UNIT 1 INTRODUCTION TO PHYSIOLOGY

Structure

1.1 INTRODUCTION

In this unit, we will familiarize ourselves with the discipline called 'Physiology', what is it and its historical development. Then we will get to know about the physiology of growth and development, the process of ageing and the changes that occur in various body systems due to ageing, as well as, theories of ageing.

Finally, we will discuss what is nutrition, its significance and role of nutrients in maintaining body processes i.e., the interaction between nutrition and physiology.

Objectives

After studying this unit, you will be able to:

- review the contributions by various scientists – historic view,
- describe the body systems,
- explain the role of metabolism, immunity etc., in contributing to growth and development,
- discuss the theories, which state why we age, and
- enumerate the role of various nutrients and their physiological contributions.

Now let us begin our discussion by going through the introduction to physiology and major historical developments of importance.

1.2 PHYSIOLOGY AS A DISCIPLINE

The term physiology – *physio* meaning native and *logos* meaning discourse, is a Greek word, a synonym for natural philosophy.

Physiology is the study of processes in living tissue at the cellular, organ and whole-body organizational levels. Physiology, as a discipline, deals with the mechanisms by which the body functions in general. In unicellular organisms, a single cell carries out all major functions. The cell functions basically on the sol-gel theory. The medium, (plasma) which is 70% water, becomes a pool of molecules. These molecules interact with each

other to produce complex molecules. These give rise to molecular basis of life. The major functional molecules are carbohydrates, proteins and lipids which contribute to the basic life functions.

As the evolutionary processes progressed, the need for a better functioning (viability) system became necessary. Thus, multicellularity evolved. These lead to the formation of group of cells performing function in a responsible manner. Similarity between cells helped them to group together. Thus, cells which are similar in structure and function formed a group called '*tissues*'. The tissues further were responsible for the development of an *organ*. Various organs lead to the formation of *organ systems*. These organ systems contributed to an individual organism. This organism was able to function better because of division of labour.

Physiology, therefore, is *the study of the physical and chemical processes that take place in living organisms during the performance of life functions*. It is concerned with such basic activities as reproduction, growth, metabolism, excitation and contraction as they are carried out within the fine structure – the cells, tissues, organs and organ systems of the body.

Physiology is intimately linked with anatomy and was historically considered a part of medicine. Its emphasis on investigating biological mechanisms with the tools of physics and chemistry made physiology a distinct discipline in the 19th century. The tendency today, however, is toward a fragmentation and merging with the many specialized branches of the life sciences. Three broad divisions are recognized: general physiology, concerned with basic processes common to all life forms; the physiology and functional anatomy of humans and other animals, including pathology and comparative studies; and plant physiology, which include photosynthesis and other processes pertinent to plant life.

"*Thales of Miletos*" is known as the first physiologist, who lived around 600BC. The modern world calls "*William Harvey*" as the first physiologist (1578-1657). *Herman Bochaave*, a physician at Laden, described physiology as the science of body functions. *Albrecht von Haller* wrote the first textbook of physiology. Some famous physiologists include *Francois Magendie, Johannes Muller, Carl Ludwig, Claude Bernard, Walter Cannon, Hermann Helmholtz* etc. *H. Helmholtz* also proposed law of conservation of energy, invented ophthalmoscope, proposed a theory of colour vision, physiology of hearing etc. *Ludwig* invented the Kymograph, which served as an important tool in understanding of various mechanical events during neuro-muscular transmission and muscle contraction.

Antony Van Leeuwenhoek's microscopes threw a lot of light in understanding the inner aspects of a cell. The observations made by *Robert Hooke* on a cork cell opened further avenues for exploring more about the cell. He also observed that the cells had different shapes and structures, which were observed in a leaf, as well as, in a liver cell. Though they differed in structural details, they could be viewed as a variation arising on a common theme. These variations were unique which attributed to a tissue. These observations culminated in formation of the cell theory - by *Schwann* and *Schleiden* (1939) – about which we shall learn in the next unit.

Among the most important advances of the 20th century are the discovery of new hormones, recognition of the role of vitamins, discovery of blood types, development of the electrocardiograph and electroencephalograph, to record the activity of the heart and brain, discovery of the cause and cure of pernicious anaemia by *George Richards Minot, William Parry Murphy* and *George Hoyt Whipple* and greater understanding of metabolism, the role of enzymes and the immune system.

The discussion above presented a brief insight into the contributions made by different scientists in the development of physiology as a discipline.

Next, let us get to know how cells joins together to form the different body systems. These organ systems, you would realize, contributed to an individual organism.

1.3 HOW CELLS JOIN TOGETHER

In a unicellular organism, the interior region of the organism is no longer in contact with the external environment. Thus simple processes of diffusion, phagocytosis, exocytosis and contact with sea water helped in exchanging the necessary molecules and nutrients. But a further increase in size and complexity of the organism lead to concentration of the pool of cytoplasm. The fluid in-between the cells was known as *interstitial fluids*. These fluids, due to constant exchange of molecules between the various cells lead to changes in the internal environment which influenced the functioning of the cell.

Physiology, we learnt earlier, is concerned with such basic activities as reproduction, growth, metabolism, excitation and contraction as they are carried out within the fine structure – the cells, tissues, organs and organ systems of the body. The various body systems of our body are enumerated next.

1.3.1 Body Systems

Based on the activities and functions, there are 9 major systems in human body. Let us get to know about them.

The *skeletal system* provides a framework of support, protection and movement of the body. Body has 206 bones, connective tissues that hold them together, ligaments, tendons and various joints that allow free movement connecting the bones.

Bones can be pulled only when there is a need. This is done with the help of muscles. Man has over 600 muscles in the muscular system. The system not only helps in the movement of arms, legs, feet, hands, fingers, head and trunk but also helps in pushing food, making the blood circulate and removing waste products. Muscles do not move bones by chance, it is done when the signaling is done. This calls for a kind of networking system. The system has to be receptive and then react to the signals. This is coordinated through the *nervous system.* It involves the brain, spinal cord and the nerves along with it. We shall learn about the nervous system later in Unit 9.

Any movement though co-ordinated activity requires energy to do so. This energy we get from food. The system, which would help in breaking and absorbing the food, is *digestive system.* Here, complex molecules of the food are broken into simpler ones and are absorbed by the body. Unit 6 presents a detailed discussion on this topic.

For release of energy from the absorbed food, O_2 is needed. Exchange of gases like O_2 and CO_2 occurs through *respiratory system* - consisting of nose, throat, trachea, bronchus, bronchioles and alveoli. This system helps in inspiration of O_2 and expiration of CO_2. When we work hard, we require more of O_2 and in exchange, we breathe out the CO_2 which is formed as an end-product. We will learn about the respiratory system in Unit 5.

Energy-producing substances taken from food by digestive system and O_2 from air by the respiratory system has to be made available throughout the body. *Circulatory system* plays a major role here. The organ system is made of arteries, veins, capillaries and heart. Blood is the fluid that carries all the necessary nutrients and gases to all parts of the body. The heart muscles help to pump the blood into the blood vessels. We shall learn about the cardiovascular system in Unit 4.

Though the blood vessels branch out to all parts of the body, food does not reach individual cells. A colourless fluid called 'lymph' squeezes the tiniest blood vessel, bathes the individual cells and supplies them with food. The *lymphatic system* consists of lymph fluid, which has WBCs, lymph vessels and lymph glands.

All these different systems require a coordination and control. This is brought out by *nervous system* and *endocrine system* together. Endocrine system produces hormones while nervous system produces neurotransmitters, which act as messengers. Together they are able to signal the body for various responses.

For maintenance of species and procreation, body has separate group of organs which brings this miraculous achievement of giving birth to new born, thereby, contributing to a new progeny. This is achieved through the *reproductive system*. Both male and female systems are separate. Male testicular duct joins with penis. Female system has a pair of ovaries, fallopian tubes, uterus, vagina and mammary glands. We will learn about these organs later in Unit 12.

All the systems about which we have discussed above, are completely covered and protected by the epidermis. It has several layers of cells stretched and flattened. These layers keep changing according to wear and tear. E.g. healing a cut/ wound is achieved very fast by body's own mechanism. Dermis plays a major role here, which also keeps the skin moist. Hair follicles are kept smooth and silky by the temperature by opening up the pores to remove the sweat. Skin uses the melanin, which is a pigment, which darkens according to sun's exposure. Skin cells are basically sensory in nature.

Having gone through the dicussion above we now have a good understanding of the organ systems of our body, let us get to know about the physiology of growth and development, next.

1.4 PHYSIOLOGY OF GROWTH AND DEVELOPMENT

Growth refers to '*increase in size*' and development refers to '*maturation of function*'. They are generally associated with each other, but there can be exemptions, as in hypertrophy, where there is only increase in size.

Growth of various parts of the body does not follow a similar pattern, but there is a comparable relativity to size and shape, adaptability to various situations, responses to different stimuli etc. These would keep changing as the infant grows to adult stage. An adult differs from an infant with respect to the functional maturity. Secondly, the homeostatic mechanisms (the state of sustained equilibrium in which all cells, and all life forms, exist) are not as efficient as one observes in an adult. Certain components can be discussed where we can observe a change in-between infants and adults. These include:

i) *Metabolism:* Resting metabolic rate of a newborn is twice as that of an adult/unit body weight basis. Since only colostrums is available for 1st or 2nd day, infant depends on its reserve of fat and protein for energy. After this, carbohydrate is the preferred fuel. Since their liver functions are poor, there would be lot of fluctuations as far as glucose metabolism is concerned. The rate of protein synthesis is higher and a lot of amino acids are utilized for this.

ii) *Temperature regulation:* Surface area of the infant per unit weight is larger than the adult, hence infant loses/gains heat from the surroundings very easily. The temperature regulatory mechanisms are not so well developed as those of an adult. Due to this, the infant needs special care and protection from the extreme environmental conditions.

iii) *Immune mechanisms:* The immune system starts functioning in a baby through the inherited antibody (Ab) of the mother. But these antibodies keep breaking in the body. By another $1^1/_2$- 2 years, the normal level is attained. But there would be a lot of changes occurring till the thymus, an endocrine gland, becomes dysfunctional. This is attained only by the age of 8. Hence, we observe that babies

are more prone to diseases like common cold, respiratory disorders, diarrohea etc. This is because of the poor development of immune mechanisms. Further, the infant is more prone to allergic responses to its own Ab. This is known as *autoimmunity*. The second contribution to these allergies can be due to the high absorptive power of the gastrointestinal tract. Here, many major proteins are absorbed fully which possibly might be leading to allergic reactions.

iv) *Systemic physiology:* There is a change in the blood count and rate of haemoglobin (Hb) production during the early days. Cardiovascular and respiratory changes are observed, i.e. the Hb level after a few days fall down considerably. The first breath has a lot to do with O_2 accommodation and an adjustment between pCO_2 and pO_2 to have a good residual O_2 available for the body.

The components discussed above gives a good idea of the physiological changes typical in the infancy stage. The process of growth, development continues till the adult stage. What happens next? We shall get to know about the physiology of ageing in the next section.

Check Your Progress Exercise 1

1) Define physiology.

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2) List the different systems in the human body.

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3) Differentiate between growth and development.

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4) Discuss how an adult distinctly differs from an infant with respect to functional physiology.

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5) Match the following:

A	B
i) Thales of Miletos	a) first textbook on physiology
ii) H. Helmholtz	b) first physiologist
iii) Albercht Von Haller	c) Ophthalmoscope
iv) Ludwig	d) cell theory
v) Schwann and Schleiden	e) Kymograph

1.5 PHYSIOLOGY OF AGEING

Ageing in simple terms refers to *a physiological process that occurs in an organism as it gets older.*

Ageing physiologically refers to *the impaired ability to maintain homeostasis in the face of external or internal challenges or stresses.* Hence, the individual becomes more vulnerable to those changes and stresses and thus succumbs to the end of life. The rate by which functional deterioration occurs in various parts of the body is neither simultaneous nor they are perpendicular in pattern. Hence, ageing process implies progressive deterioration of cells, tissues, organs and their functioning associated with increased age.

Let us look at the age related changes first.

1.5.1 Age Related Changes

Age related changes are mainly observed at a cellular level. The connective tissues throughout body show an increase in stiffness because of collagen (a fibrous protein which constitutes the connective tissue) fibers and hydrolysis of elastin which you might be aware is a protein similar to collagen. The changes observed in the different body systems and tissues are summarized next.

a) *Blood:* Here the haemopoiesis (the formation of blood cells) slows down. Fatty marrows replace the heamopoietic (red) marrow. Thus, the proliferation capacity gets reduced.

b) *Immune mechanisms:* The immune competence decreases with age. This affects the cell-mediated and humoral immunity. We will learn about these aspects later in Unit 3. The thymus *involutes* (roll inwards), there is an increase in T cell auto reactivity and autoantibody *titre*. This makes the elderly more susceptible to infections. The severity of ageing can be reduced by good nutrition, regular physical exercises and mental tranquility.

c) *Respiratory system:* During ageing, alveoli (present in the lungs) become flatter and shallower, alveolar ducts enlarge, walls become thinner, contains less capillaries, respiratory surface area decreases, elastic recoil response is lost, pulmonary diffusing capacity gets reduced. The respiratory response to hypoxia and hypercapnia is sluggish in the elderly. There is an overall impairment in ventilation, diffusion, regulation etc. that leads to slowing down of the *respiratory responses.*

d) *Cardiovascular system:* There is a decrease in elasticity of the aorta and other large arteries as age increases. Thickness of blood vessels increases leading to a rise in blood pressure. The myocardium (muscle wall of the heart) shows atrophy. There are structural changes in the valves. Number of pacemaker cells gets reduced, thereby a reduction in heart rate is observed.

e) *Alimentary canal:* Advancement in ageing leads to loss of teeth. In this process, first the enamel changes then dentine and cement. Thus their mastication (chewing) efficacy slows down. Frequent weakness of the pharyngeal musculatures leads to dysphagia (difficulty in swallowing), owing to decreased esophageal motility.

   Mucosal atrophy occurs in gastrointestinal tract leading to reduced gastric and pancreatic secretions. The height of villi gets reduced as ageing progresses. Lactose activity gets reduced in brush border cells. Hence, the nutrient absorption is adversely affected. Liver function decreases due to decrease in hepatocytes.

f) *Excretory system:* There is a progressive decrease in the number and size of nephrons (basic unit of the kidney). There is a 10% decrease in renal plasma flow. Blood flow changes in glomeruli. Both secretory and reabsorptive function decreases. Glomerular filtration is hampered.

g) *Endocrine system:* There is a decrease in blood concentration of the hormone / binding protein transport. Sensitive hormone receptors diminish. Age-related decreases are seen in glucose response. As far as reproductive hormones are concerned – in females, there is a decrease in estrogen and progesterone after menopause. There is a negative feedback effect. In males, the testosterone levels go down tremendously. Though the leydig cells volume increases, it cannot achieve the normal testosterone level.

h) *Nervous system:* Varying degrees of atrophy in neuronal areas can be observed. neurotransmitter functions are hampered. The cholinergic deficits seen in Alzheimer's disease, dopaminergic deficit in Parkinson's disease are examples. Senile dementia, hyperkinesias (tremors) etc. can be observed.

i) *Special senses:* Presbyopia (decline in the ability to focus near objects), senile cataract etc. can be observed as eye dysfunction. Ear shows diminished sensitivity (presbyeusis). Differentiating various sounds and speeches are hampered. Reduced mobility of transmission of sound in these areas in the ear can be observed. Sensation of smell also changes, but the tactile responses remain for a much longer time.

Having learnt about the age related changes, the next question that comes to mind is why does ageing occur? Various theories have been postulated. Let's get to know them.

1.5.2 Theories of Ageing

Ageing is primarily a genetically determined process where natural factors have a potential effect. The various theories of ageing include:

a) *Error catastrophe theory:* As the cells age, there is a random increase in error in protein synthesis due to insertion of wrong amino acids. They become non-functional. Thus cell signaling goes wrong.

b) *The somatic mutation theory:* Random mutation makes the cells inefficient. An increase in the number of inefficient cells in an organ impairs their functioning. Random mutation can lead to the chromosomal aberration. This has an adverse effect.

c) *Free-radical theory:* The body is subjected to a dilemma. On one hand, O_2 is essential for life and on the other hand, oxidative reactions can set free a lot of impaired electrons which are highly reactive. These can possibly damage vital macromolecules like DNA, proteins etc. by the process of peroxidation.

d) *Genetic theory:* Rate of ageing varies between species. The difference is in the genetic changes in the species. Thus it can be said that gradual impairment of a function is genetically programmed. Progeria (ageing by 10 years of age) is due to a defect in genetic programming.

Well then ageing is a natural phenomenon. It is inevitable. One cannot stop it but certainly can modulate the process of ageing. How? Read and find out.

1.5.3 Modulating Process of Ageing

Despite various researches, ageing becomes an inevitable process. The only option is to have good control measures. These are highlighted herewith:

a) *Nutrition:* Caloric restriction retards ageing. Isn't that interesting? This is due to decrease in O_2 consumption, decrease in free radicals and a decrease in peroxidation.

b) *Exercise:* Regular exercises increase O_2 uptake capacity. It improves cardiac performance and reduces muscular-skeletal disabilities. Age-related 'Resting Metabolic Rate' (RMR) gets reduced in exercising individuals and helps to increase antioxidant reactions.

The only organism, which does not die, are the unicellular ones, they just divide as two cells. During meiosis (cell division process), recombination occurs. It replaces damaged DNA. Thus, the zygote has a perfect genome. Further life continues.

Check Your Progress Exercise 2

1) What do you understand by the term 'ageing'?

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2) Give the theories of ageing.

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3) Discuss briefly any two age-related changes occuring in the body systems.

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4) Suggest a few good control measures to delay the process of ageing.

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In the section above, we studied about the role of nutrition in modulating the process of ageing. What is the relation between nutrition and physiology as such? We shall find out in the next section.

1.6 NUTRITION AND PHYSIOLOGY

To common man, the word 'Nutrition' implies *food.* Food is essential for growth and development. Physiology becomes an interlink between nutrition and healthy human body. This includes processes like digestion, absorption and intermediary metabolism of nutrients. The analysis of nutrients and its impact on daily life appropriates for the physiological disturbances caused. Any nutrient which is in excess or deficient can cause alterations in the general metabolism and the health of a person. The nutrients are

classified into six major groups, as you already know: (1) Carbohydrates (2) Proteins (3) Fats (4) Vitamins (5) Minerals, and (6) Water. These entire components become a base for providing new life. They interact with each other and are capable of making new compounds which would provide energy for life.

The interrelationship of these components with physiology is enumerated next.

Nutritional components and their interrelationship with physiology

- *Carbohydrates:* Sugar, like a candle, can burn but burning requires oxygen. We eat to do work. To do their work, cells need an important group of food known as 'carbohydrates'. They are made up of C, H and O in a wide variety of combinations. Each combination is a different substance. The most important role of carbohydrates is to provide energy. The simplest form is glucose, one energy-packed molecule for muscular contractions, cell functions including brain cells. Carbohydrates are mainly stored in liver and muscles. Body converts all carbohydrates into simple sugars.

  Energy from food is measured in units known as 'calories'. For example, a tablespoon of honey contains 100 calories. Scientists have figured out how much of food is to be consumed to do normal work; a one year old child needs 44 calories for every pound he/she weighs. As a general rule, a man of average weight of 70 kg with sedentary habits needs from 1800-2500 calories/day.

- *Fats:* Once the body stops eating, it begins to live on its fat. Fat storing depots 'adipocytes' are located in the different parts of the body. It gives twice the amount of energy than carbohydrates. It helps to remain as a blanket which keeps us warm during cold seasons. The storage under skin helps this process. It helps to anchor kidneys and other organs. The fat around joints, muscle fibres etc. acts as a cushion to prevent the injury.

- *Proteins:* These form building block through their 'amino acids'. They pass through blood stream and go to liver, where they are broken down further for repair mechanisms. Protein – rich foods are milk, cheese, meat, eggs, nuts etc.

- *Vitamins and minerals:* They play a major role in the body's functioning. Vitamin A is necessary for night vision in the eyes. Vitamin B complex - a collection of 12 components helps the functioning of the body in many ways (nerve transmission, RBC formation, skin texture). Vitamin C for small blood vessels and to work against scurvy. Vitamin D and E for bones and skin development and vitamin K for blood clotting. This comes from various food products. They are used by the body in different ways.

Thus, we can say that the food components play major role physiologically in maintaining a healthy status by their own interdependent mechanisms. Nutritional science, you would realize, is a highly interactive area. Though many complexities remained unanswered in the understanding of food molecules, development of physics, chemistry, biology, biotechnology, food technology etc. have contributed to better solutions.

Our culture and civilization has influenced our beliefs on various food identities. The relation between food and temperament is highly emphasized in ancient Indian history. *Upanishads* says that purity of food leads to purity of thought. *Geeta* is suggestive in categorizing food as 'satwic', 'rajasic' and 'tamasic'.

Satwic are juicy fresh foods, are supposed to be favourites of the saintly and scholarly temperamented (*the Rishi's*). *Rajasic* are sour, salty, and pungent, preferred by those who are crazy for power and wealth. *Tamasic* foods are stale, rotten, and impure and are preferred by superstitious and ignorant. *Charaka* and *Sushruta samhita* (old Indian texts) emphasizes on foods and seasons, food and temperament, diseases,

regional influences, various cooking practices and the impact on foods, usage of vegetarian and non-vegetarian foods, storage of food items etc.

Hippocrates, father of modern medicine considered food as a single entity. He provided valid advices on diet and diseases. If we pay attention to the quality and quantity of food consumed, a lot of diseases can be prevented. *Celsus* in first century AD classified food into strong, medium, weak based on their energy contributions. *Galen* in second century wrote three books on: 1) Cereals and Pulses 2) Fruits and vegetables 3) Animal foods. He postulated that after digestion food is absorbed and incorporated by the body tissues.

The contribution of critical thinking, rational and experimental approach during 16th century developed remarkable areas of physics, chemistry and biology. This development, lead to advances in the area of nutrition science from 18th century onwards. The experimental evidences and contributions in this area are discussed next.

The Experimental Evidences and Contributions

James Lind in 1747 performed controlled experiments on people who were sailors and who developed scurvy. He divided these sailors into different groups. The group receiving 2 oranges and 1 lemon everyday showed dramatic improvements (in their health) over those who did not receive them. The group receiving cyder everyday showed some improvement, other groups did not show much improvement.

Lavosier's contributions were the ones which demonstrated more on combustion and biological oxidation which is very similar to utilizing O_2 and producing CO_2. He introduced the concept of 'Respiratory Quotient', effect of food and exercise on metabolism. The effects of fasting, a post prandial contribution etc. were performed by *Seguin* and *Lavosier* and was published in 1789. Unfortunately during the French Revolution, he was executed. Anyhow *Lavosier* is considered as father of modern Nutrition.

Another scientist, *William Stark* performed experiments with simple diets on himself. He used water and bread diet, found that it was not even providing enough energy. Addition of milk, sugar, olive oil etc. contributed to better health. Due to self experimentations he developed nutritional deficiencies and expired in 1770.

In the 19th century the energy contributions by carbohydrates, proteins, fats etc. were identified. A controversy developed whether the body can convert carbohydrates to fats. This was proposed by *Dumas*, a French chemist. *Liebig*, another equally reputed German chemist suggested that lean goose could be fatted on corn. Since corn is a rich carbohydrate based food, *Liebig* argued that, fat deposited by the goose had been derived by conversion of carbohydrate into fat. *Dumas* proved that corn contained 9% fat and proposed that 63% of fat must have come from corn. *Liebig* repeated the analysis of corn and found that corn had less fat. This led to further arguments and investigations.

In 1843 *Milne Edwards* experimented on bees. He fed them with honey. It was concluded that wax which was a fatty substance was manufactured by the bee, by converting the carbohydrates of the honey into fat. Another experiment by *Boussingault* was on pigs. The pigs were fed on potatoes. The pigs started drinking 9-10 liters of water per day. The conclusion was, a diet of carbohydrates when over fed led to fat conversion.

It was further established that carbohydrates and fat are preferred fuels, both at rest and during exercise. The body shifts from one fuel to the other depending upon the availability of nutrients. By 20thcentury the role of minerals and vitamins etc. were established by *Lunin, Hopkins*, and *Eijkman & Funk*. The term vitamin was coined by *Funk* by combining vital and amine.

The discussion above focused on experimental evidence and contributions at the international level. What about the Indian scenario? The next section highlights the contribution at the national level.

The Indian Scenario

Nutrition research in India was pioneered by *Dr. Robert Mc Carrison.* His works on beriberi gained attention on interlinks between nutrition and health. Further, 'Nutrition Research Labs' (NRL) were developed in Coonoor in 1929. *Dr. Wallace Akryod* was the next director who contributed meaningful research for improving nutritional status of vulnerable groups in India. In the initial 10 years the major research contributions were from the British, but the successive years were more contributory from the Indian scenario. *Dr. V.N. Patvardhan* was the first Indian director who was succeeded by *Dr. C. Gopalan, Dr. V. Ramalingaswami* and *Dr. S.G. Srikantia* to be named as a few. NRL was shifted to Hyderabad in 1966 and was renamed as 'National Institute of Nutrition', NIN for nutritional research in India.

Recent advances in cellular and molecular biology have opened new avenues for research in nutrition. Various interactive fields have been developed between nutrition and immunology, nutrition and neurosciences, nutrition and genetics etc. as major thrust areas.

Understanding the major nutritional problems of the country and contributing to the meaningful research, thereby developing proper solutions to combat the nutritional disorders lead to interactive areas of physiology of absorption / action of a particular nutrient. Major contributions have been made in the area of iron deficiency anaemia, vitamin A control programme, fluorosis, lathyrism, iodine deficiency disorders etc. To combat major deficiency disorders, fortification programmes are being developed. This has been achieved because of the major understanding about the physiological role of a nutrient and its metabolic influences on health.

Check Your Progress Exercise 3

1) Which basic molecules are essential for sustaining life?

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2) According to our culture and civilization, how can foods be classified?

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3) Enumerate the experimental evidences for the following nutrients:

a) Vitamin C

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b) Carbohydrates and fats

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1.7 LET US SUM UP

In the beginning of this unit, we learnt that in a single cell the interior regions were not able to maintain contact with external environment, hence multicellularity evolved in the cells. Subsequently, we learnt that the various systems of the human body coordinate with each other to function better. Skeletal system has 206 bones and various muscles which help in movements. The energy for any system comes from food where digestive system plays a major role. Respiratory system helps in intake of O_2. O_2 is transported to all tissues along with other metabolites by circulatory system where blood acts as a main transporting system. Along with this system, runs the lymphatic system which contains WBCs, which help in maintaining immunity. All these systems require control and coordination. This is carried out by the nervous and endocrine systems. Propagation of species is achieved through reproductive organs.

The unit also focused on physiology of growth and development. The later part of the unit dealt with ageing. Ageing, we learnt, is a natural process and refers to the impaired ability to maintain homeostasis. Age-related functional differences are seen in all the systems of the body. In general, the efficiency decreases. Good and healthy diet, ample amount of exercise can slow down the ageing process by consistently maintaining the functions but in a slow manner.

Finally the unit highlighted the contributions of many scientists towards the role of food and nutrients in maintaining a good physical and mental health.

1.8 GLOSSARY

Adipocytes : fat-storing cells/ depots.

Ageing : a physiological process which leads to a progressive deterioration of cells, tissues, organs and their functions associated with increased age.

Alzheimer's disease : a specific disease associated with the breakdown of nervous tissue in the brain, giving rise to dementia in the patient.

Autoimmunity : a condition in which the body's immune system fights and rejects itself.

Haemopoiesis : the formation of blood cells in the living body.

Interstitial fluid : the fluid in-between the cells.

Kymograph : an instrument for measuring and recording graphically the pressure of the blood in any of the blood vessels of a living animal.

Lymph : a colourless fluid which bathes individual cells and supplies them with food.

Ophthalmoscope : an instrument for viewing the interior of the eye, particularly the retina and optic nerve.

Parkinson disease : a disorder of the brain characterized of tremor and difficulty with walking, movement and coordination.

Plasma : colourless watery fluid of blood and lymph containing no cells and in which erythrocytes, leukocytes and platelets are suspended.

Progeria : a group of inherited conditions resembling accelerated ageing starting in childhood.

1.9 ANSWERS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress Exercise 1

1) Physiology deals with the mechanisms by which the body functions in general.

2) The different systems in the human body are skeletal system, muscular system, nervous system, digestive system, respiratory system, circulatory system, lymphatic system, endocrine system and reproductive system.

3) Growth refers to an increase in size while development refers to maturation of function.

4) An adult differs from an infant with respect to the functional maturity. The homeostatic mechanisms are not so efficient in children as in adults.

5) i) – b)

   ii) – a)

   iii) – c)

   iv) – e)

   v) – d)

Check Your Progress Exercise 2

1) Ageing physiologically refers to the impaired ability to maintain homeostasis in the face of external or internal challenges or stresses.

2) The theories of ageing are:

   a) Error Catastrophe Theory: As the cells age, there is a random increase in error in protein synthesis due to insertion of wrong amino acids and they become non-functional.

   b) The Somatic Mutation theory: An increase in the number of inefficient cells in an organ impairs their function. Random mutation makes the cells inefficient and can lead to the chromosomal aberration.

   c) Free-radical theory: Oxidative reactions occurring in the body can set free a lot of impaired electrons which are highly reactive and can possibly damage vital macromolecules by the process of peroxidation.

   d) Genetic Theory: The gradual impairment of a function is genetically programmed. Rate of ageing varies between species depending on the genetic changes.

3) Two age-related changes are:

   a) Blood: The haemopoiesis slows down and fatty marrows replace the heamopoietic marrow. Thus, the proliferative capacity gets reduced.

   b) Cardiovascular system: There is a decrease in elasticity of the aorta and other large arteries, as age increases. Thickness of blood vessels increases leading to a rise in blood pressure. The myocardium shows atrophy with structural changes in the valves. Number of pacemaker cells gets reduced.

4) A few good control measures to delay ageing process are:

   a) Nutrition: Caloric restriction retards ageing due to a decrease in O_2 consumption, free radicals and peroxidation.

b) Exercise: Regular exercise increases O_2 uptake capacity. It improves cardiac performance, reduces muscular-skeletal disabilities. Age-related resting metabolic rate (RMR) gets reduced in exercising individuals and helps to increase antioxidant reactions.

Check Your Progress Exercise 3

1) The basic molecules which provide energy for life sustenance are:

   a) Carbohydrates: instant energy producers

   b) Proteins: building blocks of the body

   c) Fats: long-term producers of energy

2) According to our culture and civilization, food has been categorized as Satwic, rajasic and tamasik.

   a) Satwic foods: Juicy fresh foods which are supposed to be favorites of the saintly and scholarly temperamented.

   b) Rajasic foods: Foods that are sour, salty and pungent; preferred by those who are crazy for power and wealth.

   c) Tamasic foods: Foods that are stale, rotten and impure and are preferred by superstitious and ignorant.

3) a) *James Lind* in 1747 performed controlled experiments on people who were sailors and who developed scurvy. He divided them into different groups. The group receiving 2 oranges and 1 lemon everyday showed dramatic improvements. The group receiving cyder everyday showed some improvement, other groups did not show much improvement.

   b) In 1843, *Milne Edwards* experimented on bees. He fed them with honey. It was concluded that wax, which was a fatty substance was manufactured by the bee, by converting the carbohydrates of the honey into fat. Another experiment by Boussingault was on pigs. The pigs were fed on potatoes. The pigs started drinking 9-10 liters of water per day. The conclusion was, a diet of carbohydrates, when over fed, led to fat conversion.