UNIT 3  SENESCE

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Learning Objectives

Once you have read this unit, you will know:

- theories of ageing;
- ways to slow down the ageing process; and
- structural and functional changes in various systems of the body with age.

3.1 INTRODUCTION

Senescence is all those manifestations in structure and function of various organs of the body which are of declining or deteriorating nature which take place during the later period of life. It is a general biological phenomenon which affects all the living organisms. Ageing is a continuous process of change throughout the whole life span of an individual. In humans, ageing takes the form of a morphological and functional involution as a progressive and irreversible change, which affects most of the organs and leads to a gradual decline in all the activities of the individual (Nägele, 1981).

All individuals follow the same pattern, i.e., growth, reproductive maturity, senescence and death. The pattern of activity from birth to death roughly follows the path of a parabola. In ontogenesis, most of the properties of man exhibit progressive changes in youth and regressive ones in old age. However, the latter are not reversal to the previous conditions but an emergence of the new qualities; hence they represent a development, but a regressive one (Nägele, 1981).
Life expectancy has risen and is expected to go on rising. The reason for this is the sharp decline in premature mortality from many infections and chronic diseases during this century. Improvements in sanitation, housing, nutrition and medical innovations including vaccination and discovery of antibiotics have contributed to the steep increase in the number of people reaching ripe old age. India has already announced a national policy for the elderly aiming at providing them with financial security, health care, shelter and protection.

A biological system be it unicellular or multicellular maintains itself in a state of dynamic equilibrium known as homeostasis. Homeostasis is the property of a living system to maintain their stability and functional integrity while adjusting to internal and external sources of disturbances. Human body is equipped with a highly complex mechanism of maintenance and repair. Failure of homeostasis or the failure of maintenance is the primary cause of ageing. To explain the phenomenon of ageing, a number of theories have been purposed by different scientists from time to time.

### 3.2 THEORIES OF AGEING

Cell biologist Leonard Hayflick (1965), made a significant discovery that in each cell there is an hour glass that gives it a definite time to live and no more. Can we find this cellular time keeper and can we reset it? Orgel (1963) reported that it is due to the result of somatic mutations or due to the accumulation of errors in the DNA or protein synthesis machinery.

McFarlane (1973) and Burnet (1973) emphasized the role of hormonal and neural control mechanisms which cause ageing. According to Wilson (1974) ageing is considered to be a genetically programmed phenomenon, which involves a definite set or sequence of events. The sequential loss of oocyte from the ovary, the onset of menarche and menopause in female are examples of this kind of mechanism.

Hallgreen et al. (1963) have studied the relationship between the functioning of immune system and ageing. It has been reported that when a person gets older his immunological system becomes less able to distinguish self from non-self and as a result proceeds to destroy normal and desirable proteins of the body resulting in the senescence or ageing. The appearance of autoantibody in old individuals is a very common event.

Theories that explain ageing can be divided as programmed and error theories of ageing. Programmed theories imply that ageing is regulated by biological clock operating throughout life span. Error theories blame environmental impacts on living organisms that induce cumulative damage at various levels as the cause of ageing e.g., damage to DNA, damage to tissues and cells by oxygen radicals and cross-linking. Therefore, ageing process seems to be a cumulative action of both programmed and error theories of ageing depending upon both heredity and environmental factors.

It is now generally believed that the pineal gland and its principal hormone melatonin are involved in the central master clock mechanisms that regulate time and trigger both developmental and ageing processes. This is accomplished by melatonin through its regulation of the activity of pacemaker cells located in the hypothalamus of the brain. This pineal gland is both a primary clock and a pacemaker. It is a primary clock because it measures and is synchronized with the most constant environment which is the light dark cycle through its regulation of the activity of the neurons in the hypothalamus. Its function as a pacemaker is carried out through the production of new hormones which subsequently control the entire nervous system and endocrine axis and hence maintains homeostasis. This affect is achieved through very small concentrations of melatonin and serotonin produced in the pineal (www.lef.org).
It is believed that very few individuals actually attain their maximum longevity, it depends upon various physical and biological factors in its environment. Thus, there is a need to study the influence of both heredity and environment of an individual’s ageing process and life span under carefully controlled conditions.

3.3 SOME WAYS TO SLOW DOWN THE AGEING PROCESS

Research on ageing is going on to examine the possibility of living a healthy life in the last quarter of life.

A) Restriction of Caloric intake

One of the successful ways of prolonging life and to reduce many signs of ageing as proposed by many scientists is the restriction of caloric intake. Studies have shown that animals, mostly rats and mice fed on low calorie diet lived longer and did not develop any disease associated with ageing. Lindah et al (1983) claimed that radically altered diet such as lacto vegetarian diet can improve or care for a number of diseases including hypertension. George Roth a molecular physiologist with the US National Institute of Ageing has explained this on the basis that when calories are restricted, body temperature drops by about one degree Celsius. Lower body temperature means a less vigorous metabolism, which means less food is processed. The animals switch from a growth mode to a survival mode, which is the necessity of an individual. A caloric restriction can certainly increase the life span of an individual. The diurnal day night rhythms of melatonin can be substantially preserved during ageing by restriction of food intake starting early in life. These treatments increase life span and prevent premature ageing as well as delay the onset of degenerative diseases.

B) Physical Activity

Physical activity also decreases in direct proportion to every decade after 60. There is also a steady reduction in bone mass. Therefore, a diet ranging from 1500 to 1800 kcal a day is sufficient to maintain the normal activities during old age. According to WHO after the age of 40 years the energy requirements should be reduced by 5 per cent per decade till 60 years and by 10 per cent till 70 and by further 10 per cent after 70 years of age. Carbohydrates, proteins and fats yield four, four and nine kcal per gram respectively. The total energy requirement in a balanced diet must be made in the recommended ratio of 50, 35 and 15 per cent from carbohydrates, proteins and fats respectively in order to maintain a balanced composition of the human body.

Many studies have explored the effect of physical activity on longevity and ageing in experimental animals showing positive effects. It has been reported among human beings that regular physical activity leads to greater functional capacities, i.e. increase in bone density, lowered cardio-vascular risk and overall fitness in men and women (Brown and Holloszy, 1991; and Owens et. al., 1992). Malina (1980) believed that role of physical activity in the ageing process may be mediated through its tendency to reduce weight.
Singal and Sidhu (1981) studied females of two endogamous groups residing at two different places i.e., rural and urban with different physical activity. The rural women folk are mainly engaged in hard manual work like house keeping, care of children as well as cattle and in addition to this they lend a helping hand to their men folk in the fields. On the other hand urban women lead comparatively an easy and comfortable life in terms of physical work. Even the household work is shared by the part time or full time domestic help. It has been found that rural women who possessed more lean body mass were at an advantage and the signs of ageing were slightly delayed as compared to urban women e.g., the ageing estimate in stature was slightly lesser in rural women i.e., 0.99 cm/per decade whereas in urban females it was 1.27 cm per decade. Similarly the onset of menopause is also earlier in urban females i.e., 47.33 years and in rural females it is 48.62 years. It has been reported that healthier women experience menopause at a later age (Singal and Sidhu, 1982).

An association of occupational activity- with the variation of hormone levels was explored by Purifoy et al. (1980) in the American females from age 20 to 87 years. The three steroid hormones were found to be significantly more in those females who were engaged in extra domestic career than those who were only housewives. These steroid hormones were found to decrease with age and were responsible for many morphological, physiological and behavioral changes that occur in females with age. The need for such type of studies become all the more important in the wake of changing socio-cultural norms of the Indian society, due to the increasing number of working women.

It has now been universally accepted that the role and activity pattern of women are changing with time. The urban educated women are increasingly joining out of home employment some due to economic reasons while others for having satisfaction of an independent career. In Indian setup; a working woman has to perform the traditional role of a housewife along with a full or part time job. The time pressure and conflicting demands of work in and outside home have changed the life style of the working women as compared to the housewives who may be involved in the household work but with a flexible schedule. Double strain of the working women may have adverse effects on their health. On the other hand financial independence and busy schedule might have beneficial effect also on their mental and physical outlook.

Sethi et al. (1996) have studied age changes in morphological characteristics and some physiological variables of working and non-working females belonging to one endogamous group from 20 to 85 years of age and have reported that the hectic and busy life style of the working females does not have any negative effect on their health and senescence rather it has helped them in delaying ageing as compared to non-working females.

C) Antioxidants

In all organisms, cells produce waste as they metabolize energy. One of the most troublesome by-products of this process is a free-radical, an ordinary oxygen atom with an extra-electron. The oxygen radical seeks to rectify this electrical imbalance by trying to bond with other molecules. So it can damage cells leading to various degenerative diseases including those affecting brain, heart and blood vessels and many disorders, ranging from cancer to more general symptoms of aging such as wrinkles and arthritis etc. In recent years some nutritionists have advocated diets high in fruit and vegetables containing specific vitamins or, pro-vitamins called antioxidants. These are the substances that are believed to react with or engage free radicals and drain them out of the body. Some vitamins and minerals also possess anti-oxidant activity especially beta-carotene, vitamin C, vitamin E, selenium, manganese, zinc, copper and iron. Various studies carried out, suggest that high intake of food rich in beta-carotene, Vitamin C and E decrease the risk of certain
diseases like cancer and cardiovascular disorders etc. In the case of vitamin E, it is very difficult to get very high level of intake based on diet alone as no food has very high level of this vitamin. So the diet has to be supplemented with vitamin E.

Some of the foods which are considered as rich sources of antioxidant phytochemicals are garlic, onion, ginger, sweet potato, soya bean, green tea herbs and spices. Herbs and spices have been used for centuries not only to add flavor but also to extend the shelf life of various foods. Black pepper, clove, sage, organ, rosemary, thymine and turmeric possess antioxidant activity. Various oilseeds like mustard and rapeseed contain phenolic compounds. Varieties of onion with colored skin have exceptionally higher flavonol content than those with white skin.

Soya bean flour and other soya bean derivatives are sources of a large variety of antioxidant compounds. In soya bean oil, the active antioxidant is tocopherol.

The whole grains are universally recommended as an important part of the diet. Many of the protective compounds in whole grains are also found in fruits and vegetables. Nutrients and phytochemicals are not evenly distributed throughout the grain. These are present in higher concentrations in the outer part of the grain. So, refining of grains results in a significant loss of these useful nutrients. The major cereal grains include wheat, rice, barley, sorghum, millet etc. Rice grains are high in dietary fiber also. So, daily servings of normal diet along with fruits and vegetables are recommended to avail of their protective effect.

People are hoping to buy immortality through the science of cryonics. The science of cryonics is a process of freezing bodies at a very low temperature in liquid nitrogen. It has been shown to be a means of transporting today's patient to a time in the future when cell and tissue repair technology will be available and restoration to full health possible. The cost of this bid for eternal life is 80,000 pounds. Today many people are paying this huge sum. Most of them live in USA. The bodies of British customers are frozen in England, packed in ice and flown to Arizona where the final temperature is kept at -196 degrees Celsius. They are just hoping for the impossible. There is no scientific basis at the moment. But those who are interested, lose sight of the fact and are paying huge sums of money for an outcome which is at present beyond reach of man.

Similarly nanotechnology holds the dream of tiny machines small enough to be injected in to the blood stream that will build copies of themselves and they would go about repairing a body's damaged cells.

3.4 STRUCTURAL AND FUNCTIONAL CHANGES IN VARIOUS SYSTEMS OF THE BODY WITH AGE

3.4.1 Anthropometric Measurements and Body Composition

A) Weight

Weight is one of the most important physical characteristics as it reflects the health status of an individual. It undergoes considerable changes during adult life, although its magnitude varies with age, as well as from one individual to another. During middle years, the body weight has shown a progressive tendency to increase up to fifth or sixth decade after which it declines giving essentially a parabola type of curve. In economically weaker sections of the society, there is a minimal weight gain throughout maturity followed by decline in old age. Therefore, where energy expenditure is higher, especially, when food supply is restricted, weight gain in the middle years does not occur. It has also been reported that obesity tends to shorten life, thus a selective survivorship of thin persons would exaggerate the apparent weight loss in late life. However in spite of the difficulties of differential survivorship interfering in cross-sectional studies, many of the conclusions derived
from longitudinal studies also provide similar results i.e., a trend of decrease in weight with advancing age (Singal, 1979).

B) **Height**

Like weight, height also undergoes changes with advancing age. Shrinkage in height has been reported to begin at different ages, may be in the fourth decade of life. In the shrinkage of stature, sitting height seems to play a major role as the trunk region is attributed to degenerative changes in the spine. The degeneration of intervertebral discs and postural habits that lead to kyphosis are responsible for some shortening of stature. During old age, slight flexion at the knees and hips also diminishes the stature.

**C) Head and Face Measurements**

With advancing age, head and face measurements also undergo many changes. Head circumference, head length and morphological upper facial height show a slight increase up to the sixth decade or so. This is followed by a decline from the 7th decade of life. The morphological height may show early decrease but is more marked after sixty years. This shortening of facial height after sixty years of age is mainly attributed to loss of teeth and to the resorption of the alveolar bone in old age resulting in facial shortening, with a marked shrinkage in the lower portion of the face. An increase in folding of the mouth and slow closing of the distance between chin and nose has been observed in old age. The other transverse measurements like the head breadth, bizygomatic and bigonial breadths may increase up to the 4th decade followed by a decrease. Nose and ear lengths have shown continuous increase with advancing age.

**D) Diameters**

The biacromial diameter has been reported to be maximum during the 4th decade followed by a decrease with advancing age. The narrowing of the biacromial diameter during old age may be attributed to the shrinkage of bone, muscle and fat at these sites. The bicristal diameter and other diameters of the extremities also broaden slightly up to sixth or seventh decade followed by a decline.

**E) Circumferences and Skinfolds**

The circumferences and skin folds follow the same trend as that of weight i.e., an increase up to middle years followed by decrease in all the dimensions during old age.

**Body Composition**

During long periods of adulthood, the size, shape and proportions of the body change. The human body consists of different components like fat, muscle and bones. The changes observed in various anthropometric measurements suggest that body composition must also undergo changes with ageing. The changes observed in various components past maturity is as under:

**A) Body Fat**

The body fat undergoes a variety of changes during the entire life span of an individual. There is an increase in body around the abdomen and thighs after thirty years although subcutaneous fat decreases from distal parts of extremities. A gross inspection of the individual in their old age reveals that fatty depots tend to disappear from the periphery, although their bellies are bulging-out with lot of fat deposition.

**B) Muscles**

The amount of muscle tissue and muscle strength decreases with age. Loss of muscle mass begins around 30 years of age and continues throughout life
The decrease in muscle mass is due to the decrease in the number of muscle fibers, which is due to the changes in growth hormones and testosterone. These hormones stimulate muscle development but due to their decline with ageing there are numerous changes in muscle mass, which result in a decrease in weight of the individual. This causes weakness in an individual i.e., the capacity to work hard decreases.

Regular exercise can partially overcome, or at least significantly delay the loss of muscle mass and strength. Physical inactivity especially bed rest during an illness can greatly increase this loss. Even as mild an exercise as walking for at least 30-40 minutes a day is a wonderful antidote to this loss.

C) Bones

Bones tend to become weaker and brittle, that is, more susceptible to fractures and cracking with ageing. This is due to the loss of calcium and other minerals from bone matrix, i.e., the bone marrow. In females, this loss begins after age 30 years, which is accelerated around 40 to 45 years as the level of hormone estrogen decreases during the period of menopause. By the age of 70 years, 30 per cent of the calcium in bones is lost. On the other hand, among males the calcium loss begins at the age of 60 years.

The bones become less dense because the amount of calcium they contain decreases. It is partly due to the reason, that lesser amount of calcium is absorbed in the digestive tract and level of vitamin D which helps the body to use calcium decreases. With ageing, the amount of bone marrow also decreases. Therefore, fewer blood cells are produced. Although with this decrease the bone marrow is able to produce enough blood cells throughout life. Problems occur when the need for blood cells greatly increases. For example, when anaemia or an infection develops or bleeding occurs. In such cases, bone marrow is unable to increase production of blood cells in response to the needs of the body (www.merckmanuals.com).

With ageing, there is a decrease in the rate of protein synthesis which causes a decrease in the ability to produce the organic portion of bone matrix, mainly collagen, which gives the bones their tensile strength. The loss of tensile strength causes the bones to become brittle and susceptible to breakage. Protein synthesis slows down partly due to a decrease in activity of human growth hormones. The bones become porous and this condition is called osteoporosis, which is most common in females as compared to their male counterparts.

3.4.2 Integumentary System

With ageing the skin becomes thinner, lesser elastic, drier and finally wrinkled. Elastic fibers lose some of their elasticity as a result the skin forms crevices and furrows known as wrinkles, exposure to sunlight during the life time also makes the skin rough and blotchy. The layer of fat under the skin becomes thin and is replaced by more fibrous tissue. Due to the thinning of the fat layer the skin is torn more easily and tolerance for hot as well as cold decreases. The number of nerve endings also decrease, as a result, sensation, including sensitivity to pain is also reduced. The number of sweat glands and blood vessels also decrease. Therefore, the heat which is moved from the inner parts of the body through blood vessels to the surface of the body cannot leave the body and so it remains hot and lesser sweat glands cannot cool the body effectively. Thus, older people are more likely to develop disorders due to over heating, such as heat stroke.

The growth of hair and nails becomes slow with increasing age. There is a decrease in the number of functioning melanocytes resulting in grey hair and lighter skin pigmentation. Due to increase in the size of some melanocytes, pigmented blotching
are produced. Decreased size of sebaceous glands leads to dry and broken skin which becomes more susceptible to infections.

3.4.3 Articulatory System

With ageing the cartilage that lines the joints becomes thin. The surfaces of the joints may not be able to slide over each other as smoothly as before and the joint may with passage of time, become more susceptible to injury. The life long use of joints often leads to osteoarthritis, which is one of the most common disorders of later life. Ligaments which bind joints together become less elastic which make the joints stiff. This may be due to chemical changes in the proteins that make up the ligaments. The ligaments tend to tear more easily and when these tear, healing is also slower and these become very painful and sometimes swollen. All these changes in the joints cause lots of pain in the old age.

3.4.4 Nervous System

A fully developed brain in the 20-25 years old adult human male weight about 1300-1400 g and in females it is 1200-1300 g. The brain loses on an average from 5-10 per cent of its weight in the age span from 20-90 years. The volume of brain at the age of 20-25 years is about 1300 cm$^3$ in males and 1000 cm$^3$ in females. A decrease of about 200 cm$^3$ has been reported from 20-80 years with a pronounced decrease beginning after 50 years. With advancing age there is slight loss of neurons in the brain or nerve cells, which may lead to poor responses and memory defects. The structures involved in sending messages in the brain changes with age. The level of some neuro-transmitters and enzymes decrease, because of these changes the brain functions may slow down with age. In older people, some mental functions are reduced, such as vocabulary, short-term memory, the ability to learn new material etc. After the age of 60 years, the number of cells in the spinal cord decreases which results in the decrease in sensation. Physiologically, conduction velocity decreases with advancing age. Voluntary motor movements slow down and the reaction time is also slowed with an increase in reflex time.

There are a number of nervous disorders which make their appearance after 50 years of age. These include Parkinson’s disease, Alzheimer’s disease, senile dementia and stroke. Parkinson’s disease is caused by the degeneration of an area called basal ganglia in the brain.

The degenerative changes also involve the sensory organs. The sense of touch begins to reduce after 50 years. The feet lose their sensitivity to touch and vibration faster than the hands. Presbyopia (far sightedness) occurs between 40-50 years of age with cataracts occurring in 30 per cent of elderly persons. The adaptation to dark as well as acuity of night vision also gradually decreases with advancing age. Cataracts also occur during later years of life. The sclera becomes thick and rigid and may become slightly yellowish due to long exposure to ultraviolet light of sun and dust. The muscles that regulate the size of the pupil get weaker with age and become slower to react to light and dark. Glaucoma develops with age. Some diseases of the retina may also occur with passing years. The eye lids lose their elasticity and become wrinkled.

Due to neuronal loss with advancing age, there is also a loss of hearing particularly as regards the high frequency tones. There is a progressive loss in the ageing persons’ capacity for taste as well as smell. This combined reduction in sensitivity of the senses concerned with intake, aggravates the problems of the dietary needs of the older individuals. Due to degenerative changes in the neuronal elements of the inner ear, there are balance disturbances, which are responsible for high rate of falls among the elderly.
3.4.5 Cardiovascular System

There are general changes with ageing in the cardiovascular system which includes loss of extensibility or compliance of the aorta, reduction in cardiac muscle fiber size, progressive loss of cardiac muscular strength, reduced cardiac output, a decline in maximum heart rate and an increase in systolic blood pressure (Tortora, 1992). Changes in blood vessels that serve brain tissue, such as atherosclerosis reduce nourishment to the brain that may result in the malfunctioning or death of brain cells. By 80 years of age, cerebral blood flow is 20 per cent less and renal blood flow is 50 per cent less than in the same person at age 30 years (en.wikibooks.org).

The effects of ageing on heart functioning become evident when the individual is exercising at a steady state of maximal activity and relying on aerobic muscle metabolism. It results in decrease of maximum oxygen consumption which has been reported to be linear throughout the adult years and it amounts to a total loss of 30-40 per cent in the 65 years old individual as compared to a young adult. The reduction in heart rate during maximum level of activity also indicates a loss in the efficiency of heart as a pumping device.

The mechanism that seems to be responsible for diminished cardiovascular functioning may be due to the reduced capacity of the left ventricle of the heart, which propels blood into the aorta. Therefore, the stroke volume (amount of blood pumped at each beat) is reduced. As a result the total cardiac output also becomes lower. The maximum oxygen consumption is reduced which results in less blood flowing through the arteries from which oxygen is extracted. The anatomical changes, that appear to be responsible for the decreased functioning of left ventricle, are an increase in the thickness of the wall of left ventricle and the total ventricular mass, which reduces its potential to contract completely. As a result of these changes more time in required to complete the cardiac cycle.

The arterial walls become more rigid with age and so are less able to dilate to accommodate the increase in blood flow especially during exercise, when more blood flow is required for skeletal muscles. The rigidity of the arterial walls which offers resistance to blood flow is due to the accumulation of lipids in the arteries during individual’s lifetime. It narrows the internal diameter of the blood vessels through which the blood is pumped, thereby increasing the work of the heart. Total blood cholesterol increases with age especially low density lipoproteins (LDL) whereas the high density lipoproteins (HDL) tend to decrease with age. So, there is an increase in the incidence of coronary artery disease, hypertension and other cardiovascular ailments.

3.4.6 Respiratory System

With advancing age, the air ways and tissues of the respiratory track including the alveoli become less elastic and more rigid. The chest wall also becomes more rigid and there is a decrease in lung capacity. Vital capacity decreases as much as 30 per cent by 70 years of age. There is also a decrease in the levels of oxygen in the blood. The lower level of oxygen in blood is due to resistance with age, to oxygen diffusion across the membranes in the alveoli and also the capillaries. Another cause of reduced oxygenation of the arterial blood in older adults appears to be due to an irregular distribution of air through the lungs which lowers the efficiency of gas exchange. The blood is more freely distributed to the lower parts of the lung due to gravitational forces. There is a greater likelihood of disparity being present in the lower part of the lungs in older persons between flow of air and blood. The lower portion of the lungs in the older individuals is less ventilated than younger humans.

The reduction of ventilation in the lower part of the lung is due to changes in elastic recoil. The loss of elastic recoil with age is due to alternations in the composition and structure of the elastic and collagen. The increase in the rigidity of the chest
wall along with loss of elastic recoil of the lungs, lowers the ability of the lungs to be fully compressed during expiration and fully expanded during inspiration. The gas exchange is therefore, compromised.

The total lung capacity decreases by an average of 4.5 cm$^3$/m$^2$ of body surface. Vital capacity which is about 4.8 liters at 20 years of age decreases to 3.42 liters at 80 years. Due to all these age related factors, elderly people are more susceptible to pneumonia, bronchitis, emphysema and other pulmonary disorders.

The smoking further lowers the respiratory efficiency. Nicotine narrows the terminal bronchioles, which decrease the air flow into and out of the lungs. Carbon monoxide in smoke binds to hemoglobin which reduces its oxygen carrying capability. Irritants in smoke cause increased fluid secretion by the mucosa of bronchial tree, which causes swelling of the mucosal lining. These impede airflow into and out of the lungs. With the passage of time, smoking leads to destruction of elastic fibers in the lungs which causes emphysema.

### 3.4.7 Digestive System

The effects of ageing on the digestive system have been noticed in different ways. During later adulthood the functions carried out by salivary sections in the mouth have been found to decrease. The symptom of a dry mouth has been reported to occur as a function of age in later adulthood. The reduction in the volume of saliva also results in the decreased protection of teeth and tongue from bacteria. There is also a reduction of taste sensations. The loss of teeth and incidence of oral diseases also increases the difficulty in chewing of food.

With advancing age the muscles of the digestive track (esophagus) contract with lesser strength than during younger ages. Food from the stomach moves slowly. The secretion of hydrochloric acid in the stomach and other digestive enzymes decrease with age. In some people less lactase is produced, as a result older people develop intolerance to dairy products and may feel bloated or have flatulence or diarrhoea after they consume milk products. The secretion of gastric juice decreases to about 75 per cent of the normal value during later age, thereby making food less digestible. The reduction in vitamin B$_{12}$, i.e., intrinsic factor contributes to changes in the intestinal absorption of iron, calcium, folic acid and proteins. Some reduction in the absorption of fats has also been reported. The normal digestion of fats is made possible by bile secreted by the liver. But with age, there are some changes in the liver also. Certain enzymes produced in the liver work less efficiently. These enzymes help the body to digest various drugs and also to get rid of unwanted by-products.

The motility in the large intestine is greatly reduced in elderly persons. This reduction may be due to loss of strength and atrophy of the muscles responsible for moving fecal material through the large intestine which may lead to constipation thereby requiring more medication. Some pathologic changes that increase with ageing include peptic and duodenal ulcers, appendicitis, gall bladder problems, jaundice, cirrhosis and acute pancreatitis. In the large intestine cancer of the colon and rectum are frequently observed.

### 3.4.8 Excretory System

With aging the kidneys shrink in size. Less blood flows through these and thus the quantity of filtered blood is reduced. The mass of the two kidneys decreases from an average of almost 300 g at 20 years to about 200 g at 80 years of age. The flow of blood and its filtration declines to about 50 per cent. By the age of 80 years nearly 40 per cent of the glomeruli are not functioning due to decrease in number and get damaged, thus leading to a decrease in filtration, reabsorption and secretion.

The urinary track changes that make control of urine difficult and sometimes bedwetting or spotting occur. The maximum volume of urine that the bladder can hold
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decreases with age. The muscles of the bladder weaken; as a result more urine is left in the bladder after urination is complete. Older people are less able to delay urination after they first sense a need to urinate. The bladder muscles may contract without any need to urinate. Due to these changes the uncontrollable loss of urine becomes more common in older people. Among women, the muscles that control the passage of urine through the urethra are less able to close tightly and prevent leakage. These changes may result from a decrease in the estrogen level that occurs with menopause. In men, the prostate gland may enlarge with age. In some males it may partly block the passage of urine, thereby making the time of urination much longer and sometimes painful. The bladder may not be completely empty even after frequent urinations. So urine may stagnate in it and may lead to bladder stones. Thus urinary tract infections become commoner in the elderly. Many problems, like excessive urine production, higher frequency of urination at night, painful urination accompanied by blood, are quite common among the aged persons.

3.4.9 Immune System

With ageing the immune system becomes less effective. Elderly people are more susceptible to all types of infections. The immune system loses ability to distinguish the body's own cells from the attacking cells. As a result the immune system may attack the body's own cells in addition to the attacking of the bacteria leading to the autoimmune reactions. An old person's immune system reacts more slowly to destroy bacteria or the attacking agents. The infections of the lungs become common in later stages of life. Thus tuberculosis, pneumonia, bronchitis etc. are commonly seen in the elderly. As the body becomes weak, it is not able to stand harsh weather - like hot sun in the summer and chilly winds during winter days. Thus, there is a continuous decrease in both cell mediated as well as antibody mediated responses of the body in later years of life.

3.4.10 Endocrine System

The endocrine system has several organs and glands which are responsible for the production of hormones. Hormones are the body's messengers that regulate the functions of the body. These are also the substances which coordinate various activities and responses of the body. With advancing age these are secreted in smaller amounts and their activity is also lowered. Thus the lowering of growth hormones reduces the muscular strength of the body; lowering the muscle mass and thus a person becomes weak during old age. In the same way the level and effect of adrenal glands, sex glands etc., also decreases, thus making a person less aggressive with age. The decrease in aldosterone makes the older people susceptible to easy dehydration.

Most changes of hormones may not affect the activities of the body, the pancreas secretes hormone insulin that helps in the use of sugar in addition to other nutrients. When the level of insulin produced or utilized becomes smaller, it leads to a disease called diabetes. As a result of this the utility of glucose is lowered and the energy available to cells is lowered. Hence, cell may utilize the fats and proteins instead of glucose for energy requirements leading to other problems with advancing age. Thus, as insulin is not used efficiently, the blood sugar level rises after taking heavy meals and it takes longer to return to normal values leading to onset of damages to vital organs that become more pronounced with advancing age.

3.4.11 Reproductive System

The reproductive system functions differently for males and females as the age advances. In women, the ability to reproduce is lost well before old age sets in, i.e., during the fifth decade of life. The menstrual periods become irregular and ovulation fails to occur during many of the cycles. The permanent cessation of menstruation signifies the onset of menopause. Menopause is described as a phase in a woman's
life, when both ovulation and menstruation come to an end. Before menopause, there are many changes in the female reproductive function. This transitory phase is termed as climacteric phase or it is also known as change of life. It may start as early as 35 to 40 years or may appear as late as 50-55 years depending upon various factors like parity, race, heredity, socio-economic conditions etc. In western countries the age at menopause has been reported to be 50 years, whereas in Indian populations it is around 48 years.

During this period of climacteric, there is a spurt in the ageing process with all its physical and mental characteristics leading to old age. Certain characteristics like hot flushes, feeling of dizziness, heat, perspiration, irritability, anxiety, depression etc., may develop in some women so that the person feels quite sick and exhausted. There are many hormonal changes especially the estrogen deficiency has been reported to be responsible for these changes. The female morphology undergoes various changes during this period. The strength of bones is significantly reduced due to the loss of mineral content. It is because of an increased rate of bone absorption, which is kept in check by estrogens. Muscle tone is reduced. The ovaries and uterus shrink. The tissues of the vagina become thinner, drier and less elastic. The breasts become less firm and more fibrous and these tend to sag. Some of the changes that begin at menopause may interfere with sexual activity. However, for most women, ageing does not significantly affect sexual activity. There is certain amount of obesity or at least fatty tissues redistributed. The subcutaneous fat on the abdomen and thighs thickens. Facial features undergo changes and wrinkles grow deeper and there may be a growth of hair on the upper lip. The process of osteoporosis is also accelerated after menopause along with other characteristics like backache, wedging of vertebrae leading to kyphosis.

The decline in reproductive function in males is a gradual process often decreasing with the general fitness of the individual. Healthy men often retain reproductive capacity during seventies or even eighties. During sixth decade of age a decline in testosterone synthesis leads to less muscle strength, less sperm count and a decrease in sexual activity. However, abundant sperm may be present even in old age. The most common problems in older males are an enlargement of the prostate gland which squeezes the urethra and causes a difficulty in urinating. This enlargement is often benign in nature, but prostate cancer is quite common during old age.

### 3.5 SUMMARY

After carefully going through these facts it appears that delay in ageing will require us to transmit the required information to the body for which new technology will be necessary. The most promising technologies to solve this problem can be gene therapy and single-gene intervention, cell therapy, stem cells and nanotechnology. Most of these technologies already exist. What remains is an engineering problem of making them work according to our needs.

The study of ageing has a bearing on many diverse fields of science. Problems of ageing are linked to all branches of medicine and physiology as well as to psychology and sociology. Many eminent gerontologists are of the opinion that in human beings when it comes to ageing and longevity power of mind appears to be dominant over any physical and biological means. Mind has a powerful role to play in regulating all organs of our body. Negative emotions like, greediness, ego, anger, too much materialistic achievements result in high blood pressure, whereas the positive emotions like selfless service have a beneficial effect on blood pressure. Music, meditation, and yogic practices help in setting the mind in equilibrium and provide mental relaxation which is essential to face the daily challenges of life.
So to live a healthy long life one should try to develop all those characteristics in life which have been found in centenarians throughout the world. These include being optimistic, having adaptability to the wake of changing socio-cultural conditions, having commitment to some idea or activity able to enjoy loneliness, enjoying rightful pleasures and having a sense of humor. In addition to these personality characteristics which can be learned and developed by will and by training, of course all other approaches of maintaining a healthy body e.g., healthy food habits, physical activity can also help.

Thus, looking into the advances in research going on in the field of gerontology it is hoped that in the near future we may be living in a disease free healthy old age a the motto of all throughout the world.

### 3.6 REFERENCES


Website

www.deardeath.com as on April 27, 2012
www.lef.org as on May 8, 2012
www.merckmanuals.com as on May 7, 2012

Suggested Reading


Sample Questions

1) Define senescence and describe various changes that occur in the skin, muscles and bones during ageing.

2) Describe various theories of ageing and discuss the causes of delay in the process of ageing.

3) Explain the effects of ageing on the following systems of the body:
   a) Nervous System
   b) Cardiovascular System
   c) Digestive System
   d) Respiratory System
   e) Reproductive System

4) Define climacterics. Discuss various changes in females during this period.