Subsystems of Human Body

Human body is a system consisting of many subsystems and they function in a coordinated manner. Following are the subsystems in the human body:

Skeletal System

The skeletal system gives reinforcement and shape to the human body similar to steel structures in concrete buildings. In addition to this it supports, protects and allows bodily movement. It also stores minerals and produces blood cells. This system has 206 bones to support tissues and other organs of the human body. It does many important functions. This system protects organs for living like brain, heart and lungs through skull, sternum and rib cage respectively. All the bones are connected by ligaments to form joints. Bones are covered by muscles through tendons. The combination of bones and muscles is called musculo-skeletal system. Musculo skeletal system provides the bodily movement through interaction between muscles and bones. Similarly, the joints can be stretched and folded by relaxation and contraction of muscles. One can fold the elbow by contraction of biceps and relaxation of triceps. On the other hand, elbow can be stretched by contraction of triceps and relaxation of biceps.

Circulatory System

The primary parts of the circulatory system are the heart, arteries, veins and capillaries. It is like a hydraulic cooling system in a car engine. In a car, liquid medium circulates inside an engine and takes out the heat. Similarly, the circulatory system takes carbon dioxide, the waste product of cells of entire human body, to the lungs. In addition to this, it carries oxygen and nutrients to all the cells of the body. In the circulatory system, the blood acts as the transport medium.

Heart is a pump to pump the oxygenated blood to the entire body. The returned blood pumps is rich in carbon dioxide. Heart pumps this blood to the lungs to enrich oxygen and to remove carbon dioxide. This process is called circulation. The oxygen in the transported blood is important for the body cells to function.

Respiratory System

The respiratory system consists of mouth, nose, trachea, lungs, and diaphragm as shown in Figure 2.1. In a car, radiator radiates the engine heat to the outside ambient medium. Similarly in the human body, the lungs send out the carbon dioxide and enrich the blood with oxygen. It is a port to send out carbon dioxide and get in the oxygen. The primary work of the respiratory system is to remove carbon dioxide from the blood and to enrich blood with oxygen. This process can be achieved through breathing. Breathing will happen if the diaphragm contracts

and relaxes. During breathing, air rich in oxygen is inhaled and air rich in carbon dioxide is exhaled. That is, the carbon dioxide in the blood is replaced by oxygen. Oxygen-rich air enters through mouth, nose larynx, trachea and two bronchi then reaches the lungs cavity. From there, it splits into two paths called bronchi. Finally, the air enters the alveoli in the lungs. At alveoli, the carbon dioxide in the blood is replaced by oxygen and the blood becomes oxygen-rich.

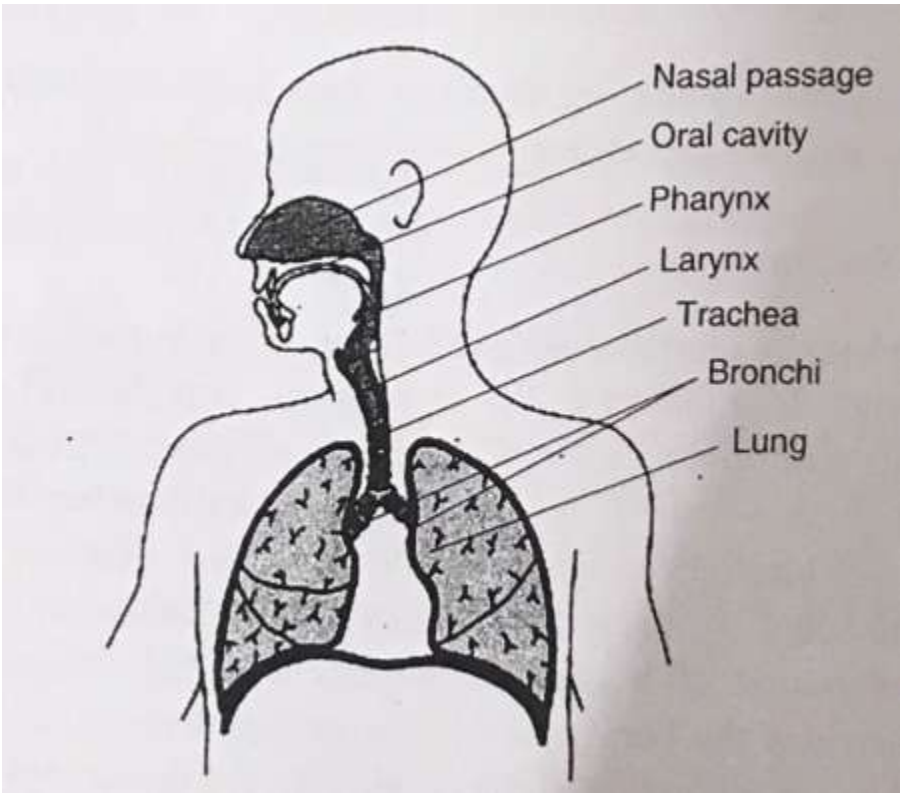
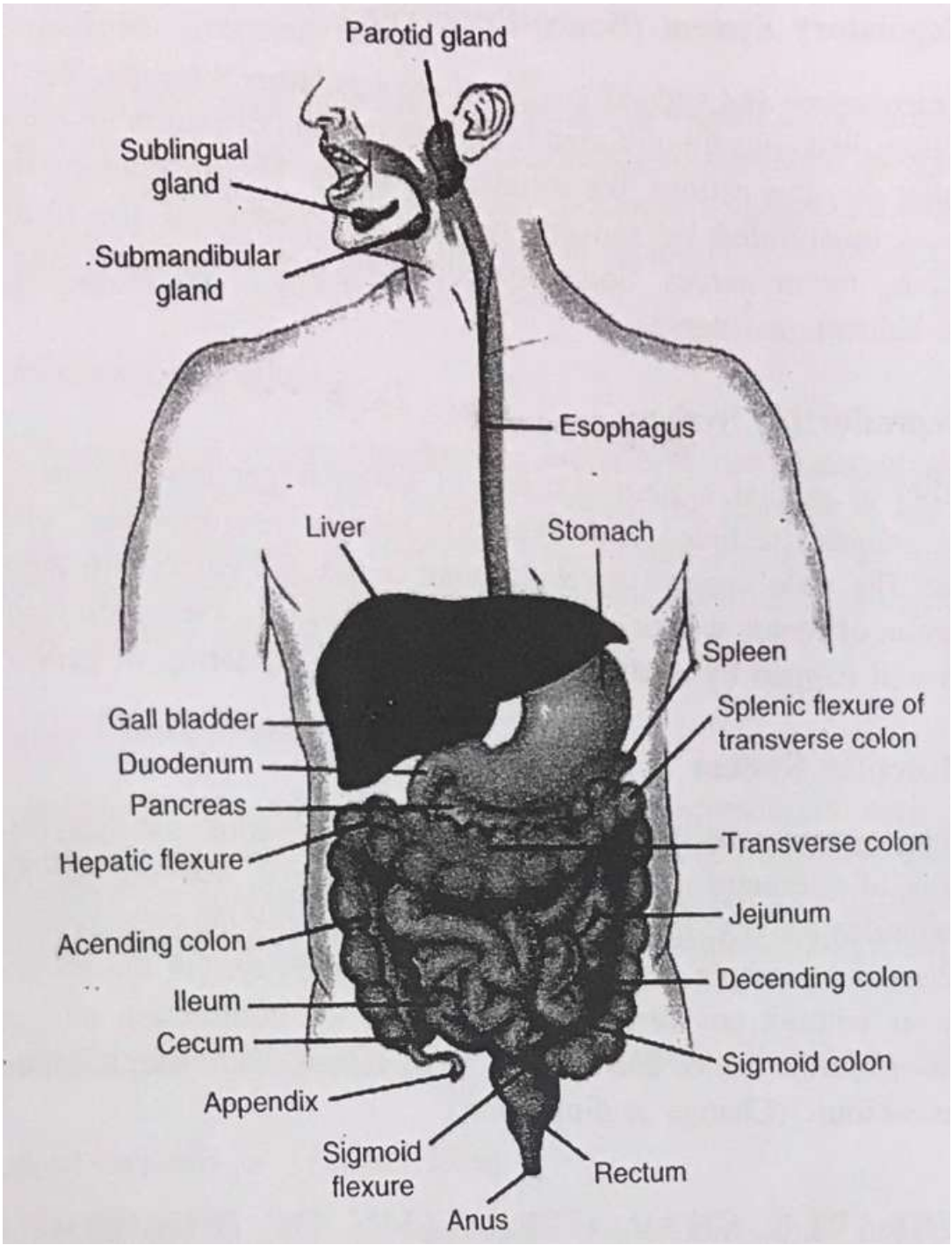


Figure 2.1 respiratory system.

Digestive system

The digestive system consists of mouth, esophagus, stomach, small intestine, large intestine, rectum, and anus as shown in Figure 2.2. These organs are serially connected from mouth to anus to form the digestive system. The inner side of the digestive system is covered with mucosa. The process of converting the food into molecules of nutrients, and then absorbed into the blood is called digestion. These absorbed nutrients will be used to build and nourish the cells. The food is converted into molecules of nutrients because of addition of digestive juices produced by the salivary glands, stomach, intestines, liver, and pancreas. Layers of

smooth muscle along the digestive tract will move the food further. Gallbladder temporarily stores the digestive juice produced by liver before it is added to the food. Circulatory system and nervous system are also responsible for the proper functioning of digestive system.



2.2 Digestive system.

Excretory System

Excretory system consists of two kidneys, ureters, bladder, and urethra as shown in Figure 2.3. The function of excretory system is to remove metabolic wastes and keep correct proportional quantity of water, salt and other nutrients in human body. Bodily process discharges metabolic waste and unused materials. These waste and non-useful materials are nitrogenous products. The excretory system will remove all these wastes from the human body.

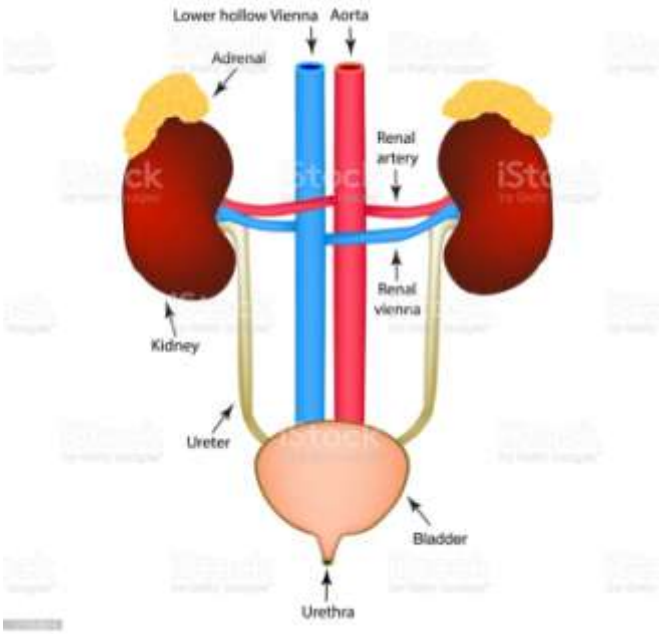


Figure 2.3 Excretory system.

Regulatory System (Neuro-Endocrine*)*

Both nervous system and endocrine system are regulatory system. Nervous system looks after the fast actions likes secretion of glands and contraction of muscular system. Endocrine system of looks after the slow actions like metabolic process. The information between the subsystems and brain is transmitted by sensory nerves. The order of the brain to the muscles are transmitted by motor nerves.

Endocrine system

Endocrine systems, also referred to as hormone systems They are made up of:
Glands located throughout the body as shown in Figure 2.4, hormones that are made by the glands and released into the bloodstream or the fluid surrounding cells, and receptors in various organs and tissues that recognize and respond to the hormones.

Hypothalamus - The hypothalamus links our endocrine and nervous systems together. The hypothalamus drives the endocrine system.

Pituitary gland - The pituitary gland receives signals from the hypothalamus. This gland has two lobes, the posterior and anterior lobes. The posterior lobe secretes hormones that are made by the hypothalamus. The anterior lobe produces its own hormones, several of which act on other endocrine glands.

Thyroid gland - The thyroid gland is critical to the healthy development and maturation of vertebrates and regulates metabolism.

Adrenal glands - The adrenal gland is made up of two glands: the cortex and medulla. These glands produce hormones in response to stress and regulate blood pressure, glucose metabolism, and the body's salt and water balance.

Pancreas - The pancreas is responsible for producing glucagon and insulin. Both hormones help regulate the concentration of glucose (sugar) in the blood.

Gonads - The male reproductive gonads, or testes, and female reproductive gonads, or ovaries, produce steroids that affect growth and development and also regulate reproductive cycles and behaviors. The major categories of gonadal steroids are androgens, estrogens, and progestins, all of which are found in both males and females but at different levels.

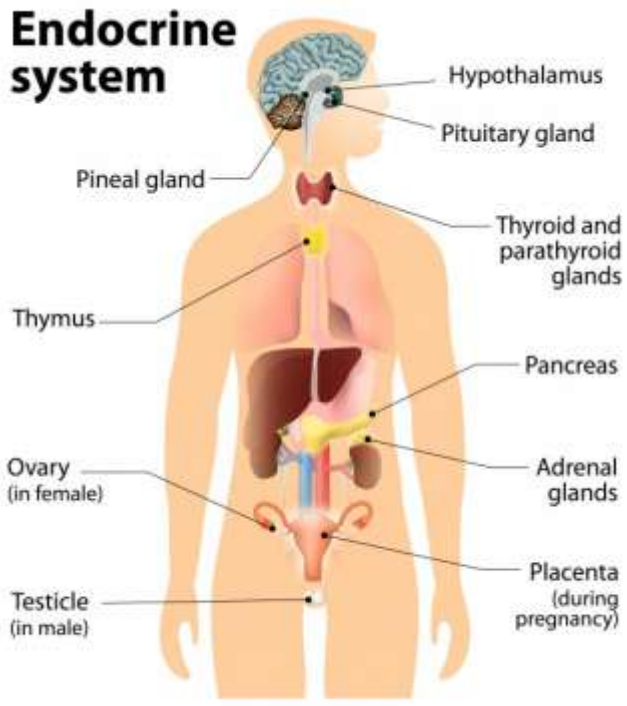


Figure 2.4 Endocrine system.

Reproductive System

Reproductive or genital system consists of external genitalia (penis or vulva) and gamete producing gonads *(*testicles and ovaries). Human reproduction will happen as internal fertilization. The male's sperm travels through cervix and enters into the uterus for fertilization. Then gestation of fetus will occur for about nine months. Gestation leads to a child birth. Child birth will happen by contraction of uterus and dilatation of cervix.

Muscular System

The muscular system consists of voluntary muscles, involuntary muscles and cardiac muscles. The working of voluntary muscles is under our control. Moving our hand is an example of voluntary muscles activity. Involuntary muscles will work unconsciously. Movement of food in our intestine is an example of involuntary muscle activity. On the other hand, cardiac muscle works forever without any rest. Nerves regulate the contraction and relaxation of muscle. Contraction of muscle can be done in two ways. One is isometric (no change in dimensional the other is isotonic (Change in dimension).

Desirable characteristics of biomedical Instrumentation systems

Biomedical instrumentation system should have the following desirable characteristics.

1- Signal Characteristics

The desirable signal characteristics of biomedical instrumentation systems are sensitivity, range, linearity, frequency response and accuracy. Already this has been discussed in the design factor of biomedical instruments. The other important signal characteristics are transient response, differential or absolute input, input impedance and reliability. Transient response is the ability of the instrument to give steady state output as quickly as possible. Differential input is the ability of the instrument to ignore common mode signals. The input impedance of an instrument has to be as high as possible so that the instrument will not consume much current. If an instrument consumes more current, then the input signal may be altered due to loading effect. The final important signal characteristic is reliability.

2- Environmental Characteristics

The instrument should have very good signal-to-noise ratio under all working conditions. The instrument should not be affected by ambient temperature, humidity, pressure, acceleration, shock vibration, and radiation. It should be tough enough to withstand all these environmental conditions. The power consumption of the instrument should be as small as possible. The size and shape of the instrument should be easy to use.

3-Medical Characteristics

The medical instrumentation system should have either invasive or non-invasive tissue-sensor depending upon the requirement. The interface between the instrument and patient (subject) should be simple. The chemicals or materials used should not be toxic to the patient. The instrument must be electrically safe. It should not dissipate harmful radiation and heat. Primarily the patient should not feel the discomfort.

4- Economic Characteristics

The cost of the equipment must be affordable. The accessories used and replacement components should be available. The instrument should have minimum warranty period. The consumables required for operation should be cost effective and locally available. It should be compatible with the existing and old versions of equipment preferably it should be updatable.

Engineering Analogy of Physiological Systems

Chemical System vs Human Body

Human body can be viewed as a self-contained chemical factory. It produces energy for the body growth, repair, messengers for communication and all other requirements to carry out the various functions. It takes food, water and air as input at one point. It has a set of control systems to monitor and control the chemical operations. It also incorporates a waste disposal system.

Cardiovascular System vs Hydraulic System

Cardiovascular system is identical to a complex closed hydraulic system. It has four chambers with two pumps connected through flexible tubing (blood vessels).

Veins act as blood reservoirs, and they change diameter to control the pressure. System of gates and variable hydraulic resistances alter blood flow. Two stage pumps are there. One is on the left side and the other is in the right side. Right side pump collects blood from main hydraulic system and sends for oxygenation (lungs). Left side pump collects blood from oxygenation system, and then supplies to main hydraulic system with laminar flow. It acts as a communication system and supplies system. Speed and stroke volume changes to meet the demand. Blood acts as carriers of fuel and supplies to the cells. Waste materials are transported to predetermined destination by the blood. It has the ability to control small punctures and reject foreign elements. It has sensors to detect the demand at one particular point. It has one way valves to protect the flow against gravity.

Pneumatic System vs Respiratory System

Respiratory system is analogous to pneumatic system. It creates positive and negative pressure by diaphragm (Thoracic cavity). It has a valve to allow air or prevent solid (food) in the same passage. It inhales oxygen and exhales carbon dioxide. Brain maintains the important variable like rate (respiratory). Volume, air in flow and carbon dioxide concentration in expelled air.

Communication Network vs Nervous System

Nervous system is analogous to adaptive information processor. It is like a computer with memory *(*brain) and computational power. Nervous system is working even though partly damaged. Input signals to the nervous system are light, sound, pressure, heat and cold. Output of this nervous system is given to motor system (muscles). It has feedback and reflexes automatic responses.

Conclusion

Instruments must be subject to legal, moral and ethical considerations. The manufacturer of the equipment should be aware of issues and regulations that are brought about by the technological, economical and political realities, in the geographical location concerned.