Aging and the Genetic Program

In order to understand the programmed (adaptive) aging vs. non-programmed (non-adaptive) aging controversy we need to examine in some detail what is meant by genetic programming.

Genetic Plans and Schedules

If we were building a house or other complex structure, we would need a *plan* and a *schedule*. The plan tells us which components go where: Perhaps there is a brick wall of certain dimensions in a particular location. The schedule tells the order or sequence in which the components are installed: We must install the supporting structure before installing the roof. We must install the roof before installing components that would be damaged by rain. Plans and schedules are limited in the amount of detail they contain. The plan may call for a brick wall of certain dimensions made of a particular type of brick but does not specify precisely how many bricks to use or the exact placement of individual bricks.

The development and growth of any complex organism involves the same sort of processes. Genetic data (the "program") in the organism specifies both the structures and mechanisms involved in the physical design of the organism and the order or sequence in which those structures develop or grow. As with the house plan, there is a limit to the detail possessed by **genetic instructions**. Example: All humans have an aorta and other major blood vessels. However, minor blood vessels are not individually genetically specified but grow on an as-needed basis according to some genetically specified rule.

Growth and Non-growth Events

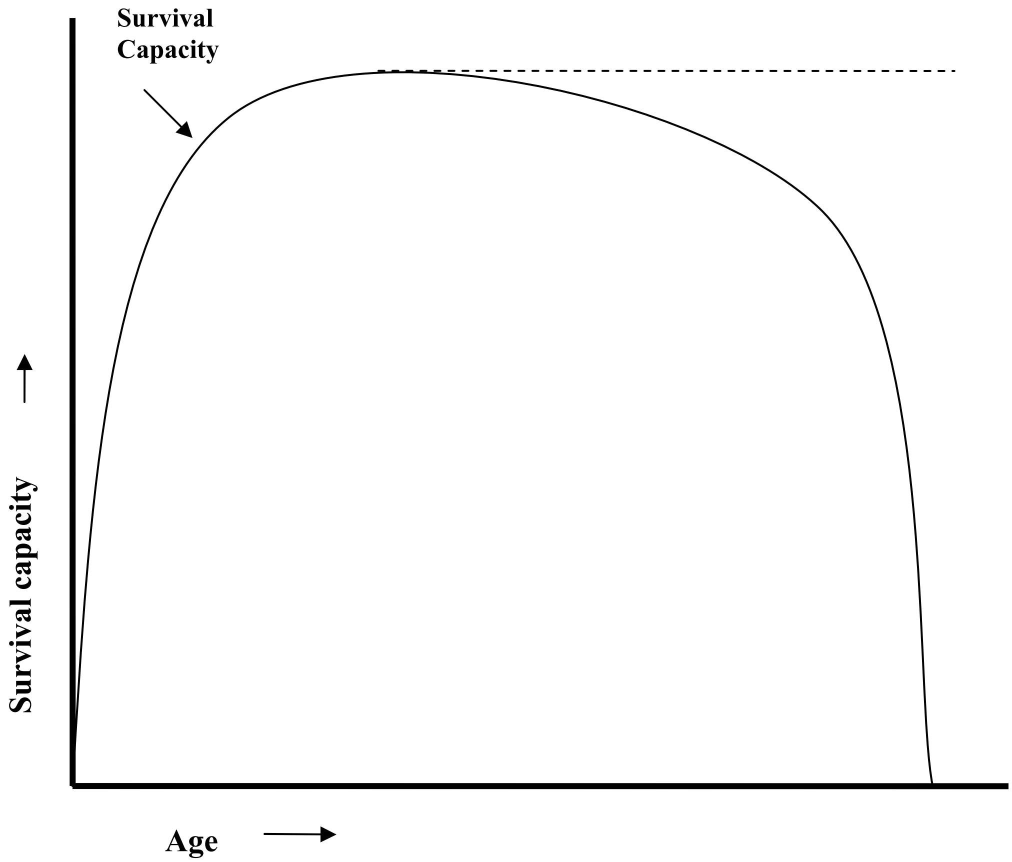
As with house construction, events in the growth of an organism are determined by the *internal* necessity to follow a logical order and sequence. Growth (development) is constrained by fundamental limitations such as the time required for cell division. The scheduling of the beginning of a task is determined by the completion of some prior task or tasks. Many events in the life of an animal are obviously determined by a necessity to fit into a logical growth process. However, some events are clearly not entirely determined by internal growth considerations but also by other considerations as described below.

Fitness, Development, and Age

Let's define survival capacity as the unaided ability to overcome adverse conditions, predators, difficulty in finding food and other circumstances surrounding wild animals. Suppose we wanted to draw a curve representing survival fitness as a function of age for a typical mammal such as a deer. The curve might look as shown below. This curve describes the animal's physical capability for survival from birth to physical maturity to extreme old age and death and is the composite of all of its physical survival traits such as strength, speed, mobility, and sensory acuity. Animal studies show that indeed survival probability declines from maturity onward in many animals. Although the shape and, of course, length of the curve is highly species dependent, we can agree that the curve starts and ends at zero. Human physical athletic capability follows a similar curve.

Theorists agree that the ascending portion of this curve (growth and development) is genetically programmed. The 64 billion dollar question is whether the descending portion is *also* purposely programmed. The default or prima facie conclusion is that both portions are determined in the same way. The main (some would say only) reason for believing otherwise is that purposely programmed decrease in fitness is contrary to traditional evolutionary mechanics theory. Note that programmed deterioration is common in nature. A frog's tail not only deteriorates but disappears completely. Everyone accepts that this is an instance of purposely programmed deterioration. The difference is that loss of the frog's tail could plausibly result in a net increase in fitness and thereby be compatible with traditional mechanics.

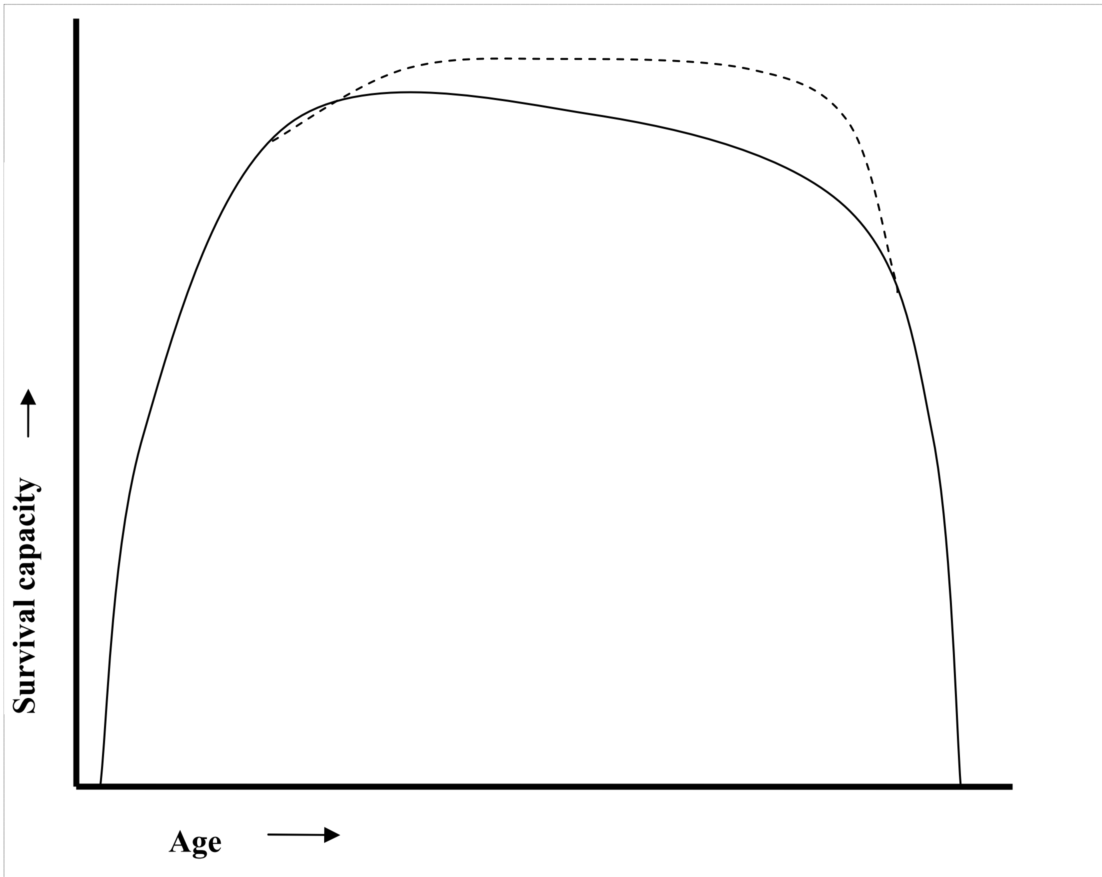
Concepts that ***are*** compatible with traditional mechanics include the following: Perhaps, the genetic program stops at maturity (dotted line) and the declining portion of the curve results from deteriorative processes acting against a design that is fixed subsequent to maturity. Perhaps the declining portion is the result of a tradeoff between some characteristic that improves survival potential (or reproductive capacity) during the early portion of the curve at the expense of the later portion. There are substantial arguments and empirical evidence against either of these explanations as described in the sections on **mutation accumulation** and **antagonistic pleiotropy**. For example, the existence of genetic diseases that only cause problems during late life suggests that genetic programming continues to change into late life.



Now let's add the effects of intelligence and immunity (dotted line below). These are inherited capabilities that have a progressively increasing beneficial effect with increasing age. A more intelligent animal has a greater survival capacity but only by acquiring non-genetic information (knowledge, skill, experience) that accumulates during its life. A *wiser* animal is more likely to survive. Wisdom is therefore the property that would be selected by natural selection rather than intelligence. Intelligence without experience has no fitness value. Wisdom could be described as the product of experience (acquired, increases with age) and inherited intelligence. This is the intelligence quotient (IQ) concept.

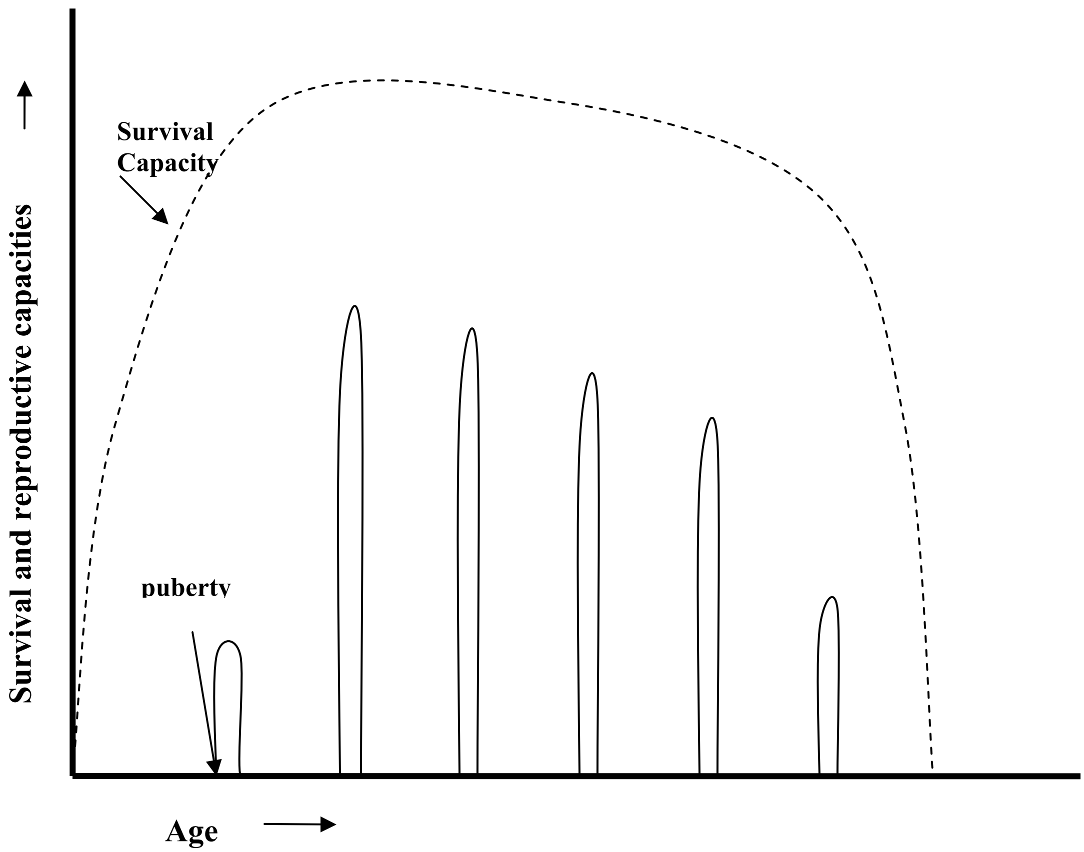
Immunity mechanisms also operate similarly by means of the progressive accumulation of pathogen exposure.

The shape of this curve depends on the extent to which intelligence and/or immunity are important to a particular species. In a non-aging species, the situation described here would tend to prevent evolution of intelligence and immunity because the non-genetic (acquired) component would be competing with the genetic component. An older and more experienced animal would be more fit than a younger, more intelligent animal. This suggests that a limited life span is essential to the evolution of intelligence and immunity and that more complex organisms therefore have a greater need for a limited life span (**Goldsmith**).



Reproductive capacity or ability to mate (solid lines below) is generally ***not*** an entirely developmental (growth) function but largely determined by other factors. The *minimum* age of sexual maturity is constrained by development of the necessary structures and systems. However, actual sexual maturity is typically delayed by a program that incorporates mating seasons of a species-specific length, which are positioned at a particular point in the planetary (seasonal) cycle, and which begin at a particular age.

The timing of the mating cycles therefore requires that the organism possess a facility for determining the planetary cycle, presumably incorporating a sense function, in addition to the capability for a species-unique clock or timing function. Since life spans are more correlated with actual sexual maturity than growth, these observations are a problem for theories that suppose a rigid relationship between growth/development and aging.



Non-Deteriorative Aging

The idea that the declining-fitness portion of an animal's life is not programmed conflicts with observations of physiological changes in later life that are not deteriorative or are obviously programmed. Examples: Male pattern baldness is obviously genetically programmed. *Increases* in ear-hair and other redistribution of tissue as a function of late life age are not deteriorative.

Reproductive version of Weismann's hypothesis

Weismann's hypothesis suggests that there is **evolvability** benefit in purposely limited life span because freeing resources for younger and therefore incrementally more evolved individuals enhances the evolution process. An extension of this idea suggests that there would also be evolvability benefit to a behavior in which animals prefer mating with relatively younger mates. Such a behavior would require that an animal be able to determine the relative age of a prospective mate, which in turn would require external visual or other sensory cues from which age could be determined. This is a possible explanation for programmed physiological changes in external appearance that extend throughout human life span.