Darwinian Evolution

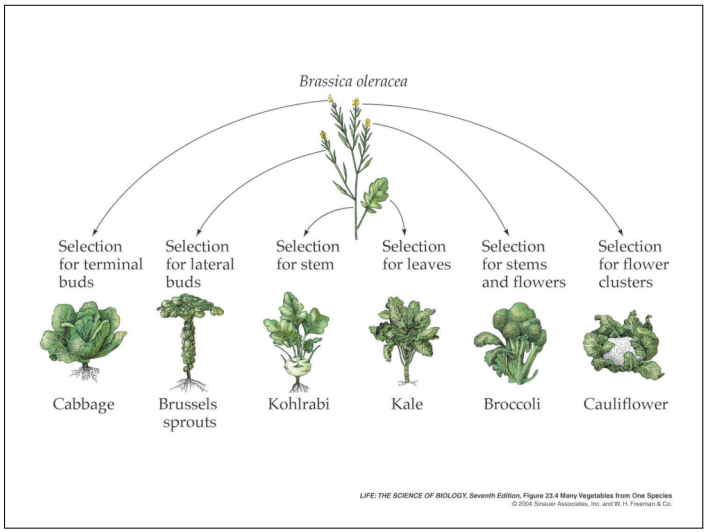
- Part 1 (today): A quick Introduction to biological evolution & Darwin's theory
- Part 2 (tomorrow): Broader implications for Complex Adaptive Systems

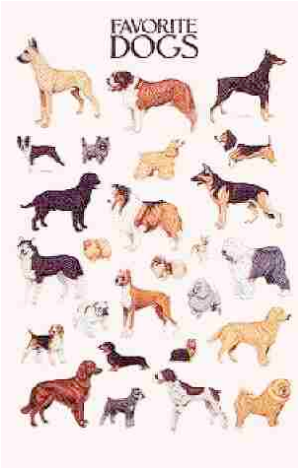
Evolution: Part I

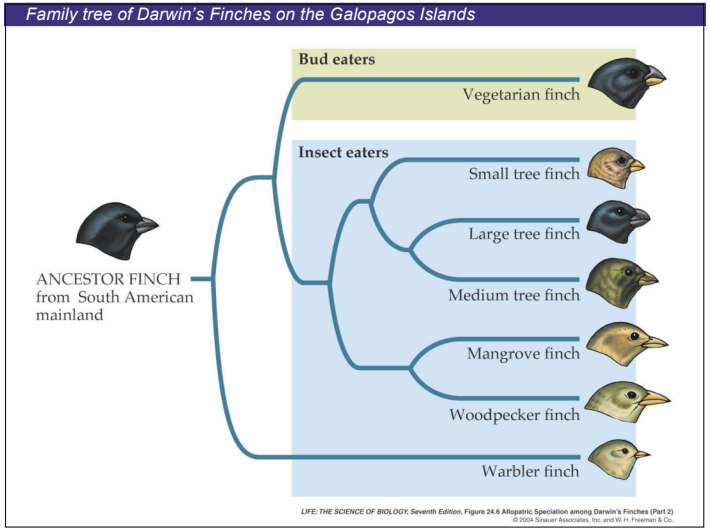
John Pepper

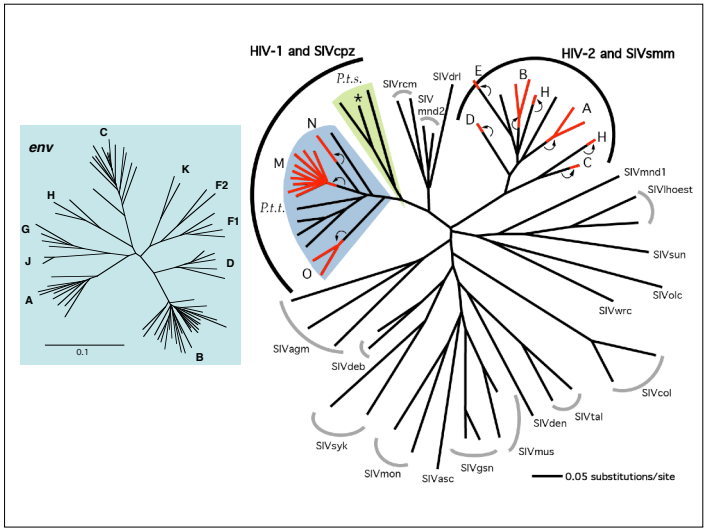
Artificial selection

- We can see that just by choosing which individuals will reproduce, humans have caused lots of change in domestic animals and crops.
- Darwin suggested the same can happen in nature by 'self-selection' when only some individuals have what it takes to survive, reproduce, and pass their traits on to the next generation


Brassica oleracea
Selection for terminal buds
Selection for lateral buds
Selection for stem
Selection for leaves
Selection for stems and flowers
Selection for flower clusters
Cabbage
Brussels sprouts
Kohlrabi
Kale
Broccoli
Cauliflower
LIFE: THE SCIENCE OF BIOLOGY, Seventh Edition, Figure 23.4 Many Vegetables from One Species


FAVORITE DOGS


Family tree of Darwin's Finches on the Galopagos Islands
Bud eaters
Vegetarian finch
Insect eaters
Small tree finch
Large tree finch
Medium tree finch
Mangrove finch
Woodpecker finch
Warbler finch
ANCESTOR FINCH from South American mainland
LIFE: THE SCIENCE OF BIOLOGY, Seventh Edition, Figure 24.6 Allopatric Speciation among Darwin's Finches (Part 2)


HIV-1 and SIVcpz
HIV-2 and SIVsmm
env
P.t.s.
P.t.t.
SIVrcm
SIVdrl
SIV mnd2
SIVmnd1
SIVlhoest
SIVsun
SIVolc
SIVwrc
SIVagm
SIVdeb
SIVcol
SIVden
SIVtal
SIVmus
SIVgsn
SIVasc
SIVmon
SIVsyk
0.1
0.05 substitutions/site

Darwin's observations

- Like begets like (heritability)
- Descent with modification (offspring can be different from parents)
- Because of their differences, some individuals are more successful than others at reproducing, and thus passing their traits to the next generation

Darwin's claims (1):

- The long-term result of these observed processes is that after a vast number of generations, the only traits present in a population will be those that increase the likelihood of an individual surviving, reproducing, and thereby passing its traits on to the next generation.

Darwin's claims (2):

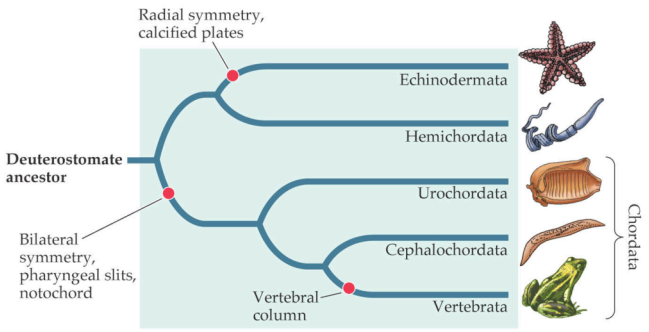
- If different populations evolve adaptations to different environments, they will become increasingly dissimilar
- This creates new species, and biological diversity

Key consequences

The key consequences of evolution by natural selection are:

- Phylogenies – family trees linking living things though their common ancestors.
- Adaptation and functionality (with certain characteristic limitations)

Figure 34.2 *A Current Phylogeny of the Deuterostomes*



LIFE: THE SCIENCE OF BIOLOGY, Seventh Edition, Figure 34.2 A Current Phylogeny of the Deuterostomes

A new way of thinking about origins of functionality:

- Darwinian adaptation is highly non-intuitive, and it challenged widely held assumptions…

A new way of thinking about functionality:

- Darwinian adaptation is highly non-intuitive, and challenged widely held assumptions…

The reaction:

It does seem just obvious, doesn't it, that there *couldn't be* any such designs without designers, any such creations without a creator! The vertigo and revulsion this prospect provokes in many was perfectly expressed in an early attack on Darwin, published in 1868:

- Daniel Dennett

The reaction (2):

It does seem just obvious, doesn't it, that there *couldn't be* any such designs without designers, any such creations without a creator! The vertigo and revulsion this prospect provokes in many was perfectly expressed in an early attack on Darwin, published in 1868:

- Daniel Dennett

The reaction (3):

"In the theory with which we have to deal, Absolute Ignorance is the **artificer**; so that we may enunciate as the fundamental principle of the whole system, that, IN ORDER TO MAKE A PERFECT AND BEAUTIFUL MACHINE, IT IS NOT REQUISITE TO KNOW HOW TO MAKE IT. This proposition will be found, on careful examination, to express, in condensed form, the essential purport of the Theory, and to express in a few words all Mr. Darwin's meaning; who, by a strange inversion of reasoning, seems to think Absolute Ignorance fully qualified to take the place of Absolute Wisdom in all the achievements of creative skill." (MacKenzie, 1868)

A new way of thinking…

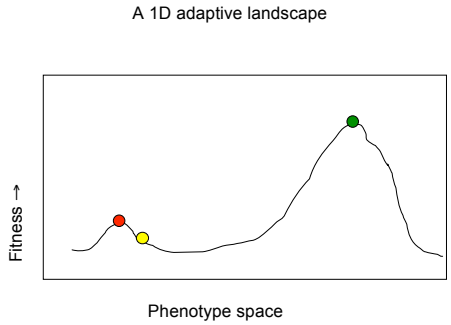
Exactly! Darwin's "strange inversion of reasoning" was in fact a new and wonderful way of thinking, completely overturning the mind-first way that even David Hume had been unable to cast aside, and replacing it with a bubble-up vision in which intelligence – the concentrated, forward-looking intelligence of an anthropomorphic agent--eventually emerges as just one of the products of mindless, mechanistic processes. These processes are fueled by untold billions of pointless, undesigned collisions, some vanishing small fraction of which fortuitously lead to tiny improvements in the lineages in which they occur.

- Daniel Dennett

Constraints on Darwinian adaptation:

- Conservatism and gradualism
- Accidents and path-dependence
- Trade-offs
- Slow speed, & novel environments
- Evolutionary conflicts (arms races)

Conservatism & gradualism



Conservatism & gradualism…

Can lead to “frozen accidents”:

- The persistent appendix
- The reversed retina