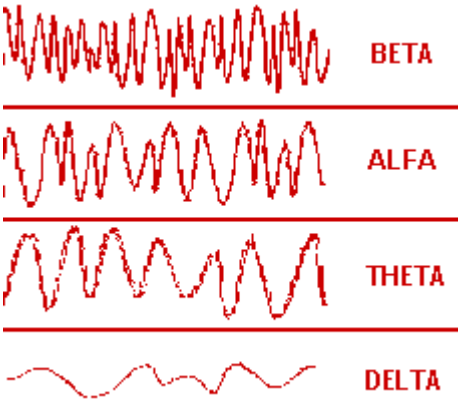



Figure 4.4: Brain wave samples with dominant frequencies belonging to beta, alpha, theta, and delta band.

The best-known and most extensively studied rhythm of the human brain is the normal alpha rhythm. Alpha can be usually observed better in the posterior and occipital regions with typical amplitude about 50 μV (peak-peak). Alpha activity is induced by closing the eyes and by relaxation, and abolished by eye opening or alerting by any mechanism (thinking, calculating). Most of the people are remarkably sensitive to the phenomenon of “eye closing”, i.e. when they close their eyes their wave pattern significantly changes from beta into alpha waves. The precise origin of the alpha rhythm is still not known. Alpha waves are usually attributed to summated dendrite potentials. Evoked potentials (e.g. generated in brain stem) often consist of fibre potentials (axonal) and synaptic components. The alpha rhythm is the principal resting rhythm of the brain, and is common in wakeful, resting adults, especially in the occipital area with bilateral synchrony. Auditory and mental arithmetic task with the eye closed lead to strong alpha waves, which are suppressed when the eye are opened (that is, by a visual stimulus).

Various regions of the brain do not emit the same brain wave frequency simultaneously. An EEG signal between electrodes placed on the scalp consists of many waves with different characteristics. A large amount of data received from even one single EEG recording presents a difficulty for interpretation. Individual’s brain wave patterns are unique. In some cases, it is possible to distinguish persons only according to their typical brain activity.

The alpha wave is replaced by slower rhythms at various stages of sleep. Theta waves appear at the beginning stage of sleep; delta waves appear at deep-sleep stage. High-frequency beta wave appears a background activity in tense and anxious subjects. The depression or absence of the normal (expected) rhythm in a certain state of the subject could indicate abnormality, The presence of delta or theta (slow) waves in a wakeful adult would be considered to be abnormal. Focal brain injury and tumors lead to abnormal slow waves in the corresponding regions. Unilateral depression (left - right asymmetry) of a rhythm could

indicate disturbances in conical pathways. Spikes and sharp waves could indicate the presence of epileptogenic regions in the corresponding pans of the brain [198].

### 4.1.6.2 Recording Electrodes and Recording of EEG

The EEG recording electrodes and their proper function are critical for acquiring appropriately high quality data for interpretation. Many types of electrodes exist, often with different characteristics. Basically there are following types of electrodes:

- Disposable (gel-less, and pre-gelled types)
- Reusable disc electrodes (gold, silver, stainless steel or tin)
- Headbands and electrode caps
- Saline-based electrodes
- Needle electrodes

For multichannel montages, electrode caps are preferred, with number of electrodes installed on its surface. Commonly used scalp electrodes consist of Ag-AgCl disks, 1 to 3 mm in diameter, with long flexible leads that can be plugged into an amplifier. AgCl electrodes can accurately record also very slow changes in potential. Needle electrodes are used for long recordings and are invasively inserted under the scalp.

In 1958, International Federation in Electroencephalography and Clinical Neurophysiology adopted standardization for electrode placement called 10-20 electrode placement system. This system standardized physical placement and designations of electrodes on the scalp. The head is divided into proportional distances from prominent skull landmarks (nasion, preauricular points, inion) to provide adequate coverage of all regions of the brain. Label 10-20 designates proportional distance in percents between ears and nose where points for electrodes as shown in Figure 4.5 are chosen. Electrode placements are labeled according adjacent brain areas: F (frontal), C (central), T (temporal), P (posterior), and O (occipital). The letters are accompanied by odd numbers at the left side of the head and with even numbers on the right side. Left and right side is considered by convention from point of view of a subject.

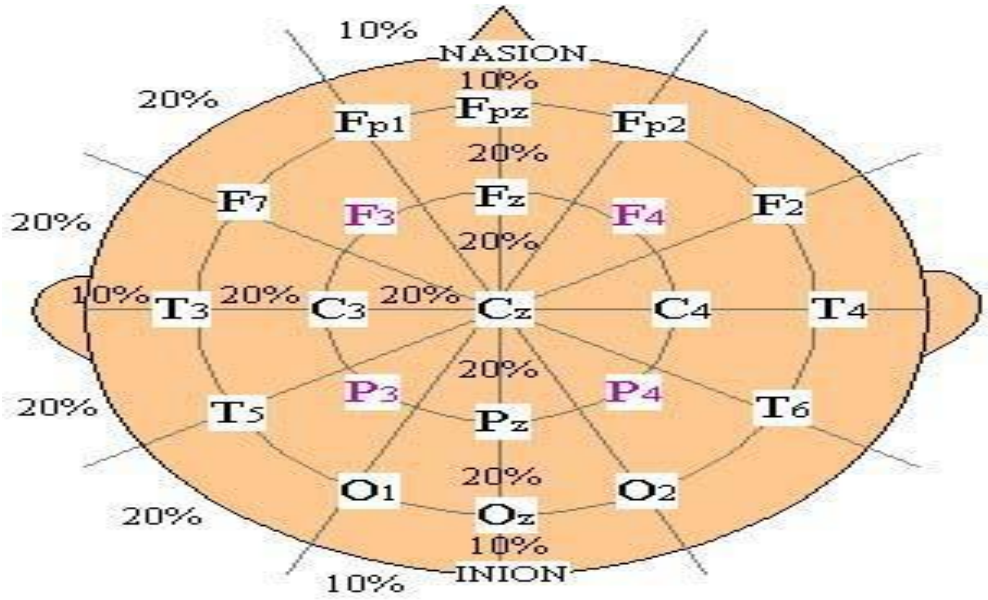



Figure 4.5: Labels for points according to 10-20 electrode placement system.

As it is known from tomography different brain areas may be related to different functions of the brain. Each scalp electrode is located near certain brain centres, e.g. F7 is located near centres for rational activities, Fz near intentional and motivational centres, F8 close to sources of emotional impulses. Cortex around C3, C4, and Cz locations deals with sensory and motor functions. Locations near P3, P4, and Pz contribute to activity of perception and differentiation. Near T3 and T4 emotional processors are located, while at T5, T6 certain memory functions stand. Primary visual areas can be found bellow points O1 and O2. However the scalp electrodes may not reflect the particular areas of cortex, as the exact location of the active sources is still open problem due to limitations caused by the non-homogeneous properties of the skull, different orientation of the cortex sources, coherences between the sources, etc.[197]

EEG signals exhibit several patterns of rhythmic or periodic activity. (Note: The term *rhythm* stands for different phenomena or events in the ECG and the EEG.). Figure 4.6 illustrates a four second sample of an EEG data.

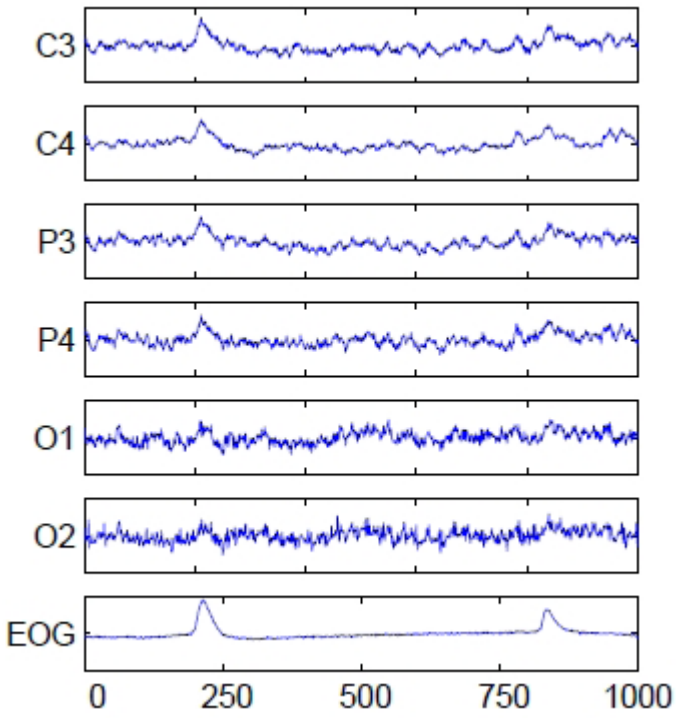



Figure 4.6: A four second sample of an EEG data

### 4.1.7 The Electromyogram (EMG)

Movement and position of limbs are controlled by electrical signals traveling back and forth between the muscles and the peripheral and central nervous system. When pathologic conditions arise in the motor system, whether in the spinal cord, the motor neurons, the muscle, or the neuromuscular junctions, the characteristics of the electrical signals in the muscle, change. Careful registration and study of electrical signals in muscle (electromyograms) can thus be a valuable aid in discovering and diagnosing abnormalities not only in the muscles but also in the motor system as a whole. Electromyography (EMG) is the registration and interpretation of these muscle action potentials. It is the study of muscle function through analysis of the electrical signals emanated during muscular contractions.

In 1849, Dubios-Raymond discovered that it was also possible to record electrical activity during a voluntary muscle contraction. The first recording of this activity was made by Marey in 1890, who also introduced the term electromyography [21]. In 1922, Gasser and Erlanger used an oscilloscope to show the electrical signals from muscles. Because of the stochastic nature of the myoelectric signal, only rough information could be obtained from its observation [133]**.** The EMG, a high frequency component, is due to the random contraction of muscles, while the abrupt transients are due to sudden movement of the body [111]**.** Electromyography (EMG) signals can be employed for clinical and biomedical applications.

Electromyography is measuring the electrical signal associated with the activation of the muscle. This may be voluntary or involuntary muscle contraction. The EMG activity of

voluntary muscle contractions is related to tension. The functional unit of the muscle contraction is a motor unit, which is comprised of a single alpha motor neuron and all the fibers it enervates. This muscle fiber contracts when the action potentials (impulse) of the motor nerve which supplies it reaches a depolarization threshold. The depolarization generates an electromagnetic field and the potential is measured as a voltage. The depolarization, which spreads along the membrane of the muscle, is a muscle action potential. The motor unit action potential is the spatio and temporal summation of the individual muscle action potentials for all the fibers of a single motor unit.

Therefore, the EMG signal is the algebraic summation of the motor unit action potentials within the pick-up area of the electrode being used. The pick-up area of an electrode will almost always include more than one motor unit because muscle fibers of different motor units are intermingled throughout the entire muscle. Any portion of the muscle may contain fibers belonging to as many as 20-50 motor units. A single motor unit can have 3-2,000 muscle fibers. Muscles controlling fine movements have smaller numbers of muscle fibers per motor units (usually less than 10 fibers per motor unit) than muscles controlling large gross movements (100-1,000 fibers per motor unit).

There is a hierarchy arrangement during a muscle contraction as motor units with fewer muscle fibers are typically recruited first, followed by the motor units with larger muscle fibers. The number of motor units per muscle is variable throughout the body. When stimulated by a neural signal, each motor unit contracts and causes an electrical signal that is the summation of the action potentials of all of its constituent cells. This is known as the *single-motor-unit action potential* (SMUAP, or simply MUAP), and may be recorded using needle electrodes inserted into the muscle region of interest, Normal SMUAPs are usually biphasic or triphasic. 3 - 15 *ms* in duration, 100 - 300 *J.LV* in amplitude, and appear with frequency in the range of 6 - 30/8. The shape of a recorded SMUAP depends upon the type of the needle electrode used, its positioning with respect to the active motor unit, and the projection of the electrical field of the activity onto the electrodes.

Although the SMUAP are biphasic or triphasic, the same SMUAP displays variable shape from one channel to another. The shape of SMUAPs is affected by disease. Neuropathy causes slow conduction and/or desynchronized activation of fibers, and a polyphasic SMUAP with an amplitude larger than normal. The same motor unit may be observed to fire at higher rates than normal before more motor units are recruited. Myopathy involves loss of muscle fibers in motor units, with the neurons presumably intact. Splintering of SMUAP occurs due to asynchrony in activation as a result of patchy destruction of fibers (e.g. muscular dystrophy), leading to polyphasic SMUAP. More motor units may be observed to be recruited at low levels of effort.

**Gradation of muscular contraction**

Muscular contraction levels are controlled in two ways:

• Spatial recruitment, by activating new motor units with increasing effort: and

• Temporal recruitment, by increasing the frequency of discharge (firing rate) of each motor unit with increasing effort.

Motor units are activated at different time and at different frequencies causing asynchronous contraction. The twitches of individual motor unit sum and fuse to form tetanic contraction and increased force. Weak volitional effort causes motor units to fire at about 5 - 15 pps (pulses per second). As greater tension is developed, an interference pattern EMG is obtained, with the constituent and active motor units firing in the range of 25 - 50 pps. Grouping of MUAP has been observed as fatigue develop, leading to decreased high-frequency content and increased amplitude in the EMG.

Spatio-temporal summation of the MUAP of the entire active motor unit gives rise to the EMG of the muscle. EMG signal recorded using surface electrodes are complex signals including interference patterns of several MUAP train and are difficult to analyze. An EMG signal as shown in Figure 4.7 indicates the level of activity of a muscle and may be used to diagnose neuromuscular diseases such as neuropathy and myopathy.

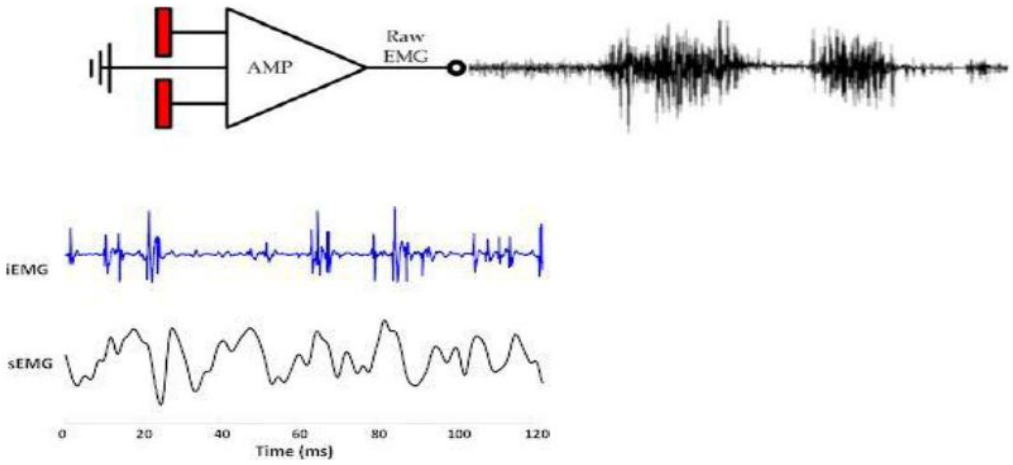



Figure 4.7: EMG Signal

### 4.1. 7.1 Recording of EMG

A considerable amount of information regarding the bioelectrical state of a muscle is hidden in the time-varying spatial distribution of potentials in the muscle. Unfortunately, it is not clinically feasible to obtain high-resolution three-dimensional samples of the spatial potential distribution, since this would require the insertion of hundreds of electrodes into the muscles. In order to minimize the discomfort of the patient, routine EMG procedures usually employ only a single electrode that is inserted into different regions of the muscle. As the SFAPs (Single Fibre Action Potential) of an active motor unit pass by the electrode, only their summation, i.e., the MUP, will be registered by the electrode. The electrode is effectively

integrating out the spatial information hidden in the passing potential complex, leaving only a time-variant potential waveform to be recorded and interpreted. It goes without saying that such a constraint on the recording procedure puts the electromyographist at a considerable disadvantage. To partially circumvent this setback, technical innovations and new procedures have continued to refine EMG examinations to such a level that some of the spatial information originally obscured by the electrode can be extracted intuitively from the temporal waveforms by an experienced electromyographist. With a detailed understanding of the bioelectric principles involved, e.g., the bioelectric sources, the volume conductor, and the recording properties of the electrode, the electromyographist can quickly recognize and explain the waveform characteristics associated with various neuromuscular abnormalities. To increase the amount of diagnostic information, several sets of EMG investigations may be performed using electrodes with different recording characteristics. Figure 4.8 illustrates three of the most popular EMG needle electrodes. The concentric and monopolar electrodes have an intermediate pickup range and are used in conventional recordings. The single-fiber electrode is a more recent innovation. It has a very small pickup range and is used to obtain recordings from only one or two muscle fibers. The macro electrode, which is the cannula of either the concentric or single-fiber electrode in combination with a remote reference electrode, picks up potentials throughout the motor unit territory.

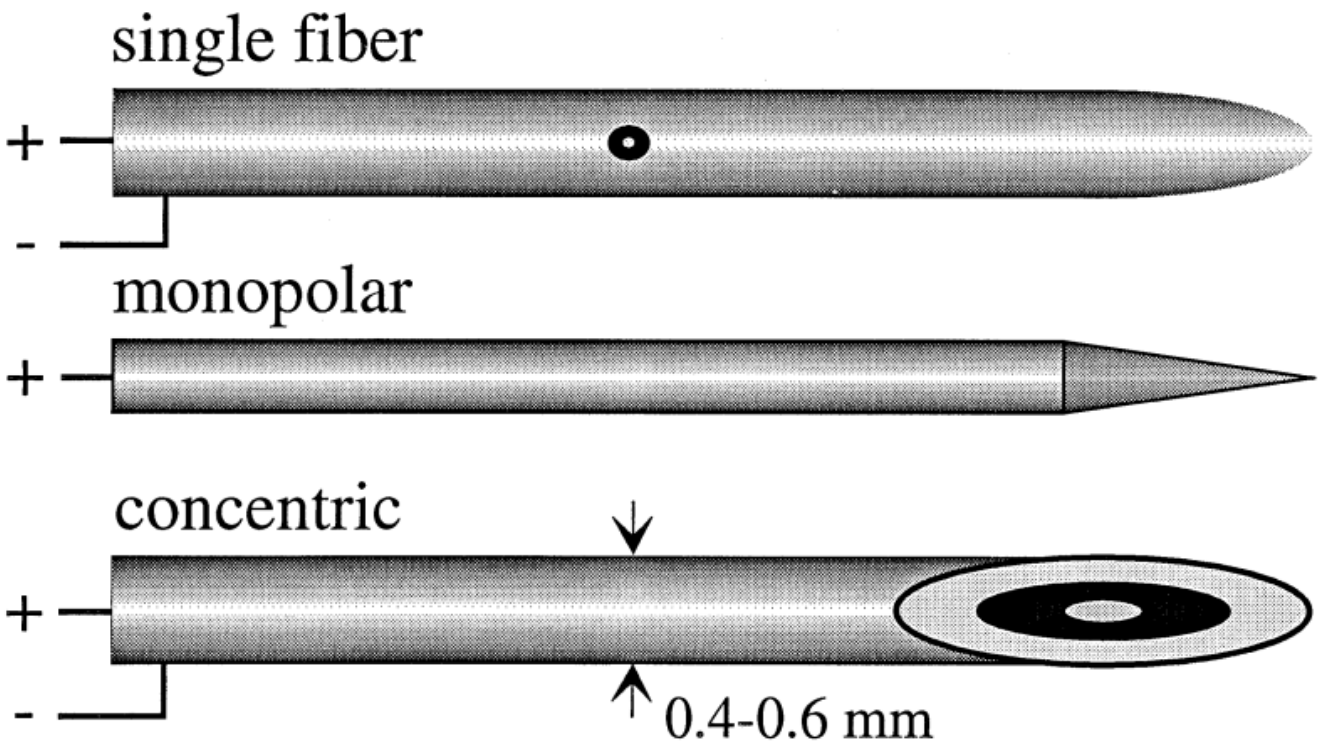


Figure 4.8 Electrodes used for Electromyography

At present, there are three common applications of the EMG signal, first, determining the activation timing of the muscle; that is, when the excitation to the muscle begins and ends; second, estimating the force produced by the muscle; third, obtaining an index of the rate at which a muscle fatigues through the analysis of the frequency spectrum of the signal [133]**.**

Electromyography (EMG) signals in multifunction upper limb prosthesis control are normally collected by surface electrode for simplicity and convenience. However, they also contain non-invasive characteristic that usually induce some noises. EMG signal denoising based on wavelet transform is a useful tool to remove noises in myoelectric recognition [122].

### 4.1.8. Electroretinogram (ERG)

Electroretinogram is another helpful technique to study electrical response of retina human eye. It helps in diagnosing status of retina in case of eye diseases. When a light stimulus is applied through LED or strobe lamp, an electrical activity takes place in neural and non-neural cells of retina. This produces a biphasic waveform comprising of three important waves known as

- a-wave
- b-wave
- c-wave

Due to sodium ion channel closure in outer membrane, there exists hyperpolarization of photo receptors. a- waves are reflected from rods and cones of outer photoreceptor layers of the retina. When a light stimulus is applied on the retina, rhodopsin gets triggered leading to activation of transducin. This further activates cyclic guanosine monophosphate phosphodiesterase(cGMP). cGMP helps sodium ions to move inside the membrane. a waves are negative in nature and are measured from baseline to trough of a wave. b-waves are positive corneal deflection from inner retina. Due to hyperpolarization of photoreceptors, there is decrease in number of sodium ions. This leads to depolarization of bipolar cells which further increases amount of potassium ions. This balancing of sodium and potassium ions across the cell membrane generates current. These are measured from trough of a-wave to the peak of b-wave.

c-waves are result of pigments of retina i.e. epithelium and photoreceptors

ERG is helpful in diagnosing retinitis pigmentosa, cone dystrophy, choroideremia.

### 4.1.9. Electrooculogram (EOG)

Electrooculography is one of great medical technique in which electrodes are placed on forehead near the eyes to record eye movements. It records the resting potential between cornea and retina known as corneal retinal potential.

Electrically active nerves in the eye produce potential difference. Cornea are said to be positive while retina is negative, as a whole eye acts as dipole. Eye movements can be

recorded by placing electrodes either left or right of eye or above and below eye. When eye moves towards one of the electrode it is positive side of retina and to the other electrode it is negative side. Eye movement gives the positive and negative impulses due to presence of action potential which is about -0.06 to +0.06 volt. Four to five electrodes are used to record EOG signal. Two of them are placed on sides of eye to detect horizontal movement while other two are placed above and below to detect vertical movement. EOG is used in ophthalmological diagnosis.

**4.1.10 Mechanomyogram (MMG)**

Mechanomyogramis: a technique that uses mechanical signal to observe muscle activity. When a muscle is contracted, a peak is experienced in a MMG signal. As we know a muscle is combination of millions of muscle fibers. When these fibers are oscillated, vibration is experienced in muscles. In this technique, electrodes are placed over the skin surface. These vibrations create pressure wave showing muscle activity. An MMG signal can be recorded using an accelerometer or microphone, piezo electric contact sensors.

MMG is used to find muscular pain, fatigue, diseases etc.

**4.1.11. Magnetoencephalography (MEG)**

It is one of popular technique to record neuronal brain activity. Brain consists of millions of neurons that are responsible for transmission and reception of information from body. Neurons of brain undergo ions exchange chemically that creates a magnetic field across the cell membrane. Axon of the neuron has bidirectional current hence two dipoles of opposite polarity exist. This leads to cancellation of magnetic field. Post synapses of neurons have unidirectional current. Hence magnetic field persists here. Magnetic field of a single neuron cannot be measured so neurons of same spatial orientation are taken together and their combined magnetic field is measured using sensitive magnetometers. Superconducting quantum interference devices commonly known as SQUIDs are best suited to measure MEG signal. MEG provides high spatial and temporal resolution.

MEG is used to study brain processes, parts of brain, neuro feedback etc.

| Self-Check -1 | Written Test |
|---|---|

**Directions:** Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. Which of the following signal is a biomedical signal?(2pts)

   A. Biochemical signal B. Bioelectrical signal C, Biomechanical signal

   D. All E. None

2. A device/machine used to measure audio recording of the heart's mechanical activity(2pts)

   A. ECG B. PCG C. EGG D. EOG E. All

3. SA node is located (2pts)

   A. right atrium B. right ventricular C. left atrium D. left ventricular

***Note:*** **Satisfactory rating - 3 points** **Unsatisfactory - below 3 points**

**Answer Sheet**

Score = _____

Rating: _____

Name: _____ Date: _____

**Short Answer Questions**

| Information Sheet-2 | **Describing Measurement techniques of bio-potential signals** |
|---|---|

**4.2 Describe Measurement techniques of bio-potential signals**

**What are resting and action potential, bio electric potential?**

The membrane potential caused by the different concentration of ions is called resting potential. It is caused by very rapid change of membrane Permeability to sodium ions followed by recovery period.
The positive potential of the cell membrane during excitation is called action potential. Certain systems of the body generate their own monitoring signals conveying useful information about the functions they represent. Such signals are bio electric potentials and are related to nerve conduction, brain activity, heart beat etc.

**The basic requirements of measurement**

The standard used for comparison purpose must be accurately defined and should be commonly accepted. The apparatus used and the method adopted must be provable.

**Methods for measurement**

1. Direct method and 2. Indirect method

**The function of measurement system**

The measurement system consists of a transuding element which converts the quantity to be measured in an analogous form the analogous signal is then processed by some intermediate means and is then fed to the end device which presents the results of the measurement.

**Define Instrument**

Instrument is defined as a device for determining the value or magnitude of a quantity or variable.

**Types of instruments**

The 3 types of instruments are
1) Mechanical Instruments 2) Electrical Instruments and
3) Electronic Instruments

**Classification of instruments**

1) Absolute Instruments 2) Secondary Instruments

**Action Potential**

Cell has a slightly positive potential on the inside due to imbalance of potassium ions. This positive potential of the cell membrane during excitation is called Action Potential and is about 20 mV.

**Factors to be considered when we design any medical Instrument**

Accuracy, Frequency Response, Linearity, S/N ratio, Stability, sensitivity

**Electrode Potential**

The voltage developed at an electrode-electrolyte interface is known as Electrode Potential.

**The purpose of electrode paste**

The electrode paste decreases the impedance of the contact the artifacts resulting from the movement of the electrode or patient.

**Different types of electrodes**

Microelectrodes, Depth and needle electrodes, Surface electrodes

**The different types of Surface electrodes**

1) Metal Plate electrodes 2) Suction cup electrodes
3) Adhesive tape electrodes 4) Multi point electrodes
5) Floating electrodes.

**PH electrode**

The chemical balance of human body is identified by measurement of Ph content of blood and other body fluids. PH is defined as logarithm of reciprocal of hydrogen ion concentration.

**Polarized and non-polarized electrode**

An electrode in which no net transfer of charge occurs across the metal electrolyte interface is called as perfectly polarized electrodes. Electrodes in which un hindered exchange of charge occurs across the metal electrode interface is called perfectly non polarizable electrodes.

**Nernst Equation:**

When two aqueous ionic solutions of different concentration are separated by an ion-selective semipermeable membrane, an electric potential exists across the membrane.

The Nernst equation for half-cell potential is

$$E = E^0 + \frac{RT}{nF} \ln\left[\frac{a_C^{\gamma} a_D^{\delta}}{a_A^{\alpha} a_B^{\beta}}\right]$$

Where E0: Standard Half Cell Potential E: Half Cell Potential

a: Ionic Activity (generally same as concentration)

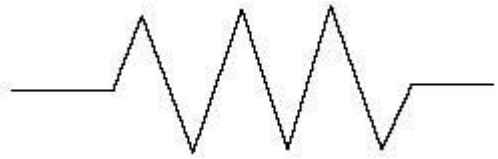
n: Number of valence electrons involved

**Perfectly Polarizable Electrodes**

These are electrodes in which no actual charge crosses the electrode-electrolyte interface when a current is applied. The current across the interface is a displacement current and the electrode behaves like a capacitor. Example: Ag/AgCl Electrode

**Perfectly Non-Polarizable Electrode**

These are electrodes where current passes freely across the electrode-electrolyte interface, requiring no energy to make the transition. These electrodes see no Over potentials.



Example: Platinum electrode

**Equivalent Circuit**

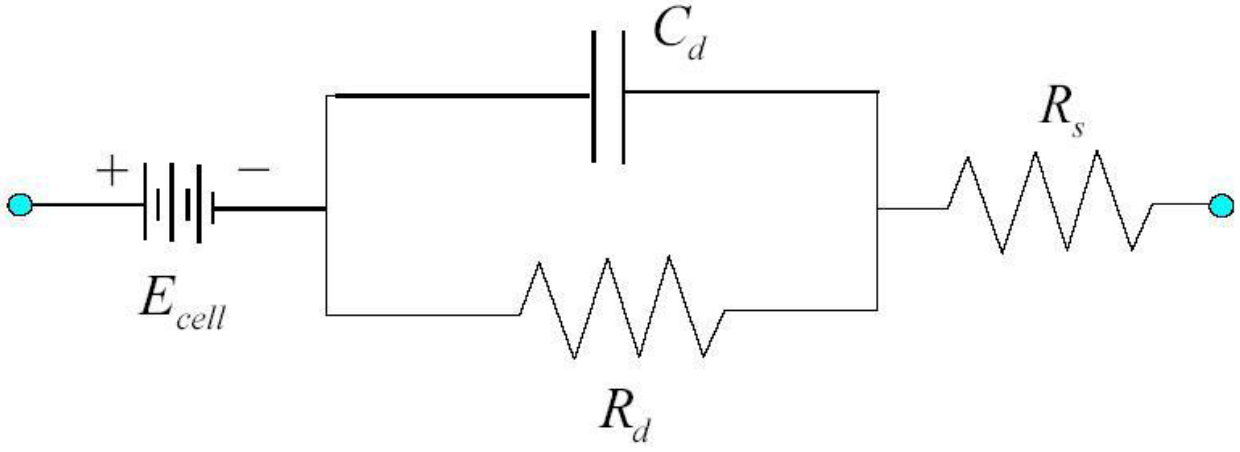


Figure 2.1 Platinum electrodes

*Cd:* capacitance of electrode-electrolyte interface
*Rd:* resistance of electrode-electrolyte interface
*Rs:* resistance of electrode lead wire
*Cell:* cell potential for electrode

**Half Cell Potential**

A characteristic potential difference established by the electrode and its surrounding electrolyte which depends on the metal, concentration of ions in solution and temperature (and some second order factors) .

**Half-cell potential cannot be measured without a second electrode.**

The half-cell potential of the standard hydrogen electrode has been arbitrarily set to zero. Other half cell potentials are expressed as a potential difference with this electrode.

**Reason for Half Cell Potential: Charge Separation at Interface**

Oxidation or reduction reactions at the electrode-electrolyte interface lead to a double-charge layer, similar to that which exists along electrically active biological cell membranes.

**Measuring Half Cell Potential**

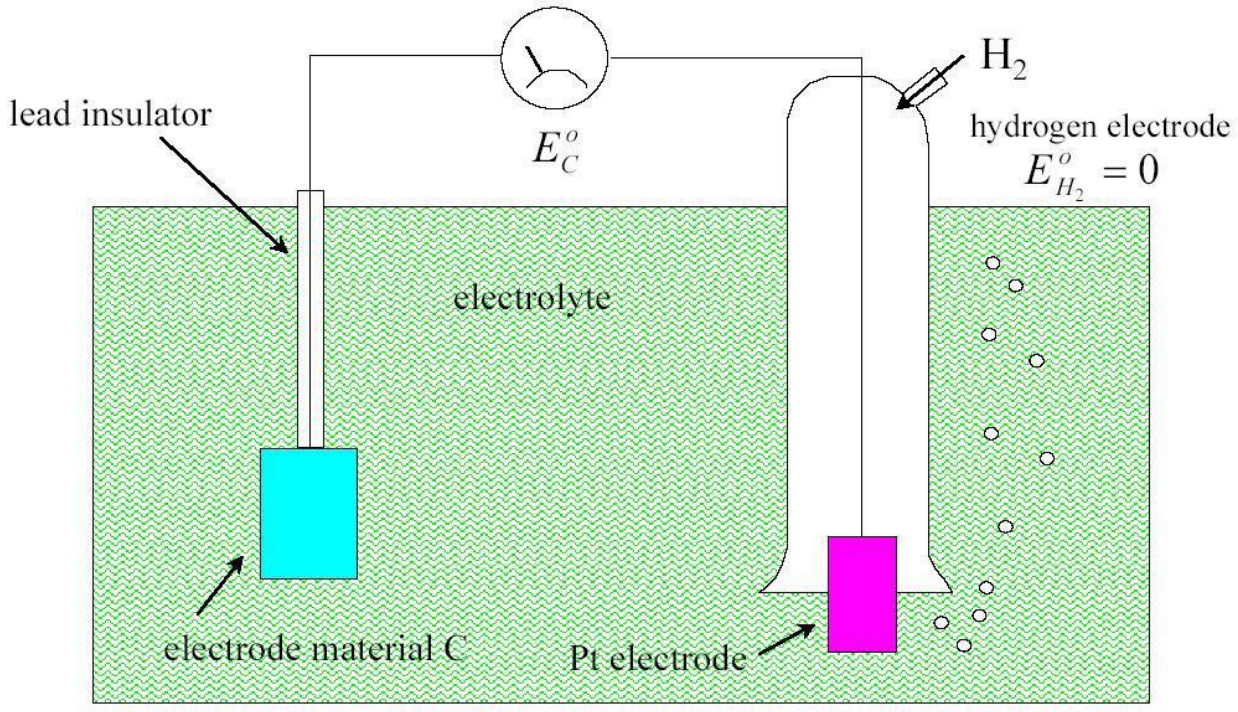



**Figure 2.2 Measuring Half Cell Potential**

**Basic types of bio potential electrodes and their applications**

Metal plate electrodes
– Large surface: Ancient, therefore still used, ECG
– Metal disk with stainless steel; platinum or gold coated
– EMG, EEG
– Smaller diameters

– Motion artifacts
– Disposable foam-pad: Cheap

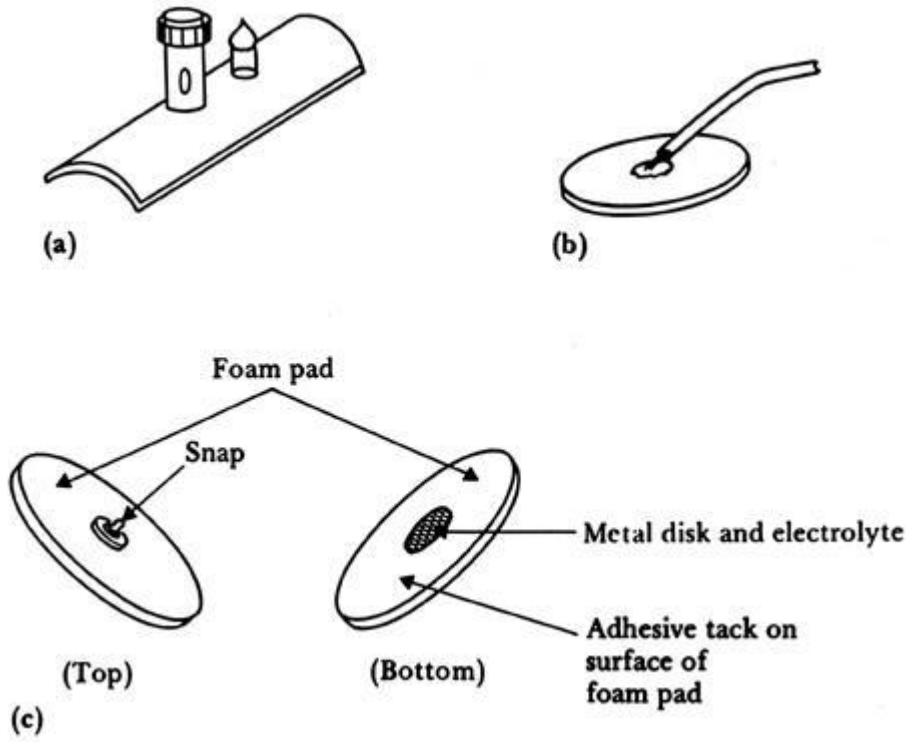



Figure2.3 Types of Metal plate electrode
(a) Metal-plate electrode used for application to limbs.
(b) Metal-disk electrode applied with surgical tape.
(c)Disposable foam-pad electrodes, often used with ECG

**Suction electrodes**

- No straps or adhesives required
- Precordial (chest) ECG
- can only be used for short periods

**Floating electrodes**

- Metal disk is recessed
- swimming in the electrolyte gel
- Not in contact with the skin
- reduces motion artifact

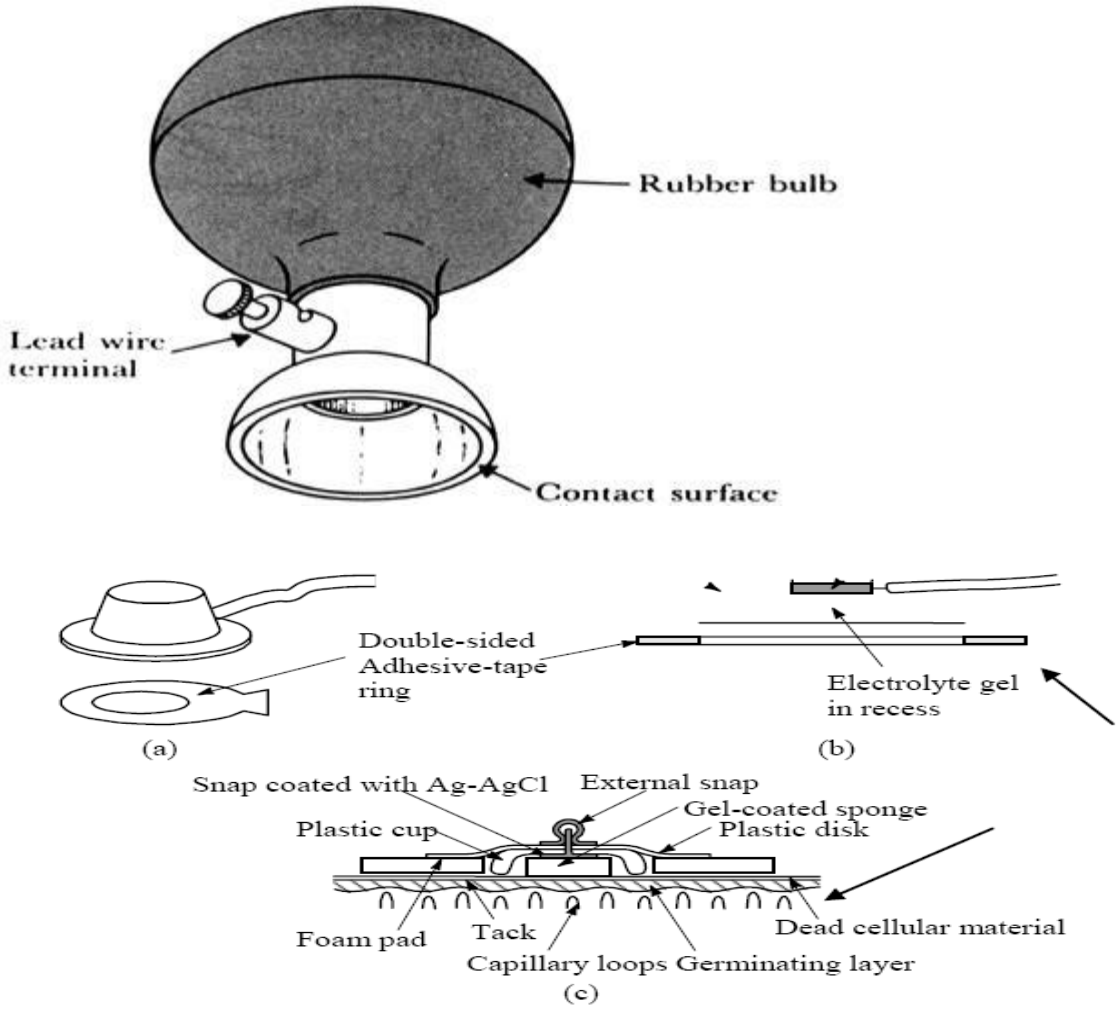



**Figure2.4 Metal plate electrode detail**

**Flexible electrodes**

- Body contours are often irregular
- Regularly shaped rigid electrodes may not always work.
- Special case : infants
- Material

Polymer or nylon with silver

- Carbon filled silicon rubber (Mylar film)

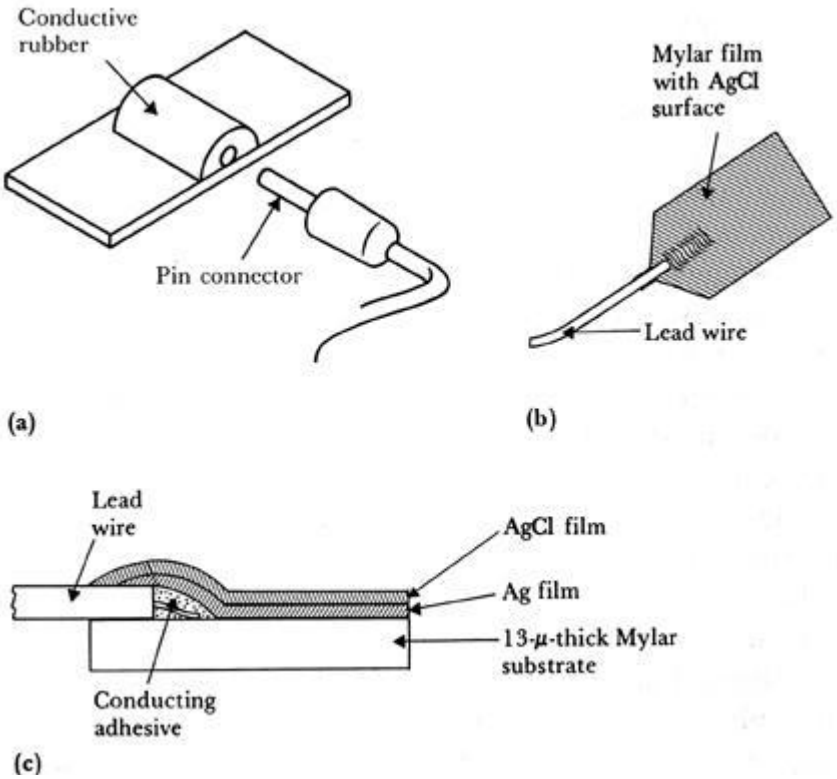


Figure 2.5 cross-sectional of electrode
(c) Cross-sectional view of the thin-film electrode in (b).

**Bio potential amplifiers**

• These are very important part of modern medical instrumentation

• We need to amplify bio potentials which are generated in the body at low levels with high source impedance

• Bio potentials amplifiers are required to increase signal strength while maintaining fidelity

**Basic Requirements of Bio potential Amplifiers**

Essential functions of a bio amplifier are:

• To take a weak bio potential and increase its amplitude so that it can be processed, recorded or displayed

• To amplify voltage, but it could be considered as a power amplifier as well

• To amplify current since in some cases a bio potential amplifier is used to isolate the load from the source

- current gain only

**Input Impedance (Zin)**

• All bio potential amplifiers must have **high input impedance**

- minimize loading (remember the characteristics of bio potential electrodes resulting into loading and distortion if input impedance of the amplifier is not high enough) – typical values of Zin over the frequency range of the measurand = 10 MΩ (remember the loading rule)

**Protection & Isolation**

• The input circuit of a bio potential amplifier must provide protection to the live measurand

• Any potential or current at amplifier's input terminals can affect

• Electric currents produced by the bio potential amplifier can result in micro shock and macro shock

• The bio amplifier must have isolation and protection circuitry so that the current through the electrodes can be kept at safe levels and any artifact generated by such current can be minimized

**Output Impedance (Zout)**

• The output circuit does not present any critical problems, all it needs to do is to drive the load

• **Output impedance must be low** with respect to the load impedance and it must be capable of satisfying the power requirements of the load

**Bandwidth (BW)**

**Frequency response** requirements

• The bio potential amplifier must be sensitive to important frequency components of the bio signal

• Since bio potentials are low level signals, it is important to limit bandwidth optimize signal-to-noise ratio

**Gain (G)**

• Bio potential amplifiers have a gain of **1000** or greater

**Mode of Operation**

• Very frequently bio signals are obtained from bipolar electrodes

• Electrodes **symmetrically located with respect to ground** need differential amplification

• High **CMRR** required because:

1. Common mode signals much greater than the bio signal appear on bipolar electrodes
2. Symmetry with respect to ground is not perfect (mismatch between electrode impedances) – more on this later

**Calibration Signal**

- Medical and clinical equipment require quick calibration
- The gain of the bio potential amplifier must be calibrated to provide us with an accurate indication of the signal's amplitude
- Push button to apply standard signal to the input of the bio potential amplifier
- Adjustable gain switch carefully selects calibrated fixed gains (in microprocessor–based systems, gain adjustment)

**The typical ECG waveform with its characteristics**

**Electrocardiography**

♥ a very widely used medical instrument, which is utilized to diagnose and monitor cardiac beat abnormalities, is the Electrocardiograph

♥ It measures the electrical activity of the heart (more precisely bio potential differences arising from the electrical activity of myocardium). We've already talked about the genesis of the ECG signal.

♥ The ECG machine uses surface electrodes and high input impedance

♥ Differential amplifiers with good common mode rejection ratio to record the electrocardiogram

♥ Normal ECG amplitude ranges between 0.5-4 mV. Normal frequency content of ECG (for diagnostic purposes) is 0.05-100 Hz. A typical ECG waveform is shown below:

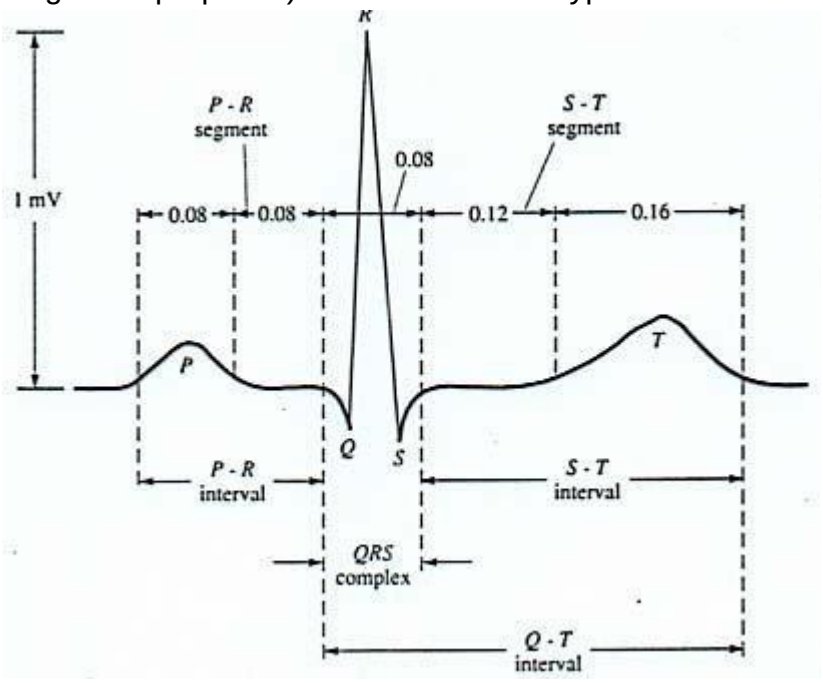



Figure2.6 ECG Bio potential signal

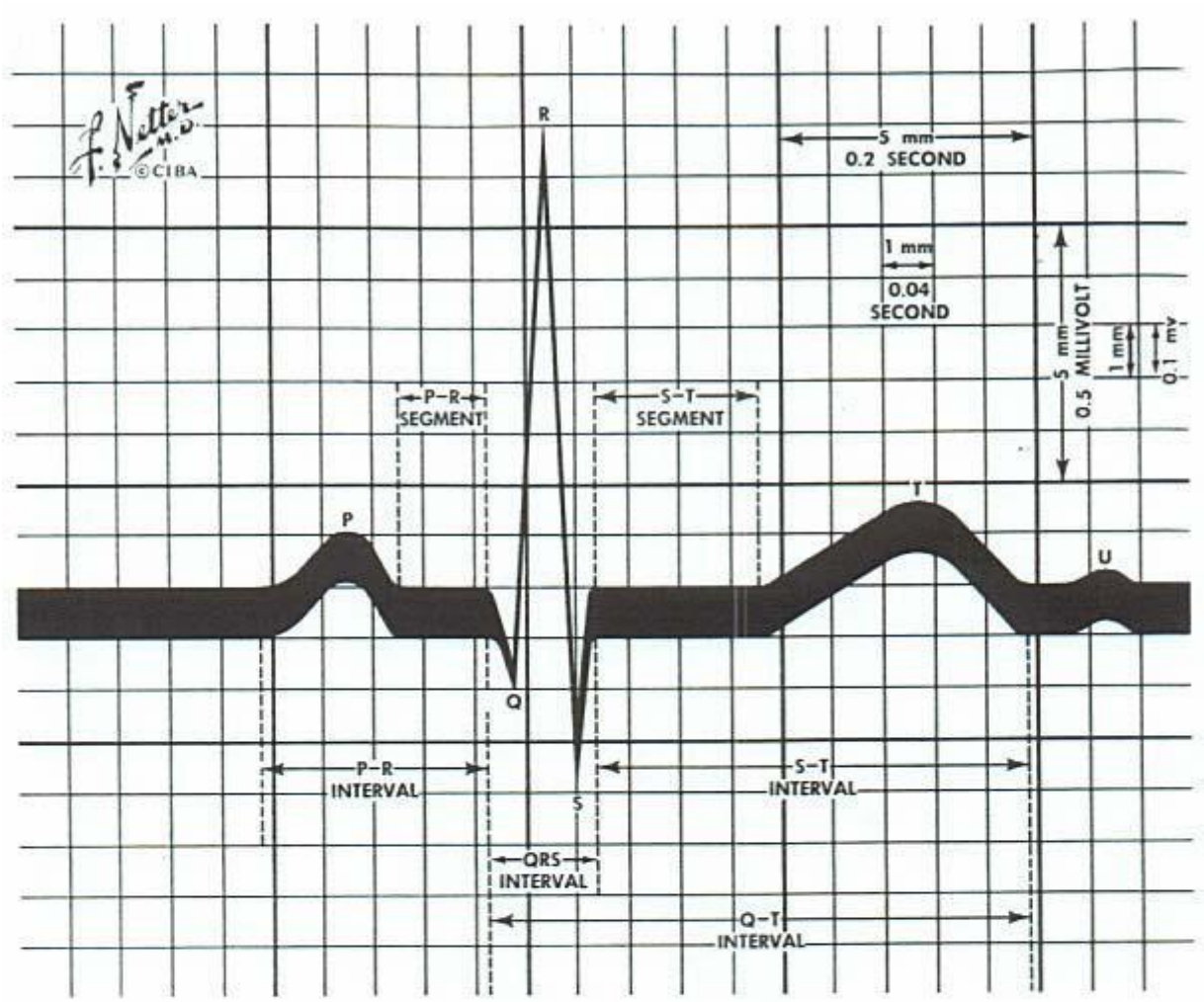
Obviously all human hearts are not the same and this leads into variability in different parts of the ECG signal.

Significant diagnostic features of the ECG signal are:

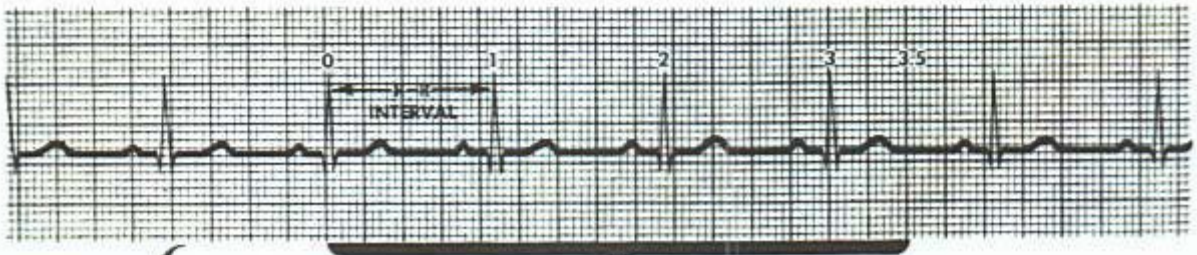
♥ Duration of component parts of the signal

♥ Polarities and magnitudes

♥ The details of the ECG signal and the degree of variability in different parts of the ECG signal is shown below:




| NORMAL RANGES | P–R INTERVAL | QRS INTERVAL | RATE | Q–T INTERVAL | S–T SEGMENT |
|---|---|---|---|---|---|
| ADULTS | 0.18 TO 0.20 SECOND | 0.07 TO 0.10 | 60 | 0.33 TO 0.43 SECOND | 0.14 TO 0.16 SECOND |
| CHILDREN | 0.15 TO 0.18 SECOND | SECOND | 70 | 0.31 TO 0.41 SECOND | 0.13 TO 0.15 SECOND |
| | | | 80 | 0.29 TO 0.38 SECOND | 0.12 TO 0.14 SECOND |
| | | | 90 | 0.28 TO 0.36 SECOND | 0.11 TO 0.13 SECOND |
| | | | 100 | 0.27 TO 0.35 SECOND | 0.10 TO 0.11 SECOND |
| | | | 120 | 0.25 TO 0.32 SECOND | 0.06 TO 0.07 SECOND |




CALCULATION OF RATE: COUNT NUMBER OF R–R INTERVALS (3.5) IN 3 SECONDS (15 TIME SPACES OF 0.2 SECOND EACH)

MULTIPLY 3.5 BY 20 TO GIVE RATE PER MINUTE (70 IN THIS CASE)

The QRS amplitude, polarity, time duration, the RR interval (indicator of heartbeat per min.) and the T-wave amplitude are some very important and distinctive features of the ECG signal.

The **heart rate** in **BPM** = Beats Per Minute) is simply = **60 (RR interval in seconds)**

Some ECG waveform abnormalities that may indicate illness are:

♥ An extended PR interval may be diagnosed as AV node block

♥ A widening of the QRS complex may indicate conduction problems in the bundle of His

♥ An elevated ST segment may indicate occurrence of myocardial Infarction (**MI**)

♥ A negative polarity in the T wave may be due to coronary insufficiency

**ECG Leads**

Normal ECG recordings for the **standard lead** connections lead **I, II and III** (Lead **II** provides the strongest signal)

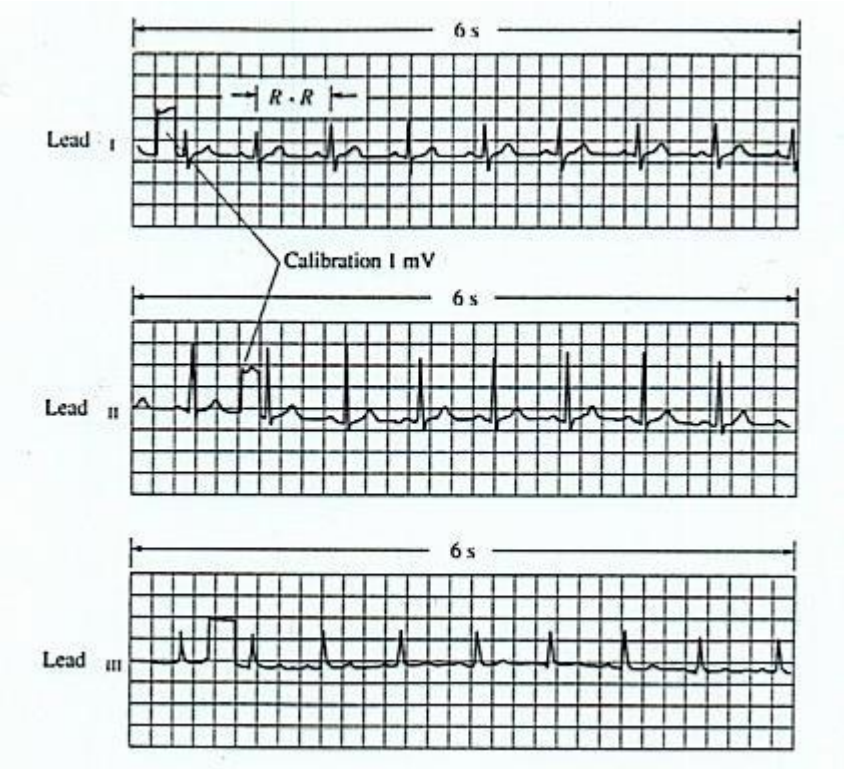



Figure2.7 three standard leads

Obviously, all human hearts are not the same and these results into a high degree of **variability**

♥ Note the degree of variability of different parts of the ECG Signal

**TABLE 6.1**
**Amplitudes of ECG Waves for Standard Lead Connections**

| Wave | Lead voltage magnitudes [nominal (range)] | | |
|---|---|---|---|
| | $V_I$ (mV) | $V_{II}$ (mV) | $V_{III}$ (mV) |
| *P* | 0.07 (0.01 to 0.12) | 0.01 (0 to 0.19) | 0.04 (0.0 to 0.13) |
| *Q* | 0.03 (0 to 0.16) | 0.03 (0 to 0.18) | 0.04 (0 to 0.28) |
| *R* | 0.53 (0.07 to 1.13) | 0.71 (0.18 to 1.68) | 0.38 (0.03 to 1.31) |
| *S* | 0.10 (0 to 0.36) | 0.12 (0 to 0.49) | 0.12 (0 to 0.55) |
| *T* | 0.22 (0.06 to 0.42) | 0.26 (0.06 to 0.55) | 0.05 (0.0 to 0.3) |

Some abnormalities that may indicate illness:

♥ an extended P-R interval may be diagnosed as AV node block

♥ widening of the QRS complex conduction problems in the bundle of His

♥ Elevated ST segment may indicate occurrence of MI

♥ Negative polarity T wave may be due to coronary insufficiency QRS amplitude, polarity, time domain, PR interval (indicator of heat beat per min. & T-wave amplitude are some very important distinctive features.

1. Loss

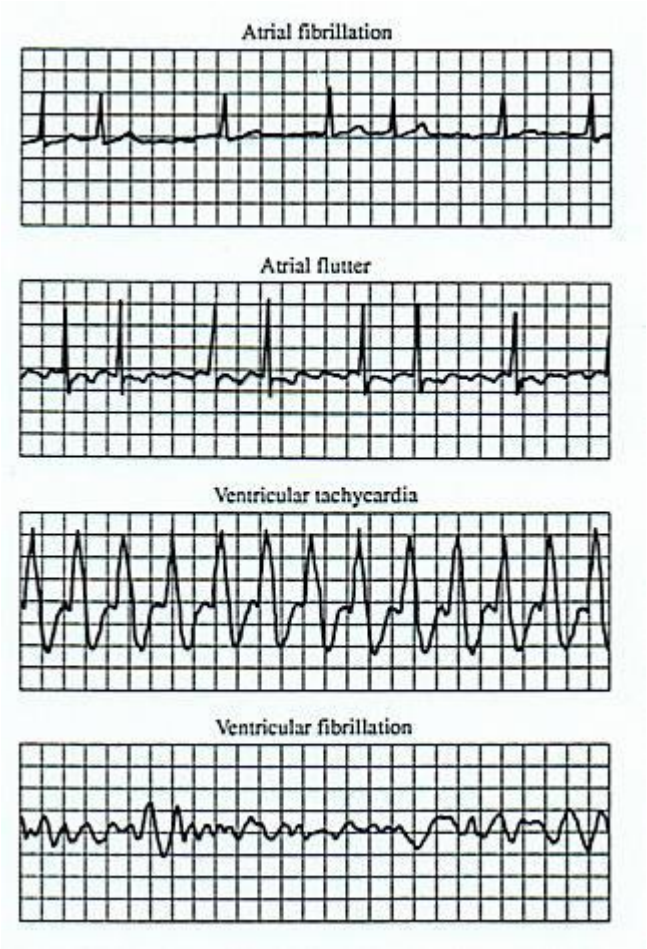



**Figure2.7 Loss in ECG**

**The different lead configurations used in ECG.**

**♥ Standard Limb Leads (I, II, III)**

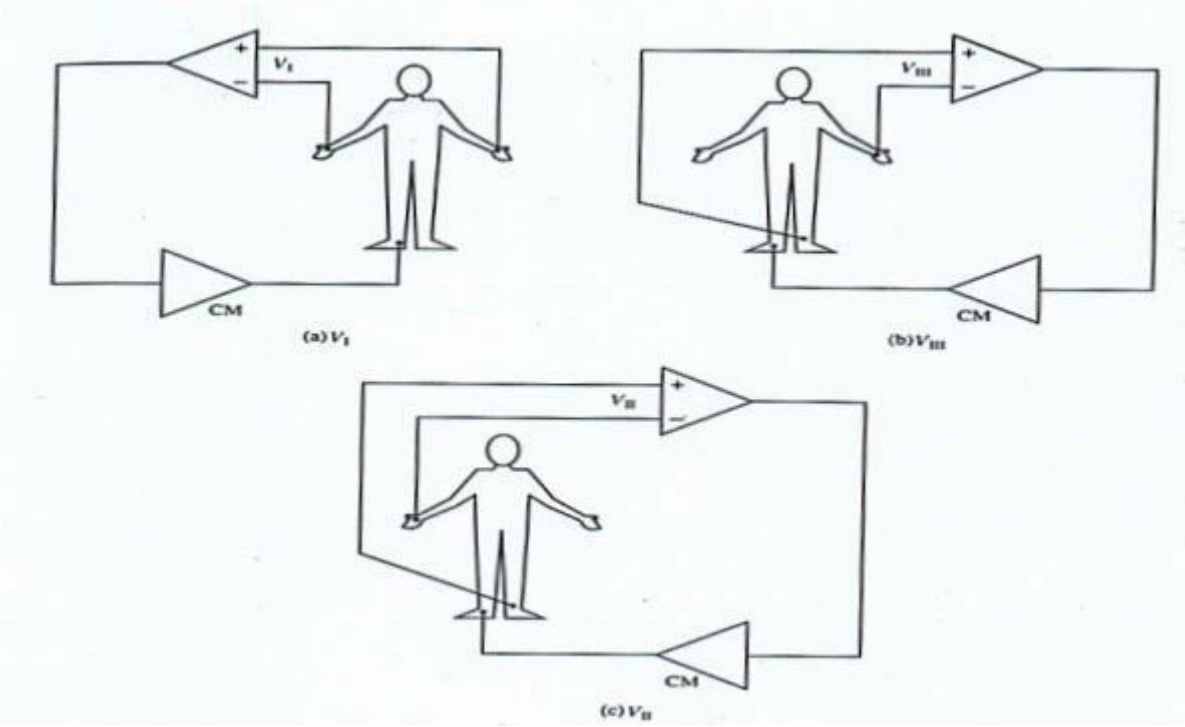



Figure2.8 Signal Amplifying ckt

The lead wires are color-coded according to some conventions. One example is: White –**RA** (Right Arm),

Black – **LA (**Left Arm**)**, Green – **RL (**Right Leg**)**, Red – **LL (**Left Leg**)**, and Brown – **C** (Chest)

**Note:** There is a **CM** (common mode) amplifier connected to the right leg. We will discuss this in detail later.

**Augmented Limb Leads**

These leads offer a free 50% increase over leads **VR, VL**, and **VF** connections (unipolar leads) with respect to Wilson terminal **AVR** = **-I – III**/2, **AVL** = **I – II**/2, **aVF** = **II – I**/2

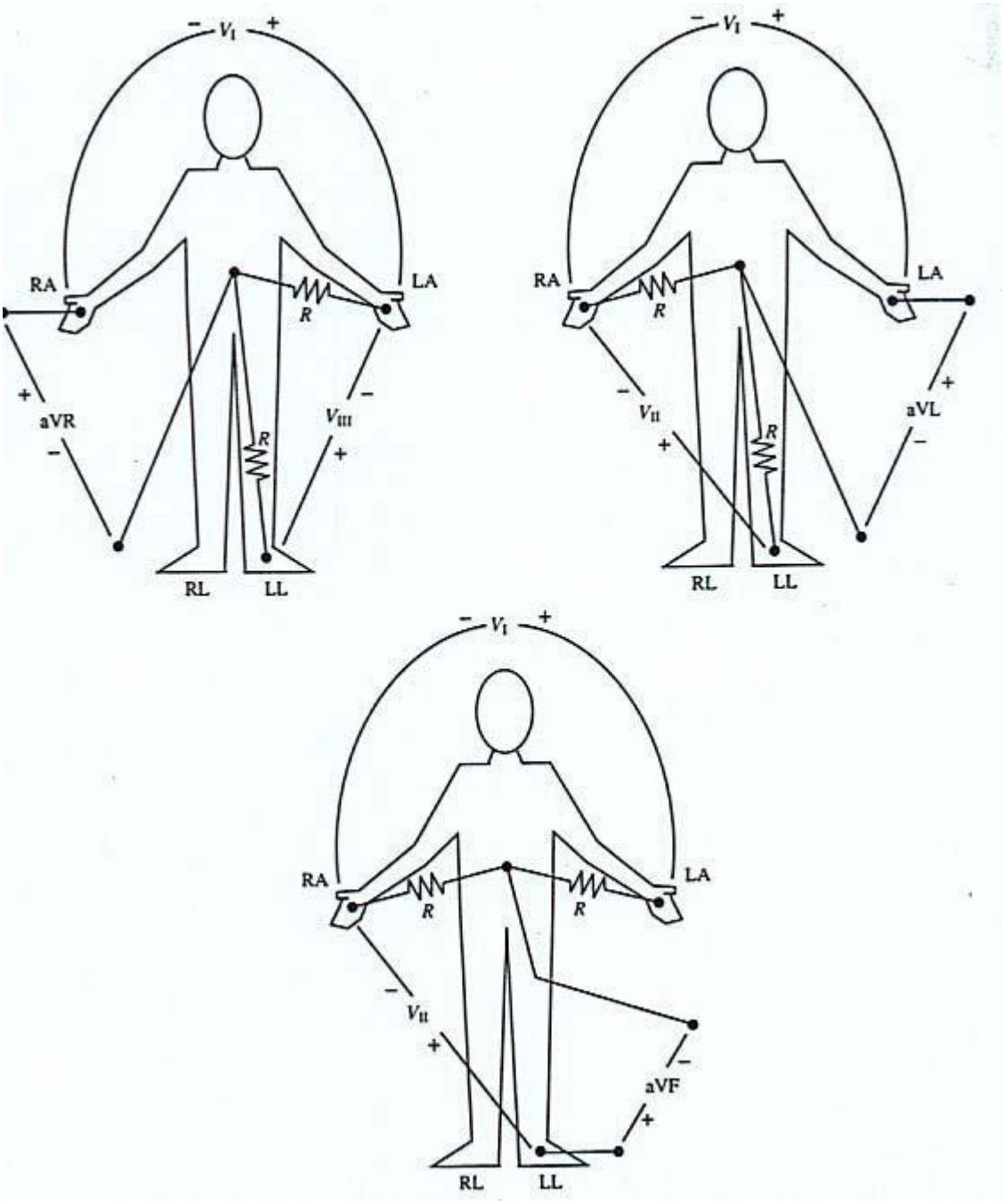
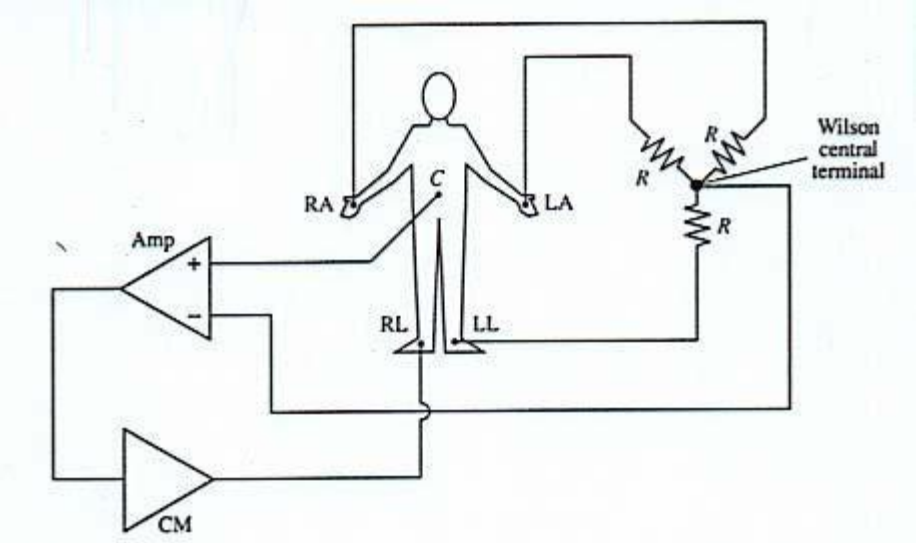



**Figure2.9 Augmented Limb Leads ckt**

Each measurement is made from the reflected limb and the average of the other two limbs.

**Chest Leads (Precordial)**



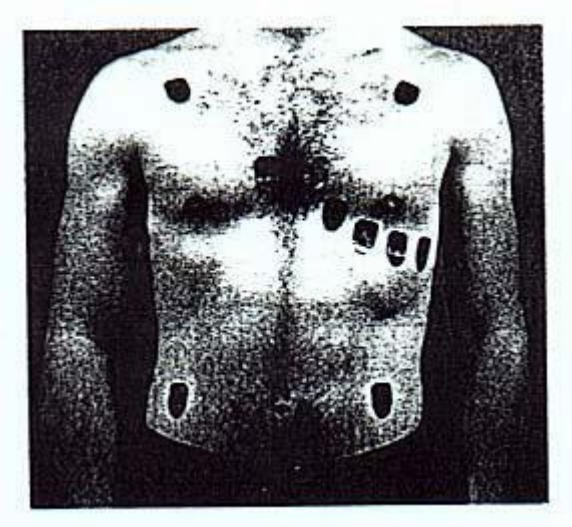



Figure2.10 **Chest Leads**

**Chest Lead Anatomical Positions V1 - 4th intercostal space – Right sternal margin**
**V2 - 4th intercostal space – Left sternal margin**
**V3 – Midway between V2 & V4**
**V4 – 5th intercostal space on mid-clavicular line**
**V5 – Same as V4, on the anterior axillary line**
**V6 – Same as V5, on the mid-axillary line**

**12 Lead Clinical Electrocardiography**

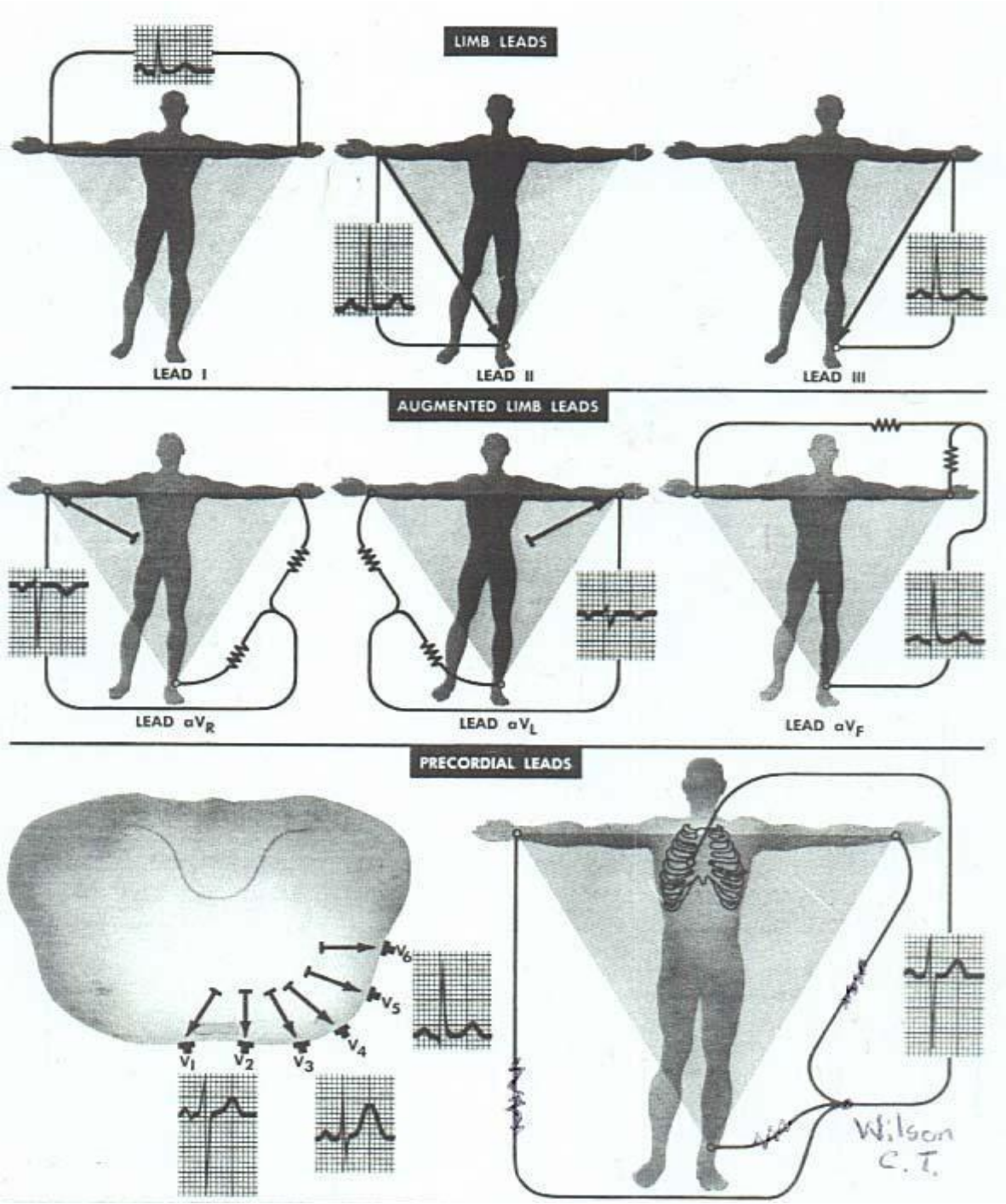



**Figure2.11 ECG recording**

# The Electroencephalogram (EEG)

- EEG is the recorded representation of bioelectric potentials generated by the neuronal activity of the brain.
- Basically, the brain is a gelatinous mass suspend in the meanings, the cerebrospinal fluid, skull and scalp.
- The brain is composed of three major subdivisions:

1. Cerebellum,
2. Brainstem
3. (Medulla, pons, midbrain, diencephalon) and
4. Cerebrum

The cerebellum is mainly involved with skeletal muscle functions and maintenance of balance. It coordinates smooth and directed movements.

The brain stemis the stalk of the brain and serves as a relay station for all afferent (sensory) and efferent (motor) nerve fibers between the spinal cord and higher brain canters. It also gives rise to ten of the twelve cranial nerves, which supply the muscles and glands of the head and major organs in the thoracic and abdominal cavities

Throughout the entire brainstem runs a core of tissue called the reticular formation, which serves as a highly complex cluster of neurons involved in integration of information from many afferent pathways as well as from numerous other parts of the brain.

The cerebrum consists of the right and left hemispheres. The outer part of the cerebral hemispheres, the cerebral cortex, is a cellular shell 1.5 – 4 mm thick of grey matter.

The cerebral cortex is highly convoluted and is the most complex integrating center of the nervous system. It brings together basic sensory information into meaningful perceptual images and formulates ultimate decisions for control over the motor systems of the body.

- The cerebral cortex is comprised of two layers: the pale cortex and the neocortex.
- The pale cortex is located on the median surface and the base of the brain and the neocortex is present on the superior and lateral aspects of the cerebral hemispheres.
- The neocortex is composed of six layers and its cells can be categorized as pyramidal and non-pyramidal cells. There are approximately 1010 neurons in the human cerebral cortex, about 75% of, which is pyramidal.
- Pyramidal cells, named originally after their shape, have several characteristics. Their cell bodies are commonly triangular in shape, with the base down and the apex directed toward the cortical (superficial) surface.
- The cell bodies vary in size, from axial dimensions of 15 x 10 μm up to 120 x 90 μm. A typical pyramidal cell consists of a long apical dendrite, about 2 mm long, that ascends from the apex of the cell body and enters the overlaying layers and terminally branches within the outermost layer of the neocortex.
- There is a dominant apical dendrites tree, looking like a forest of similarly oriented, densely packed units in the superficial layers of the neocortex, where extensive branching occurs.

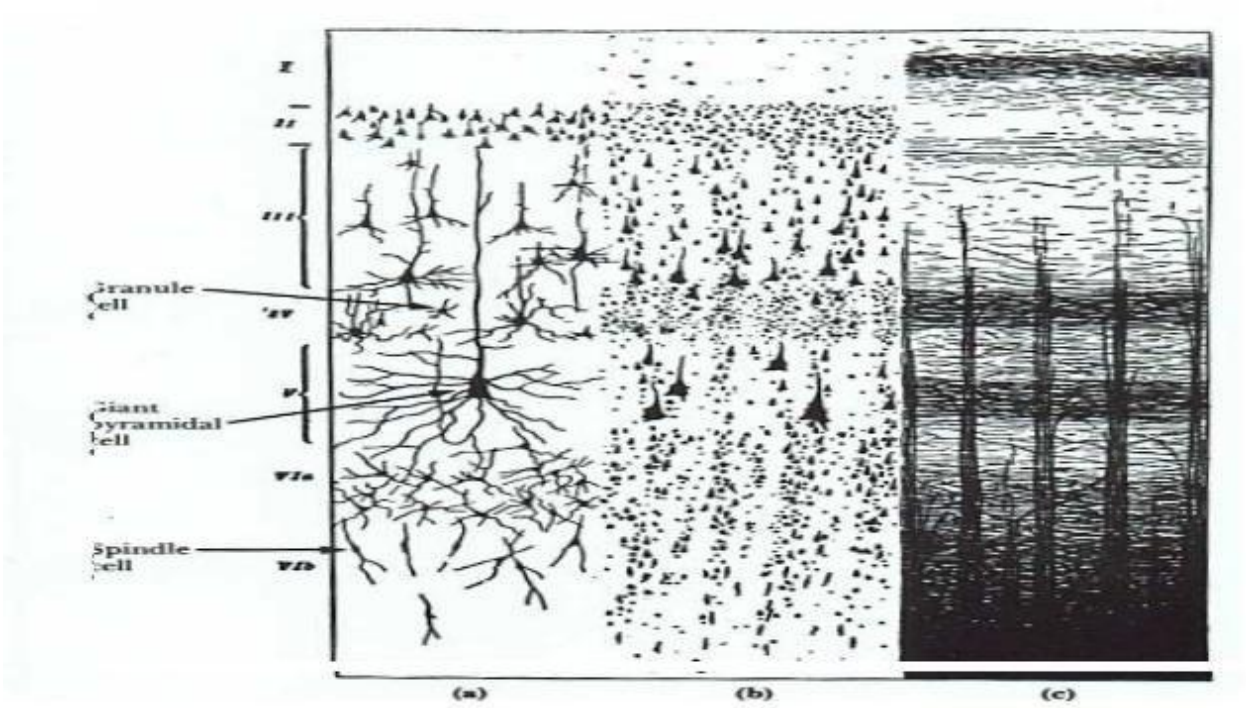



Figure2.12 EEG

- There is also a basilar dendritic system that extends out spherically from the cell body.
- Pyramidal cells also have an axon that emerges from the cell body and enters the sub cortical white matter.
- The axons of all pyramidal cells terminate in excitatory synapses. The initial segment of pyramidal cells is un myelinated, as their recurrent branches
- Axons of some pyramidal cells turn back toward the cortical surface to end via their many dendritic branches on the dendrites of other cells.
- It has been shown by electrophysiological studies that under normal circumstances, propagating action potentials in axons do not contribute significantly to surface cortical recordings.

- There reason being that action potentials travel in large number of axons (running in many different directions relative to the surface) in a temporally a synchronized way.Therefore, their net contribution to the surface EEG is minimal and negligible.

- It has been shown that the vertically oriented pyramidal cells with their long napical dendrites running parallel to one another are the major contributors to the electro genesis of the cortical field potentials (EEG signal).

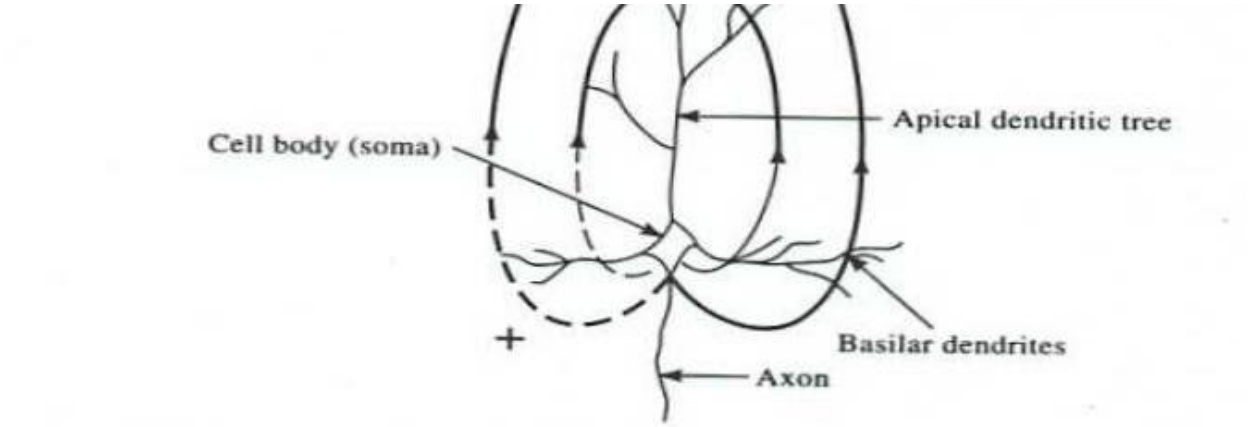



Figure2.13 Cerebrum

A highly schematic representation of a pyramidal cell and its role in the generation of surface EEG signal.

Let's consider a single pyramidal cell, and explain how potential changes in one part of the cell relative to other parts could generate the EEG signal.

- Excitatory synaptic inputs to the branches in the apical dendritic tree of the pyramidal cells cause depolarization of the dendritic membrane.
- This leads into generation of an excitatory postsynaptic potential (EPSP)
- As a result, a radially oriented dipole is set up and sub threshold current flows in a closed path through the cytoplasmic core of the dendrites and cell body of the cell, returning to the synaptic sites via the conducting extracellular medium
- The lines of current flow make the extracellular medium close to the cell body act as a source with + polarity and the upper part of the apical dendritic tree to act as a sink with – polarity.
- This leads into recording a negative potential at the cortical surface In case of inhibitory synaptic inputs to the branches in the apical dendritic tree, an inhibitory postsynaptic potential (IPSP) is generated with a reversal in the polarity of the current dipole, which leads into a generation of a positive cortical recording.
- Therefore, the influence of a particular dendritic postsynaptic potential on the cortical recording depends on its net excitatory or inhibitory effect and on its location relative to the measurement site.

The EEG (electroencephalogram) signal is a recording of the electrical activity of the brain.

The EEG signal recorded at the cortex or the scalp is generated by the polled activity of billions of cortical and sub cortical regions. The origin of the EEG signal is based on the electrical activity of the pyramidal cells. The EEG potentials primarily reflect the summated fluctuations of excitatory and inhibitory postsynaptic potentials in the pyramidal cells of the upper layers of the cerebral cortex. For reasons of geometry as well as because of extreme extracellular attenuation, action potentials from firings of pyramidal cells contribute only minimally or not all to the generation of the EEG signal.

- All we need to contend ourselves with at this stages that the EEG or brain waves are summation of neural depolarization sin the brain due to the stimuli from the five senses as well as from thought processes (indeed a very complex source). More on this in physiology in the Nervous System topic.
- EEG potentials have random-appearing waveforms with peak-to-peak amplitudes ranging from less than 10 mV to over 100mV. Required bandwidth is from below 1 Hz to over 100 Hz.

EEG is recorded with 3 types of electrodes:

1. Scalp

2. Cortical Electrocardiogram (recording from surface of cortex)

3. Depth Electrodes recording from depth of brain (thin insulated needles of various designs)

- No matter where the recording is obtained from (scalp, cortex or depth of the brain), the fluctuating potentials represent a superposition of the volume conductor fields produced by a huge variety of active neuronal current-generators.
- On the surface of the brain (i.e. Electrocardiogram), we can record voltages on the order of 10 mV! But, typical EEG electrodes measure the electrical activity propagated through skull bone and is attenuated from 1 to 100 μV.

EEG potentials vary as a function of position over the surface of the skull, making it necessary to select sets of electrodes grouped around Frontal, Parietal, Temporal and Occipital lobes.

**The EEG Signal**

- The character of the EEG signal is highly dependent on the degree of the activity of the cerebral cortex, i.e. waves change markedly between states of wakefulness and sleep
- Much of the time, EEGs are irregular and no general pattern can be observed.

Other times, distinct patterns emerge

The EEG waveform is divided into four wave groups:

1. The Alpha Waves (α) 8-13 Hz
2. The Beta Waves (β) 14-30 Hz (The Gamma Waves (γ) 22-30 Hz or higher)
3. The Theta Waves (θ) 4-7 Hz
4. The Delta Waves (δ) <3.5 Hz

**Note:** During periods of mental activity, the waves usually become asynchronous rather than synchronous, so the magnitude of summed potentials decreases in spite of cortical activity.

- In general there is a relationship between cerebral activity and the frequency of the EEG rhythm
- Frequency increases progressively with higher degrees of activity

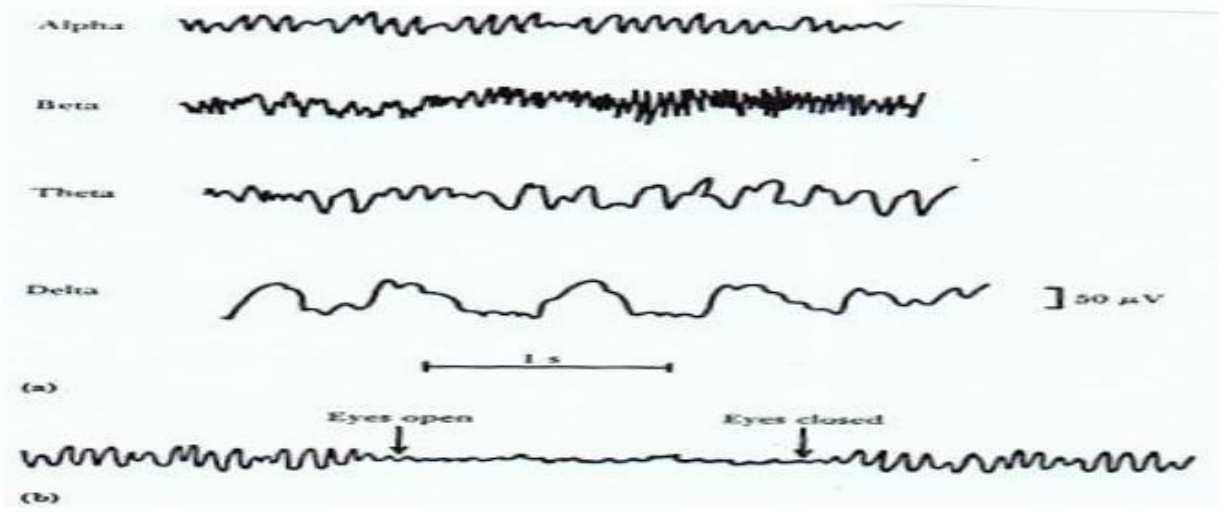



Figure2.14 EEG waveform

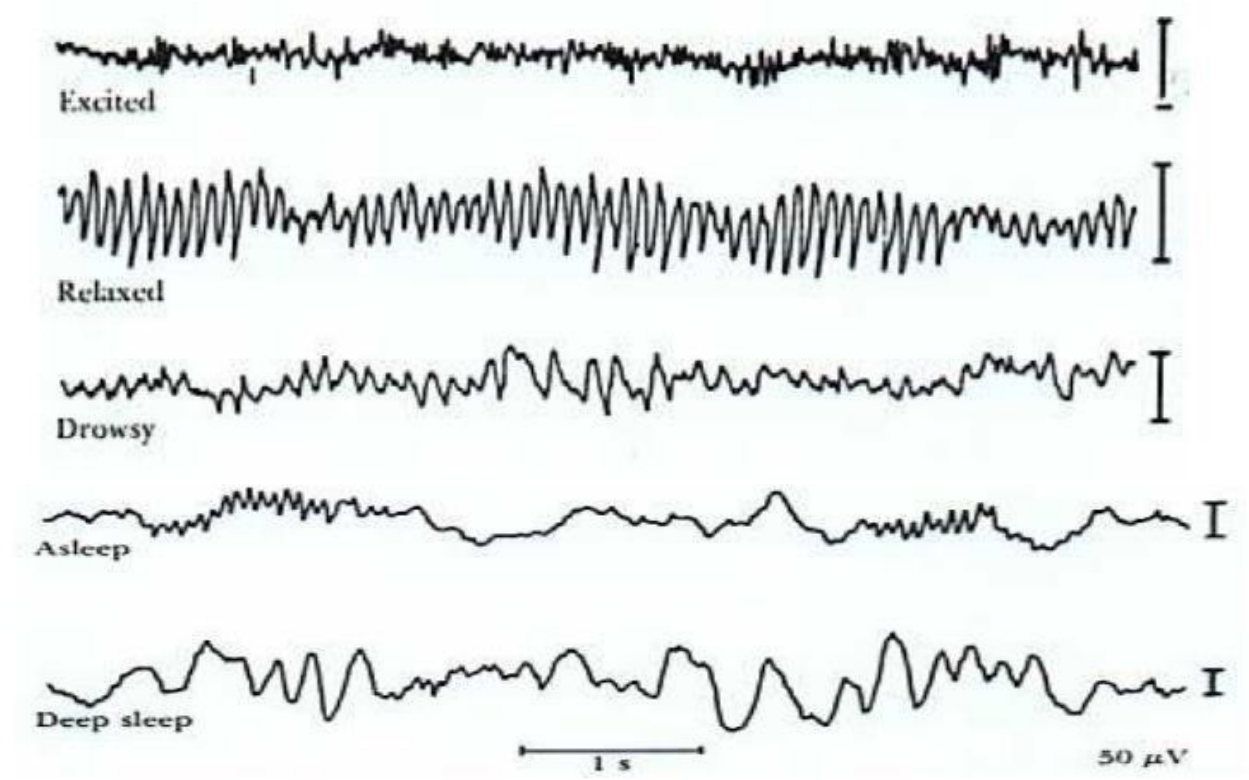



Figure2.15 Different EEG waveforms

Examples:

- δ-Waves(<3.5 Hz) occur in surgical anesthesia and sleep
- θ-Waves(4-7 Hz) occur in emotional stress and frustration
- α-Waves(8-13 Hz) occur during relaxed states

- β-Waves(14-30 Hz)occur during intense mental activity

**EEGs in Diagnosis**

The purpose of the clinical EEG is to help neurologists diagnose disease. The pathological states most commonly diagnosed using EEG are:

- Brain death (legal death)
- Brain tumors
- Epilepsy
- Multiple Sclerosis
- Sleep Disorder
- Evoked responses (diseases of the audio, visual and tactile senses)
- Modern life sustaining equipment like respirators, kidney dialyzers, ventilators, artificial heart pumps have changes the definition of death
- A sustained absence of EEG signal is a clinical measure of brain death and can be used in deciding whether to transplant a heart, liver, or lung or whether to shut down the life sustaining equipment

**Some Representative Abnormal EEGS**

**Petit mal epilepsy**– Minor for of seizure, clouding of consciousness and loss of contact with the environment

**Grand mal epilepsy**– Sudden loss of consciousness, falling down, tonic contractions (stiffening of muscles) followed by twitching and jerking movements of the limbs

**Psychomotor seizures** are parietal seizures characterized by: semi-purposeful movements, changes in consciousness, hallucinations and illusions.

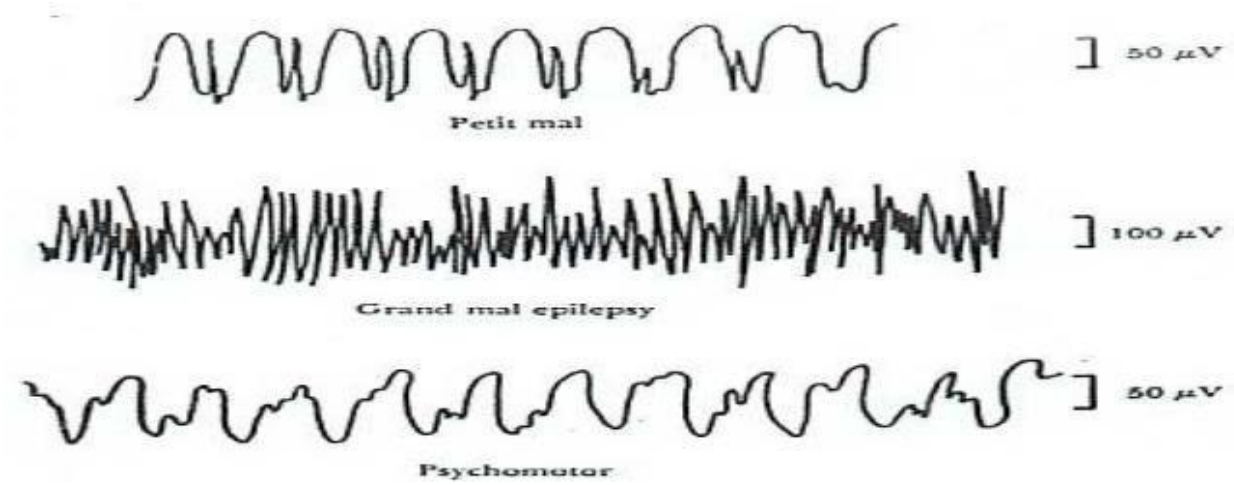



Figure2.16 Abnormal EEGs

**EEG Electrode Positions**

- In electroencephalography, the electrodes are placed in an arrangement referred to as the 10-20 system
- This is a placement scheme devised by the International Federation of Societies of Electroencephalography
- The electrodes are placed along a line drawn on the skull from the root of the nose, the nasion, to the classification (bump on the occipital lobe)
- The first mark is placed 10% of the distance along this line and others are arranged at 20% intervals

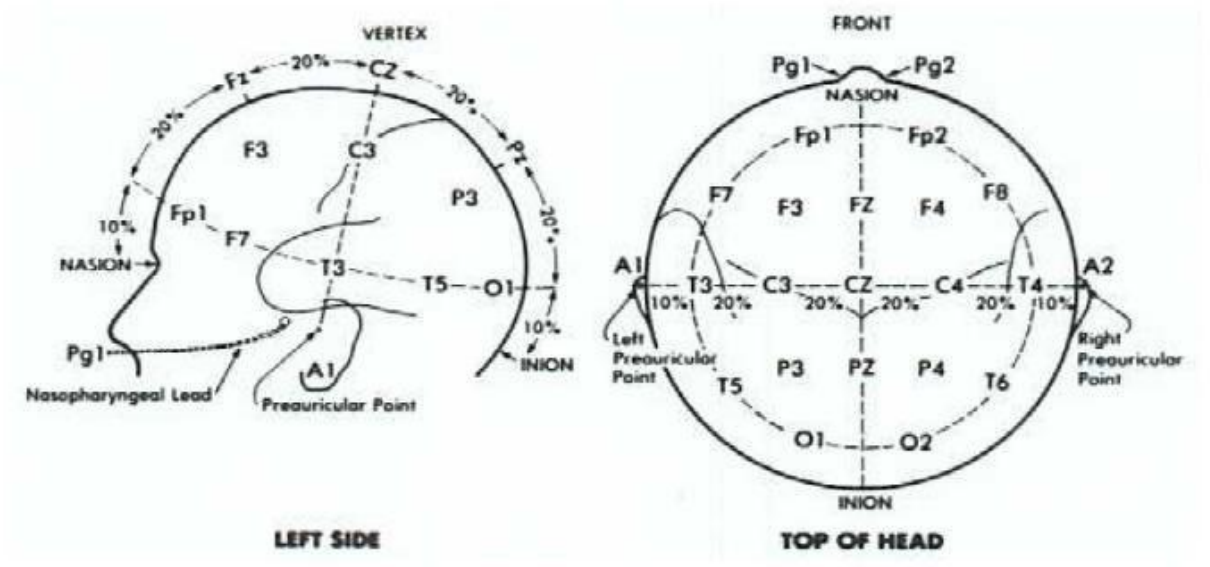



Figure2.17 EEG Electrode position

**Electroencephalograph Signal Path**

The EEG signal path is comprised of: Scalp (biosignal source) EEG electrodes, Junction box, channel selector, differential amplifier, bank filters, and display.

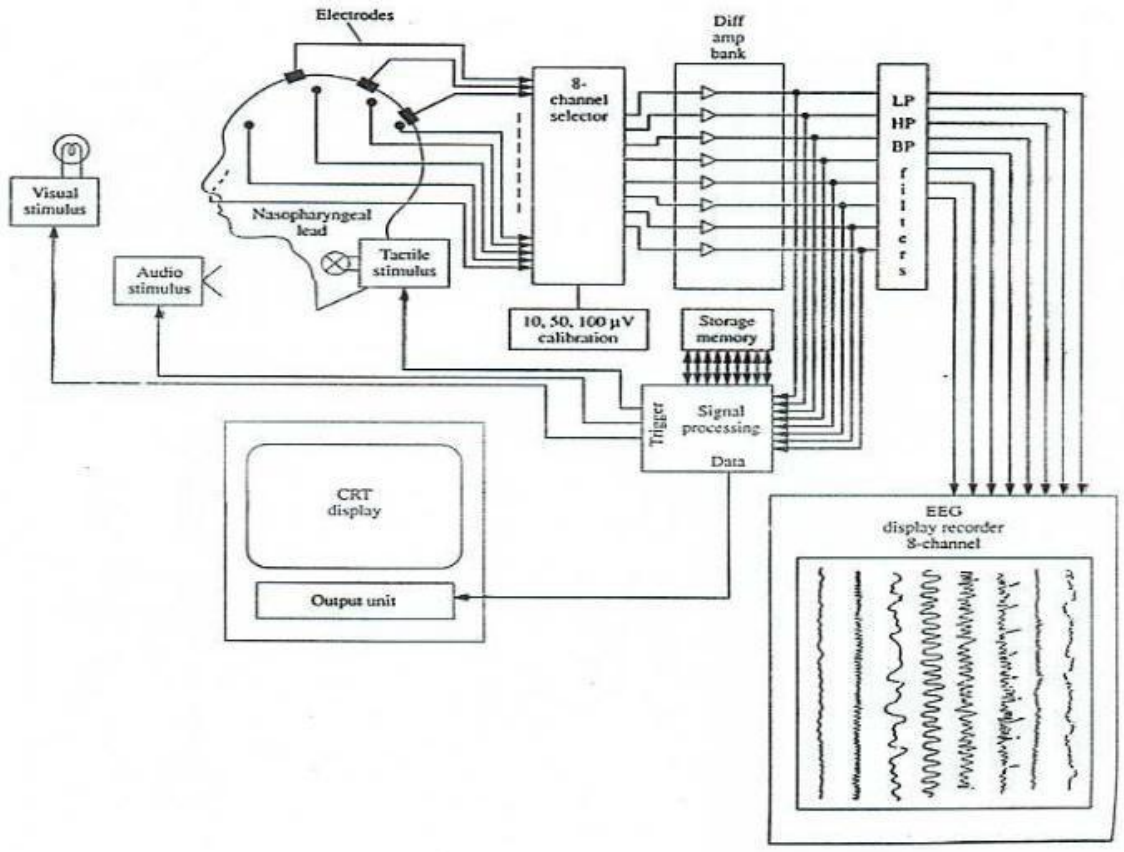



Figure2.18 Block diagram of Electroencephalograph Signal Path

- It shows the modern 8 channel EEG recorder. The patient cable consists of 21 electrodes and is connected to the 8 channel selector.
- The electrodes are attached to the channel selector in groups of 8 called a montage of electrodes.
- The right ear electrode acts as reference electrode for the right brain electrodes and left ear electrode act as reference electrode for left brain electrodes.
- The 50 Hz interference is reduced by employing differential amplifiers as preamplifiers with more than 80 dB CMRR and by use of 50 Hz notch filters.
- The effect of notch filter on signal distortion is not so much because important EEG signals have frequencies below 30 Hz.
- The output voltage from the amplifier may either be applied directly to the eight channel display through the filter bank or it may be stored as data on a tape recorder or in a computer memory for further processing.

**EMG (ELECTRO MYOGRAPH)**

- It is an instrument used for recording the electrical activity of the muscles to determine whether the muscle is contracting or not. Study of neuromuscular function is also possible by using EMG. Muscular contractions are caused by the depolarization of muscle fibers. Similarly the recording of peripheral nerves action potentials is called as electro neurography.

ELECTRODES USED FOR EMG TWO

**Types of electrodes:**

**Surface electrodes**- Usually this electrode is used for EMG. But by using this electrode, it is not possible to take the deeper potential.

**Needle electrodes** – These are inserted into tissue or closer to tissue to measure the electrical activity of muscle.

## EMG RECORDING SYSTEM

EMG potentials are taken from the tissue by using electrodes. These EMG potentials are given to differential amplifier. This is the high gain amplifier. Its frequency range is given as 10 Hz to 10 KHz.

Bandwidth of EMG is large. CMRR (Common mode Rejection Ratio) of this differential amplifier is 80 to 100 db. Input Impedance of this amplifier is 10 MΩ. Here there is no lead selector switch. Output of the differential amplifier is given to loudspeaker system, tape recorder and CRO.

Before giving the output of differential amplifier to loudspeaker, it is given to power amplifier. Power amplifier amplifies the signal that is received by loudspeaker.

The amplified signal from the output of the differential amplifier is displayed by using CRO. Here storage oscilloscope is used. Output cab be displayed and the same can be stored in the CRO. The signal from the differential amplifier is recorded by using tape recorder. It is used for the future purpose.

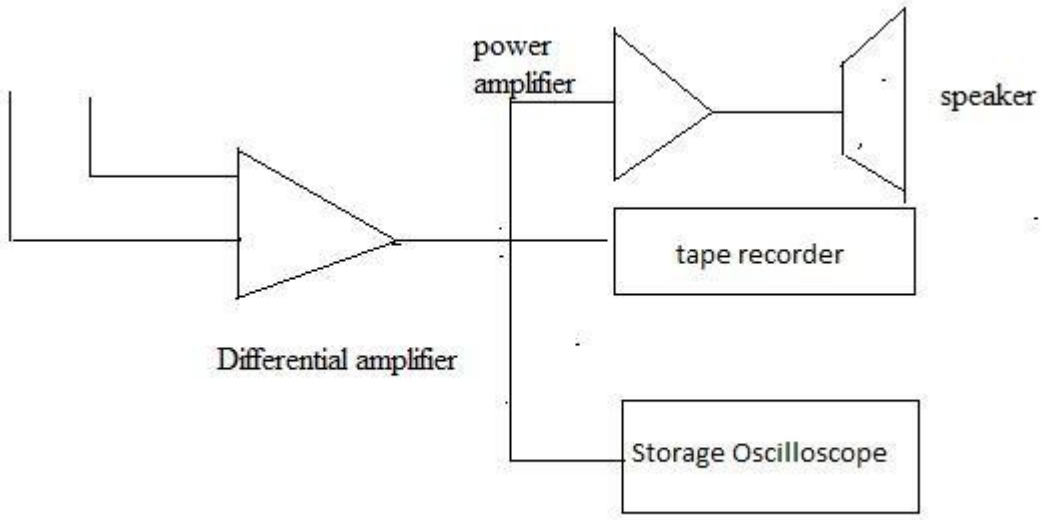



Figure2.19 EMG Recording System

## MEASUREMENT OF CONDUCTION VELOCITY IN MOTOR NERVES

In modern EMG systems, nerve conduction time and nerve velocity are measured.

For this measurement, initially nerve is stimulated and EMG is measured. This conduction velocity measurement is used to indicate the location and type of nerve lesion.

**Steps involved in measurement of conduction velocity**

- Stimulate is applied at point A
- Electrical activity of muscle is measured at point B
- The space between A and B is noted as l1 meters.
- The time delay between applying stimulus and receiving action potential is known as latency. This time delay is detoned as t1 second.
- Now change the position of A into C. Now the space is reduced. It is noted as l2 meters.
- The time delay noted is t2 second.
- Usually, l2<l1 and t2 <t1.
- Now, the conduction velocity is given as, V= l1-l2/t1-t2.
- Usually V= 50 m/sec.
- If V<40 m/s. It means there is some disorder in nerve conduction.
- Thus conduction velocity is measured in motor nerves.
- Skeletal muscle is organized functionally on the basis of the motor unit.

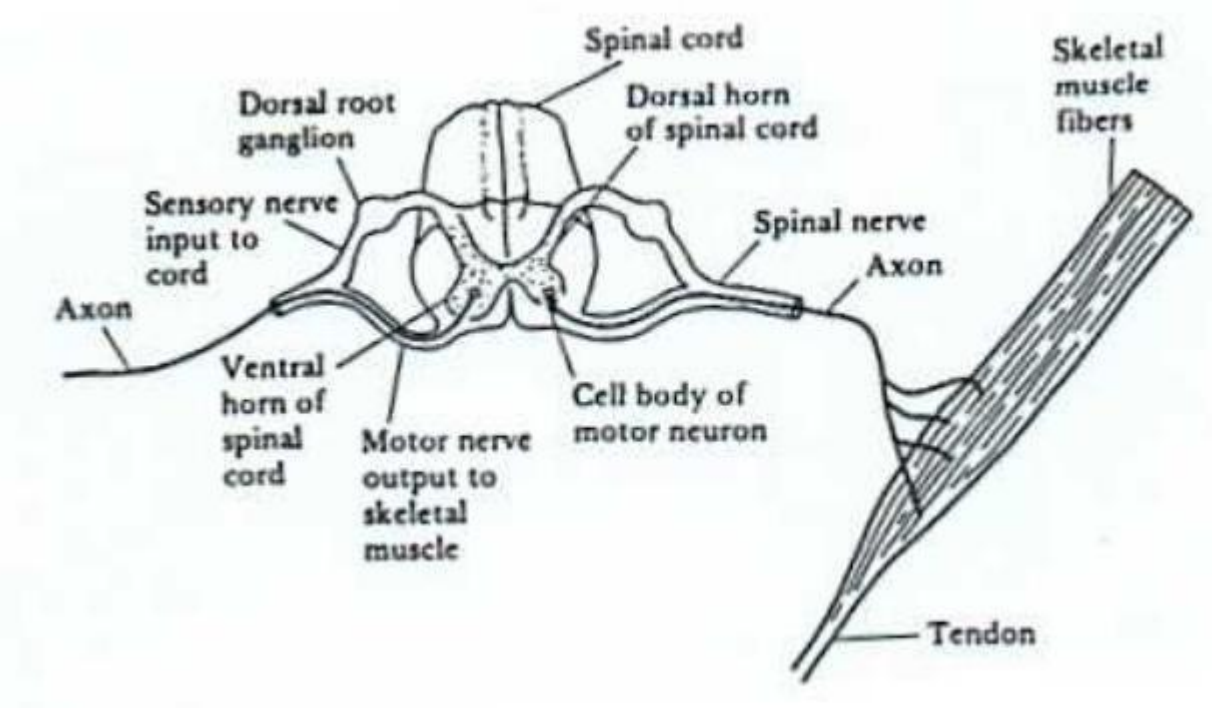



Figure2.20 Conduction Velocity In Motor Nerves

**Single Motor Unit (SMU)**

- The motor unit is the smallest unit that can be activated by a volitional effort (all constituent muscle fibers are activated synchronously)
- Single motor unit (SMU) consists of a single motor neuron and the group of skeletal muscles that it innervates
- SMU is a distributed unit bioelectric source in a volume conductor consisting of all other muscle fibers, both active and inactive.
- The evoked extracellular field potential from the active fibers of an SMU has a triphasic
- form of 3-15 ms duration and 20-2000 μV amplitude depending on the size of SMU

- The figure below shows motor unit potentials from normal muscle under graded levels of contraction. At high levels of activity, many sophisticated motor unit responses give
- Rise to a complicated response (interference pattern)

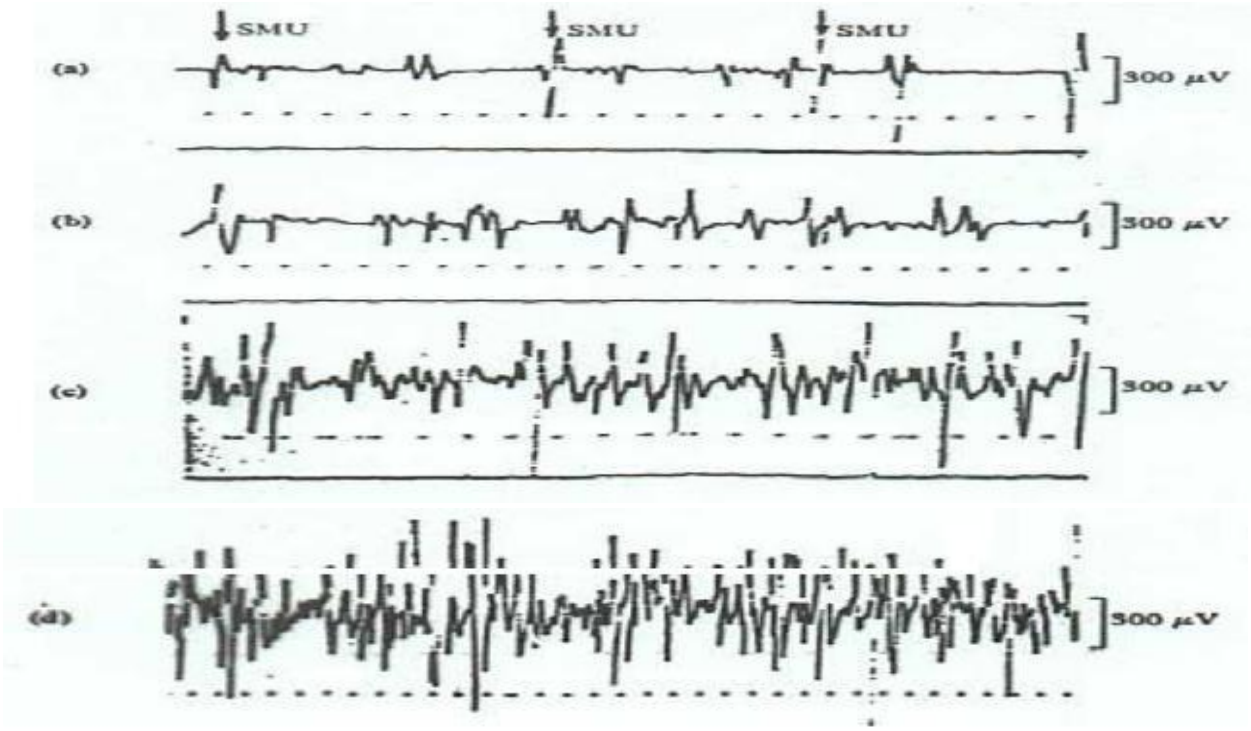



Figure2.21 EMG Recording

- A variety of electrodes have been developed for EMG recording
- The figure below shows the needle and wire electrodes used in recording the EMG signal
- The EMG is also of considerable clinical value
- The shape of SMU potentials is modified by disease
- The figure below shows the EMG response for a normal subject and one with neuropathy

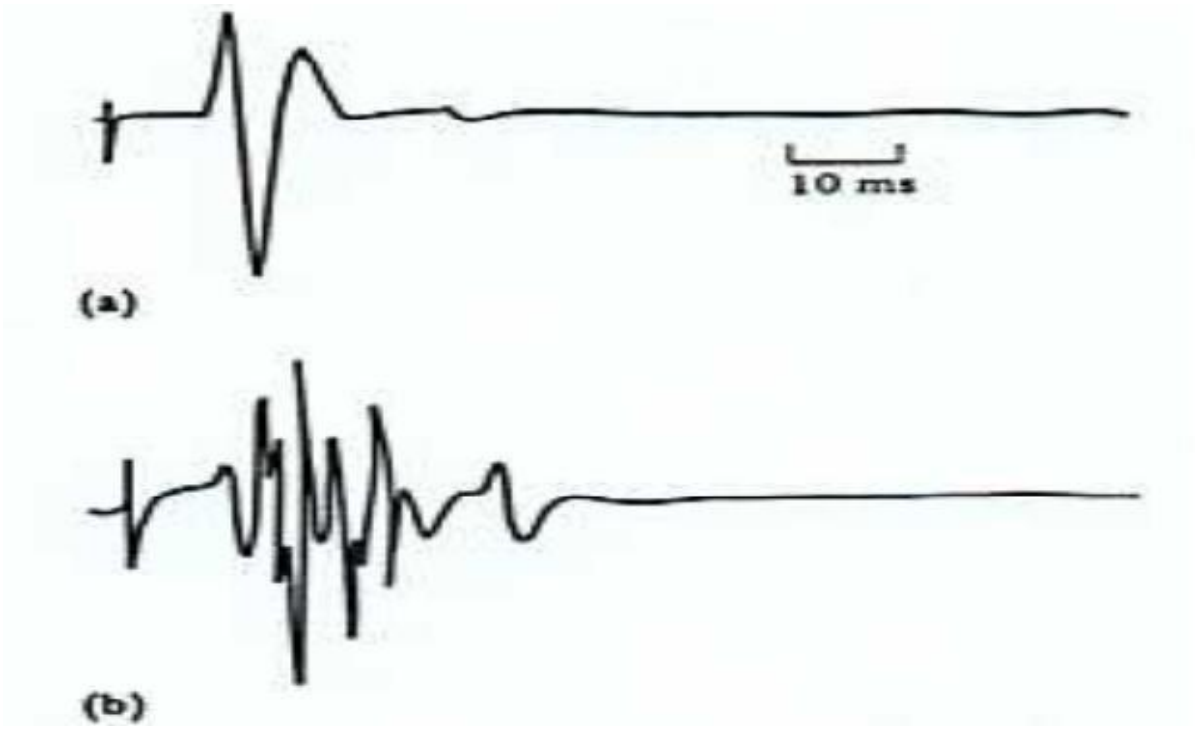


Figure2.22 EMG response of a normal and an abnormal waveforms

**Applications of EMG:**

EMG is used in the field of:

- Electrophysiological testing.
- Clinical neurophysiology.
- Neurology.
- Psychiatry.

**PCG (PHONO CARDIOGRAM)**

The graphical record of heart sound is known as Phono Cardiogram. Here Cardio means the heart. The device which is used to measure heart sound is known as phonocardiograph. Auscultation: The technique of listening sound produced by organs and vessels of the body is known as auscultation.

In PCG, different types of heart sounds are measured. These heart sounds are due to the vibrations set up in the blood inside the heart by the sudden closure of valves. In abnormal heart additional sounds are heard between the normal heart sounds. These additional sounds are known as murmurs. Murmurs is generally caused by improper opening of the valves or by regurgitation.

**CLASSIFICATION OF HEART SOUND**

It is divided into four types

- Valve closure sound
- Ventricular filling sound
- Valve opening sound
- Extra cardiac sound

**Valve closure sound**

This sound occurs at the beginning of systole and at the beginning of diastole.

**Ventricular filling sound**

This sound is occurred at the time of filling of the ventricles.

**Valve opening sound**

This sound occurs at the time of opening of atrio- ventricular valves and semi lunar valves.

**Extra cardiac sound**

This sound occur in mid systole or late systole or early diastole

**Systole**: The contraction of the heart muscle. The systolic pressure is 120mm of Hg.

**Diastole**: The relaxation of the heart muscle. The diastolic pressure is 80 mm of Hg.

**PCG RECORDING SYSTEM**

Microphone is used to convert heart sound into the electrical signals. Certain positions are recommended to pick up the heart sound by using microphone. The electrical signal picked up by the microphone is amplified by the amplifier block. The amplified output is given to filter block.

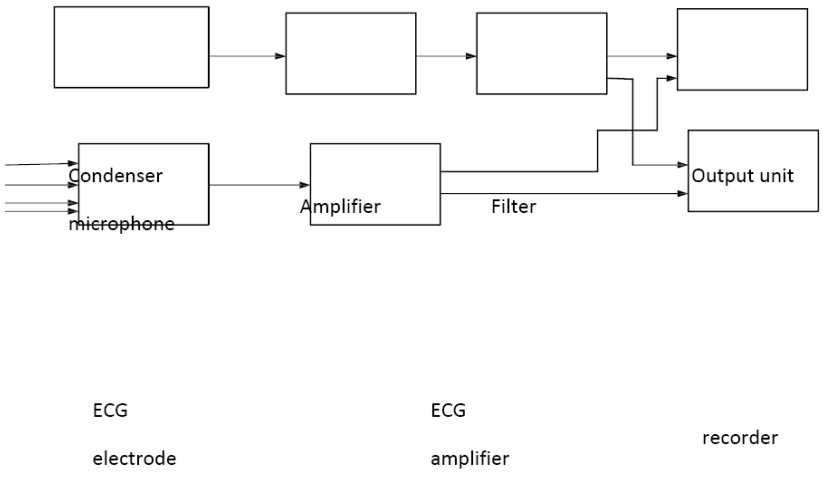



Figure2.23 Block Diagram of PCG Recording System

**TYPES OF MICROPHONES USED IN PCG**

1. Air coupled microphone- Movement of chest is transferred through the air cushion.
It provides low mechanical impedance to the chest.
2. Contact microphone – it is directly coupled to the chest wall and provides high impedance, high sensitivity, and low noise. Its light weight is also one of the advantageous factors.
The first heart sound is developed during the opening of aortic valve and during the closing of mitral valve.

**PCG waveform**

Frequency of first heart sound consists of 30 to 45 Hz. Second heart sound is usually higher in pitch than the first. Its frequency range is 50Hz to 70 Hz. Third heart sound is extremely weak vibrate sound is extremely weak vibration. Its frequency is below 600 Hz.
Aortic stenos are murmur occurred when the blood is ejected from the left ventricle through aortic valve due to resistance to ejection, the pressure in the left ventricle increased. This turbulent blood impinging the aortic valve. So intense vibration is produced. It produces loud murmur.

**Mitral regurgitation murmur**- In this murmur, blood flows in backward direction through the mitral valve during systole.

**Aortic regurgitation murmur** – During diastole, sound is heard. In diastole blood flows in the backward direction from aorta to left ventricles when valves are damaged, then this sound is heard.

**Mitral stenosis murmur** – This murmur is produced when blood is passed from left atrium to left ventricle. This sound is very weak.

**LEAD SYSTEMS AND RECORDING METHODS**

**Leads**

Graphic showing the relationship between positive electrodes, depolarization wave fronts (or mean electrical vectors), and complexes displayed on the ECG.
In electrocardiography, the word, "lead" (rhymes with 'speed') refers to the signal that goes between two electrodes. These electrodes are attached to the patient's body, usually with very sticky circles of thick tape-like material (the electrode is embedded in the center of this circle).

**Unipolar vs. bipolar leads**

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

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

**Einthoven's triangle**

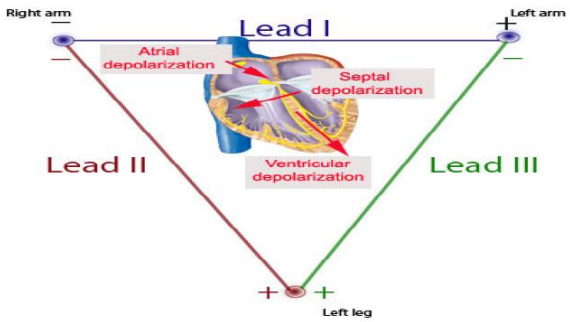



**Figure2.24**

**TYPICAL WAVEFORMS AND SIGNAL CHARACTERISTICS**

**P wave**

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

aVR to designate a cardiac rhythm as Sinus Rhythm.

- The relationship between P waves and QRS complexes helps distinguish various cardiac arrhythmias.
- The shape and duration of the P waves may indicate atrial enlargement.
- Absence of the P wave may indicate atrial fibrillation.
- A saw tooth formed P wave may indicate atrial flutter.

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

**PR/PQ interval**

The PR interval is measured from the beginning of the P wave to the beginning of the QRS complex. It is usually 120 to 200 ms long. On an ECG tracing, this corresponds to 3 to 5

small boxes. In case a Q wave was measured with a ECG the PR interval is also commonly named PQ interval instead.

**ST segment**

The ST segment connects the QRS complex and the T wave and has a duration of 0.08 to 0.12 sec (80 to 120 ms). It starts at the J point (junction between the QRS complex and ST segment) and ends at the beginning of the T wave. However, since it is usually difficult to determine exactly where the ST segment ends and the T wave begins, the relationship between the RT segment and

T wave should be examined together. The typical ST segment duration is usually around 0.08 sec (80 ms). It should be essentially level with the PR and TP segment.

**T wave**

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

**QT interval**

The QT interval is measured from the beginning of the QRS complex to the end of the T wave.

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

**U wave**

The U wave is not always seen. It is typically small, and, by definition, follows the T wave. U waves are thought to represent repolarization of the papillary muscles or Purkinje fibers.

Prominent U waves are most often seen in hypokalemia, but may be present in hypercalcemia, thyrotoxicosis, or exposure to digitalis, epinephrine, and Class 1A and 3 antiarrhythmics, as well as in congenital long QT syndrome and in the setting of intracranial hemorrhage. An inverted U wave may represent myocardial ischemia or left ventricular volume overload.

**BIO-CHEMICAL AND NON ELECTRICAL PARAMETER MEASUREMENT**

**PO2 MEASUREMENT**

The term po2 is defined as the partial pressure of oxygen respectively. The determination of po2 is one the most important physiological chemical measurement. The effective functioning of both respiratory and cardiovascular system can be by po2 measurement.

The partial pressure of a gas is proportional to the quantity of that gas present in the blood.

The platinum wire, which is an active electrode, is embedded in glass for insulation and only its tip is exposed. It is kept in the electrolyte solution in which the oxygen is allowed to diffuse. The reference electrode is made up of silver-silver chloride (Ab/AgCl). A voltage of 0.7 is applied between the platinum wire and the reference electrode. The negative terminal is connected to the active electrode through a micro ammeter and the positive terminal is given to the reference electrode.

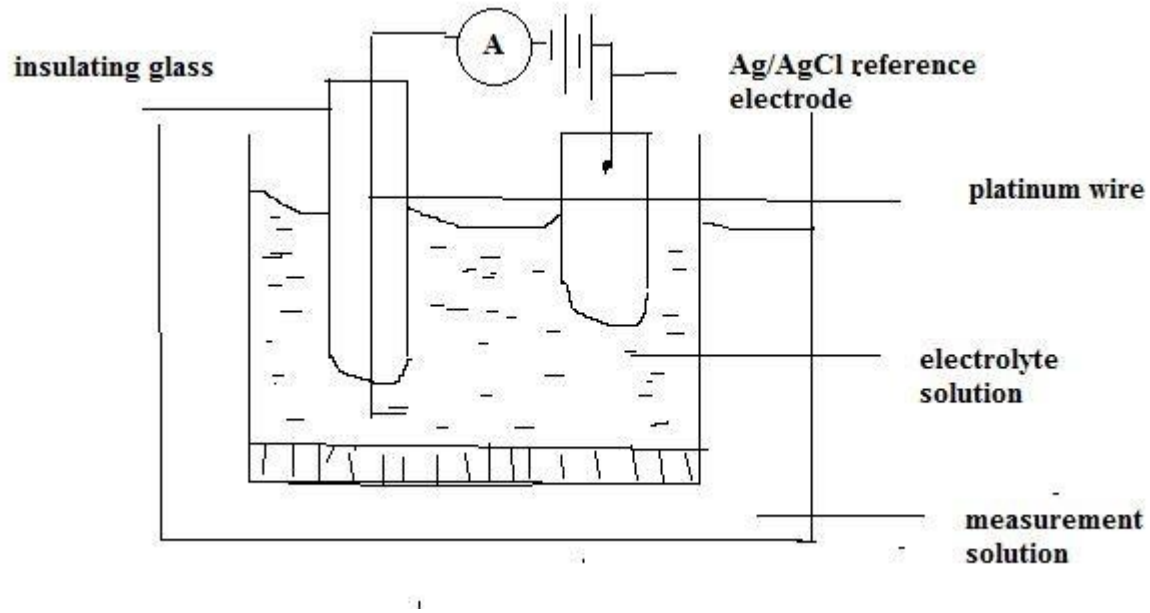



Figure2.25 $pO_2$ Electrode

Due to the negative terminal, the oxygen reduction takes place at the platinum cathode.

Finally the oxidation reduction current proportional to the partial pressure of oxygen diffused into the electrolyte can be measured in the micro ammeter. The electrolyte is generally scaled in the electrode chamber by means of a membrane through which the oxygen can diffuse from the blood or sample solution.

There are two types of pO2 measurement. They are

I) Vitro measurement

II) Vivo measurement

In case of dark electrode the platinum cathode and the reference electrode is present in a single unit. This electrode is used for vitro and vivo measurements.

**In Vitro Measurements**

In this method the blood sample is taken and the measurement for oxygen saturation is made in the laboratory. The electrode is placed in the sample blood solution and the pO2 value is determined.

**In Vivo Measurements**

In this method the oxygen saturation is determined while the blood is flowing in the circulatory system. A micro version of the pO2 electrode is placed at the tip of the catheter so that it can be inserted into various parts of the heart or circulatory system.

The pO2 measurement also has some disadvantages in it. The reduction process in the platinum cathode removes a finite amount of the oxygen from the cathode. And there is a gradual reduction of current with respect to time. However careful design and proper procedures in modern pO2 electrodes reduce the errors.

**COLORIMETER**

- Measures the color concentration of a substance in a solution by detecting the color light intensity passing through a sample containing the substance and a reagent
- Optical color filters are used to detect the color wavelength of interest. E.g., urine passes yellow light and absorbs blue and green
- Laser LEDs are preferred if their wavelength is suitable due monochromatic color.

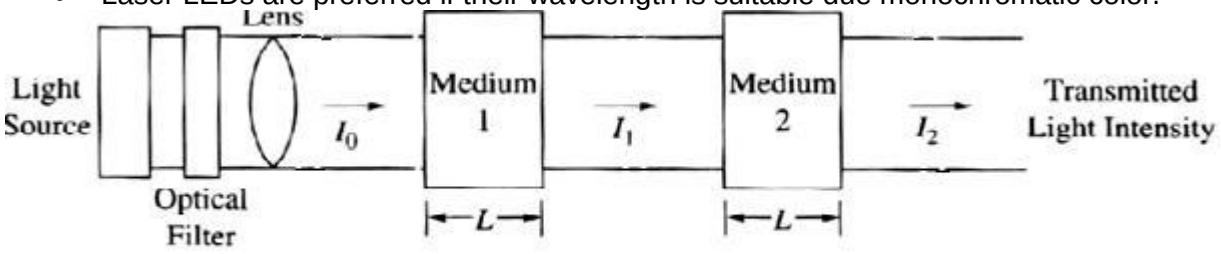



Figure2.26 Colorimeter

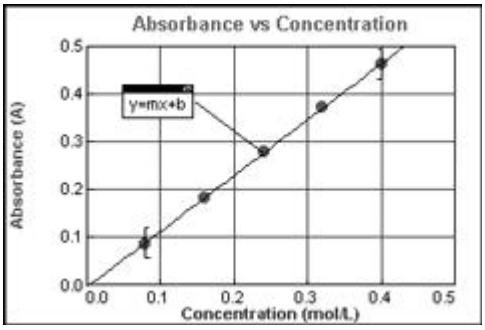



Figure2.27 Concentration vs Absorbance

**Transmittance**

$T = I_1/I_0 * 100\%$

**Absorbance**

$A = - \log I_1/ I_0$

$A = \log 1/T$

If the path length or concentration increases, the transmittance decreases and absorbance increases, a phenomenon expressed by Beer's Law.

**ELECTROMAGNETIC FLOWMETERS**

- Electromagnetic blood flow meters measure blood flow in blood vessels
- Consists of a probe connected to a flow sensor box

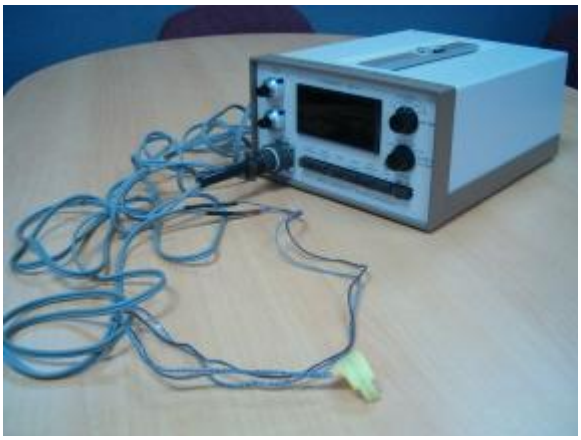


Figure2.28 Blood flow meter

An Electromagnetic Flow Meter is a device capable of measuring the mass flow of a fluid. Unlike the common flow meter you can find on the market it has no moving parts, and for this reason it can be made to withstand any pressure (without leakage)and any fluid(corrosive and non corrosive). This kind of flow meter use a magnet and two electrodes to peek the voltage that appears across the fluid moving in the magnetic field.

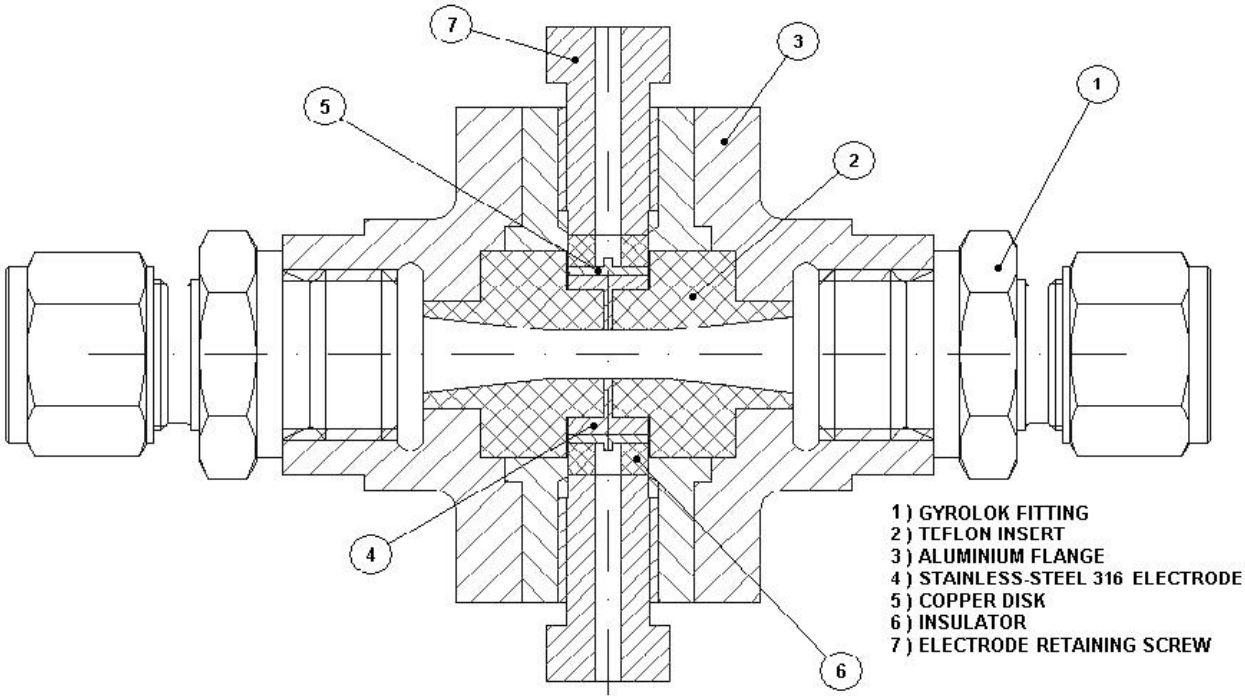



Figure2.29 Electromagnetic Flowmeter

The Neumann Law (or Lenz Law) states that if a conductive wire is moving at right angle through a magnetic field, a voltage ***E*** [Volts] will appear at the end of the conductor (Fig.1):
Where
B = Magnetic Induction
[Weber/m2]

L = Length of the
***E=B*L*V*** portion of the wire 'wetted' by the magnetic field [m]
V = Velocity of the wire [m/sec]

***Fig.2***

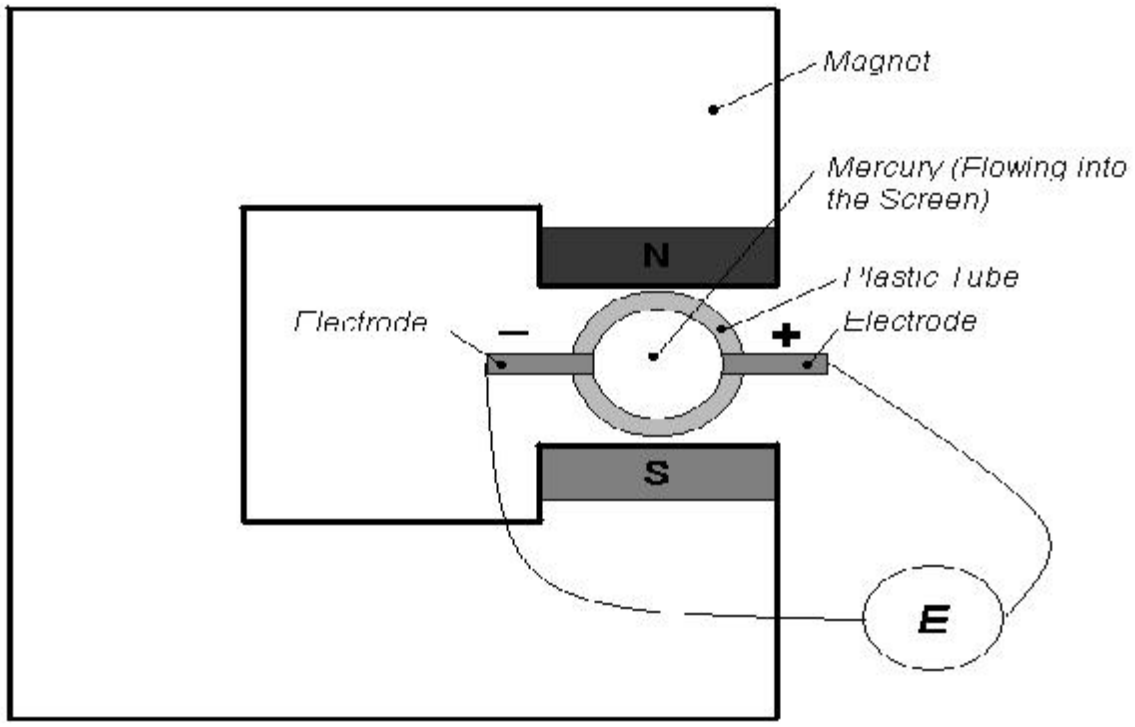



Figure2.30 Magnetic Blood flow meter principle

Now imagine you have a plastic tube with two electrodes on the diameter and Mercury flowing into it (fig.2.6.3). A voltage will appear on the electrodes and it will be

***E=B*L*V***

As in the previous example (***L*** in this case is the inner diameter of the tube).Mercury as tiny conductive wires next to each other: each wire, moving in the tube, will touch the two electrodes, and thus you can measure their voltage.

An interesting fact is that if you reverse the flow, you still get a voltage but with reverse polarity (Fig.1). Till now we have talked about a conductive fluid, Mercury, but this stuff will also work with nonconductive fluid, provided that you use an alternating magnetic field. Two physicists, Middleman and Cushing, in an unpublished work, stated that when using a non-conductive fluid, if the frequency of the alternating magnetic field is ***v*** the voltage at the electrodes will be attenuated by a factor ***a*** so that:

**Measuring the flow**

`A perfect axisymmetric construction cannot be achieved and thus some magnetic flux lines will 'wet' the connecting wires to the electrodes. The alternating magnetic field will create an

offset voltage in this wire and even if the fluid is not moving, the measured voltage will not be zero.

**ULTRASONIC FLOWMETERS**

The blood cells in the fluid scatter the Doppler signal diffusively. In the recent years ultrasound contrast agents have been used in order to increase the echoes. The ultrasound beam is focused by suitable transducer geometry and a lens.

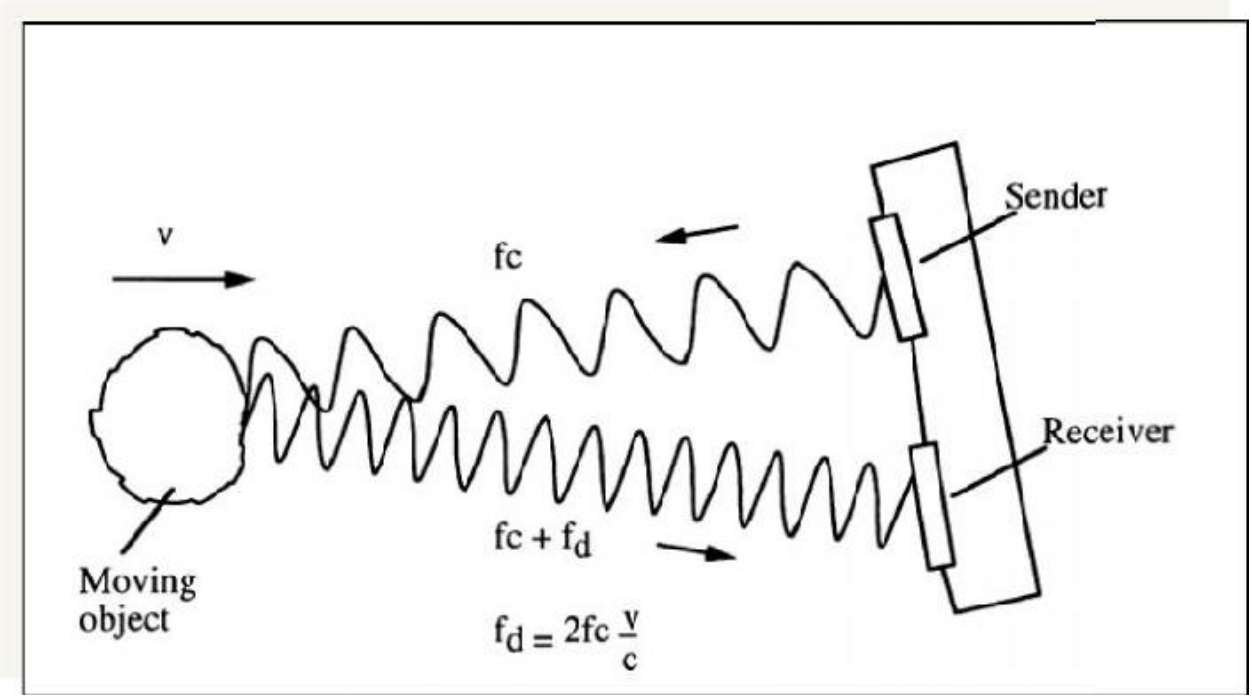



Figure2.31 Ultrasonic flow meters

fd = 2fcv/c

*f = 2- 10 MHz*

*c* = 1500 - 1600 m/s (1540 m/s)

*f = 1,3 – 13 kHz*

In order to know where along the beam the blood flow data is collected, a pulsed

Doppler must be used. The flow velocity is obtained from the spectral estimation of the received

Doppler signal the ultrasound Doppler device can be either *a continuous wave* or *a pulsed Doppler*

**A Continuous Wave**

No minimum range

Simpler hardware

Range ambiguity

Low flow cannot be detected

**A Pulsed Doppler**
Accuracy
No minimum flow
Minimum range
(Maximum flow) x (range)= limited the power decays exponentially because of the heating of the tissue. The absorption coefficient proportional to frequency the far field operation should be avoided due to beam divergence.
**$D_{nf} = D_2 / 4$**
*D* = Transducer diameter (e.g. 1 – 5 mm) .
**CARDIAC OUTPUT**
**Definition:** Volume of blood pumped by the heart per min
CO = SV x HR
Norm ~ 5 l/min
Cardiac index – corrected for body surface area
**Affected by** : Met. Rate – pregnancy, hyperthyroid, septic
Preload / contractility / afterload
**Clinical indicators of CO imprecise**
Affected by anesthetic agents used in everyday practice
Provides estimate of:

- whole body perfusion
- oxygen delivery
- left ventricular function

Persistently low CO associated with poor outcome
**Methods: Fick method**
Dilution techniques – dye / thermal / lithium Pulse contour analysis- LiDCO &
PiCCO Oesophageal doppler
TOE
Transthoracic impedance plethysmography
Inert gas through flow
Non-invasive cardiac output measurement
**Fick Principle:** Measure volume displacement 1st proposed 1870 —the total uptake or release of a substance by an organ is the product of the blood flow through that organ and the arteriovenous concentration difference of the substance. Limited by cumbersome equipment, sampling errors need for invasive monitoring and steady-state haemodynamic and metabolic conditions
**Indicator dilution techniques**

An indicator mixed into a unit volume of constantly flowing blood can be used to identify that volume of blood in time, provided the indicator remains in the system between injection and measurement and mixes completely in the blood.

**Dye dilution**

- Inert dye – indocyanin green
- Injected into pulmonary artery and arterial conc.
- measured using a calibrated cuvette densitometer
- Plot indicator dilution curve (see diagram) CO derived from area under curve.

**Indicator Dilution Curve**

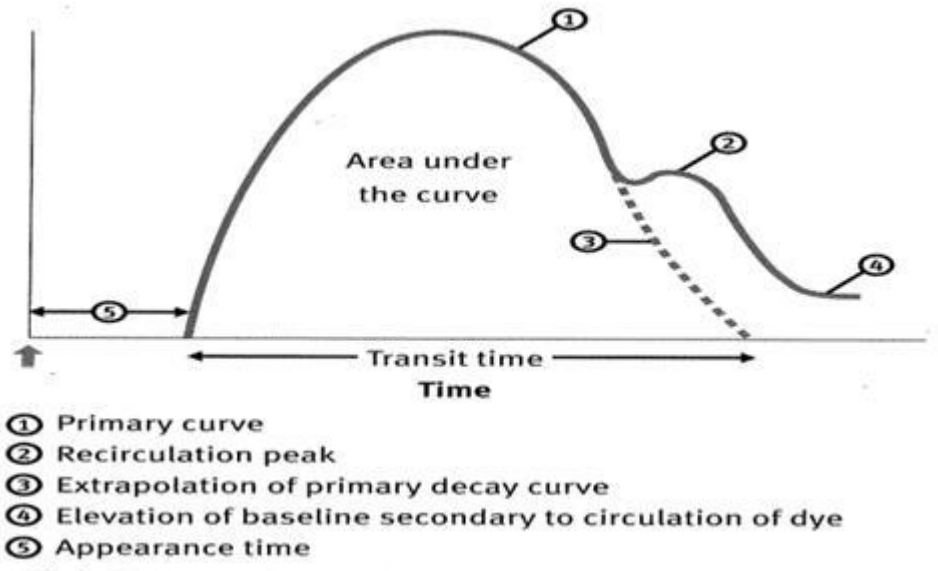



Figure2.32 Indicator dilution curve

**Cardiac Output Measurement**

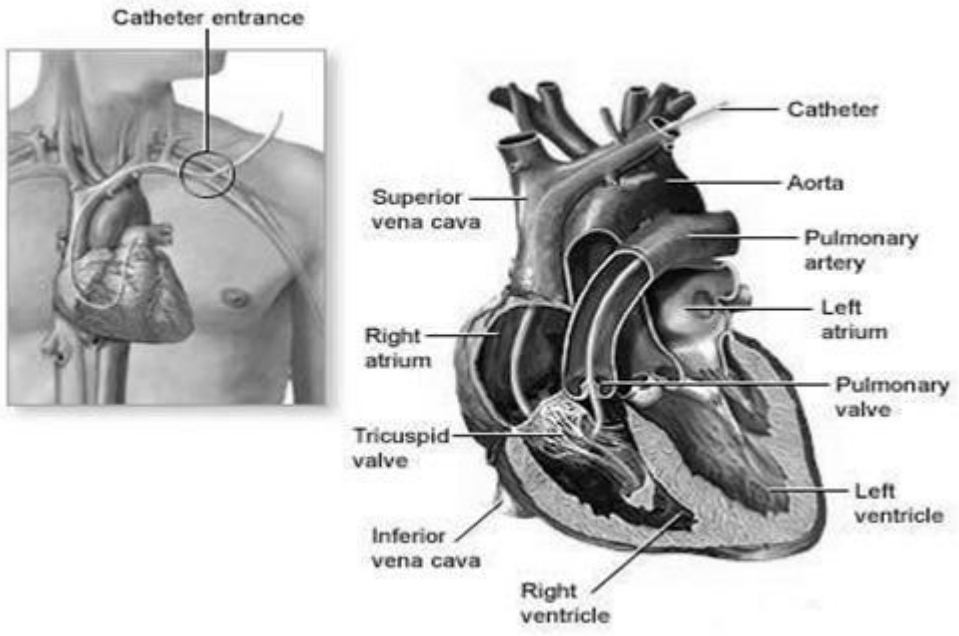



Figure2.33 Cardiac output measurement

**RESPIRATORY RATE MEASUREMENT**

Respiratory system provides a means of acquiring oxygen and eliminating CO2. Various laws are involved in the understanding of respiratory functions.

Various Gas laws are given below:

1. **BOYLE'S LAW:** It states that at constant temperature, the volume of gas varies inversely with the pressure.

V2/V1 =P1/P2 here temperature T= constant

V2= Final volume

V1 = Initial volume

P1 = Original (initial) pressure

P2 = Final pressure

2. **CHARLE'S LAW:** It states that, at constant pressure, the volume of gas is directly proportional to the absolute temperature.

V2/V1 =T2/T1 Here pressure P=constant

V2, V1 =Final, initial volume

T1 =original temperature

T2 = Final temperature

3 . **HENRY'S LAW:** It states that, if the temperature is constant, the quantity of a gas that goes into a solution is directly proportional to the partial pressure of that gas . The gas with the greater partial pressure will have more mass in solution.

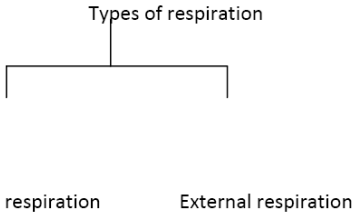
4. **DALTON'S LAW :** It states that, the total pressure exerted by a mixture of gases is equal to the sum of the partial pressures of various gases.

PT =P1 + P2 + …… +Pn

PT = total pressure

P1, P2, P3 = partial pressure of various gases

**TYPES OF RESPIRATION**




**Respiration** is nothing but the interchange of gases between an organism and the living medium

**Internal respiration** is the exchange of gases between the blood stream and nearby cells .**External respiration** is the exchange of gases between the lungs and blood stream.

**Lungs Volumes and Capacities (Respiration Parameters) Or (LVC)**

Respiration parameters are used to indicate the state of respiratory function, including lung volumes and capacities, airway resistance, lung compliance, etc .

**Dead Air**

Only a portion of the air entering the respiratory system actually reaches the alveoli. The volume of air that is not available for gas exchange with the blood is known as dead air . The total dead space is less less than 30 percentage of the total volume.

**Tidal Volume (TV)**

Tidal volume is the depth of breathing or the volume of gas inspired or expired during each respiratory cycle. It is equal to 500 ml for a normal person.

**Inspiratory Reserve Volume (IRV)**

It is the maximal amount of gas that can be inspired from the end- inspiratory position (Extra inspiration from the high peak tidal volume. It is equal to 3600 ml for a normal person

**Expiratory reserve volume (ERV)**

It is the maximal amount of gas that can be end expiratory level. It is equal to 1200 ml.

**Residual Volume (RV)**

It is the amount of gas remaining in the lungs at the end of maximal expiration. It is equal to 1200 ml.

**Minute Volume (MV)**

It is the volume of air breathed normally for 1 minute.

**Total Lung Capacity (TLC)**

It is the amount of gas contained in the lungs at the end of maximal inspiration and it is the sum of inspiratory capacity(IC)and functional residual capacity (FRC).TLC is of 6000 ml for a normal person.

**Vital Capacity (VC)**

It is the maximum amount of gas that can be expelled from the lungs by forceful effort from maximal inspiration. It is 4800 ml for a normal person.

**Inspiratory Capacity(IC)**

It is the maximum amount of gas that can be inspired from the resting expiratory level and it is the sum of tidal volume and inspiratory reserve volume. It is equal to 3600 ml for a normal person.

**Functional Residual Capacity (FRC)**

It is the amount of gas remaining in the lungs at the resting expiratory level.

FRC = ERV + RV

**Airway resistance**

It relates to the ease with air flows through tubular respiratory structures. In smaller tubes, airway resistance is high.

**Lung Compliance**

It is the ability of the alveoli and lung tissue to expand on inspiration**.**

**Lung Elasticity**

It is the ability of the lung's elastic tissues to recoil during expiration

**Intra thoractic Pressure**

It is the positive and negative pressure occur within the thoracic cavity

Types of respiration rate measurement

1. Displacement method
2. Thermistor method
3. Impedance pneumography
4. CO2 method
5. Apnoea detectors

**Displacement Method**

In this method the transducer is hold by an elastic band which goes around the chest. The respiratory movements results in a corresponding resistance changes of the strain

Gauge. It is connected as one arm of a Wheatstone bridge circuit. Its output varies with chest expansion. This output corresponds to the respiration activity.

**Thermistor Method**

Generally there is a temperature difference between inspired and expired air. This temperature is sensed by placing thermistor in front of nostrils. Thermistor is placed by using suitable stand.

The thermistor is connected with the bridge circuit. So unbalance signal is amplified to get the respiratory activity

**BLOOD PRESSURE**

One of the oldest physiological measurements

Observation of blood pressure allows Dynamic tracking of pathology and physiology affecting to the cardiovascular system, which has profound effects to all other organs of the body

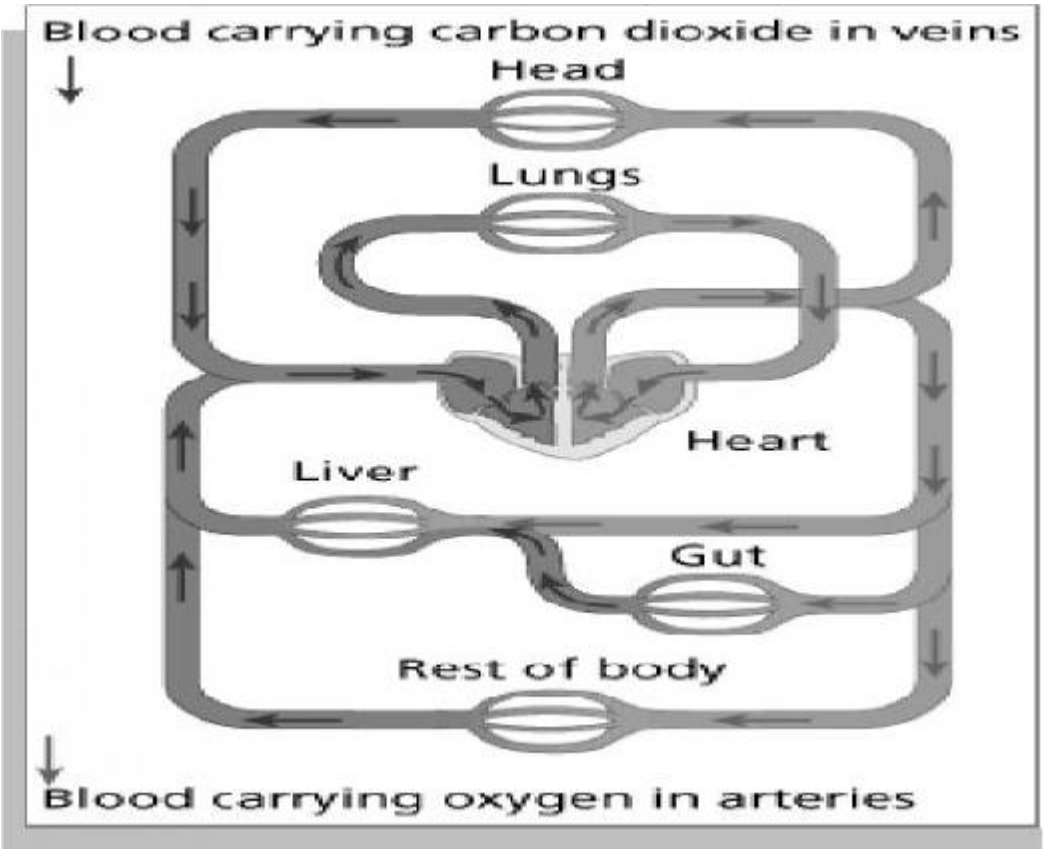


Figure2.34 Observation of blood pressure
Originates from the heart

Commonly refers to arterial blood pressure

**Value depends on 3 factors:**

- cardiac output diameter of arteries the quantity of blood
- Values should be lower than 120 / 80 mmHg(systolic pressure (SP) / diastolic pressure (DP))

- *High value* increases the risk of heart attack and strokes
- *Low value* increases the risk of lower oxygen perfusion e.g. in brains.
- However, the 'normal values' differ from person to another
- Pulse Pressure(PP) = SP - DP

**Mean pressure (MP)**

Average pressure during one cardiac cycle driving force of the peripheral perfusion. an estimate can be done by using an empirical formula:

MP = DP+PP/3

SP and DP may vary significantly throughout the arterial system but MP is quite uniform (in normal situations)

**1. Non-Invasive**

- Palpatory Method(Riva-Rocci Method)
- Auscultatory Method
- Ultrasonic Method
- Oscillometric Method
- Tonometry

**2. Invasive**

- Extravascular Sensor
- Intravascular Sensor
- General on System Parameters

**INDIRECT METHODS IN BLOOD PRESSURE MEASUREMENTS**

**Indirect measurement = non-invasive measurement**

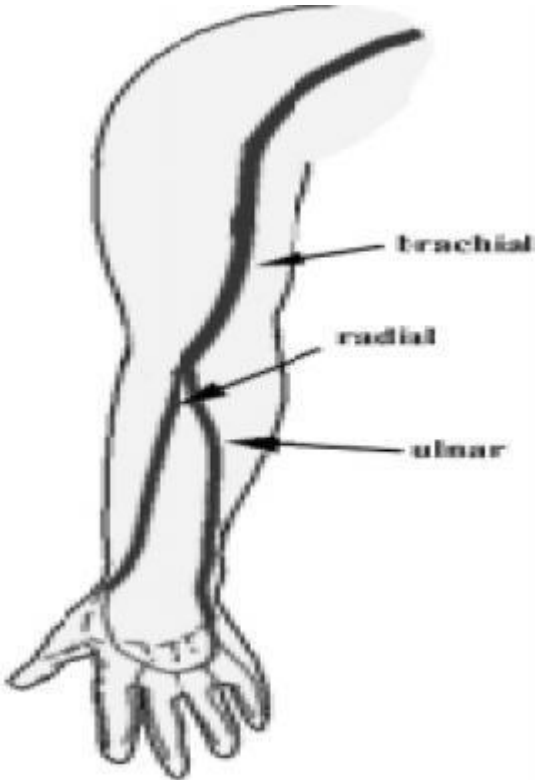



Figure2.35 Blood pressure measurements

Brachial artery is the most common measurement site

Close to heart

Convenient measurement

Other sites are e.g.: forearm / radial artery wrist (tends to give much higher SP)

The most common indirect methods are auscultation and oscillometry an occlusive cuff is placed on arm and inflated to P> SP. Then the cuff is deflated gradually and the measurement of blood flow is done.

The occlusive cuff should be of a correct size in order to transmit the pressure to the artery evenly and thus to obtain accurate results .A short cuff requires special attention in placement. Longer cuff reduces this problem. The cuff should be placed at the heart level in order to minimize the hydrostatic effects.

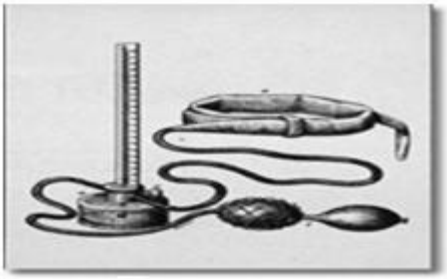


Figure2.36 Sphygmomanometer

**DIRECT METHODS IN BLOOD PRESSURE MEASUREMENTS**

Direct measurement = Invasive measurement

A vessel is punctured and a catheter (a flexible tube) is guided in The most common sites are brachial and radial arteries but also other sites can be used e.g. femoral artery A division is made into extravascular and intravascular sensor systems .This method is precise but it is also a complex procedure involving many risks Used only when essential to determine the blood pressure continuously and accurately in dynamic circumstances

**EXTRAVASCULAR SENSOR**

The sensor is located behind the catheter and the vascular pressure is transmitted via this liquid-filled catheter.

The actual pressure sensor can be e.g. strain gauge, variable inductance, variable capacitance Optoelectronic, piezoelectric, etc

**INTRAVASCULAR SENSOR**

Sensor is located in the tip of the catheter. This way the hydraulic connection is replaced with an electrical or optical connection .The displacement of the diaphragm is measured .The frequency response is not limited by the hydraulic properties of the system.

- No time delay.
- Electrical safety and isolation when using fiber optics
- Breaks easily
- More expensive

**Disposable Sensors**

Disposable sensors decrease the risk of patient cross-contamination and reduce the amount of handling by hospital personnel Cheaper and more reliable than reusable pressure sensors.

**GENERAL ON SYSTEM PARAMETERS**

Even minute air bubbles in catheter have a dramatic effect on frequency response
The natural frequency and the length of the catheter have a following relationship:

$$f_n = 1/\sqrt{L}$$

The catheter diameter has a linear relationship to natural frequency Stiffer catheters have a higher frequency response.

| Self-Check -2 | Written Test |
|---|---|

**Directions:** Answer all the questions listed below. Use the Answer sheet provided in the next page:

**1.** One of the following ion(s) is/are the major ion inside the membrane (4pts)

A. $Na^+$ B. $Cl^-$ C. $K^+$ D. all E. none

***Note:*** **Satisfactory rating - 4 points** **Unsatisfactory - below 4points**

**Answer Sheet**

Score = _____

Rating:

Name: _____ Date: _____

**Short Answer Questions**

| Information Sheet-3 | Measuring Bio-potential signals |
|---|---|

**3.1 The electrocardiogram (ECG)**

The heart has four chambers: left atrium, right atrium, left ventricle and right ventricle. Located at the top of the right atrium are a group of cells which act as the primary pacemaker for the heart. Through a complex change of ionic concentration across the cell membranes, an extra-cellular potential field is established. This potential field excites the neighboring cells, resulting in cell-to-cell electrical propagation within the heart. Since the thorax acts as a conductive medium, the potential field generated by the heart propagates to the body surface.

If pair of surface electrodes, attached to the left and right arms of a human subject, is connected to a high-input impedance differential amplifier, an electrical signal which varies in time with the heart beat will be observed at the output of the amplifier (see Figure 1). This signal, which has peak amplitude, before amplification, of the order of 1mV, is known as the electrocardiogram (ECG).

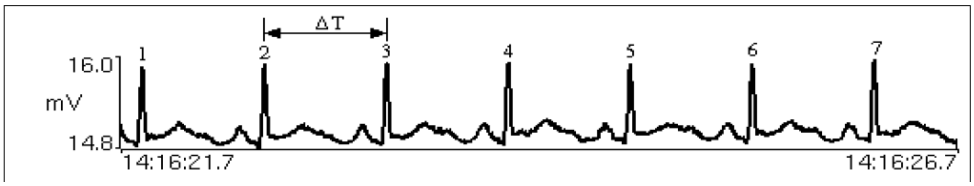


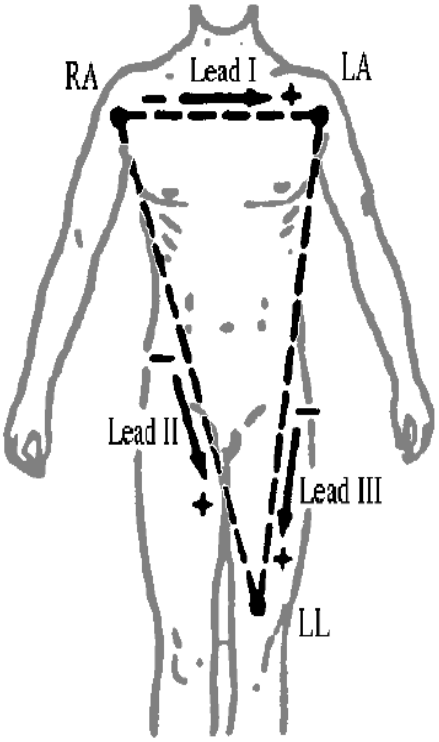

*Figure 3.1: An ECG trace. 1, 2, 3 ... are consecutive heart beats. The heart rate, in beats per minute, is* 60/ΔT

In order to record the ECG, we need a transducer capable of converting the ionic potentials generated within the body into electronic potentials which can be measured by conventional electronic instrumentation. Such a transducer consists of a pair of *electrodes*, which measure the ionic potential difference between their respective points of application on the body surface. Electrodes may be classified either as polarizable, in which case they behave as capacitors, or non-polarizable, in which case they behave as resistors. Common electrodes have characteristics that lie between these extremes; the silver-silver chloride electrode discussed below approximates more closely to a non-polarizable electrode.

**Equivalent circuit of a system for recording the ECG**

*Electrode placement*

The most obvious way to record the ECG is between the Right Arm (RA) and the Left Arm (LA) although another two combinations using the Left Leg (LL) are also used clinically (RA-LL and LA-LL). Figure 3.2 summarizes this.




$V_I$ = (potential at LA) – (potential at RA)

$V_{II}$ = (potential at LL) – (potential at RA)

$V_{III}$ = (potential at LL) – (potential at LA)

Figure 3.2 Typical electrode placements

A third electrode is also used to connect the patient to the common ground of the instrumentation. Usually, this ground electrode is attached to the right leg.

*Silver-silver chloride electrode*

Electrodes for recording bio potentials are composed of a metal (usually silver for ECG measurement), and a salt of the metal (usually silver chloride). In addition, some form of electrode paste or jelly is applied between the electrode (normally a flat silver disc) and the skin. The combination of the ionic electrode paste and the silver metal of the electrode forms a local solution of the metal in the paste at the electrode-skin interface (also referred to as the electrode-tissue interface or electrode-electrolyte interface). Hence, some of the silver dissolves into solution producing Ag+ ions:

Ag→Ag+e-

Ionic equilibrium takes place when the electric field set up by the dissolving ions is balanced by the forces of the concentration gradient. At this point, there is a monomolecular layer of *Ag+* ions at the surface of the electrode and a corresponding layer of *Cl-* ions adjacent to this. This combination is called the *electrode double layer* and there is a potential drop *E* across this layer, called the *half-cell potential* (0.8V in the case of the *Ag-AgCl* electrode).

*Equivalent circuit of electrode interface*

The double layer of charges of opposite sign separated by a dielectric constitutes a form of capacitance, say *C*. However, since the *Ag-AgCl* electrode behaves mostly as a non-polarizable electrode, the main component of the impedance is resistive, say *R*1.

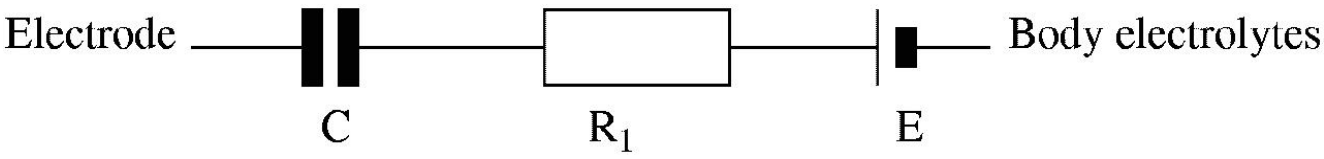



Figure 3.3: Simple R-C model of electrode-electrolyte interface

The series model in Figure3.3 needs to be modified to account for the fact that the impedance does not increase to infinity as the frequency tends to zero. This is done by adding a parallel resistance *R*2 (as shown in Figure3.4) which accounts for the electrochemical processes taking place at the electrode-electrolyte interface. The values of *R*1, *R*2 and *C* depend on the electrode area, surface condition, current density and the type and concentration of electrode paste used. (Typical values are *R*1 = 2k, *R*2 = 10k and *C* = 10F.)

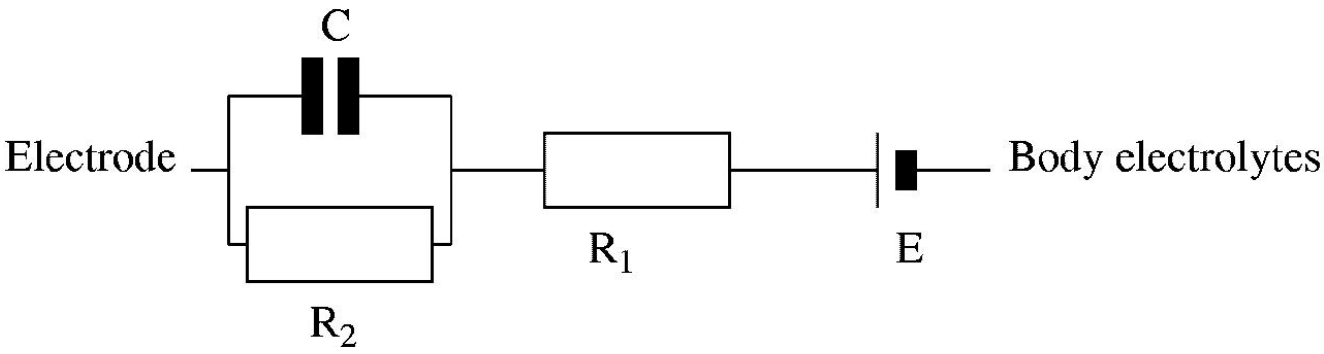


Figure3. 4: Equivalent circuit of the Ag-AgCl interface

*Movement artefact*

If the electrode is moved with respect to the electrolyte, this mechanically disturbs the distribution of charge at the interface and results in a momentary change of the half-cell potential until equilibrium can be re-established. If a pair of electrodes is in contact with an electrolyte and one of the electrodes moves while the other remains stationary, a potential difference appears between the two during this motion. This potential is referred to as *movement artefact* and can be a serious cause of interference in the measurement of the ECG (or any other bio potential).

*Overall equivalent circuit*

If we represent the electrical activity of the heart by a voltage generator, model the tissues in the thorax as resistors and use the simple model of the electrode-electrolyte interface of Figure 4, we can put together an equivalent circuit which models the electrical impedance seen by the input stage of an ECG system. This overall equivalent circuit is shown in Figure3. 5 below.

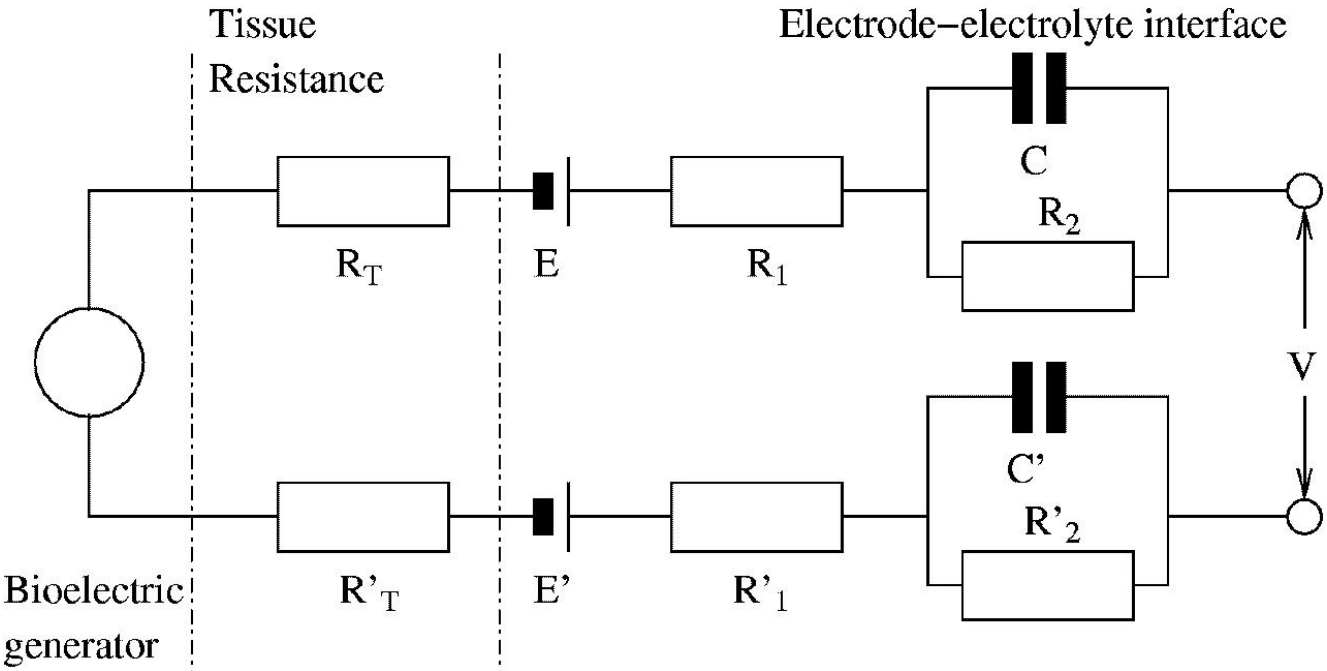


Figure 3.5: Equivalent circuit for tissue and electrode system

Although *C* and *C*', *R*1 and *R*1', *R*2 and *R*2' may not be exactly equal (different sites and modes of application on the skin), *E* should be equal to *E*' (same type of electrode). Hence *V* represents the actual difference of ionic potential between the two points on the body from which the ECG is being recorded.

| Self-Check -3 | Written Test |
|---|---|

**Directions:** Answer all the questions listed below. Use the Answer sheet provided in the next page:

**1.** In which of the following chamber is pacemaker located?

A. Left atrium B. right ventricular C. left ventricular D. right atrium

**2.** A medical device used to measure electrical activity of the heart is:

A. EEG B. EOG C. ECG D. EMG

**3.** How many electrodes are used in ECG?

A. 9 B. 10 C. 12 D. 6

***Note:*** **Satisfactory rating - 5 points** **Unsatisfactory - below 5 points**

**Answer Sheet**

| |
|---|
| Score = _____ |
| Rating: _____ |

Name: _____ Date: _____

**Short Answer Questions**

| | |
|---|---|
| **Operation Sheet 1** | **Procedure of measuring bio potential signals** |

**4.3 Measuring Bio-potential signals.**

**Steps/procedures Measure electrical activity heart using ECG**

**Step 1-** prepare all necessary materials and devices needed.

**Step 2-** Wash your hands and clarify the activity.

**Step 3-** Clarify whether the patient knows why the test is being performed (chest pain).

**Step 4-** Ensure the patient is comfortable for test.

**Step 5-** make ECG pad good contact with the skin.

**Step 6-** Input the patient's data into the ECG machine correctly, thus ensuring the correct details are printed onto the ECG.

**Step 7**- stick the pads correctly into the patient's skin using a 12 leads and 10 electrodes.

**Step 8**- Attach the leads to the pads by following standards (color code).

**Step 09** -Record the reading and print a copy on the ECG.

**Step 10**-Disconnect the leads from the pads and allow the patient to remove the pads themselves, or offer assistance if needed. Offer a tissue as the pads are sticky.

**Step 11**-Allow the patient to dress at the end of test.

| | | |
|---|---|---|
| **LAP Test** | Practically Demonstrate Measuring Bio-potential signals following the procedures | Name: _____ |

_____ Date: _____

Time started: _____ Time finished: _____

**Instructions:** Given necessary templates, tools and materials you are required to perform the following tasks within 2 hours.

**Task 1:** Measure Bio-potential signals following the correct procedures in biomedical laboratory.

## Reference


1. BR4_TG_6-8.pdf
2. Anatomy and Physiology-Open Stax College-with EDITS.pdf
3. anatomy+phys+vol2a.pdf

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