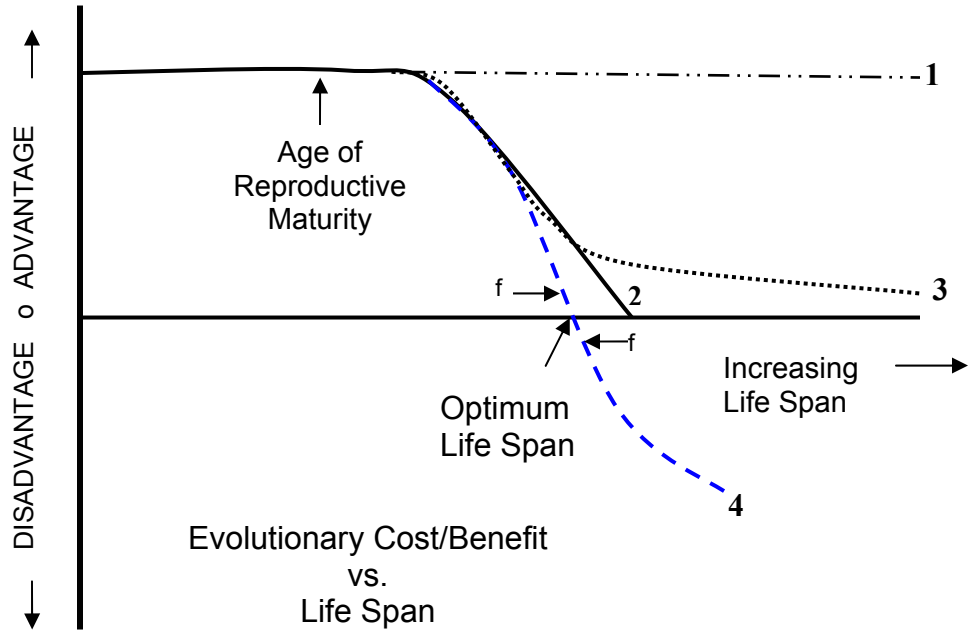
Evolutionary Value of Life

The evolutionary benefit or cost of a particular organism life span is central to theories of biological aging.

The sketch below illustrates four different scientific concepts regarding the evolutionary value of life as related to age of reproductive maturity. The benefit or cost is a measure of evolutionary force toward adapting changes in the design of an organism.

Everybody agrees that it is beneficial for an organism to live long enough to reach reproductive maturity and that degradation due to aging prior to that point would represent an evolutionary disadvantage. Further, as illustrated, life span beyond the minimum required for reproduction would be useful for organisms (e.g. mammals) that need additional time to protect, nurture, or train their young. Other characteristics of specific species could affect details of the evolutionary benefit of life and therefore the shape and length of the curves below.

There is wide agreement that life span is an evolved characteristic, that is, it is primarily determined by the evolution process rather than some fundamental limitation. There is also agreement that, like most evolved characteristics, the design of an organism in regard to life span life is somewhat determined by external conditions such as predators, food supply, habitat, and environmental conditions.



The scientific disagreements concern the later (older) portions of the curves during which aging occurs.

Darwin, (interrupted horizontal line 1), did not suggest that the evolutionary value of survival varied with organism age. Any incremental increase in life span added to an organism's opportunity for reproduction and therefore created evolutionary benefit that continued indefinitely. The force of evolution was therefore toward development of immortality. It was immediately noticed by Darwin's critics that most animals were not in fact immortal and that life spans varied greatly between otherwise similar animals. Further, some species died immediately after reproducing for the first (and only) time. These observed conflicts with Darwin's idea eventually led to development of the other three concepts.

Peter Medawar (solid line 2) proposed in1952 that the evolutionary benefit of additional life span in mammals becomes so negligible as to have no evolutionary effect at some species-specific age linked to reproductive maturity. Genetic drift could then introduce random changes that cause aging as long as their negative effects only occurred subsequent to that age. A yet longer life span has negligible evolutionary value but no disadvantage. His argument was that few wild animals live long enough for aging to become a problem and the few that do have relatively little effect on the evolution of a population. According to Medawar, a wild population of immortal animals would be very similar to a population of aging animals and would evolve in exactly the same way.

Many other proponents of non-programmed aging (e.g. G. Williams, T. Kirkwood) subsequently proposed (dotted line 3) that the evolutionary benefit of additional life span free of the deleterious effects of aging never declines to zero. A longer life would allow progressively more opportunity for reproduction and consequently at least some advantage in the propagation of an individual organism's design. Also, aging causes degradation at relatively young ages and this degradation has obvious negative effects on survival potential. These theorists therefore proposed that aging must be an unavoidable adverse side-effect rigidly linked to some beneficial design property. Because the evolutionary benefit of life declines once an organism has had some opportunity to reproduce, the ultimately catastrophic disadvantage of aging could be outweighed by a relatively smaller compensating advantage to younger animals. The assumed rigid linkage prevents the evolution process from producing a design that accomplishes the benefit without the adverse side-effect.

All of the above concepts are compatible with traditional evolutionary mechanics theory, which requires evolutionary benefits that increase the ability of *individual* organisms to *survive* or reproduce.

Finally, advocates of programmed aging (dashed line 4) contend that beyond some species-specific life span, also dependent on age of reproductive maturity, additional life span creates an evolutionary *disadvantage* and that therefore organisms evolved mechanisms for proactively regulating their life spans to achieve an *optimum* life span. In

this case there would be evolutionary force (f) to both achieve the species-specific optimum life span by means of myriad evolved survival characteristics and to avoid exceeding it by means of an evolved life span regulation mechanism. Because, unlike the other concepts, there is evolutionary force toward *limiting* life span, there is an evolutionary rationale for the development of a complex mechanism to accomplish the limiting function. In a manner similar to many evolved mechanisms, such a regulation mechanism could include means for detecting local or temporary external conditions and optimizing an individual's life span to fit those conditions. This concept provides a much better fit to experimental evidence than the others but is incompatible with traditional evolutionary mechanics theory and requires one of the more recent (post-1962) alternative evolutionary mechanics theories. Proponents suggest that various group, kin, or evolvability benefits outweigh the individual disadvantage of a purposely limited life span. Because Medawar's hypothesis suggests that the incremental benefit of extended life span is either negligible or small, the offsetting benefits could also be small. Opponents deny the possibility that any of the alternative evolutionary mechanics theories could be valid.

These issues remain unresolved today.

Important Note: All of the concepts discussed here assume that reproductive decline is a symptom of aging. A non-aging organism would have no decline in its reproductive capability with age. Some apparently **non-aging organisms** exist that indeed do not display either reproductive decline or decline of survival characteristics such as strength, mobility, or sensory acuity.

See **Aging Theories** for details of theories based on each of these benefit concepts as well as the underlying evolutionary mechanics theories and issues.