

# General Science

## Short Answers

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# **Systems in Human Machine**

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# **CHAPTER 1: SYSTEMS IN HUMAN MACHINE**

# CONTENTS

<b>1.1</b>	<b>INTRODUCTION TO GENERAL SCIENCE .....</b>	<b>1</b>
<b>1.2</b>	<b>INTEGUMENTARY SYSTEM.....</b>	<b>1</b>
<b>1.3</b>	<b>DIGESTIVE SYSTEM.....</b>	<b>2</b>
<b>1.4</b>	<b>RESPIRATORY SYSTEM.....</b>	<b>3</b>
<b>1.5</b>	<b>CIRCULATORY SYSTEM.....</b>	<b>3</b>
<b>1.6</b>	<b>NERVOUS SYSTEM.....</b>	<b>5</b>
<b>1.7</b>	<b>MUSCULAR SYSTEM.....</b>	<b>6</b>
<b>1.8</b>	<b>SKELETAL SYSTEM.....</b>	<b>6</b>
<b>1.9</b>	<b>ENDOCRINE SYSTEM.....</b>	<b>7</b>
<b>1.10</b>	<b>REPRODUCTIVE SYSTEM.....</b>	<b>8</b>

## **1.1 INTRODUCTION TO GENERAL SCIENCE**

Science encompasses the systematic study of the structure and behaviour of the physical and natural world through observation and experiment, and technology is the application of scientific knowledge for practical purposes. Science goes with conquering new frontiers of nature and technology enables the speedy growth of it. Science demystifies magic and miracles and provides satisfactory answers to human quest. Controlled methods are generally used in the discovery of science. Science also goes with fathomless human imagination and establishes truth for common observation. Universalism, objectivity, skepticism and organised criticism are the rare impulses used in the progress of science and scientific temperament. The technological apparatus has enabled humans to make many breakthroughs. The domain of science and technology can easily be comprehended through physics, chemistry and biology. Technology emerges as powerful tools to accelerate the momentum of scientific progress. The tripartite of physical observation of nature, the chemical actions and reactions and human and plant anatomy have immense power to control deterministically the living and non-living beings. Any average mind person is expected to have a clear hold on it. Aristotle is known as the father of Biology. He widely studied the natural world and examined its origins using scientific insights and systematic observations rather than connecting it to divine interference. Aristotle's biology theory outlines five major biological processes: temperature, metabolism, regulation, inheritance, embryogenesis and information processing. He was also the first to uncover the relationship between animals and establish a system of classification.

## **1.2 INTEGUMENTARY SYSTEM**

The integumentary system is the organ system that protects our body from any form of damage that includes skin, hair, scales and nails. It works as waterproofing, cushion and protection to deeper tissues. It excretes waste and regulates temperature of our body. Integumentary system is an attachment site for sensory receptors to detect pain, sensation, pressure and temperature and vitamin D synthesis.

The skin has three major layers of tissues, viz. epidermis, dermis and hypodermis. The epidermis is a thin, tough, outer layer made up of epithelial cells and it does not contain blood vessels. Stratum corneum is the outermost portion of the epidermis, prevents most bacteria, viruses and other foreign substances from entering the body. Melanocytes produce the pigment melanin, function is to filter out ultraviolet radiation from sunlight. Langerhans cells

are part of the skin's immune system which helps detect foreign substances and defend the body against infection.

Dermis is thick layer next to epidermis that is fibrous and elastic that gives the skin its flexibility and strength. It contains nerve endings, sweat glands and oil glands, hair fallacies, and blood vessels. Sweat glands produce sweat in response to heat and stress. The sebaceous glands secrete sebum into hair moist and soft and acts as a barrier against foreign substances. The blood vessels of the dermis provide nutrients to the skin and help regulate body temperature.

Hypodermis' purpose is to attach skin to underlying bone and muscles as well as supplying it with blood vessels and nerves. Fat layer helps insulate the body from heat and cold, provides protective padding and serve as an energy storage area.

### **1.3 DIGESTIVE SYSTEM**

The digestion system includes four important stages, viz. ingestion, digestion, absorption and elimination. The digestive system includes alimentary canal viz. salivary glands, pharynx, esophagus, stomach, small intestine, large intestine, large intestine ending in the rectum and anus and accessory digestive organs. These are liver, gallbladder and pancreas. Food moves from one organ to the next through muscle action called peristalsis. The salivary glands in the mouth produces saliva contains an enzyme amylase that digest the starch from food into smaller molecules. The stomach has three mechanical tasks. To store the swallowed food, to mix up the food, liquid and digestive juice produced by the stomach and to empty its contents slowly into the small intestine. The liver is the largest gland of our body. It secrets bile which helps the body to absorb fat. The pancreas produces enzymes that helps digest proteins, fats and carbohydrates. It also makes a substance that neutralizes stomach acid. Small intestine has 3 divisions such as duodenum, jejunum and ileum. The inner wall of the small intestine is covered with millions of microscopic, finger like projections called villi. The villi are the vehicles through which nutrients can be absorbed into the body. The larger enzyme secrets no enzyme and plays only a minor role in the absorption of nutrients. The three divisions of large intestine are caecum, colon and rectum. The rectum is where feces are stored until they leave the digestion system through the anus as a bowel movement. Disorders and disease of digestive system may primarily cause gastrointestinal infection, caused by virus, by bacteria such as salmonella, shigellia, compylobactor of E coli. Hepatitis is a condition when liver becomes inflamed and may lose its ability to function.

## **1.4 RESPIRATORY SYSTEM**

The respiratory system is an anatomical system of an organism used for respiration. Mouth, nose and nasal cavity are the visible parts of upper respiratory system. The nostrils act as an air intake, called Cilia that protects the nasal passageways and other parts of the respiratory tract. Pharynx is the part of the digestive system as well as the respiratory system because it carries both food and air. Larynx is also known as the voice box as it is where sound is generated. It also helps protect the trachea by producing a strong cough reflex if any solid objects pass the epiglottis. Trachea that is the wind pipe carries air from the throat into the lungs. The inner membrane of the trachea is covered with cilia. Bronchi is one of the two divided parts of trachea, one entering the left and one entering the right lung. Bronchioles is a tertiary bronchi that continues to divide and become bronchioles, very narrow tubes, less than 1 millimeter in diameter. Alveoli is an individual hollow cavities contained within alveolar sacs. Alveoli has very thin walls which permits the exchange of gases viz. oxygen and carbon dioxide. Thorax or the chest cavities is the airtight box that houses the bronchial tree, lungs, heart and other structures. Diaphragm is located below the lungs. It is a large, dome shaped muscle that contracts rhythmically and continually and most of the time, involuntarily. The tidal volume is the volume of air that is installed or exhaled in a single such breath. Breathing is a constant process where the body constantly breathe in and out of the day. Respiration is also a process of diffusion. In the process oxygen moves from the alveoli to the blood through the capillaries lining the alveolar walls. Blood contains Hemoglobin- a specialized protein that binds to oxygen in the lungs so that oxygen can be transported to the rest of the body. Carbon dioxide which produced during the process of diffusion, moves out of the cells into the capillaries, where most of it is dissolved in the plasma of the blood. As an issue in respiration a chronic inflammatory lung disease may also cause contract in the wind pipe that is also known as asthma. Asthma is triggered by irritants in the air such as cigarette smoke, asthma flares. Smoking has two fold effects on respiration. It may irritate the cells lining and respiratory tract. Long terms effects include disease like emphysema of which the earlier is much common.

## **1.5 CIRCULATORY SYSTEM**

The circulatory system is responsible for the transport of water and dissolved materials throughout the body, including oxygen, carbon dioxide, nutrients and waste. The structure of circulatory system is dependent on heart. The heart has four chambers, viz. right atrium, left

atrium, right ventricle and left ventricle. The bottom part of the heart is divided into two chambers called the right and left ventricles which pump blood out of the heart. The upper part of the heart is made up of the other two chambers of the heart, the right and the left atria. Arteries carry blood away from the heart. They are the thickest blood vessels, with muscular walls that contract to keep the blood moving away from the heart and through the body. Two coronary arteries provide oxygen and nourishment to the muscles of the heart. Veins carry blood back to the heart, waste products such as carbon dioxide are also removed by the capillaries. The working of Circulatory system consists of one complete heartbeat makes up a cardiac cycle, which includes two phases viz. the ventricles contract sending blood into the pulmonary and systematic circulation then the ventricles relax and fill with blood from the atria, which makes up the second phase of the cardiac cycle. The normal heart beat is 70-72 per minute in males and 78-82 per minute in females. The heartbeat of a child is more than that of an adult that is 140 heart beat per minute. The sinoatrial or SA node, a small area of tissue in the wall of the right atrium, sends out an electrical signal to start the contracting of the heart muscle. These electrical impulses cause the atria to contract first, and then travel down to the atrioventricular or AV node. In the systematic circulation, blood travels out of the left ventricle, to the aorta, to every organ and tissue in the body, and then back to the right atrium. In the pulmonary circulation, blood low in oxygen but high in carbon dioxide is pumped out the right ventricle into the pulmonary artery which branches off in two directions. The coronary circulation includes the coronary arteries to supply blood to the heart muscles. The blood transports life supporting food and oxygen to every cell of the body and removes their waste products. Blood has two main constituents. The cells or corpuscles comprise about 45% and the liquid portion, or plasma in which the cells are suspended, comprise 55%. The blood cells comprise three types: red blood cells (RBC) or Erythrocytes, White Blood Cells (WBC) or leukocytes and Platelets or thrombocytes. Anemia is a deficiency of hemoglobin in the blood. It can be caused by blood loss abnormal destruction of the red cells, and inadequate red cells formation by the bone marrow. Leukemia is about the excessive increase in abnormal leukocytes that may occur for unknown reasons, resulting in the disease known as the leukemia. Atherosclerosis is a disorder of large and medium sized arteries, such as the large coronary arteries that supply the heart muscles with oxygen. The disorder is characterized by a buildup of fatty deposits, called plaques, on the inner walls of arteries. The most important peripheral vascular disease of the veins is thrombophlebitis or phlebitis. This disorder involves the formation a blood clot in large veins, usually in the leg or



pelvis. Hypertension is the high blood pressure that is often secondary to hardening of the arteries. As the arteries lose their elasticity the heart has to beat harder to force the blood through. The result is high blood pressure.

## **1.6 NERVOUS SYSTEM**

The network system is a network of specialized cells called neurons that coordinate the actions and transmit signals between different parts of the body. The central nervous system of vertebrates contains the brain, spinal cord and retina. The peripheral nervous system consists of sensory neurons, clusters of neurons called ganglia and nerves connecting them to each other and to the central nervous system. All neurons have three parts: dendrites, axon and cell body. The dendrites receive information from another cell and transmit the message to the cell body. The axon conducts messages away from the cell body. The sensory neurons carry messages from sensory receptors to the central nervous system.

The largest and most complex part of the brain is the forebrain. It consists of the cerebrum. The cerebrum contains the information that essentially makes us who we are, our intelligence, memory, speech, ability to feel etc. The outer layer of the cerebrum is called the cortex. In the inner part of the forebrain sits the thalamus, hypothalamus and pituitary gland. The thalamus carries messages from the sensory organs like eyes, ears, nose and tongue to the cortex. The hypothalamus controls the pulse, thirst, appetite, sleep patterns and other processes in our bodies that happen automatically. The midbrain is located underneath the middle of the forebrain that acts as a master coordinator for all the messages going in and out of the brain to the spinal cord. The hindbrain sits underneath the back end of the cerebrum and contains the cerebellum, pons and medulla. The brainstem takes in, sends out and coordinates all of the brain's messages. It also controls many of the body's automatic functions, like breathing, heart rate, blood pressure, swallowing, digestion, and blinking. The sympathetic nervous system prepares the body for sudden stress. The parasympathetic nervous system helps the digestive tract move along so our bodies can efficiently take in nutrients from the food we eat. Disease and Huntington's disease are due to imbalances of neurotransmitters. Parkinson's is due to a dopamine deficiency. Alzheimer's disease is associated with protein plaques in the brain. One of the critical problems of the nervous system is brain tumors. They usually grow in one place and may be curable through surgery. A malignant tumor is cancerous and more likely to grow rapidly and spread. Meningitis and encephalitis are the infections of the brain and spinal cord that are usually caused by bacteria or viruses. Meningitis is the inflammation

of the coverings of the brain and spinal cord and encephalitis is the inflammation of the brain tissue.

## **1.7 MUSCULAR SYSTEM**

Three kinds of muscles are identified in our body viz. Skeletal, Visceral and Cardiac. Muscles is a specialized tissue of mesodermal origin. About 40-50 per cent of the body weight of a human adult is contributed by muscles. Each myofibril has alternate dark and light bands on it. A detailed study of the myofibril has established that the striated appearance is due to the distribution pattern of two important proteins- Actin and Myosin. Utilizing the energy from ATP hydrolysis, the myosin head now binds to the exposed active sites on actin to form a cross bridge. The myosin release the ADP and Pi goes back to its relaxed state. A new ATP binds and the cross bridge is broken. The ATP is again hydrolyzed by the myosin head and the cycle of cross bridge formation and breakage is repeated causing further sliding. Auto immune disorders affecting neuromuscular junction leading to fatigue, weakening and paralysis of skeletal muscles.

## **1.8 SKELETAL SYSTEM**

Skeletal system consists of a framework of bones and few cartilages. The system has a significant role in movement shown by the body. Bone and cartilage are specialized connective tissues. The axial skeleton comprises 80 bones distributed along the main axis of the body. The skull, vertebral column, sternum and ribs constitute axial skeleton. The skull is composed of two sets of bones-cranial and facial, that totals to 22 bones, Cranial bones are 8 in number. Vertebral column is formed by 26 serially arranged units called vertebrae and is dorsally placed. It extends from the base of the skull and constitutes the main framework of the trunk. There are 12 pairs of ribs. Each rib is a thin flat bone connected dorsally to the vertebral column and ventrally to the sternum. It has two articulation surfaces on its dorsal and hence is called bicephalic. Appendicular skeleton is the part of the skeletal system. The bones of the limbs along with their girdles constitute the appendicular skeleton. Each limb is made of 30 bones. The bones of the hand are humerus, radius and ulna, carpals, metacarpals and phalanges. Joints are essential for all types of movements involving the bony parts of the body. Locomotory movements are no exception to this. Joints are points of contact between bones, or between bones and cartilages. Fibrous joints do not allow any movement. This type of joint is shown by the flat skull bones which fuse end-to end with the help of dense fibrous connective tissues in the form of sutures, to form the cranium. Synovial joints are

characterized by the presence of a fluid filled synovial cavity between the articulating surfaces of the two bones. Such an arrangement allows considerable movement. Cartilaginous joints are the bones involved in joining bones together with the help of cartilages. Arthritis are inflammation of joints. Osteoporosis is an age related disorder characterized by decreased bone mass and increased chances of fractures. Decreased levels of estrogen is a common cause. Inflammation of joints happen due to accumulation of uric acid crystals.

## **1.9 ENDOCRINE SYSTEM**

The system that controls and coordinates the biochemical produced by body itself is called endocrine system. It mainly consists of two important parts, namely glands and hormones. 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. Exocrine glands, such as the sweat and salivary glands, release secretion in the skin or inside of the mouth. Endocrine glands, on the other hand, release more than 20 major hormones directly into the blood stream where they can be transported to cells in other parts of the body. Two important endocrine diseases are diabetes mellitus (DM1 & 2) and Osteoporosis. Diabetes mellitus (DM) is a group of metabolic disease in which a person has high blood sugar, either because the body does not produce enough insulin or because cells fail to use insulin that is produced. The diabetes can further be classified into two categories, namely Type 1 diabetes and Type 2 diabetes. Type 1 diabetes results from the body's failure to produce insulin and requires person to inject insulin. Type 2 diabetes results from insulin resistance a condition in which cells fail to use insulin properly, sometimes combined with an absolute insulin deficiency. If the body produces too much growth hormone (GH), gigantism or acromegaly (gigantism in adults) can occur, too little growth hormone results a condition called growth hormone deficiency. Osteoporosis is a condition in which bones become fragile and more likely to break. Polycystic ovary syndrome is a condition associated with symptoms of infrequent or irregular menstruation. Thyroid disorder is also produced by the complication in the thyroid gland, influence nearly all of the body's symptoms. Thyroid problems include hyperthyroidism. Cushing's syndrome is produced by cortisol hormone.

## **1.10REPRODUCTIVE SYSTEM**

The reproductive system of animals can be divided into the internal and external system. Gametes are reproductive cells that unite during sexual reproduction to form a new cell called a zygote. When the haploid male and female gametes unite in the process called fertilization, they form what is called a zygote. In the male, testes produce sperm, and in the female, ovaries make eggs. Hermaphroditism is one organism has both sexes. Earthworms and garden snails always have both male and female organs. Parthenogenesis is the ability of an unfertilized egg to develop and hatch. There are two major mechanism of fertilization. In external fertilization, used by many aquatic invertebrates, eggs and sperm are simultaneously shed into the water, and the sperm swim through the water to fertilize the egg. In internal fertilization, the eggs are fertilized within the reproductive tract of the female, and then are covered with egg shell and remain within the body of the female during their development.