

The ultimate cause of aging

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Don't get too excited. I'm using the term "ultimate" here in the sense of "evolutionary":

http://en.wikipedia.org/wiki/Proximate_and_ultimate_causation

The terms "ultimate" and "proximate" causation have been enthusiastically adopted by scientists who study human and animal behavior/psychology. But these terms were originally coined by Ernst Mayr and meant to be applied to evolutionary biology as a whole.

"The basic reason why survival and reproduction decline with age is that selection acts more weakly on later ages. Imagine an organism that does not senesce, that is, that maintains itself with the same rate of survival and reproduction indefinitely. It will still suffer accidental mortality and so, on average, reproducing early will produce more offspring than deferring reproduction until later; death might strike first. Therefore, natural selection acts more strongly on variations that act early in life and acts more and more weakly on late-acting acting variations (see Box 20.2). If, as a result, senescence starts to evolve, then there will be a feedback, so that selection on later ages becomes even weaker. In the extreme case, where an organism such as a salmon reproduces only once, there is absolutely no selection on subsequent survival."

Nicholas Barton et al, *_Evolution_*, p. 562

As an example, suppose our physiologically immortal animal is called the shmoo, and it has a death rate of 10% per year due to environmental causes such as predation, lack of food or water, parasites, diseases, heat, cold, floods, severe snowstorms, or accidents such as falling into swiftly moving rivers or from cliffs. That means that the average shmoo has only a 35% chance of living past the age of 10, and a 12% chance of living past 20. Suppose further that once a shmoo reaches maturity at the age of 5, it reproduces each year with undiminished vigor until it dies.

Now suppose the shmoo gets a mutation called the "death bomb" which is dormant until the age of 25, then gets expressed and kills the unlucky bearer within a matter of days. The evolutionary theory of aging

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predicts that there will be little negative selection against the death bomb gene because if a shmoo reaches the age of 25, which in itself is rather unlikely, it has already reproduced numerous times. The death bomb has little effect on the shmoo's fitness, hence is effectively a neutral mutation. However, it can become fixed in the shmoo population through genetic drift.

Importantly, another consequence of the evolutionary theory of aging is the following:

"Based on this evolutionary explanation of aging, we predict that in organisms with a low rate of accidental mortality, senescence should be less severe. This is consistent with the relatively long life of birds, bats and turtles, who suffer less predation because they can fly or have thick shells. Across species of birds and mammals, the rate of senescence is indeed correlated with baseline mortality (Fig. 20.12).

Nicholas Barton et al, *Evolution*, p. 562

Fig 20.12 is a log-log scatter plot of the rate of senescence plotted against baseline mortality for many different wild birds, zoo birds, and mammals. It indeed shows a fairly tight correlation between rate of senescence and accidental mortality rate.

How does this theory explain why a dog at the age of 10 experiences many of the same symptoms of old age as a human at 80 years — arthritis, cancer, blindness, extreme fatigue, etc.

Well, dogs are descended from wolves, and wolves tend to live in pretty harsh environments. Not only that, but they have to fear being attacked and possibly killed by other members of the pack in the struggle for dominance. Therefore, probably not many wolves even reach the age of ten. The domestic dog has apparently inherited the aging history of the wolf.

Interestingly, tens of thousands of years of human dog breeding, both accidental and deliberate, has done little to improve the longevity of the domestic dog. In fact, some breeds have shortened life spans due to inbreeding and possessing oddball physical traits that humans like.

My guess is that dog longevity hasn't increased much despite the rather cushy life styles dogs have by being with humans because humans have fairly tight control over dog reproduction, and they don't often allow aged dogs to breed. Again, there is no strong selection for genes that increase canine longevity.

But how do you explain the fact that the dog seems to age 8 times faster than the human if aging is simply parts wearing out? Do the dog's "parts" wear out 8 times faster than the human's? Why? Aren't the dog's "parts" pretty much the same as the human's? The same proteins, cells, organs, and so on?

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Here is where the "ultimate" explanation of aging is lacking. In order to answer these questions we have to go into the "proximate" explanations of aging involving physiology, biochemistry, cell biology, molecular biology, and so forth. There are dozens if not hundreds of proximate aging processes involved, many of which still await discovery.

However, I think it is quite encouraging that such an eightfold difference in aging rate between dogs and humans can exist. That shows what we can potentially accomplish in slowing aging once we gain control over the proximate mechanisms involved. Also, consider the fact that some tortoises can live 200 years and bristle cone pines can live 5000 years. There seems to be plenty of "headroom" in increasing our own longevity. If natural selection can control plant and animal life spans over such enormous ranges, then so can we once we develop the appropriate technology.

Finally, I don't think that the evolutionary theory of aging explains human life span very well. Throughout the hundred thousand year history of modern humans there have been people who have lived into their 80's and 90's despite the fact that the great majority of people throughout the millions of years of evolution from hominid to human seldom lived much past the age of 30. It seems to be too great a disparity to be explained by this theory.

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