# Aging is adaptive

Aging is a lifecycle stage common to all life forms and is observed in both unicellular and multicellular organisms. The primary manifestation of aging in unicellular organisms is replicative senescence. As the cell ages, cell cycles become more infrequent and ultimately division ceases. Once in this cell cycle arrested state, the cell undergoes lysis. A similar lifecycle stage occurs in cells making up a multicellular animal. However, it is within the context of a multicellular organization, that the adaptive nature of cellular aging programs becomes apparent. Aging/death programs such as senescence, apoptosis and autophagy are not adaptive to the affected cells, but these cells, while aging, give directions to nearby cells and thereby modify their behavior. This type of instructional activity performed by dying cells is critical for processes such as tissue modeling during embryogenesis and tissue repair and maintenance. In essence within the context of the whole animal, the aging and death of individual cells makes possible essential whole animal functions i.e. the aging/death of individual cells is beneficial to the functioning of the whole animal. This example leads to a principle; the adaptive nature of individual cellular aging/death programs can only be appreciated when these cellular programs are interpreted within the context of functioning of the whole community of cells. The adaptive nature of these programs cannot be appreciated when affected individual cells are considered in isolation.

The same principle holds for animals and species which live in communities occupying a shared environmental space i.e. an ecosystem. An ecosystem is composed of many different species (plants and animals) and these systems are highly regulated. It has been well established that a healthy and productive ecosystem requires a rich diversity of species and regulated population densities; no one species should dominate the ecosystem. The organization of the ecosystem is such as to optimize the functioning of all of its components, both species and individuals. One mechanism for regulating population densities is through species-specific evolved aging/death programs. Such programs would maintain appropriate species population densities necessary for optimal functioning and productivity of the ecosystem as a whole. As an analogy, we can compare an ecosystem to a super organism with species as analogs of cells in a multicellular animal. With this comparison, the adaptive nature of species specific aging/death programs is analogous to the adaptive nature of cellular aging/death programs.

Humans, however, have changed the functioning of the ecosystem which we inhabit. Through our inherited system of culture we have expanded our habitable environmental space to be global in extent. Almost three quarters of all humans now live in an urban ecosystem. Unlike a natural ecosystem, the urban ecosystem contains one dominant species, us, and a paucity of other species. The urban ecosystem is organized not to optimize the functioning of all of its components but only to optimize the functioning of one species, us. Since gene-culture co-evolution is now the primary driver of human evolution, our urban ecosystem will play a major role in shaping the aging/death program of future humans.

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## Publication

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