Different Ways of Aging

Not all organisms age at the same rate. In fact, a few species do not appear to age at all. How is this possible? The short answer is we really do not know, but we are working on it.

The most unalterable and ageless organisms are also the simplest. Some microorganisms—bacteria, viruses, protozoa—display unique reproductive and longevity characteristics that arise from their cell physiology. Lacking a sexual phase (i.e., utilizing asexual reproduction through cell division) many of these species can proliferate with no detectable degradation in future offspring. In other words, future generations appear to be exact copies of their long, lost, great, great grandparents. Paramecium (aka Lady Slippers) and Tetrahymena, two carefully studies species, do show clonal deterioration but only after hundreds of cell divisions.

Entering the plant kingdom complicates the picture even further. Here we find a process known as vegetative reproduction through which one plant can be copied and reproduced through various means (e.g., tubers, bulbs, runners, rhizomes, corns, grafting or cuttings) and, for some species, this possibly creates an inexhaustible chain of life without evidence of generational deterioration, for example, as in tulips, crocus, and banana. Sugarcane and citrus, on the other hand, are limited in this regard showing clear signs of aging and decline from grafting one generation to the next (de Magalhaes, 2009). Other plant species can take a relatively long time to reach maturity, for example, certain species of agave and bamboo can require up to 100 years to maturity, and then die suddenly after reproducing in what has been termed "big bang" reproduction. There are other species of plants that live very long as well, and some of these show minimal signs of aging: redwoods (up to 2,200 years), black-butt baobab, cedar, chestnut, cypress, oak, western juniper, yew, bristlecone pine (4,700 years), and Norway Spruce (9,550 years).

The concept of negligible senescence refers to a very slow or insignificant aging process first identified in 1990. To be part of this rare evolutionary club requires no observable age-related increase in mortality rate or decrease in reproduction rate after maturity, and no observable age-related decline in physiological capacity or resistance to disease (Finch, 2009). Some animal species that appear to qualify include bacteria, fungi, hydra, worms, sea urchin, mollusks, fish, turtles, birds, and whales. Here are some dramatic examples of species that live a really longtime.

### Examples of Negligible Aging Species

<table>
<thead>
<tr>
<th>Species</th>
<th>Lifespan in Yrs.</th>
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<tbody>
<tr>
<td>Quacking Aspen (clonal colony of 47K)</td>
<td>80,000 – 1 million</td>
</tr>
<tr>
<td>Hexactinellid sponge</td>
<td>15,000</td>
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<tr>
<td>Great Basin bristlecone pine</td>
<td>4,731</td>
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<tr>
<td>Pathogenic Armillaria fungus (Eastern Oregon)</td>
<td>2,400</td>
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<tr>
<td>Ocean quahog clam</td>
<td>400</td>
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<tr>
<td>Aldabra Giant Tortoise</td>
<td>255</td>
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<tr>
<td>Tubeworm</td>
<td>250</td>
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<tr>
<td>Bowhead whale</td>
<td>211</td>
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<tr>
<td>Rougheye rockfish</td>
<td>205</td>
</tr>
<tr>
<td>Red sea urchin</td>
<td>200</td>
</tr>
<tr>
<td>Galapagos tortoise</td>
<td>177</td>
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</tbody>
</table>

Bristlecone Pine
In the mammal world, our world, there appear to be no examples of negligible senescence other than the Bowhead whale, noted above. There is, however, tremendous variability in species aging rates and longevity. Rodents, for example, vary significantly in terms of average and maximum lifespan, ranging from four years for the common house mouse to a record 27 years for the naked mole rat. Elephants can live 70 years or more and certain types of bats, despite their small size, up to 30 years. Humans are the oldest living primates, out to a maximum range of about 125 years.

Quantitative models to explain and predict rates of aging and species longevity remain works in-progress. One is the Gompertz model of species survival that calculates a mortality curve as a function of age (or time) for each species, and then yields both an initial mortality rate ($iMR$) and a mortality rate doubling time ($MRDT$), with the $MRDT$ being an approximation of a species rate of aging (Finch & Pike, 1996). The most widely used method by scientists, however, is simply maximum lifespan ($t_{max}$). In many instances bigger animals live longer than smaller ones, as most of us have observed, due to such factors as predation, competition for scarce resources, and intelligence (i.e., ability to learn). Therefore, it is not surprising adult body mass correlates with $t_{max}$, but only slightly better than chance. Other interesting longevity predictors have included brain size and metabolism rate, but these too remain controversial among biologists.

According to Finch (2009, p.308):

Natural selection acts upon life expectancy through the reproduction schedule, and by implication on the schedule of aging. In essence, the lifespan and pattern of aging is under natural selection for a sufficient proportion of the population to survive just long enough with sufficiently slow somatic aging to propagate the next generation.

But even that has proved too simplistic. Schedules of aging appear to be highly malleable, and are clearly influenced by both genetic variation in species populations as well as induced mutations. Although fewer than 20 individuals worldwide have lived beyond 115 years of age, it has been suggested by some that if we could eliminate accelerated morbidity (i.e., late life disease), the median life expectancy of humans would approach 1,200 years (Finch, 2009).

One of the more interesting features of mammalian aging is that the phenotype is remarkably similar in most species (de Magalhaes, 2009):

Female reproductive senescence at mid-life, osteoporosis, arthritis, vascular lesions, cataracts, etc. are quite common among well-studied mammals. Despite
some exceptions, such as certain marsupials like Antechinus (pouched mouse),
the pathophysiology of aging is remarkably similar in mammals.

Despite 30 years of serious research on aging, few notable advances regarding our understanding
of the human aging processes have occurred. Why do humans live as long as we do? Why and
how do some species age negligibly? How is it that the ocean quahog clam can live over 400
years, cancer-free, while retaining its muscle strength and an intact nervous system?

These are vitally important questions that warrant the focus of the scientific community and full
funding support.

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