Cellular apoptosis and cellular aging

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Definition

Apoptosis is the process of cell suicide or programmed cell death. It is a highly regulated cell activity that occurs rapidly and produces small membrane-enclosed ***apoptotic bodies***, which quickly undergo phagocytosis by neighboring cells or macrophages specialized for debris removal. Unlike cells undergoing necrosis as a result of accidental injury, apoptotic cells do not rupture and release none of their contents. This difference is highly significant because release of cellular components causes a rapid series of local reactions and immigration of leukocytes in an elaborate reaction called an ***inflammatory response***.

Programmed cell death (apoptosis) was first discovered in developing embryos, where apoptosis is an essential process for shaping various developing organs or body regions (morphogenesis), such as the tissue between the digits on a developing limb bud. Apoptosis also plays an important role in formation of the central nervous system.

Apoptosis is an important means of eliminating cells:

- Whose survival is blocked by lack of nutrients, by damage caused by free radicals or radiation.
- By the action of tumor suppressor proteins.
- Apoptosis removes cells from the embryonic limb buds in the development of fingers and toes.
- Apoptosis also is needed in repair and remodeling of tissue throughout life.

Cells subject to wear and tear regularly undergo apoptosis and are replaced. In all examples studied apoptosis occurs very rapidly, in less time than required for mitosis.

The process involves the following features:

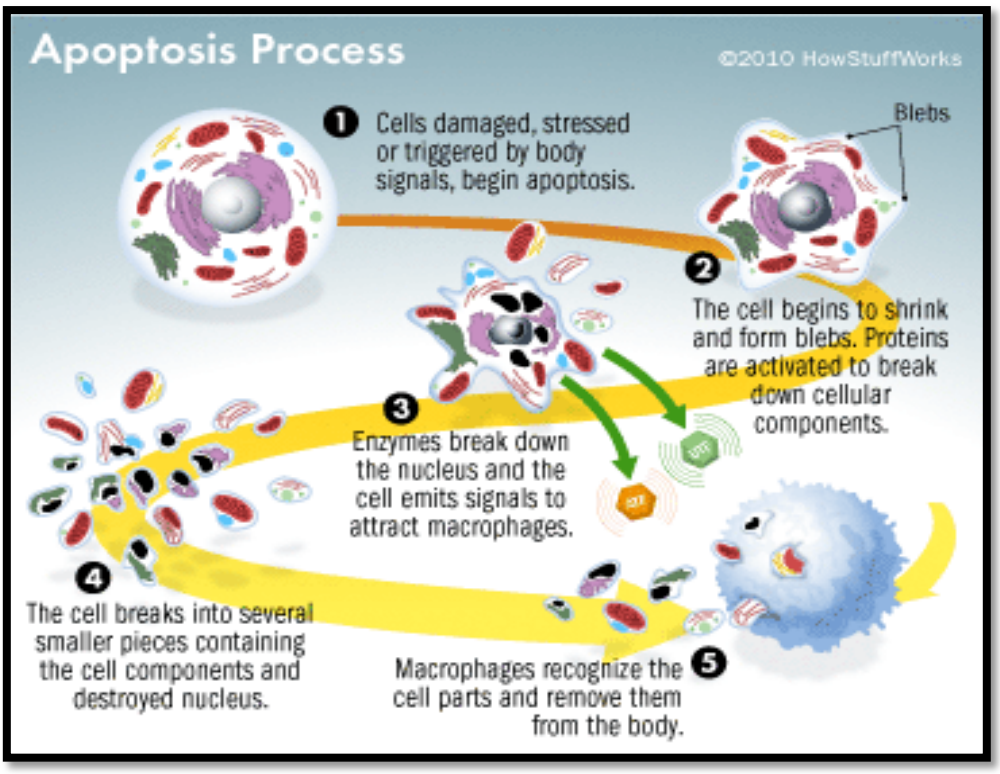
1- ***Loss of mitochondrial functions*:** Mitochondrial membrane integrity is not maintained, causing the end of normal activity and release of ***cytochrome c*** into the cytoplasm where it activities proteolytic enzymes called ***caspases***. The initial caspases activate a cascade of other caspases, resulting in protein degradation throughout the cell.

2- ***Fragmentation of DNA*:** Endonucleases are activated which cleave DNA between nucleosomes into small fragments.

3- ***Shrinkage of nuclear and cell volumes*:** Small dark-stained (pyknotic) nuclei can sometimes be identified with light microscope.

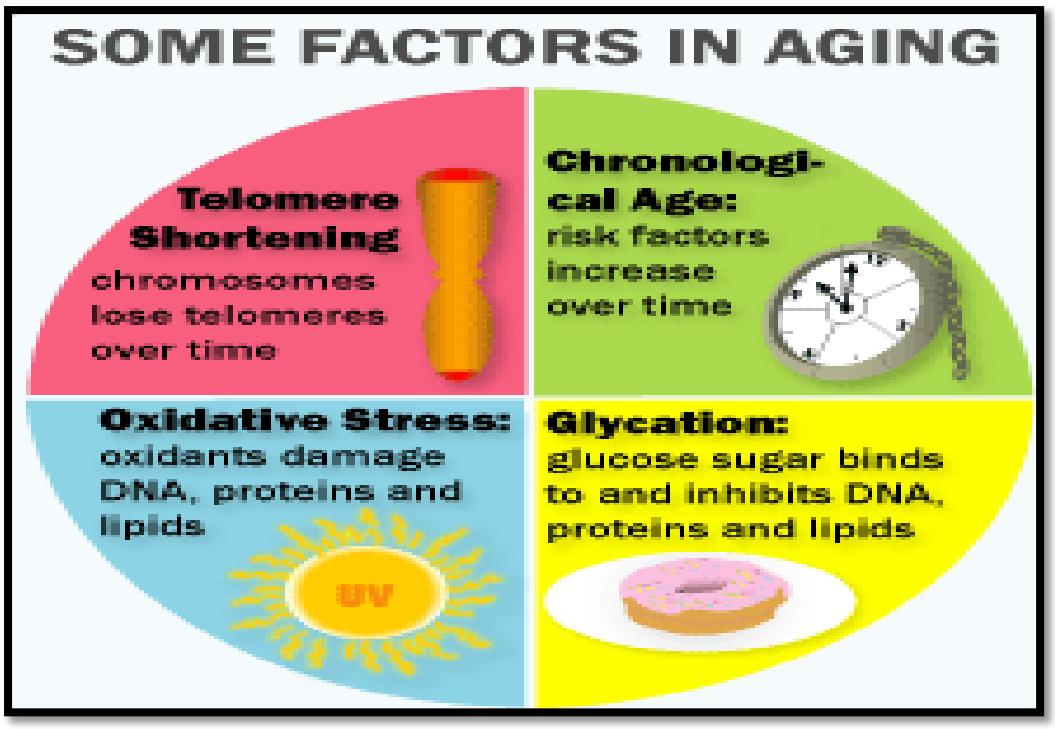
4- ***Cell membrane changes*:** The integrity of the plasmalemma is maintained, but the cell undergoes dramatic shape changes, such as "blebbing" (Figure 1-78), as membrane proteins and cytoskeleton are degraded. Phospholipids normally found only in the inner layer move to the outer layer, serving as signals to induce phagocytosis.

5- ***Formation and phagocytic removal of these apoptotic bodies*.**



Cellular aging

Most scientists now agree that aging is, at least in part, the result of accumulating damage to the molecules—such as proteins, lipids, and nucleic acids (DNA and RNA)—that make up our cells. If enough molecules are damaged, our cells will function less well, our tissues and organs will begin to deteriorate, and eventually, our health will decline.



Scientists have already uncovered clear links between reactive oxygen compounds and aging. Fruit flies genetically engineered to produce high levels of enzymes that destroy reactive oxygen species lived almost 50 percent longer than normal flies. ***Antioxidants***- compounds, such as vitamins E and C, found in fruits and vegetables as well as within our own bodies. Antioxidants are less potent than the enzymes that quash reactive oxygen species, but like the enzymes, they can disarm dangerous reactive oxygen compounds.

●The causes of cell aging at a molecular level can be summarized :

1- Damage to vital proteins called histones plays a big role in cellular aging.

2- Shortening of telomeres, the protective tips of chromosomes, leads to production of defective histone.

Although hypothetical, Mary's case is a classic example of ***Werner syndrome***, a rare inherited disease that in many respects resembles premature aging. People with Werner syndrome are particularly prone to cancer, cardiovascular disease, and diabetes, and they die at a young age—typically in their 40s . At a genetic level, their DNA is marked by many mutations. These characteristics support the theory that accumulating DNA mutations is a significant factor in normal human aging.

Loss of telomeric DNA (the regions at the ends of our chromosomes) during cell proliferation may play a role in ageing and cancer. Since telomeres permit complete replication of eukaryotic chromosomes and protect their ends from recombination.

Each time a cell divides, the protective "caps" at the tip of chromosomes, as telomeres wear down , their DNA undergoes massive changes in the way it is packaged. These changes likely trigger “ Cell aging."