Chapter

Cellular Aging from Physiological and Economical Perspectives

Marjan Assefi, Kai Uwe Lewandrowski, Alireza Sharafshah and Seyed Majid Hosseini

Abstract

The study of biological processes and functions of the human body under normal circumstances is known as physiology. Cellular physiology is the study of biophysical and biochemistry processes taking place in a cell. Cells age with time. They all have a certain lifespan after which they die common features that can be observed in an aging cell include damaged protein and organelles accumulation even when there is the absence of mutation. Many physiological changes are experienced as cell ages, resulting in the deterioration of normal cell functioning. Examples of such changes include: Cells may enlarge and are unable to multiply or divide, fats and pigments may get deposited in some cells, and some cells may function abnormally, while others may start functioning in the right manner. Any organism that is multicellular and receives energy from the sun can only live for a specific time. As the cellular organism ages, it losses its efficiency and after sometime it might end up dying. Many biologists studying the evolution of organisms deny that aging is genetically caused but rather takes place after natural selection requirements are fulfilled by the organisms. After an organism has had off-springs, it ages with time and eventually dies; however, recent research has shown that genetic components also contribute to aging.

Keywords: cellular aging, physiological, biological, genetics, aging

1. Introduction

Aging in a cell may result from a cell being damaged continuously or from the genetic structure expressing predetermined information [1–5]. Thus, it is important to note that aging in cells is caused by genetics or an individual's lifestyle. Cellular aging is known as cellular senescence. Senesces do a lot of changes in the body system that requires the victim to be given special care, attention and medication, failure to which the victim of senescence can die. Cellular aging is divided into two:

1. Chronological aging refers to the maximum time a post-mitotic yeast population can survive. Time units are used to measure chronological aging. A single cell cannot be used in this case.

2. Replicative aging is the limited number of a single cell that can divide.

1.1 Cellular theory of aging

Cellular theories of aging say that human aging results from cellular aging after many cells reach senescence and are unable to divide or multiply. When a cell reaches the senescence stage, the body is unable to respond to stress and injury. Every successful division results in slower cell division until the cell reaches the replicative senescence level where no more cell division takes place. Replicative senescence is believed to involve a biological clock within the cell that counts the number of cell divisions and signals the cell to stop further division at a certain genetically predetermined time. Below are examples of cellular theories of aging.

1. Wear and tear theory

2. Free radical theory of aging.

3. Somatic mutation theory of aging.

4. Protein cross-linking theory of aging.

5. Rate of living theory.

We also have one broad category of theories known as programmed theories of aging which are broken down into various categories which include

1. Endocrine theory of aging.

2. Immunological theory of aging.

3. Programmed longevity.

1.2 Programmed theories of aging

Aging is universal and inevitable. Programmed theories of aging suggest that aging does not result from stochastic or random processes but genetically predetermined mechanisms, and environmental factors and causes certain damages. The programmed theory of aging proves that senescence in organisms results from evolved biological mechanisms to have an evolutionary advantage [6]. The programmed theory of aging also argues that it is evolutionarily programmed for organisms to age and die. As stated earlier examples of these theories include the endocrine theory of aging, the immunological theory of aging, and programmed longevity.

Hormones in some instances are known to cause aging. The endocrine theory of aging suggests that hormonal changes can result in aging. In animals, there are instances the tissues, cells, and body organs become insensitive to the hormones controlling them [7]. Cells may also experience changes in the production of hormones [6]. The hormones can be produced in higher or lesser amounts. For example, it was initially believed that when growth hormones accumulate at an old age, individuals were to become more youthful which is not the case. After several researches, it was discovered that mice with more growth hormones aged quickly and had a shorter lifespan. It is known that several age-related hormones contribute to individuals contracting age-related diseases which are chronic [8]. Individuals may also suffer

from declined physiological functions such as inflammation, decline in the immune system, diabetes, alopecia, osteoporosis and thrombogenesis. In men and women, aging is associated with a deficiency in the production of sex hormones [9]. Loss of sexual hormones may trigger muscle weakness and loss. Shorten life span and decrease the functioning of the body [10]. The levels of estrogen decreases in women and testosterone decrease in men. Both genders also experience a decline in growth hormone as they grow. Girls are believed to age earlier compared to boys when they reach puberty stage. Girls reach the puberty stage as earlier as 8 months while boys start at 9. It is the role of brain to trigger the brain for the body to start the puberty stage. Therefore, hormones play a role in aging [11]. Programmed theory of aging also suggests that it is evolutionarily programmed for organisms to age and die.

2. Causes of cellular aging

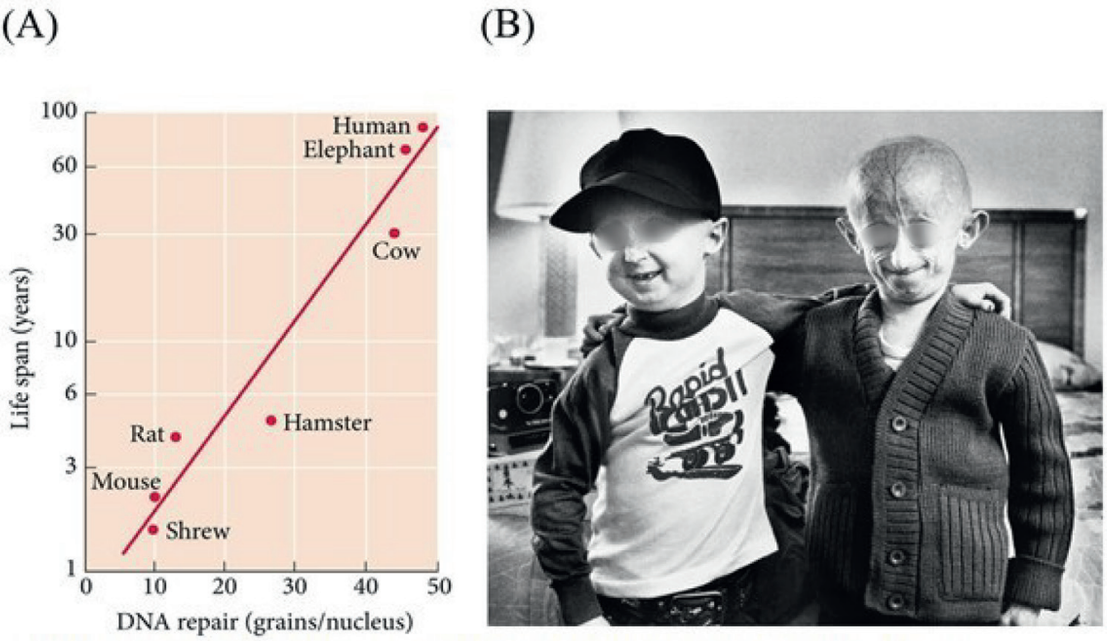
As we all know, cellular aging is a characteristic of every living organism [12]. But what we do not understand is what leads to cellular aging. There are many theories explaining the causes of aging but still most scientists have not yet developed the real cause of aging [13]. In our case, we are going to explain what causes aging at the cell level. Some of the causes of aging include:

2.1 Oxidative damage

Oxidative damage does worse than good to the body. One of its disadvantage is that it breaks down cell tissues leading to damage to the DNA. Damaged DNA may result in inflammation and lifelong diseases such as diabetes and cancer [14]. Oxidant damage occurs mostly when the body has a low antioxidant level which results from low metabolism taking place in the body. Research shows that in animals aging is caused by metabolism. According to aging theory, metabolism results in aging and mutation is not required [12]. After the mitochondria take in oxygen, about 2% of the oxygen atom gets insufficiently reduced to reactive oxygen species (ROS). ROS consists of superoxide ion, hydroxyl radical, and hydrogen peroxide. ROS is dangerous since after oxidizing it can damage nucleic acid, proteins, and cell membrane [14]. Animals are likely to experience antioxidant damage when there is an imbalance in the level of oxygen in their cells [15]. One evidence that shows that ROS contributes to aging is that calorie restriction in mammals may result in aging since it prevents ROS from being synthesized. To prevent and control antioxidant damage individuals should consume carotenoids, flavonoids, vegetables, nuts, and fruits. Vitamins E and C are also known to be inhibitors of ROS. Antioxidants play vital roles in our bodies by protecting us from free radicals. Antioxidants prevent diseases such as cancer and diabetes.

2.2 Genetic instability and general wear-and-tear

As individuals grow up, they experience different situations in life such as traumas that build up in the body after sometime. This results in an increase in point mutation, whereby the enzymes encoded in the genes decrease in efficiency. Cells are most likely to make more faulty proteins when mutation occurs in parts of protein synthetic apparatus. The mutation rate is likely to increase if occurred in the DNA synthetic enzyme. Therefore, to prevent senescence, DNA repair is very important. Cells that are efficient in repairing DNA age slowly and live longer.



A after R. Hart and R. B. Setlow. 1974. *Proc Natl Acad Sci USA* 71: 2169–2173; B © Associated Press

2.3 Damage to mitochondrial genome

In mitochondria mutation happens 10–20 times faster than in nuclear DNA. Mitochondria mutation may result in energy production defects, and faulty electron transport may produce ROS and may result in the induction of apoptosis [16]. Aging is dependent on mitochondrion functions. Research shows that there is a presence of aging mutation genomes in the mitochondrion. Mitochondria with aging mutation genomes replicate faster than the wild-type mitochondria thus dominating the cell and its progeny [17]. Mutation does not only make the Mitochondria DNA susceptible to damage caused by ROS but also results in making of more ROS. Triggers of aging such as stress may also affect the mitochondria [18]. For example someone who is going through a lot of stress in life may get his mitochondria damaged. This is because in response to stress the body produces a fight or flight mechanism for the body's survival. However, experiencing a fight or flight response everyday can be harmful to the body. Also, too much stress makes the monoamine neurons hyperactive, dysregulating neuronal activity. Taking antidepressants is believed to help different neurotransmitter system to adjust their balance. Once a mitochondrion is damaged, it dies. This is because it does not produce enough energy to help carry out its normal functions.

2.4 Shortening of telomere

At the end of chromosomes lie telomere. Several researches have shown that genes contribute to cellular aging. The genes we inherit largely determine our lifespan. According to research, how long we live is determined by our parents at the conception method and the genes they carry. Telomeres that occur at the end of chromosome determine the lifespan of a cell [19]. For example, in children, a condition known as Telomere is DNA-repeated strands. Once telomeres are damaged, they result in senescence. Shelterin is a multiprotein complex that protect telomeres from reacting to DNA damage. With this, the chromosome end-to-end fusion is prevented preventing telomere crisis.

Telomerase maintains telomere helping them get replicated by DNA polymerase and shorten at each cell division. Shortening of telomere is believed to be a clock that prevents the further division of cells since the somatic cells do not have telomerase. Therefore as cell ages, the telomere continues to shorten. Research carried out in a telomerase-deficient rat indicated that the mice had genomic instability, lacked the ability to withstand stressors, its lifespan shortened and there was an increase in age spontaneous malignancies. However, research shows a lack of correlation between the length of telomere and animals' lifespan and human life.

2.5 Cellular aging and healthy living

Cell aging is a natural process that occurs in the animal body. The body replaces the aging cells with new ones that are young and perform well as the aging ones retire. It does not matter what stage of aging a cell is experiencing but individuals can improve cellular functioning through maintaining a healthy lifestyle [20]. Maintaining good cellular is one way of supporting and helping cells age successfully. Cellular aging is unavoidable but one can prevent cells that are still functioning well and are not yet to age from aging so quickly. Some activities can trigger cells to age very fast. Humans should avoid triggers such as smoking, obesity, excess stress, abusing drugs, and sunburns so as to promote healthy cell functioning [21]. People should exercise more often. Exercising helps the heart and lungs to function well and also encourages the telomeres to lengthen [22]. Obesity results in the shortening of telomeres; thus, individuals suffer from quick aging. Aging should be enjoyed and this only happens when individuals pay attention to their aging bodies and cells by avoiding cell aging triggers and consuming diets rich in antioxidant.

3. Cellular aging and economics

Delaying aging produces complementarities between health and longevity, affects many diseases due to the rising prevalence of age-related comorbidities, and creates synergies arising from competing risks, all of which contribute to the substantial economic value of gains from targeting aging [23]. Importantly, delaying aging creates a virtuous cycle in which a slower aging process prompts demand for a slower one. The benefits that society derives from delaying aging increase with society's average age, improve quality of life in old age, and depend on the number of older people. This creates a virtuous circle. This gives an unmistakable dynamic to focusing on maturing contrasted with medicines focused on unambiguous sicknesses, in which gains reduce once fruitful therapies are found [23].

We estimate that the total gains are only worth US$21 trillion after taking into account differences in the discount rates and VSLs that were chosen and limiting our gains to those that occurred after the age of 50. The reference is responsible for the remaining differences [7]. If aging will improve gradually rather than immediately; even though there are still differences, the most important insight is that their distinct method, which employs an empirical microsimulation model based on individual data from the United States, and yields comparable estimates of the value of delaying aging to very large amounts.

Our evaluations are theoretical from the two imbalances in well-being and pay. While introducing income inequality raises significant distributional issues, allowing for health disparities is likely to increase the value of the overall gains. According to

our estimates, anti-aging treatments are extremely useful. Access to such treatments will be widespread if they are affordable. However, issues of access and redistribution will become significant if the costs are high. The magnitude of the potential values shown in our simulations makes it abundantly clear that if these social gains are to be realized to their full potential, they must be accessible to all [23].

In conclusion, we establish that as humans and animals grow older the cells go through changes that contribute to aging. In tissues with high cells, it is believed that senescent tissues will result in more aging. Individuals should adopt healthy lifestyles that improve their lives as they age.

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