

# **Biological Immortality is Real**

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# Some species age slowly, some very quickly



FIGURE 7.1F Bristlecone Pine



FIGURE 7.1C Field of Soybeans

# The Longest Lived Human



- Madame Jeanne Calment lived 122 years, dying in 1997.
- She sold paintbrushes to Vincent Van Gogh in her home town of Arles, France.

# What if we were to stop Human Aging?

- Life expectancy now (US): pushing 80 years
- Life expectancy without aging: 1,200 to 2,000 years based on the survival rate at age 12



# Is Aging “Rust”?

- Since Aristotle, most biologists have agreed that aging is due to physiological breakdown, akin to rust, as in Harman’s free-radical theory of aging



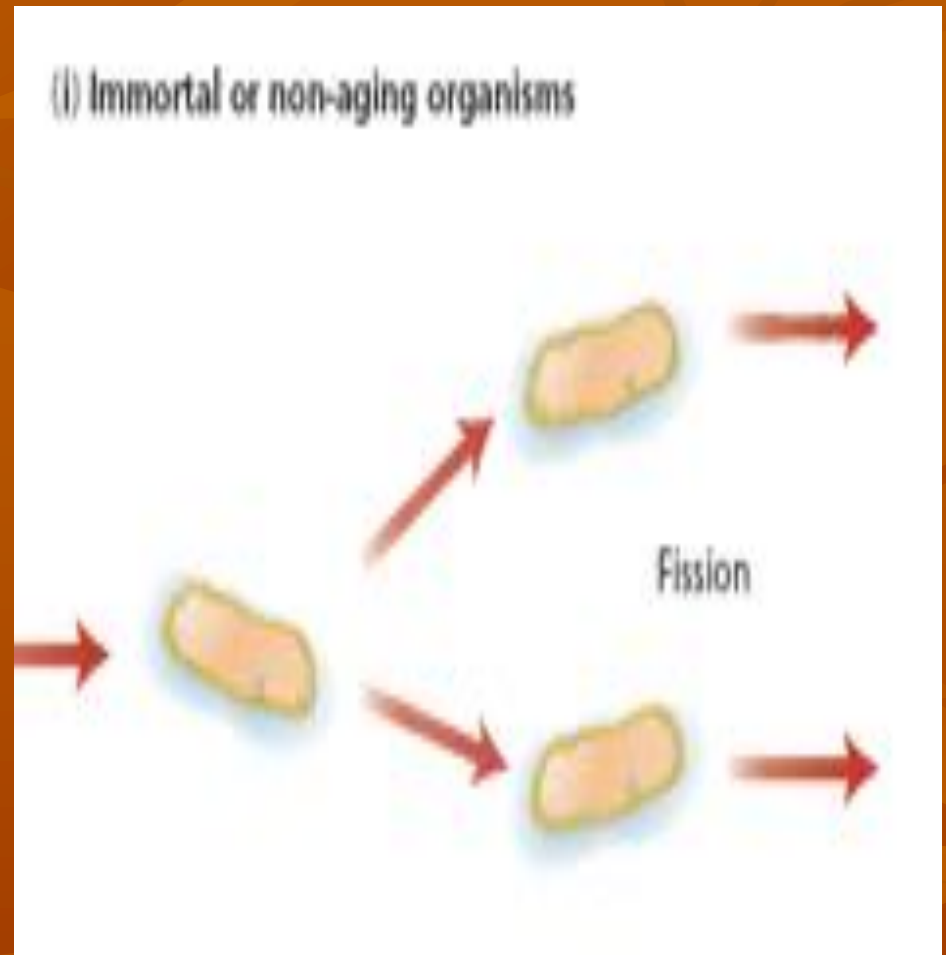
# Rust Theories are Refuted by Biologically Immortal Organisms

- This creosote bush has lived for 10,000 years.
- It grows in the Mojave Desert of California
- It started life as a small bush, and grew outwards



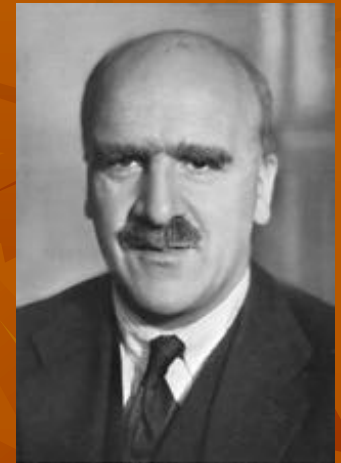
# Why some organisms don't age

- Aging should not evolve in *fissile* organisms because natural selection stays strong; it has to



# So, Aging is a Product of Evolution. But WHY?

- In 1941, JBS Haldane suggested that Huntington's Disease was common because natural selection is weak at later ages
- Huntington's Disease killed Woody Guthrie, the famous American folk-singer





# Here are some details about Huntington's Disease

- It starts to affect the brain of adults over 30
- Takes years to kill, breaking down coordination, IQ, personality, as it goes
- Due to a single bad copy of the huntingtin gene
- A common genetic disease



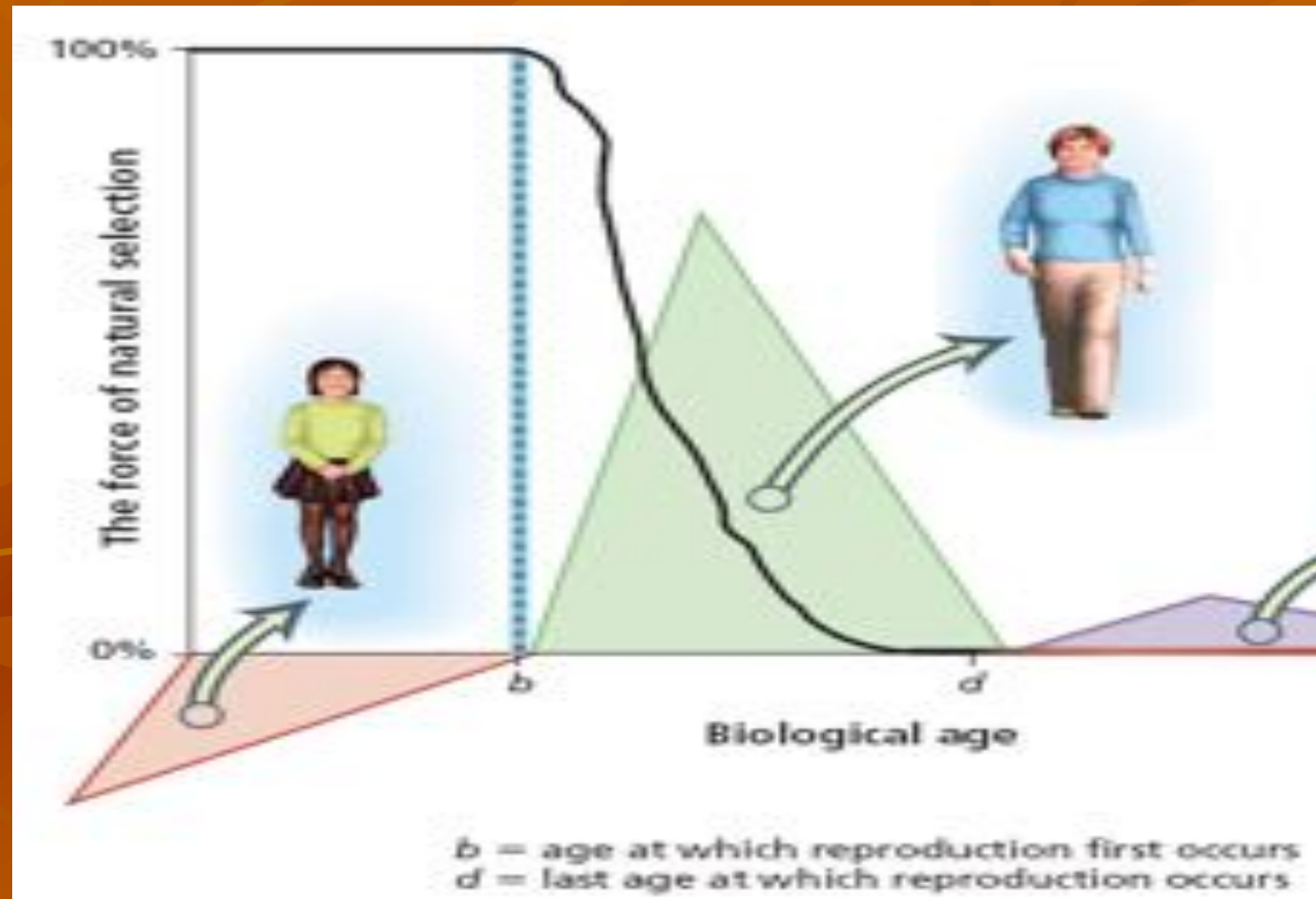
# Here is a case of an early acting lethal gene: Progeria

- The disease starts to affect young children (3-5 years old)
- Kills by 20
- Due to a single bad Lamin A gene
- Very rare disease, with just dozens of progerics alive
- NATURAL SELECTION keeps progeria rare

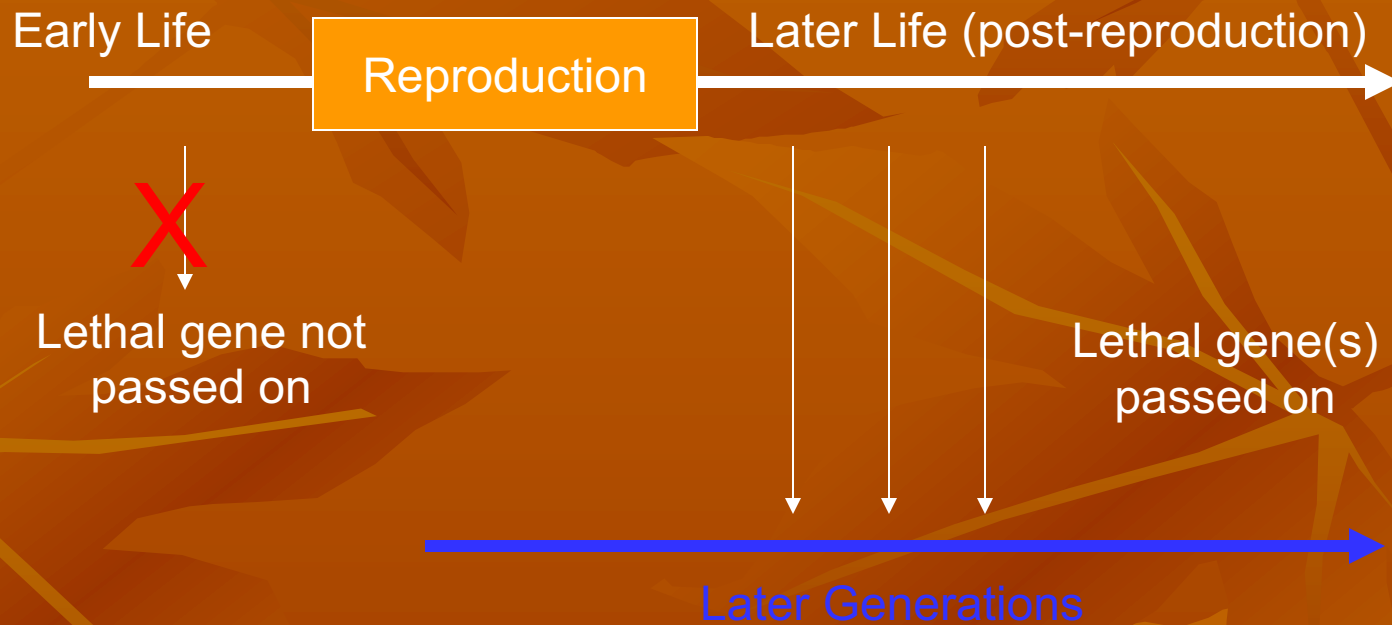


# Evolution of Aging because the Force of Natural Selection Falls

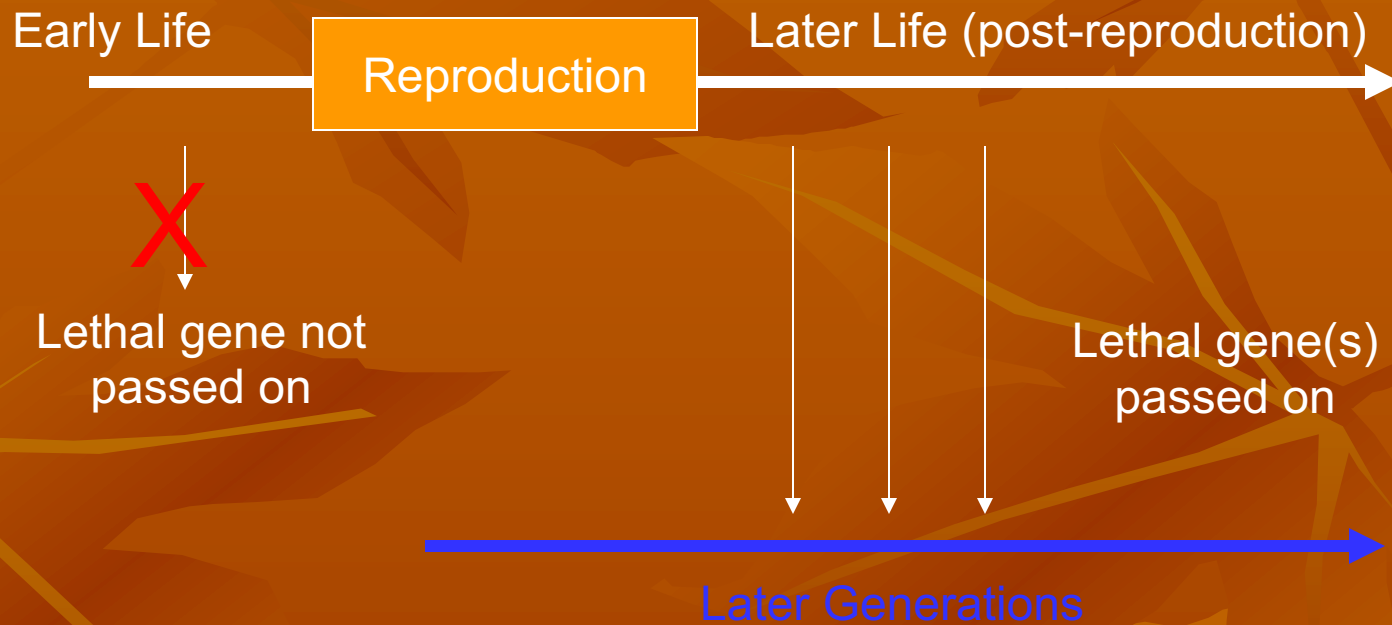
- The force of natural selection acting on survival falls with adult age



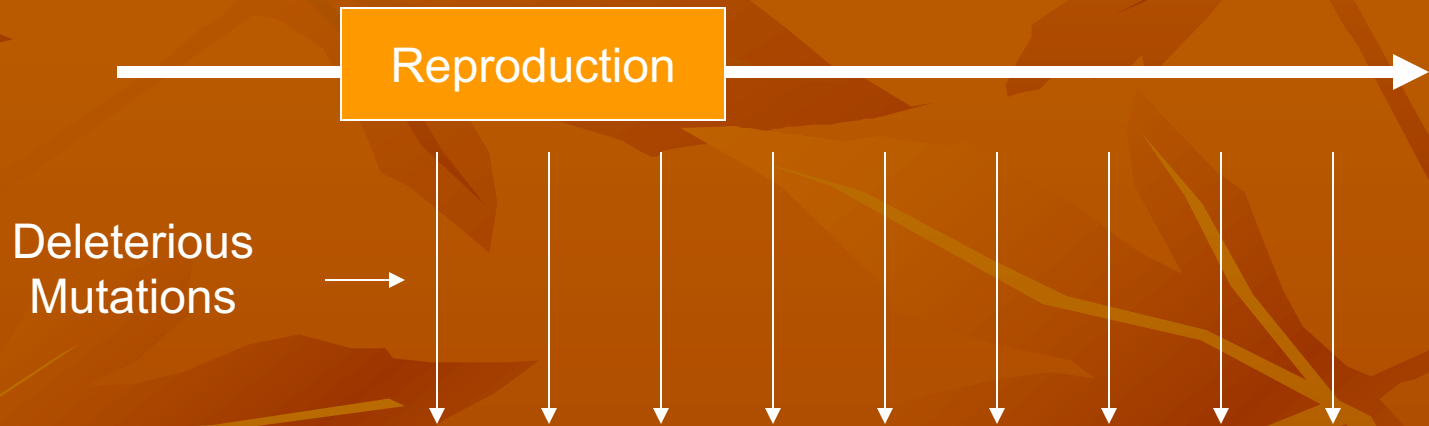
# Timing of Reproduction Controls the Evolution of Aging



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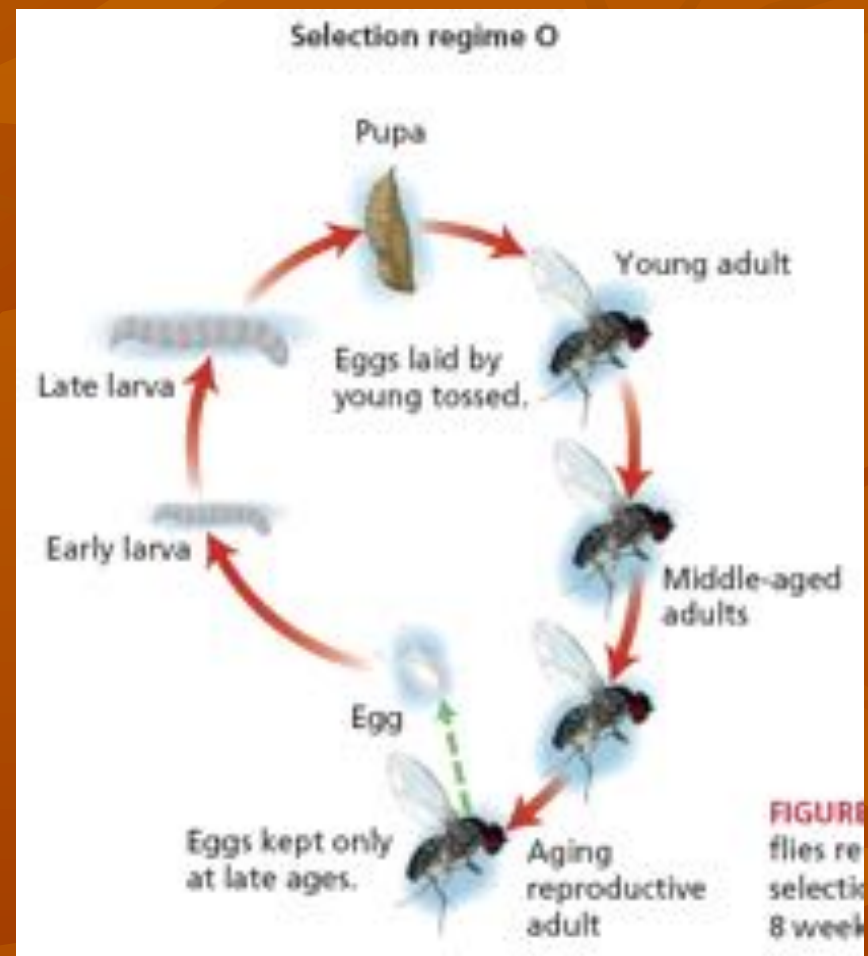
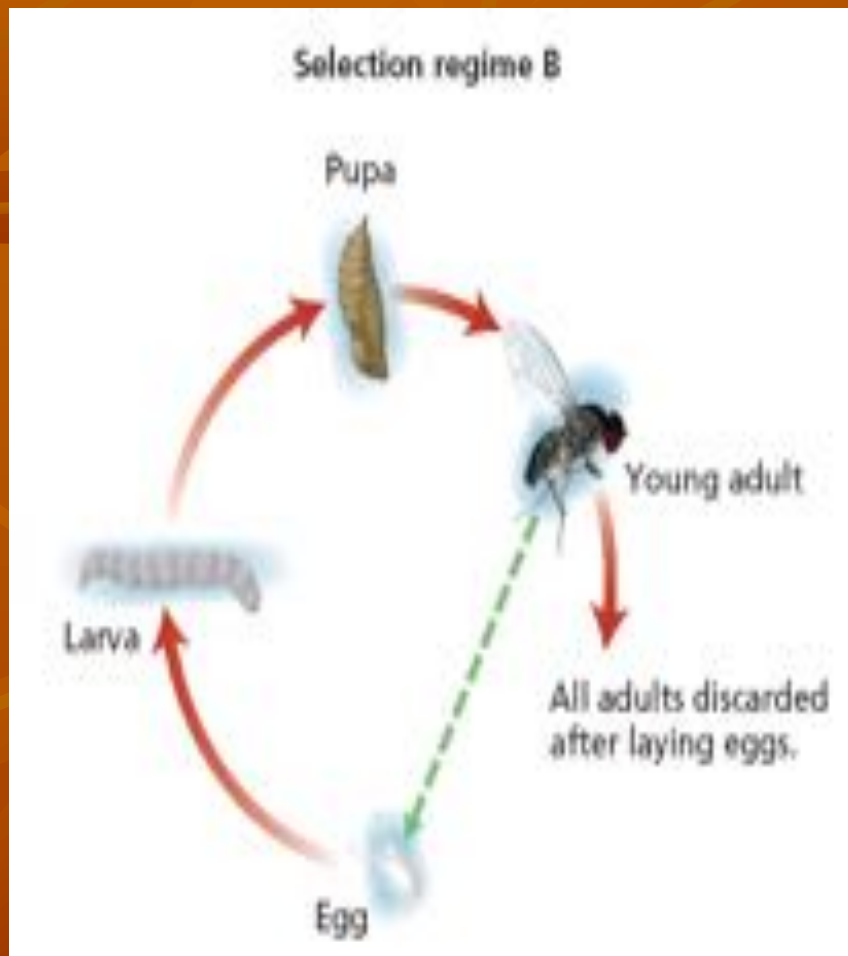


# Postponing Reproduction forces early acting deleterious genes out



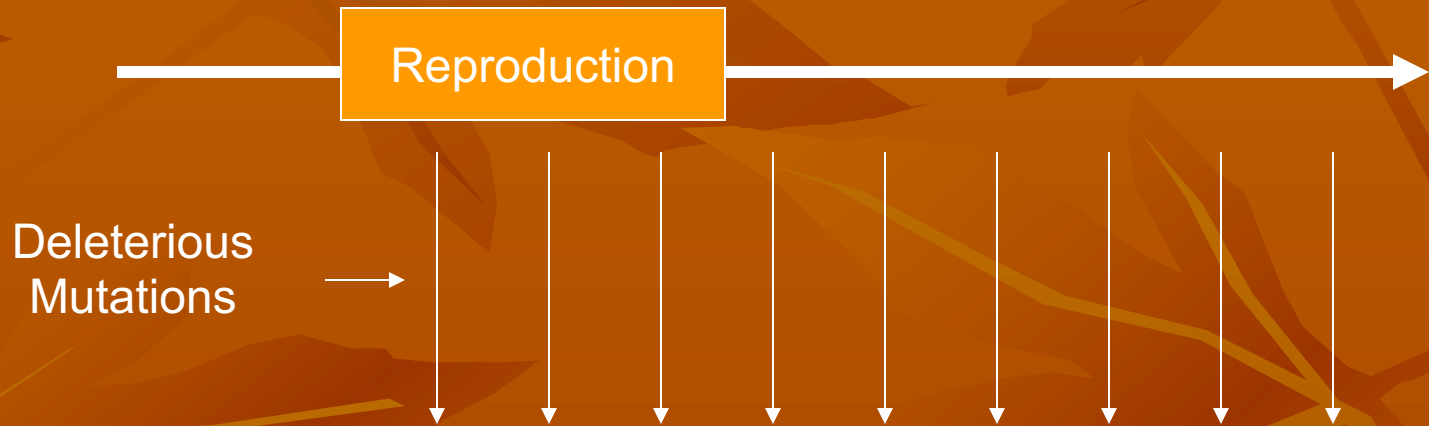
**= Longer, more robust lifespan**

# Changing the force of natural selection makes aging evolve rapidly



**FIGURE**  
flies re  
selectio  
8 week

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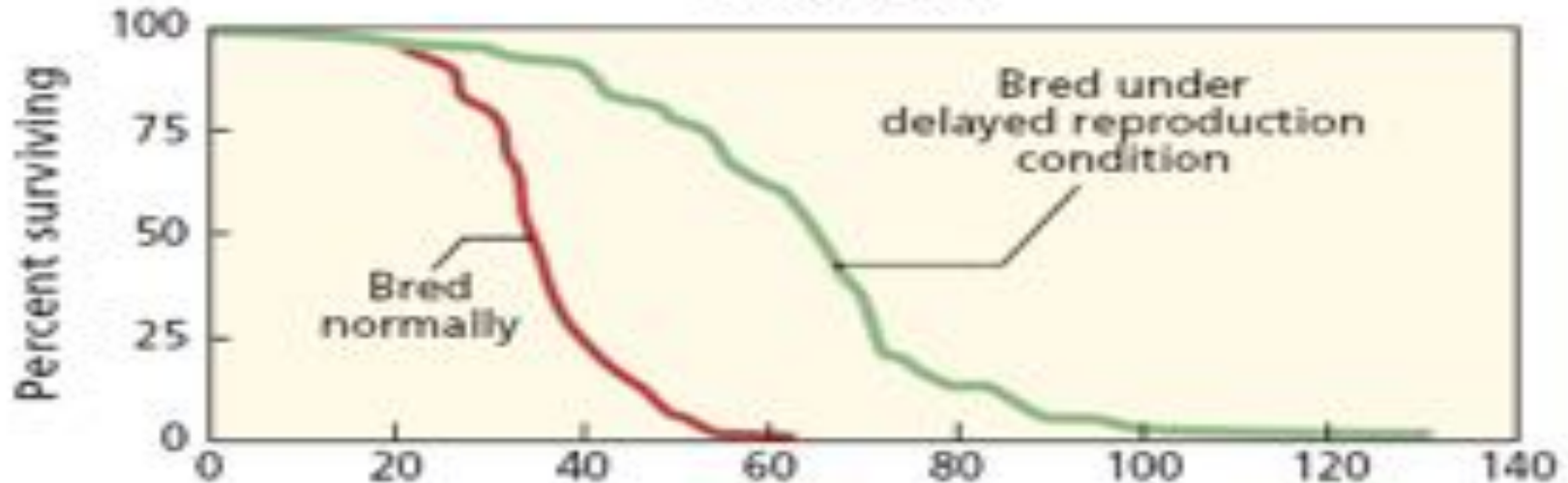


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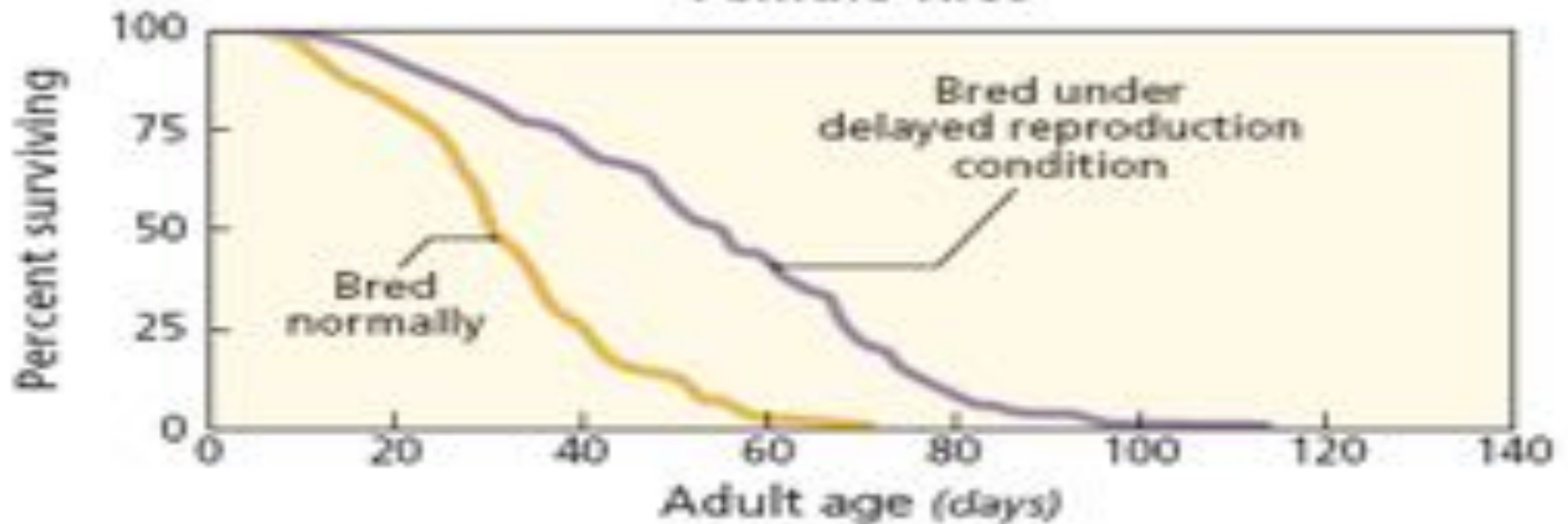


# After 80 generations of delayed breeding

## Male flies



## Female flies



# Extension of Hamilton's Original Work: Why do some live so long?

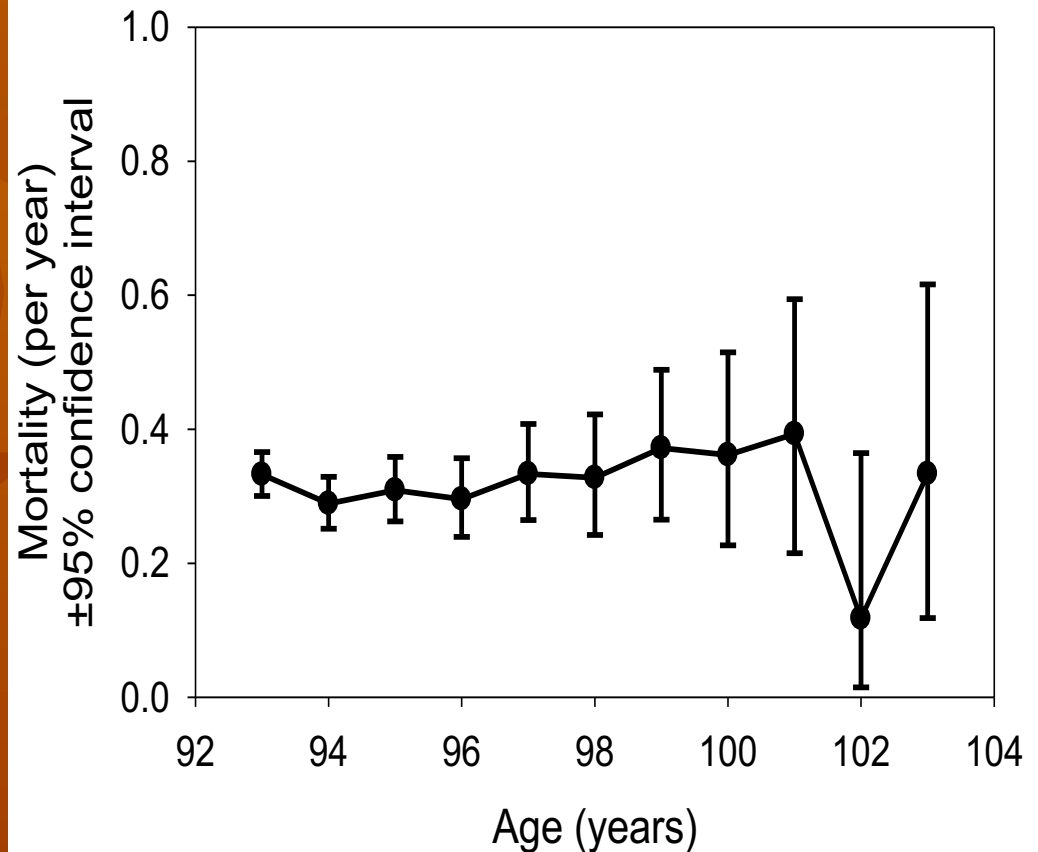
- If mortality increased with the same acceleration all our lives, almost no chance of living to 110, much less 122
- But our mortality rates don't continue to increase



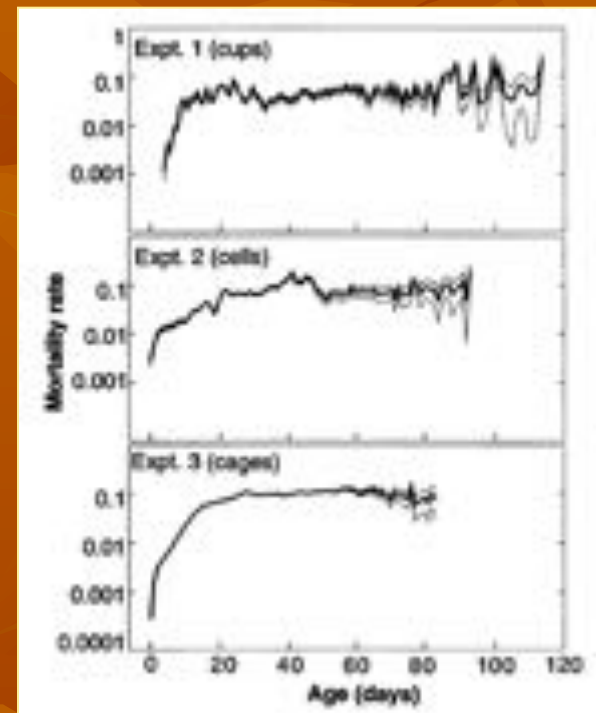
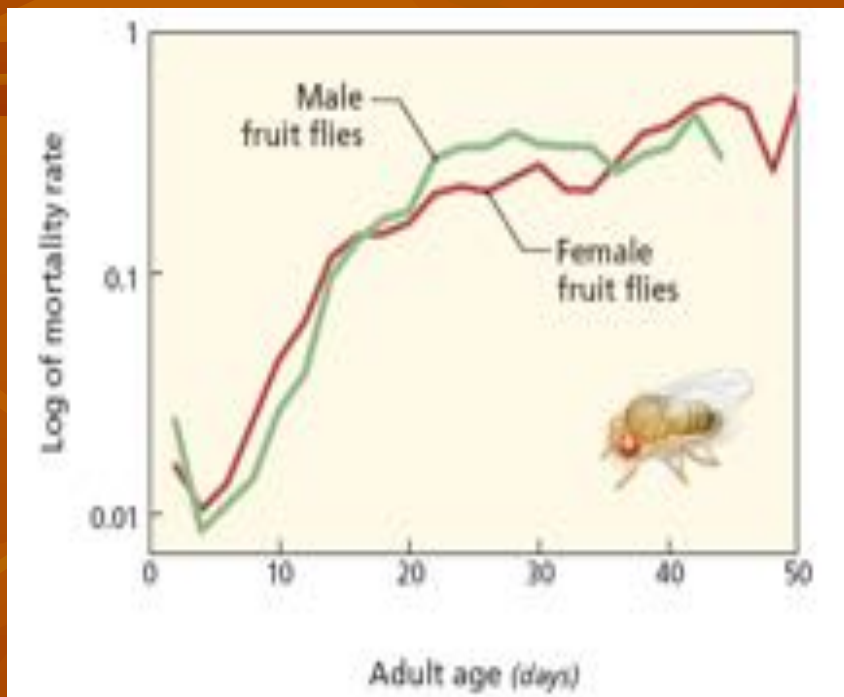
# Biological Immortality after 90 or so

Mortality rates of English women during the early 1900's.

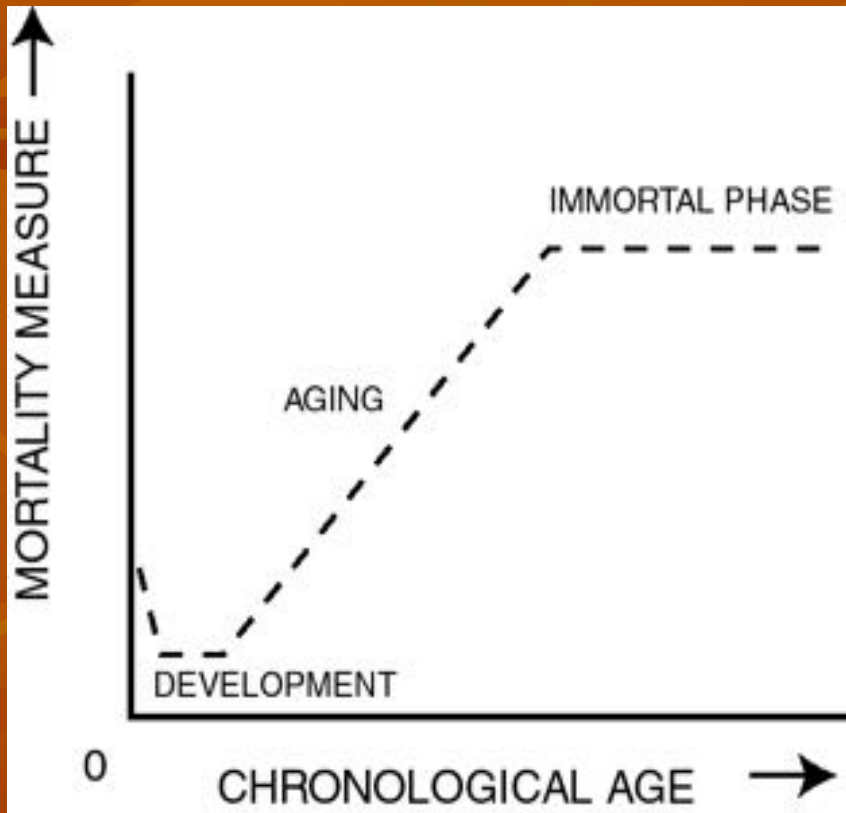
Graph from "Does Aging Stop?" by Mueller, Rauser, and Rose, Oxford Univ. Press, 2011.



# It turns out that aging stops often: Here we show some fly experiments



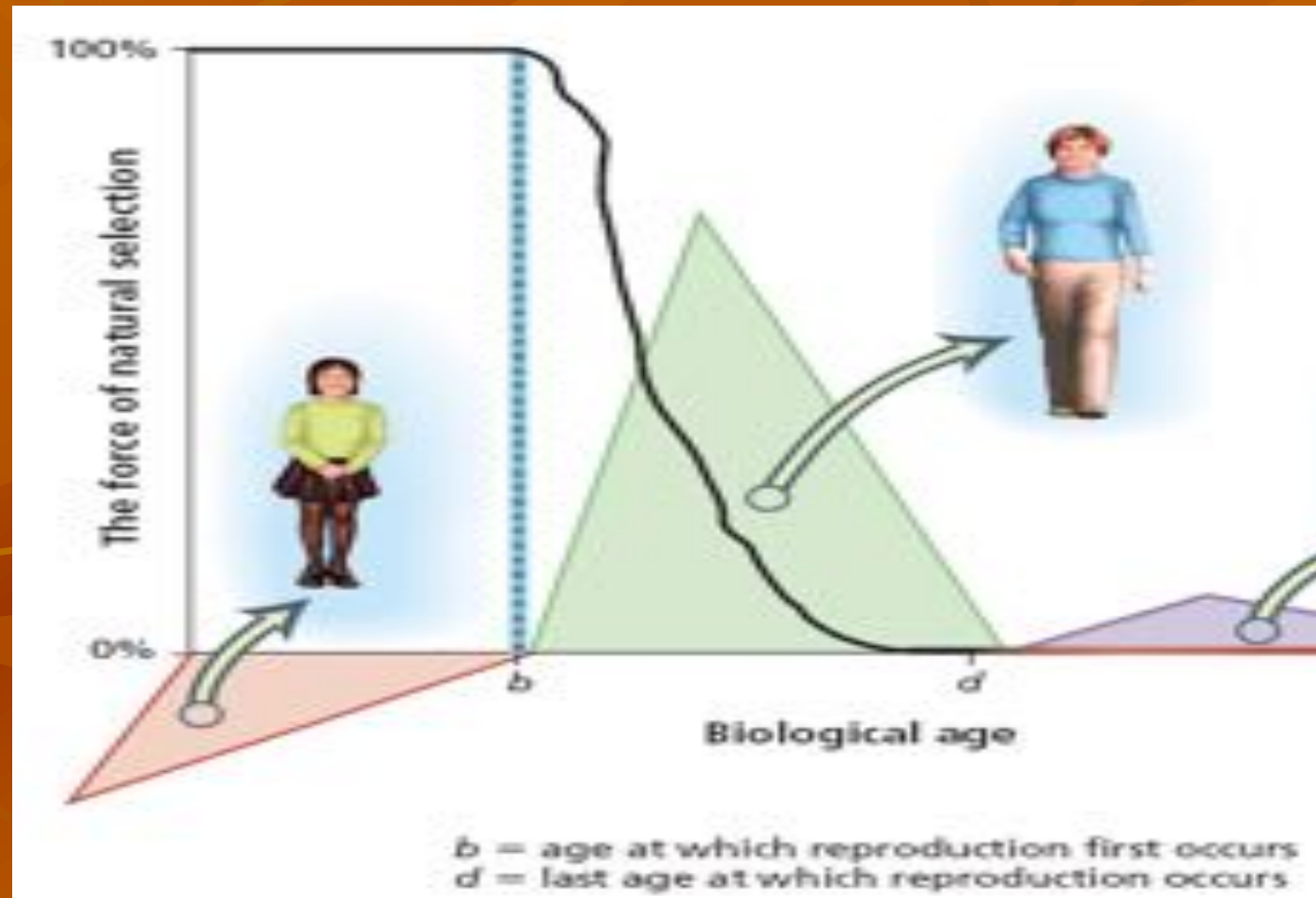
# Biological Immortality in Late Life



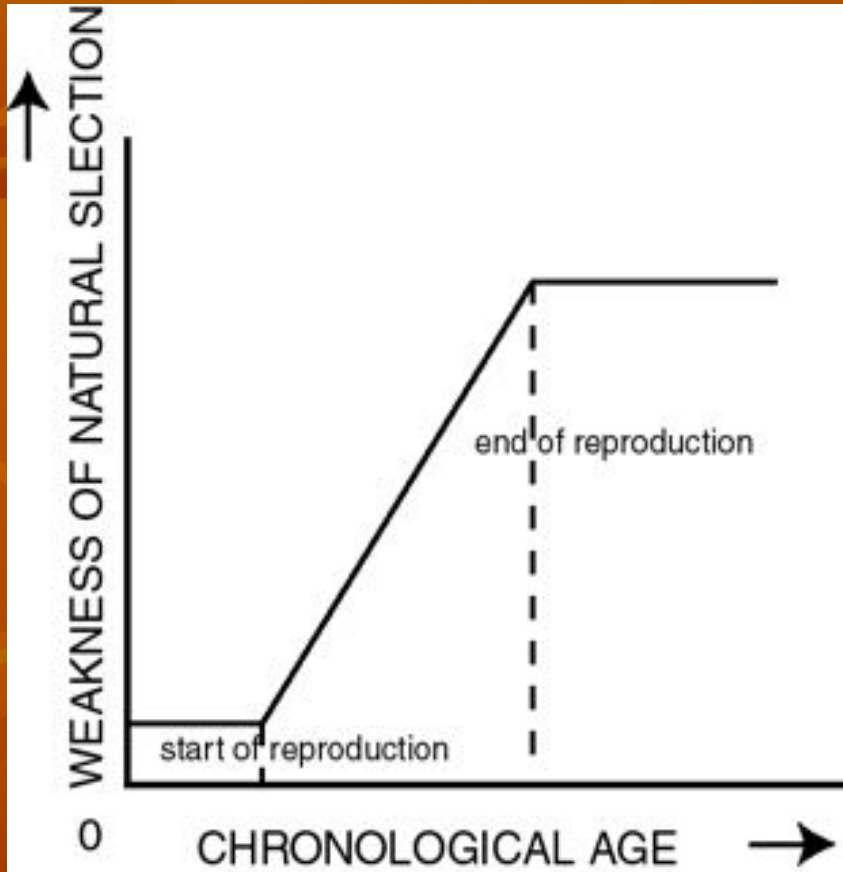
- In animals like us, life has three phases:
  - development;
  - aging; and
  - late life
- During late life, mortality stabilizes: aging stops

# What if we invert this diagram, to look at the “weakness” of selection?

- The force of natural selection acting on survival falls with adult age

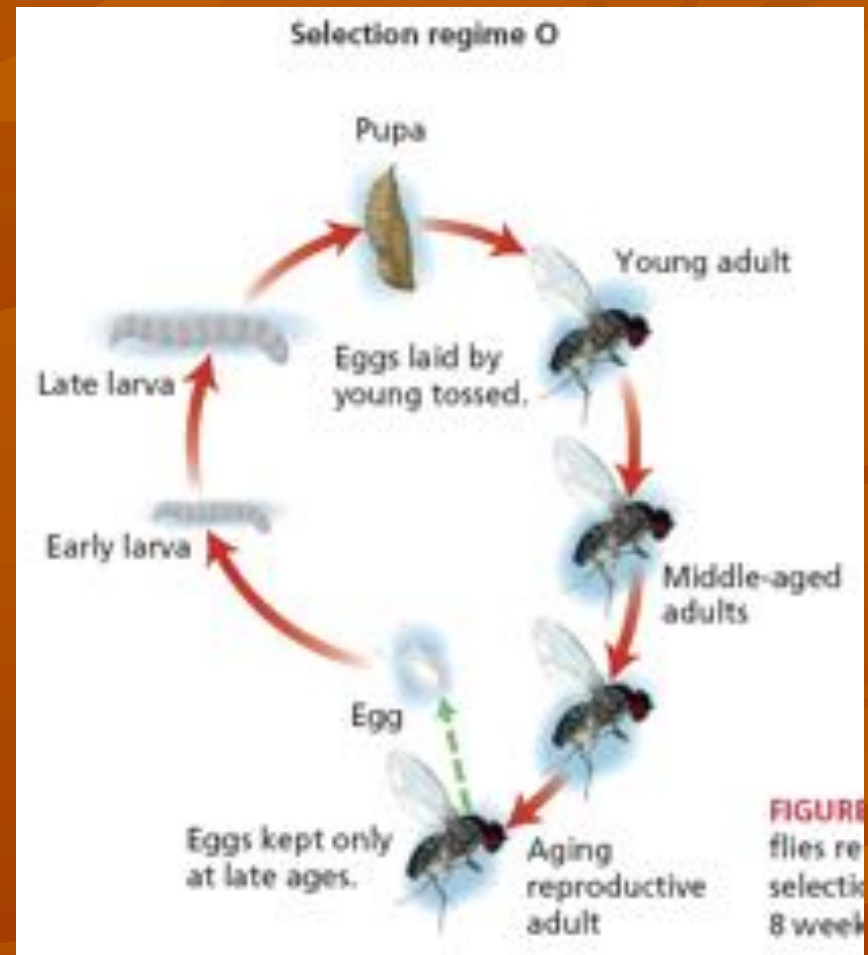
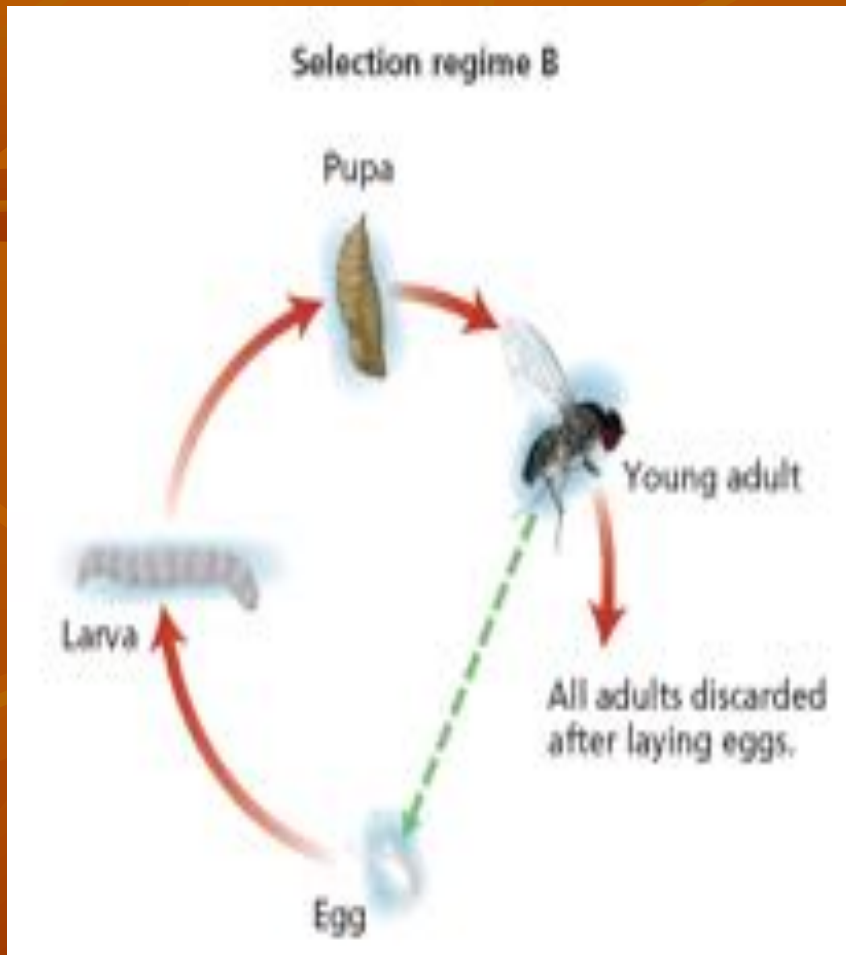


# Natural selection stops weakening late in life



- Mortality echoes the “weakness” of natural selection
- Late in life, force of natural selection plateaus

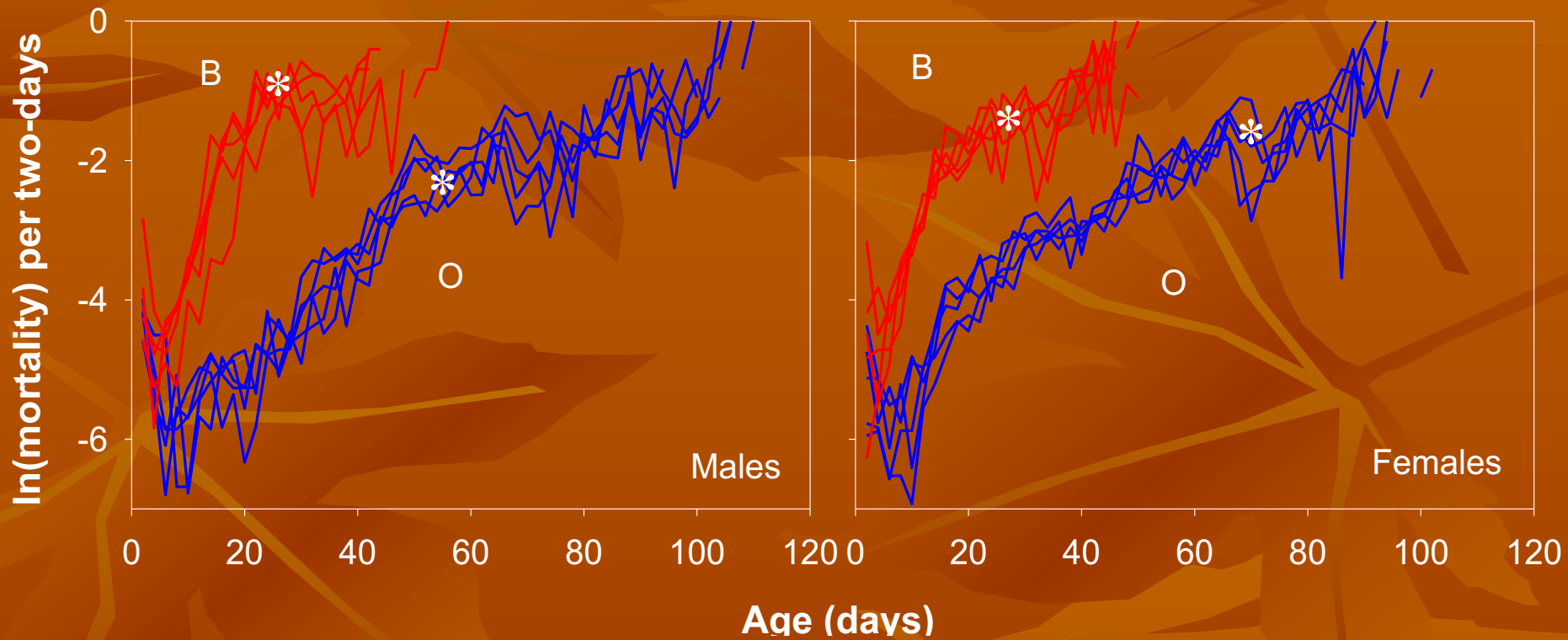
# Changing when selection stops should also change when aging stops – same as before



**FIGURE**  
flies re  
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# Late-life mortality-rate plateaus



# Conclusions

- Plenty of organisms have *biological immortality*, because selection can make it
- We know *why* aging happens: the declining force of natural selection with adult age
- Aging *stops* very late in life, because the force of natural selection stops declining:  
**we age toward biological immortality**