THEORY OF EVOLUTION

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"A century ago, in one of the greatest revolutions of human thought, Darwin demonstrated beyond reasonable doubt that man is a part of nature and kin to all life."

- Dobzhansky, 1959

Things to remember…

- What is evolutionary theory?
- Who was Darwin and how did his life experiences lead him to this idea?
- Speciation
- What did he get right?
- And what are scientists still arguing about?

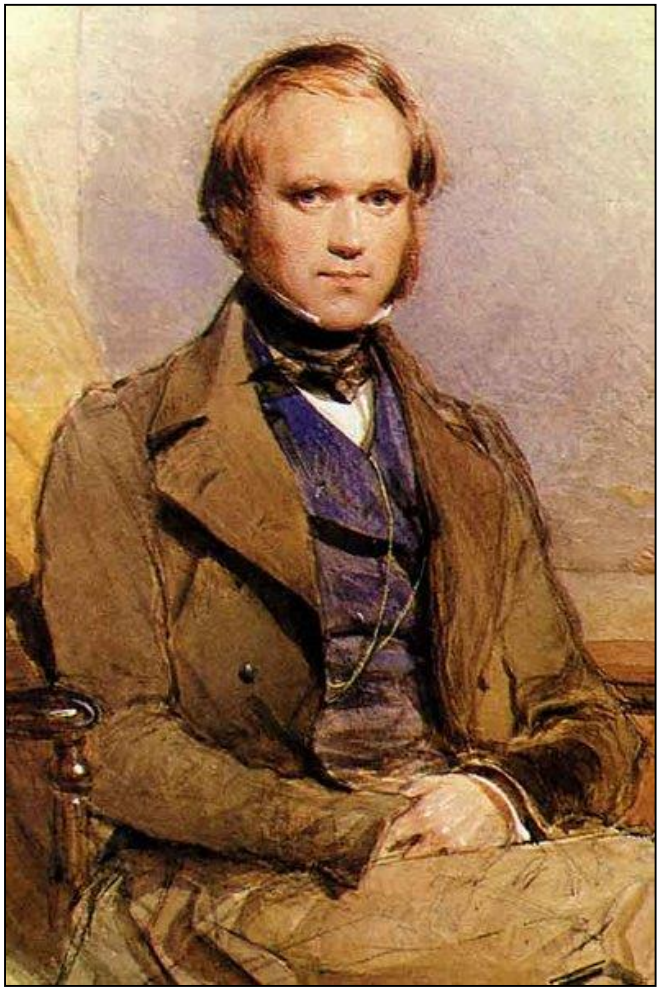
Reading material

- http://www.evolution.berkeley.edu/

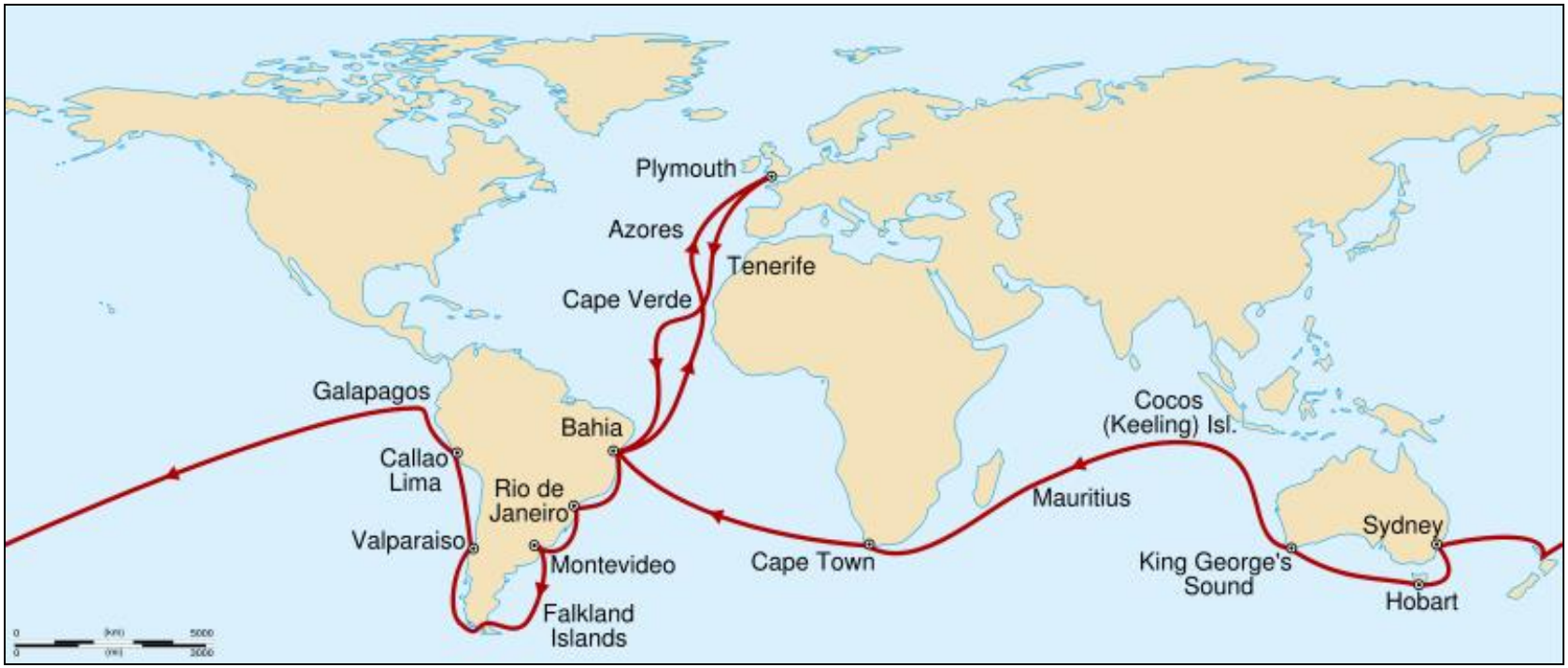
Charles Darwin (1809-1882)

- Arguably, one of the most important figures in human history.

- Through observation, he showed that life evolves by random genetic change that is then sorted out by natural selection independent of any outside guiding, intelligent force.



An epic voyage – H. M.S. Beagle



Galapagos Islands

Certhidea olivacea
Probing bill, insect eater
Feeds in trees

Camarhynchus pallidus
Probing bill, insect eater
Uses twig or cactus spine
to probe insects from cactus

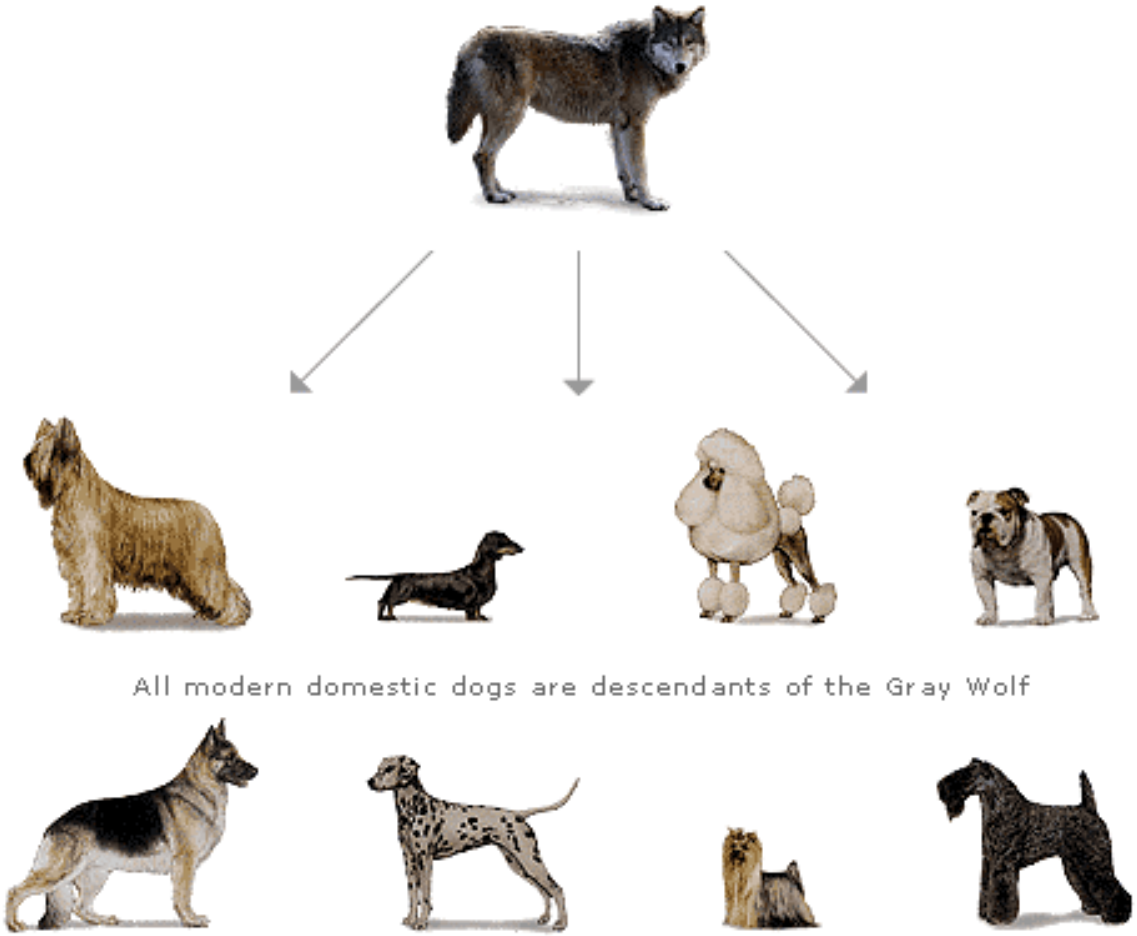
Camarhynchus heliobates
Grasping bill, insect eater
Feeds in trees

Camarhynchus crassirostris
Crushing bill, cactus seed eater

The slight differences between Galapagos finches and tortoises reminded him of pigeon breeding

Breeds “created” by breeders who *selected* and bred the most unusual pigeons to create ever more exotic varieties.

Dog Breeding



All modern domestic dogs are descendants of the Gray Wolf

Major influence on Darwin ~ Charles Lyell (1797-1875)

- *Principles of Geology* (1830)
- Principle of Uniformitarianism:
- Geological time: Geological features are the outcome of gradual processes over huge periods of time.

Major influence on Darwin ~ Thomas Malthus (1766-1834)

- *Essay on the Principle of Population* (1798)
- Population growth always threatens to overwhelm the available food supply.
- Concluded that <u>poverty, famine, war are good!</u> Some ills of humanity should not be eradicated.

Darwin's Synthesis - I

- Organisms produce far more offspring than can survive (From Malthus)

Darwin's Synthesis - II

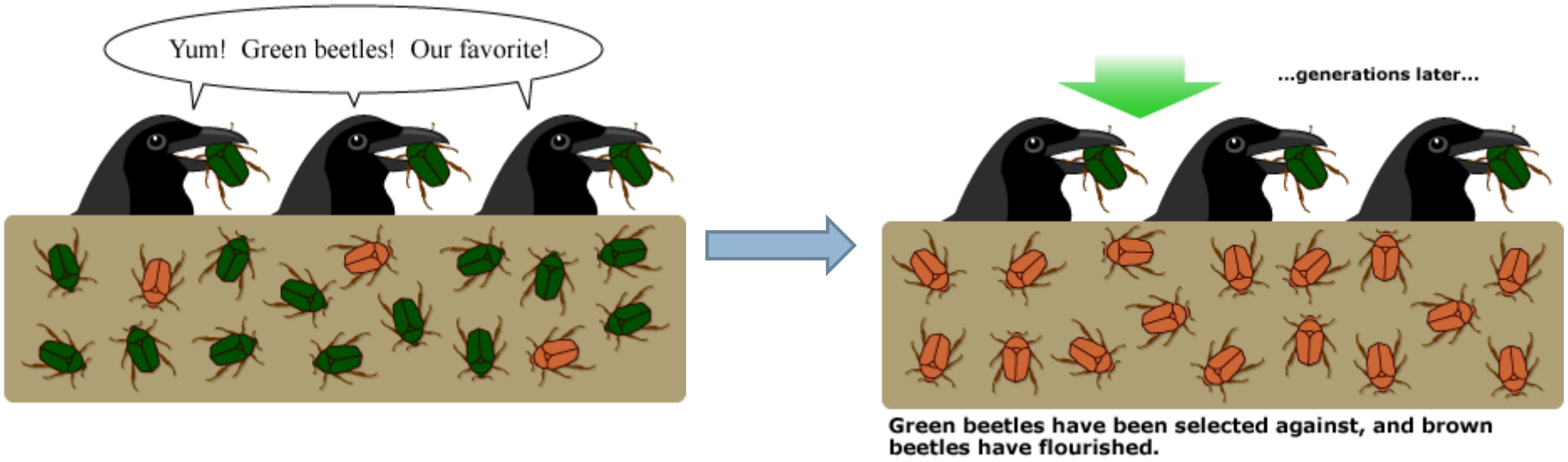
- Individuals vary in their attributes and ability to avoid early death due to starvation, disease, predation (obvious).

Darwin's Synthesis - III

- Only survivors reproduce (Logical).

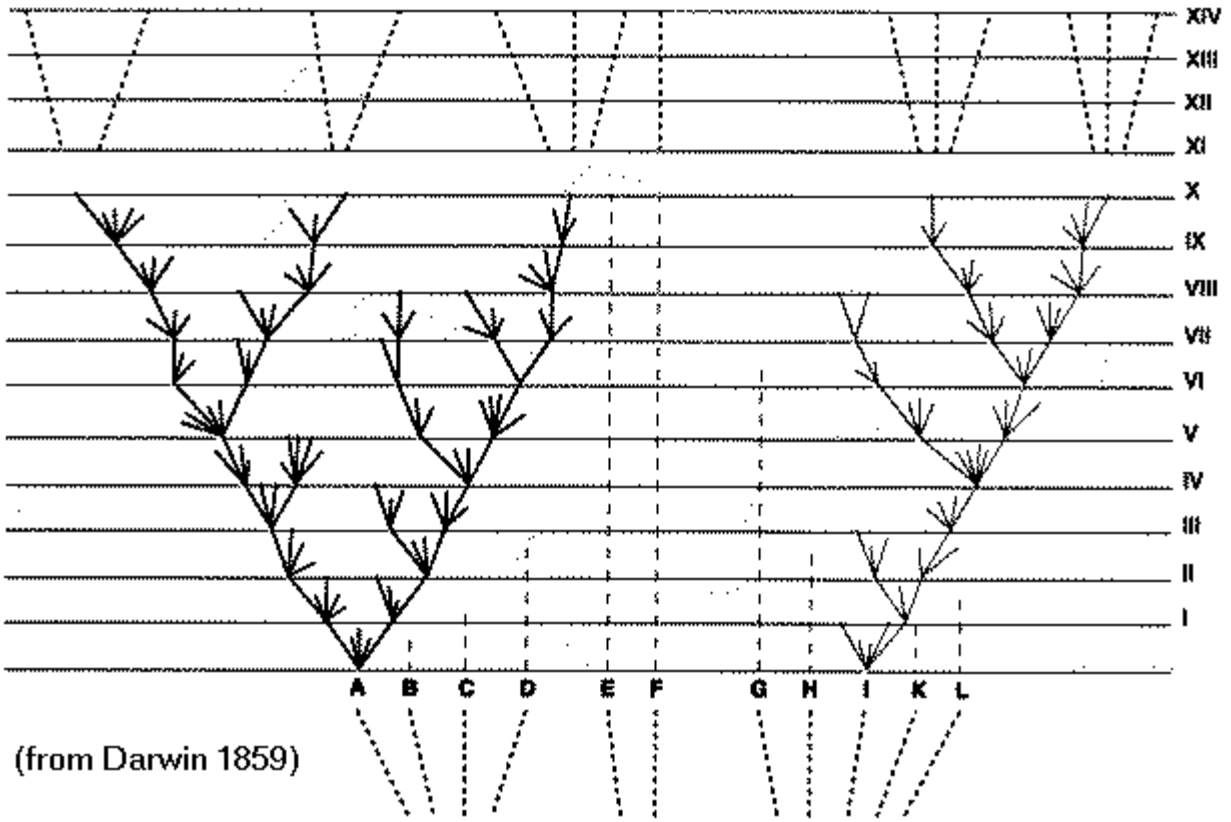
Darwin's Synthesis - IV

- Natural selection: If traits are heritable, then the next generation should consist of more resistant offspring (observations on pigeon breeding).

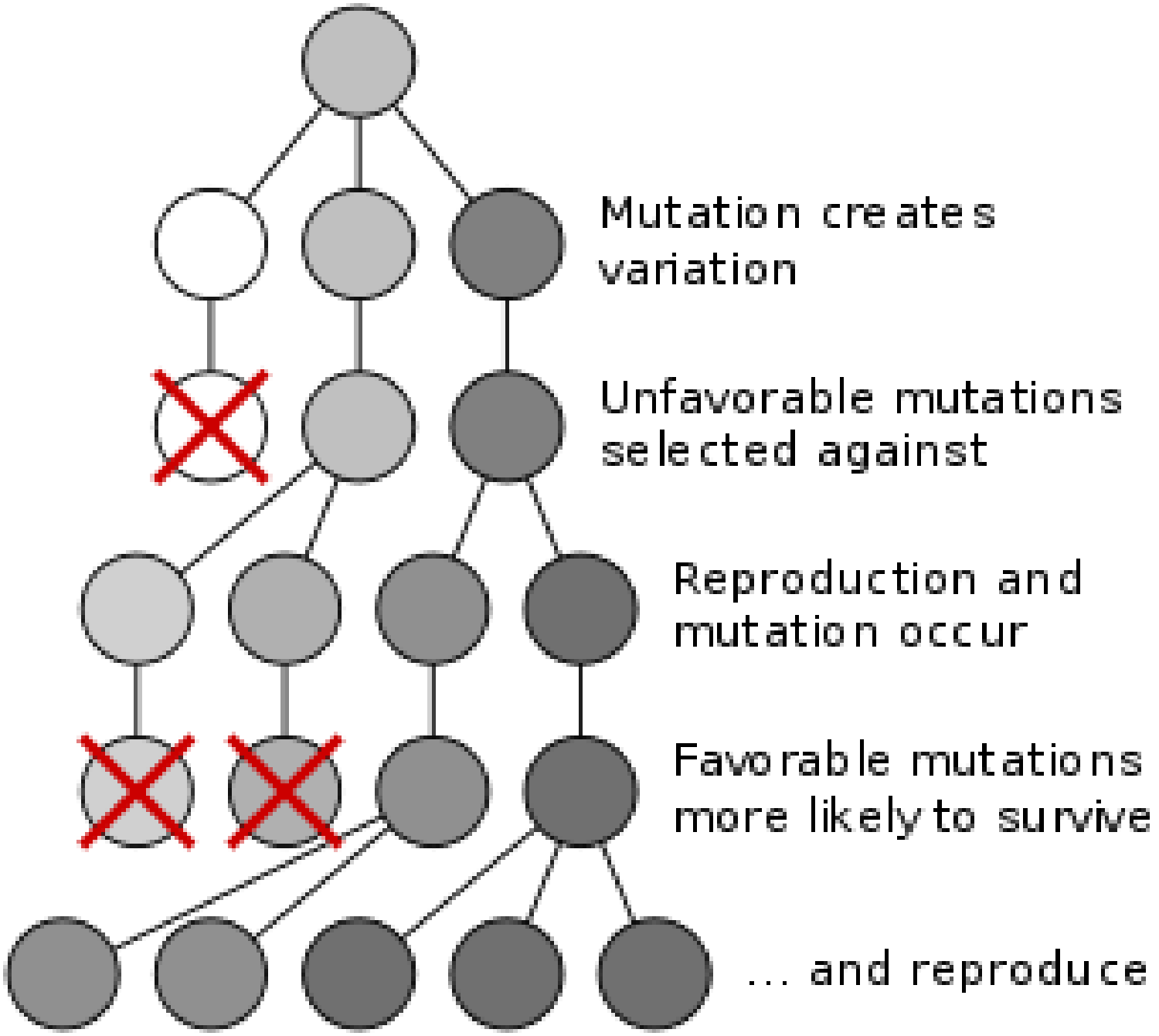


Darwin's Synthesis - V

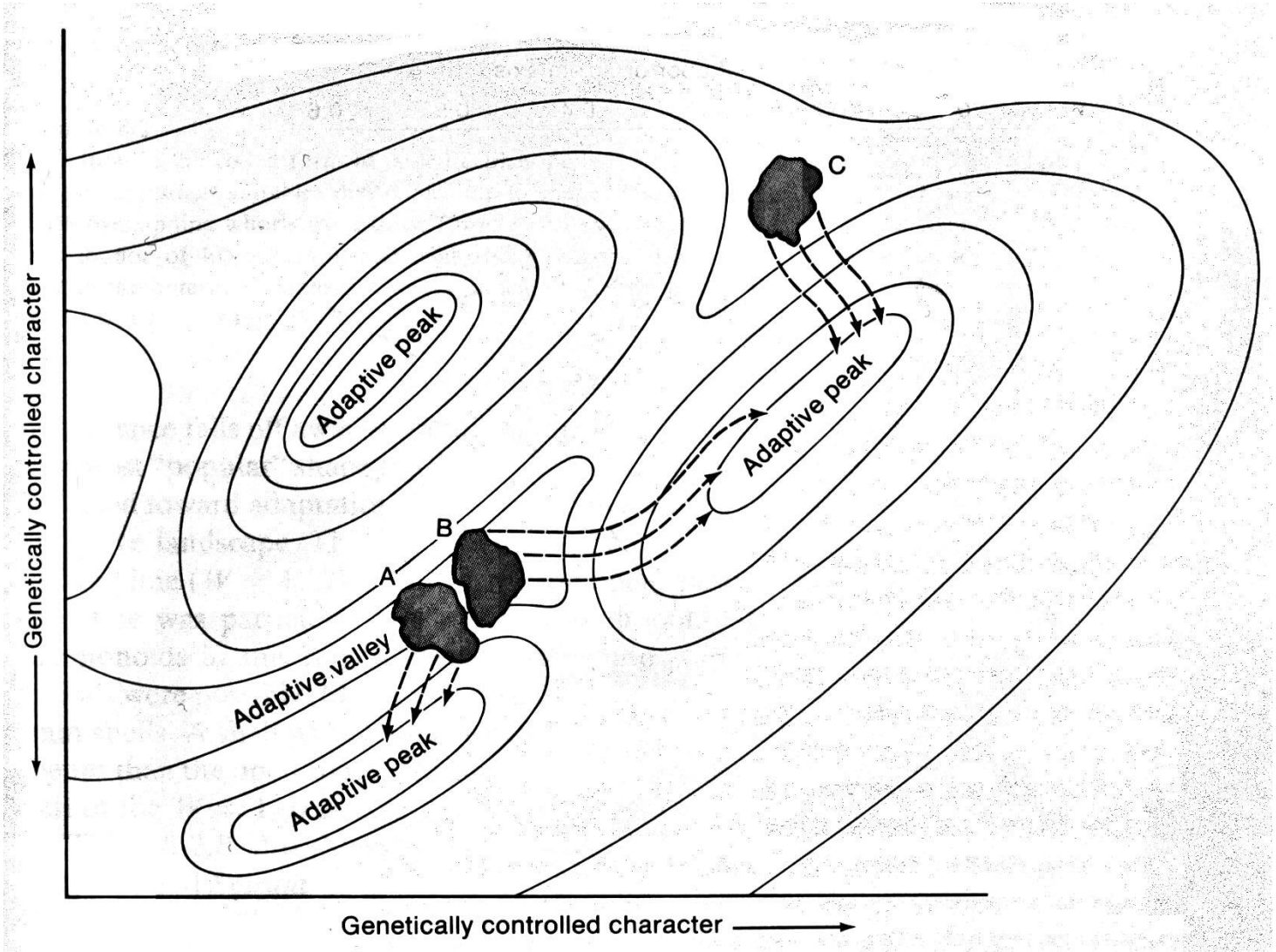
- Over geologic time, natural selection results in new kinds of life (Lyell).



(from Darwin 1859)

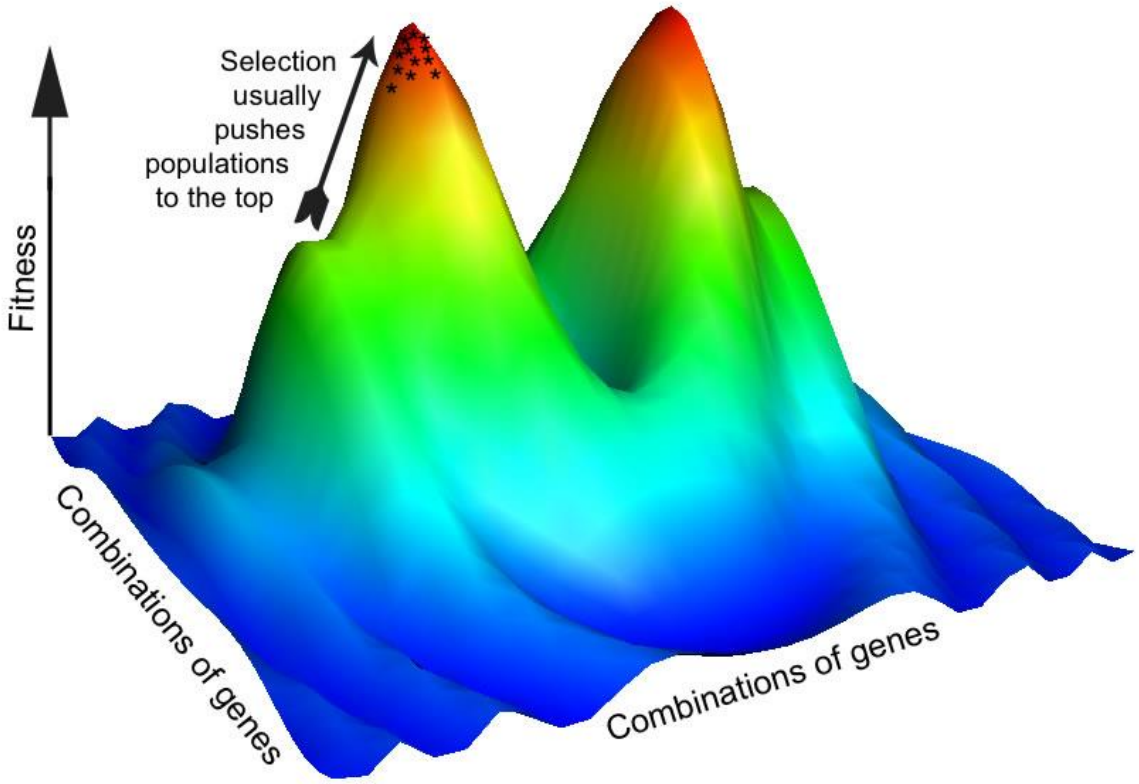

Mutation creates variation
Unfavorable mutations selected against
Reproduction and mutation occur
Favorable mutations more likely to survive
... and reproduce

Adaptive landscape (2D)



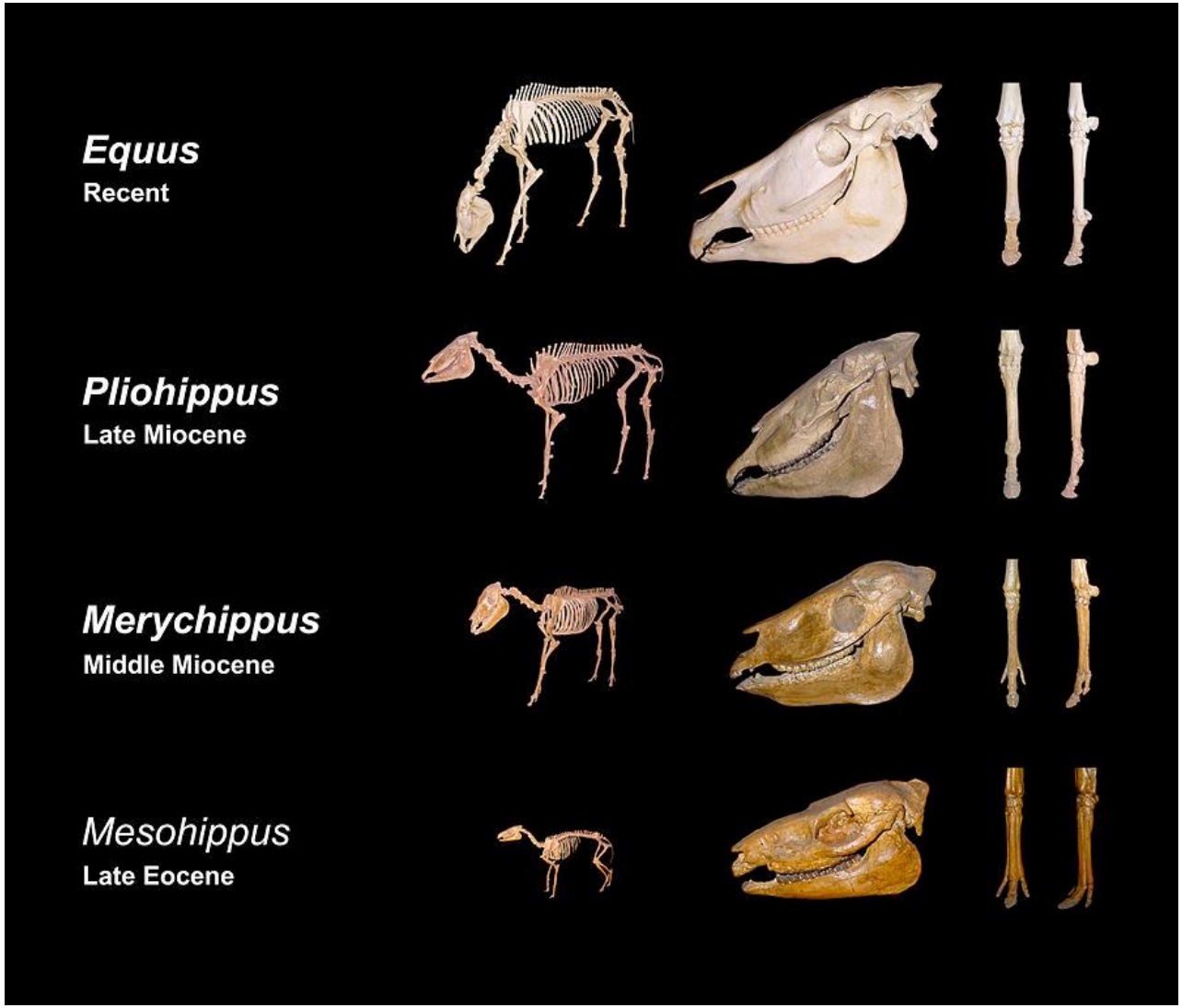
Adaptive landscape

- In reality, Adaptive landscapes are multivariate



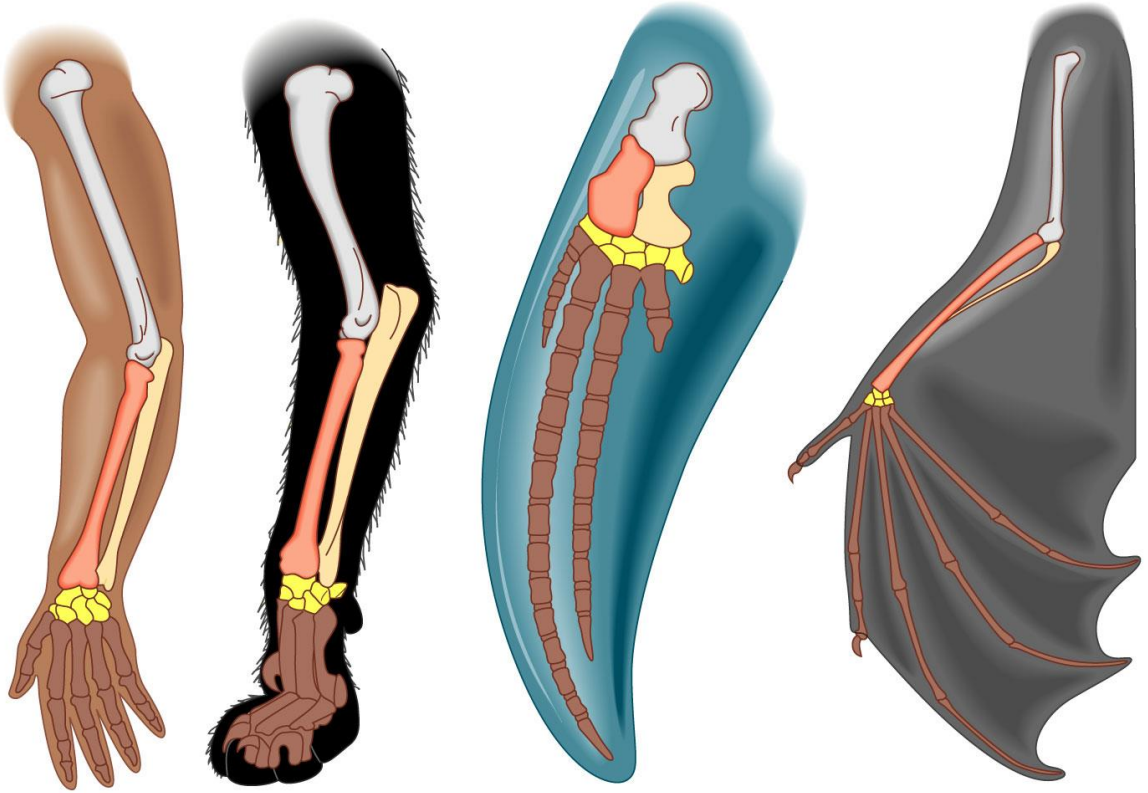
Evidence of evolution – Fossil record

- The fossil record clearly shows changes in characters of organisms



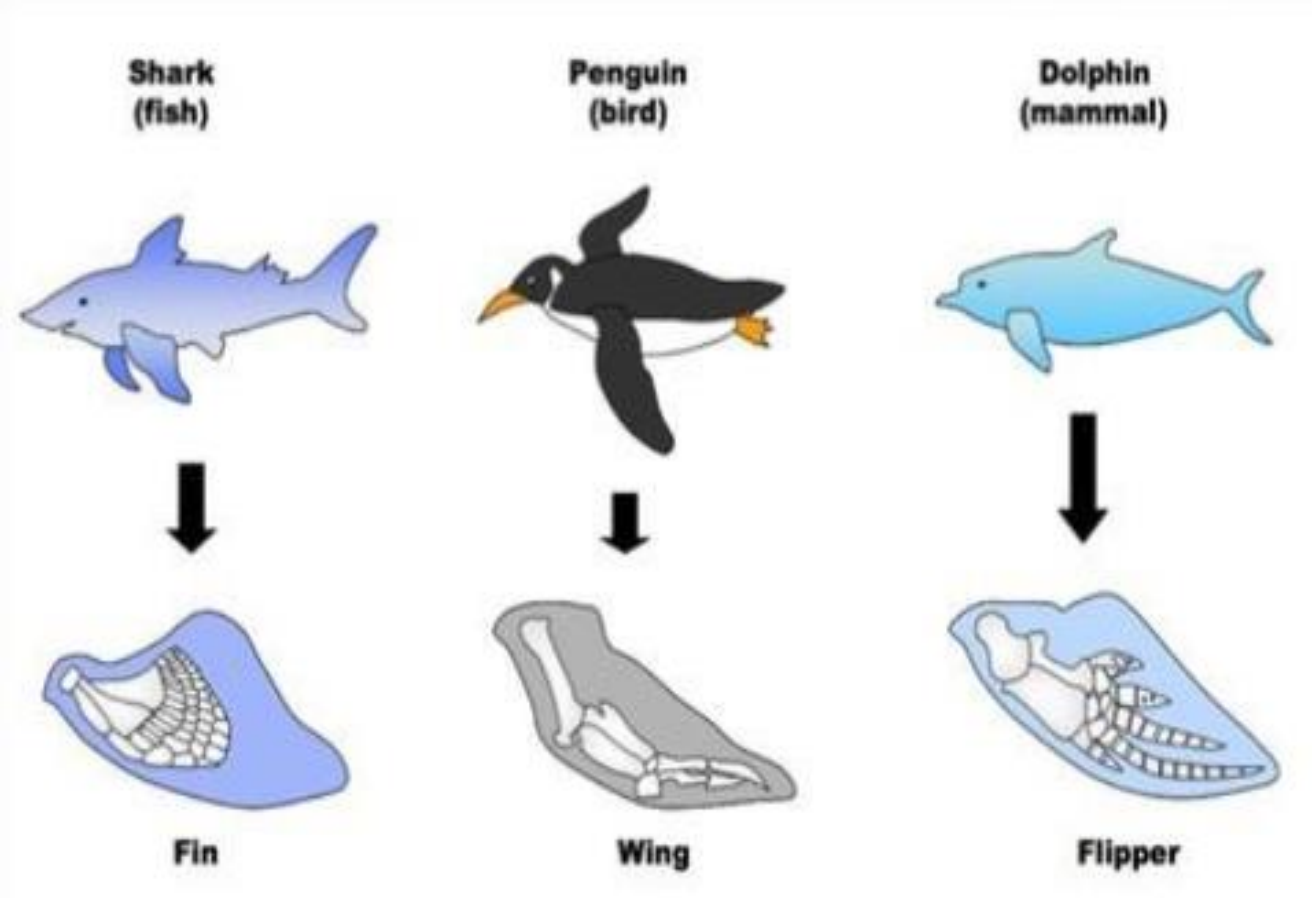
Evidence of evolution - Comparative Anatomy

- **Homologous structures**



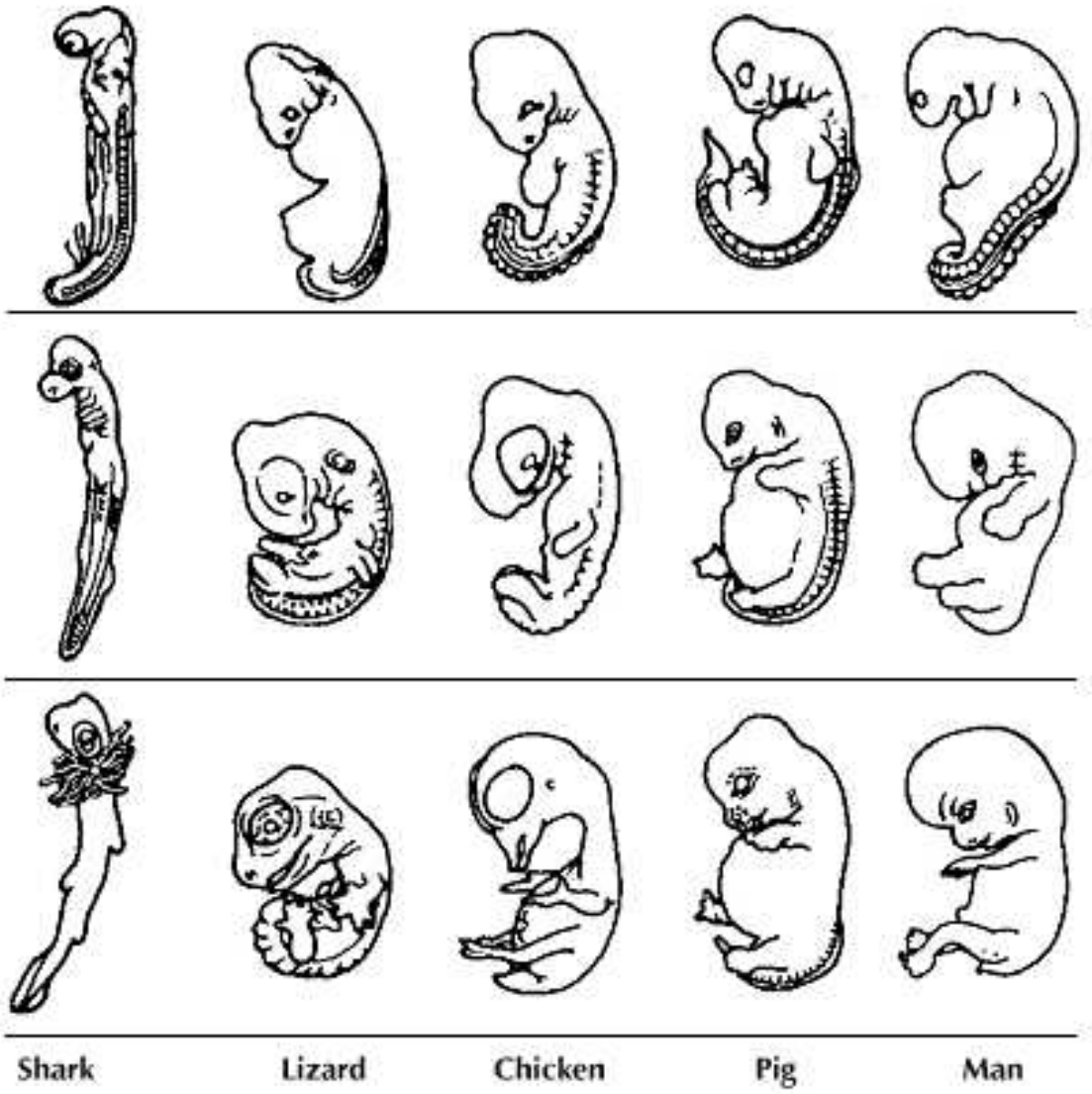
Evidence of evolution - Comparative Anatomy

- Analogous character



Evidence of evolution - Embryology

- All vertebrates go through a stage in which they have gill pouches
- Similarities suggest an evolutionary relationship among all vertebrate species



Darwin's life experience & the theory of evolution

- Wife was deeply religious. Idea that species evolve was considered a crime of blasphemy at the time.
- In 1851, his daughter, Annie, died after a long illness. She was only 10 years old.
- Alfred Russell Wallace simultaneously had come to the same idea and was about to beat Darwin to the punch!

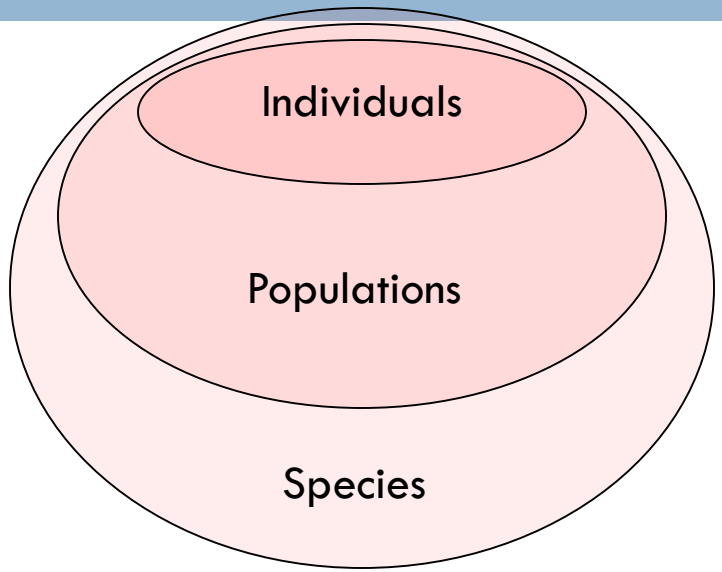
Origin of Species by Means of Natural Selection (1859)

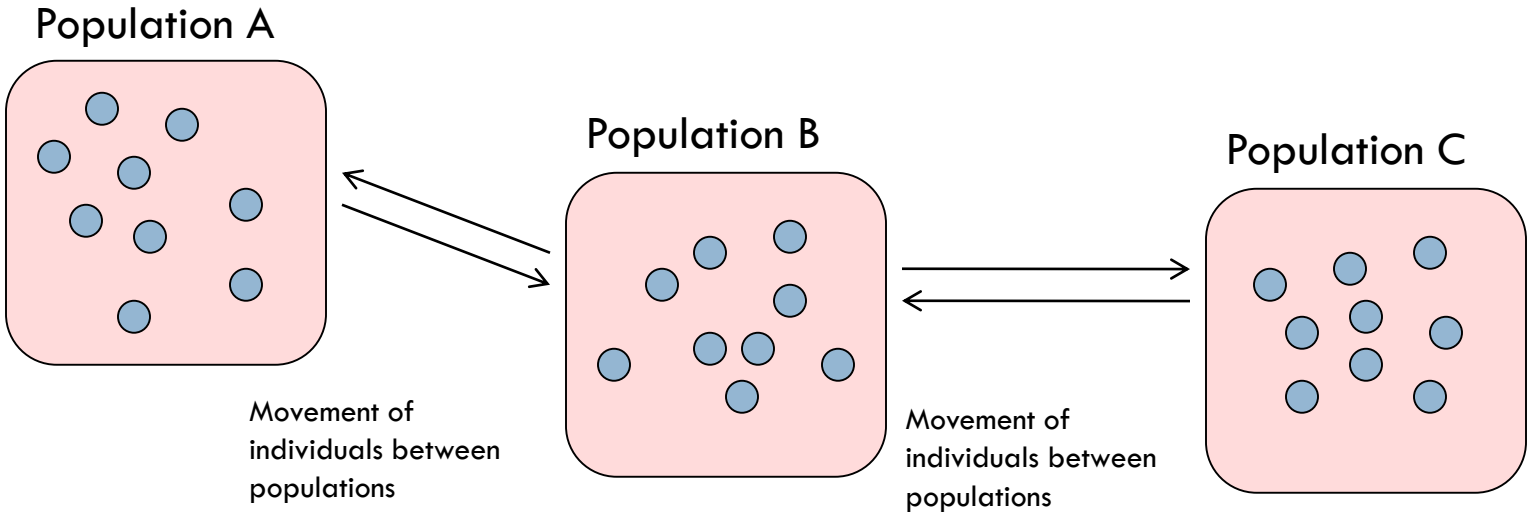
- Presented evidence that species have evolved over geologic time
- Avoided using the word 'evolution'
- Also avoided discussing human evolution in detail
- 'light will be thrown on the origin of man and his history'

Darwin's theory of evolution:

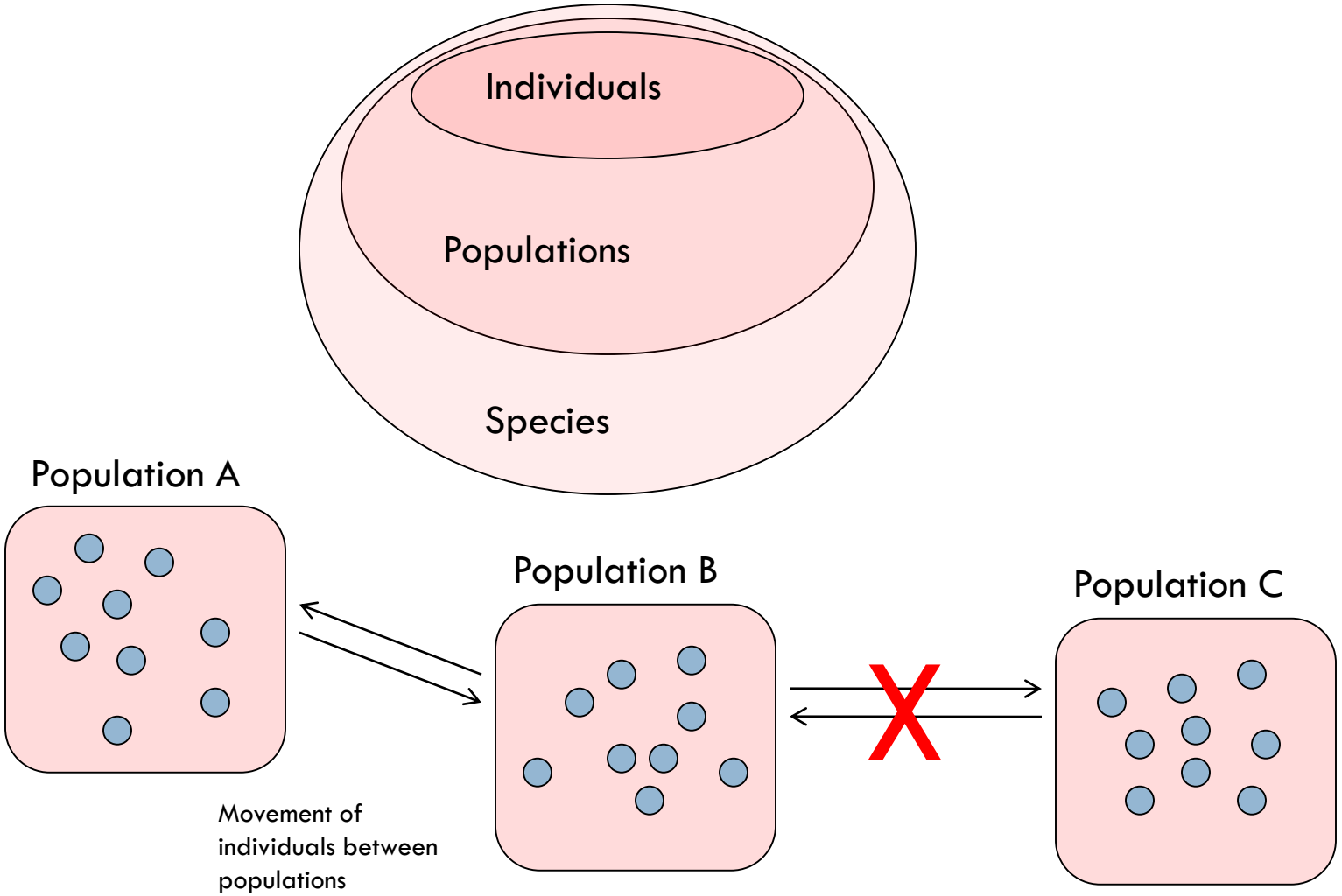
- Natural selection explains how species traits are fine-tuned.
- Darwin also understood that populations living in different places and separated from one another might evolve to become different species.
- This is the process of SPECIATION.

Important terms

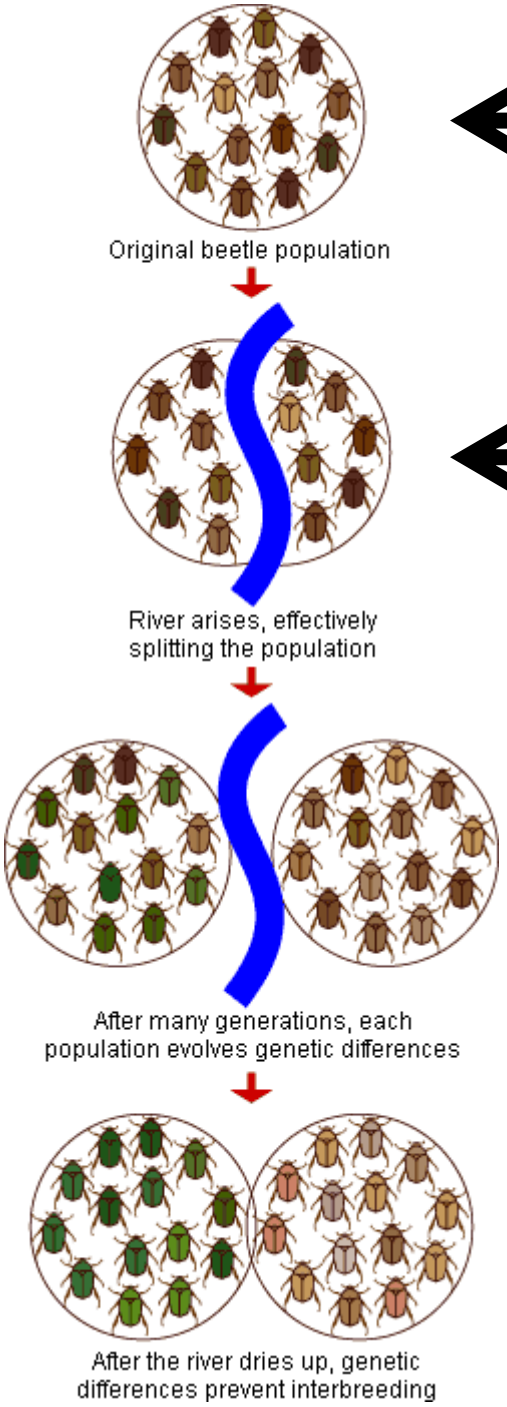




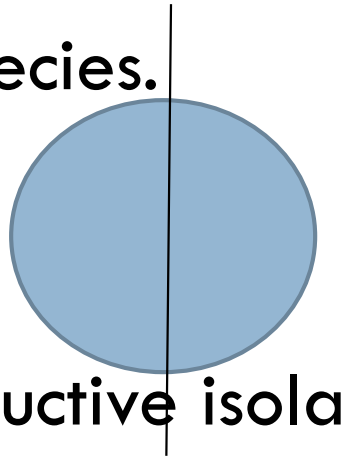
For a new species to evolve, a population must first become reproductively isolated from the others.



1. Allopatric speciation



One species.

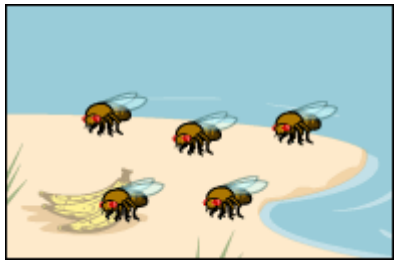


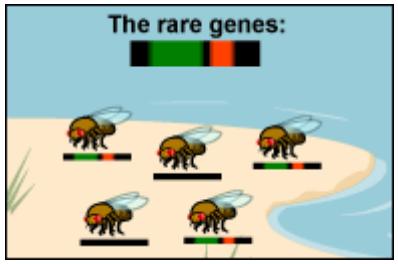
Reproductive isolation

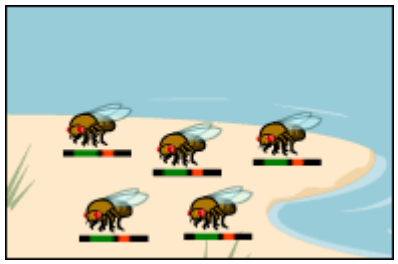
Mutation <u>and</u> Natural selection

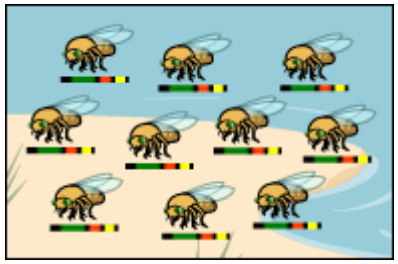
Two distinct species emerge. No hybridization possible.

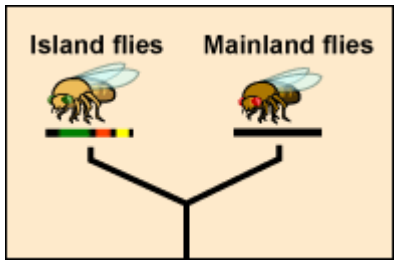
2. Peripatric speciation



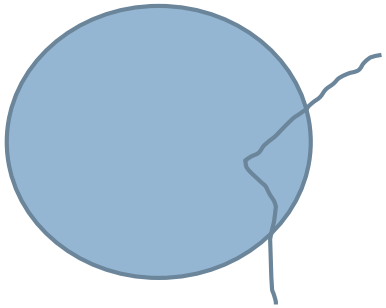








1. Double disaster



2. Rare genes survive

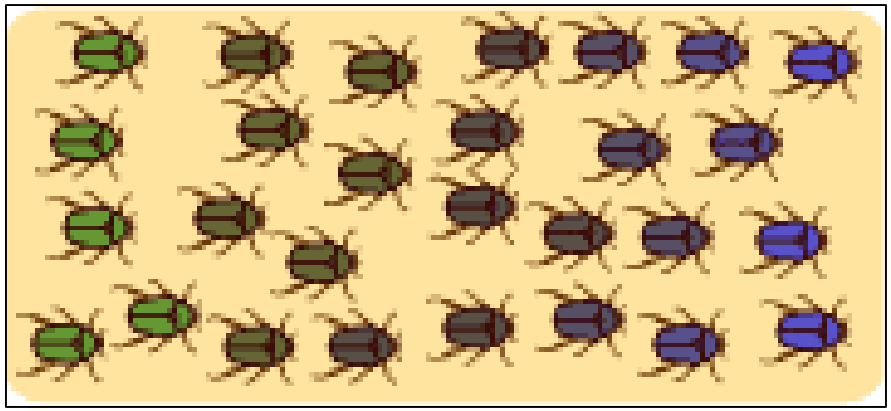
3. Genetic frequencies drift

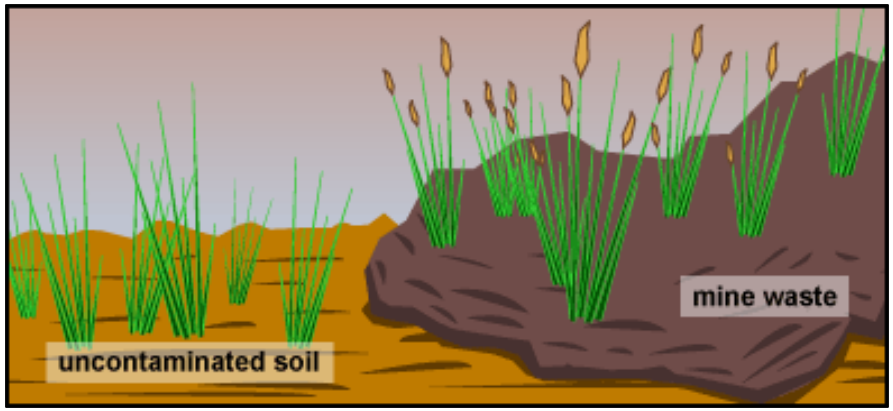
4. More changes

5. Speciation

3. Parapatric speciation

- No geographic barrier
- reduced gene flow because individuals are more likely to mate with their geographic neighbors than with individuals in a different part of the population's range.
- Different selection pressure across the population's range.



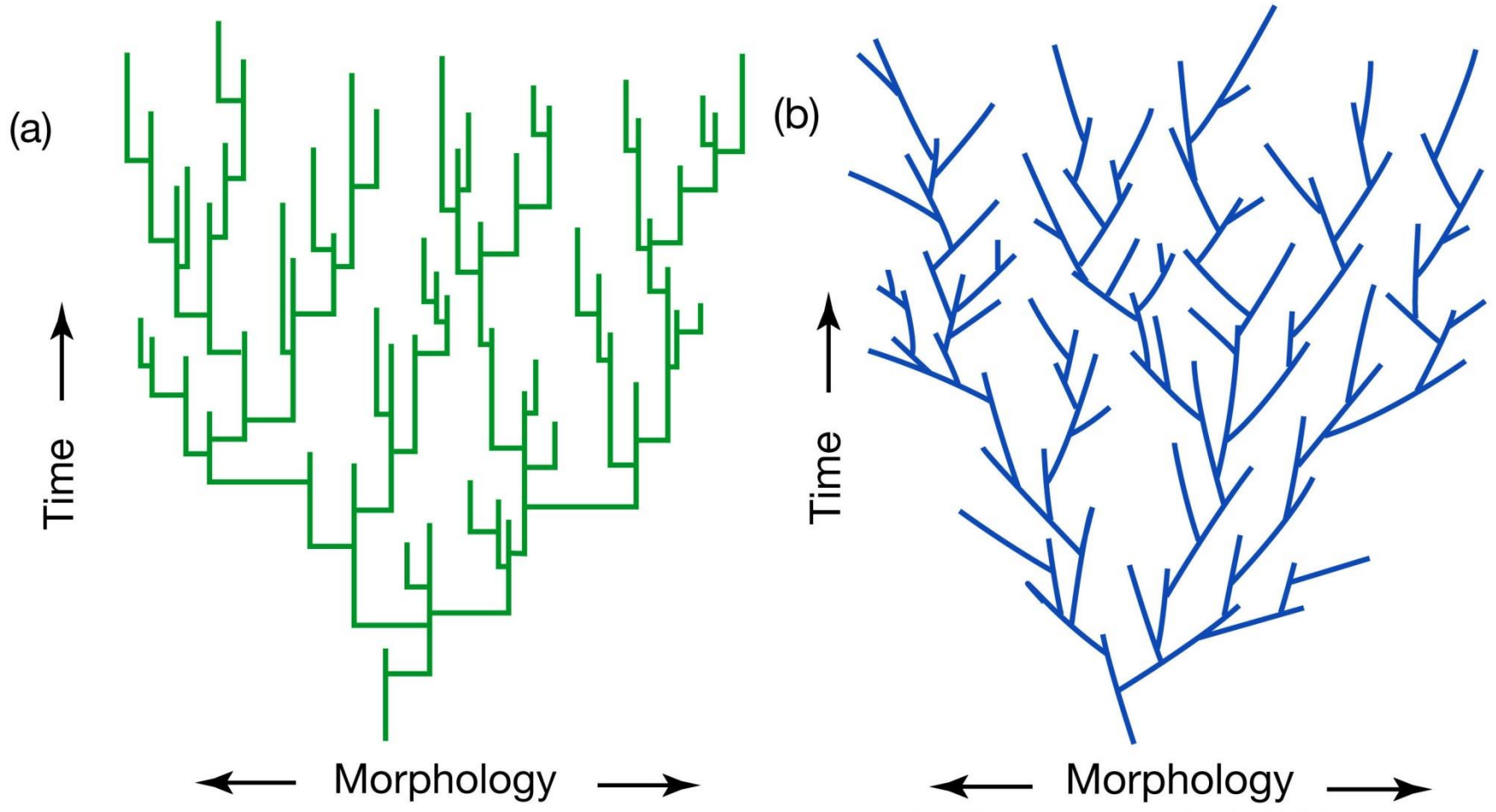


4. Sympatric speciation

- No geographic barrier
- Exploiting a new niche may automatically reduce gene flow with individuals exploiting the other niche.
- Experiencing different selection pressure.




Phyletic gradualism & Punctuated Equilibrium



For discussion after Mid-sem

What Darwin Got Wrong?

- Traits are passed from the fittest to the next generation. Darwin had no idea how this happens.

- What is the mechanism for passing traits from one generation to the next?

- **Remember: Evolution by natural selection is only a viable process if traits are heritable.**

Forces of evolution

- Genetic Drift
- Genetic Recombination
- Mutation
- Gene Flow
- Natural selection

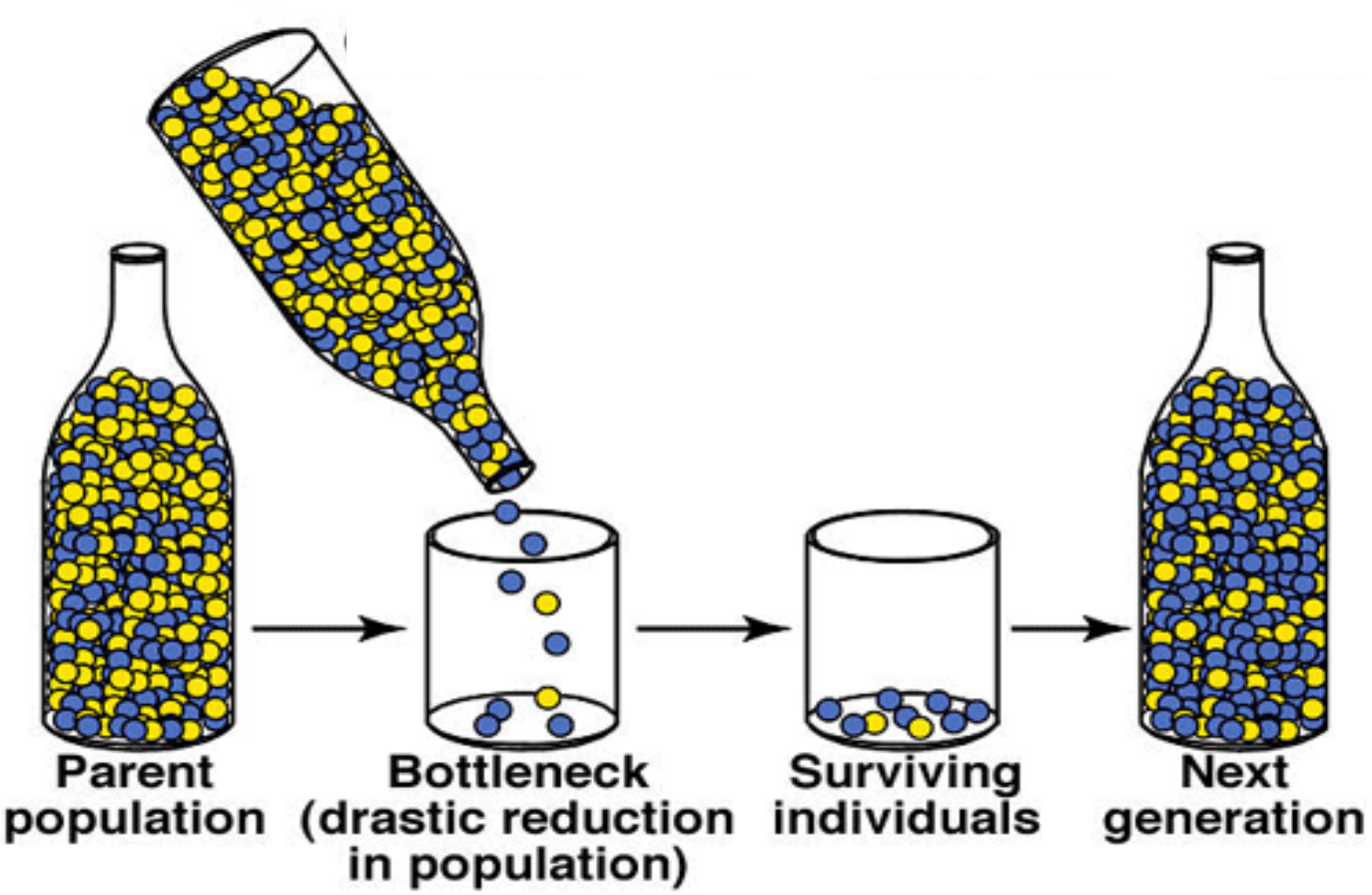
Genetic Drift

- Change in frequency of alleles (genetic variants) in a population

- Unlike natural selection, through an entirely random process. So although genetic drift is a mechanism of evolution, it doesn't produce adaptations.

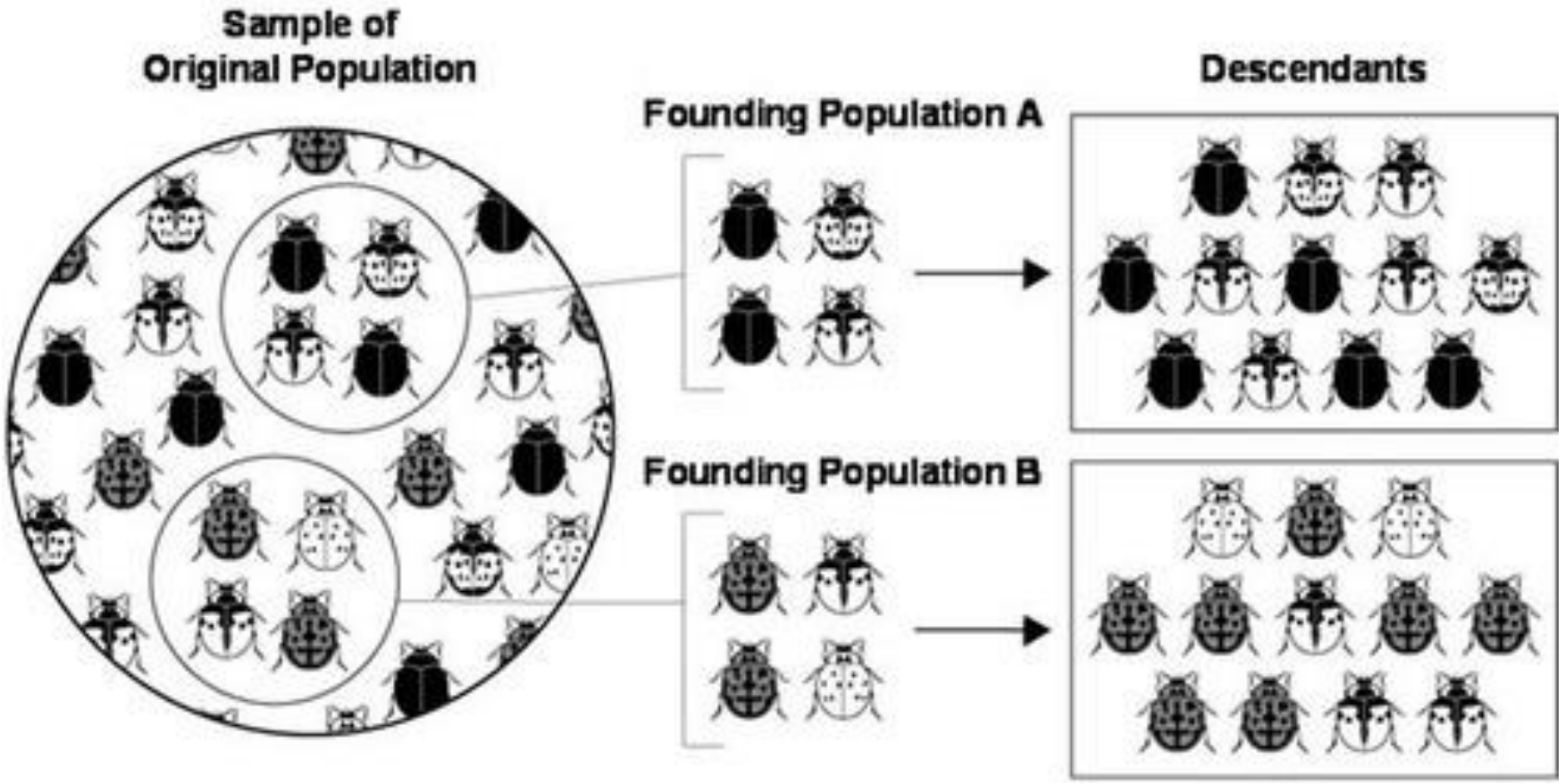
Types of Genetic Drift

- Bottleneck effect:

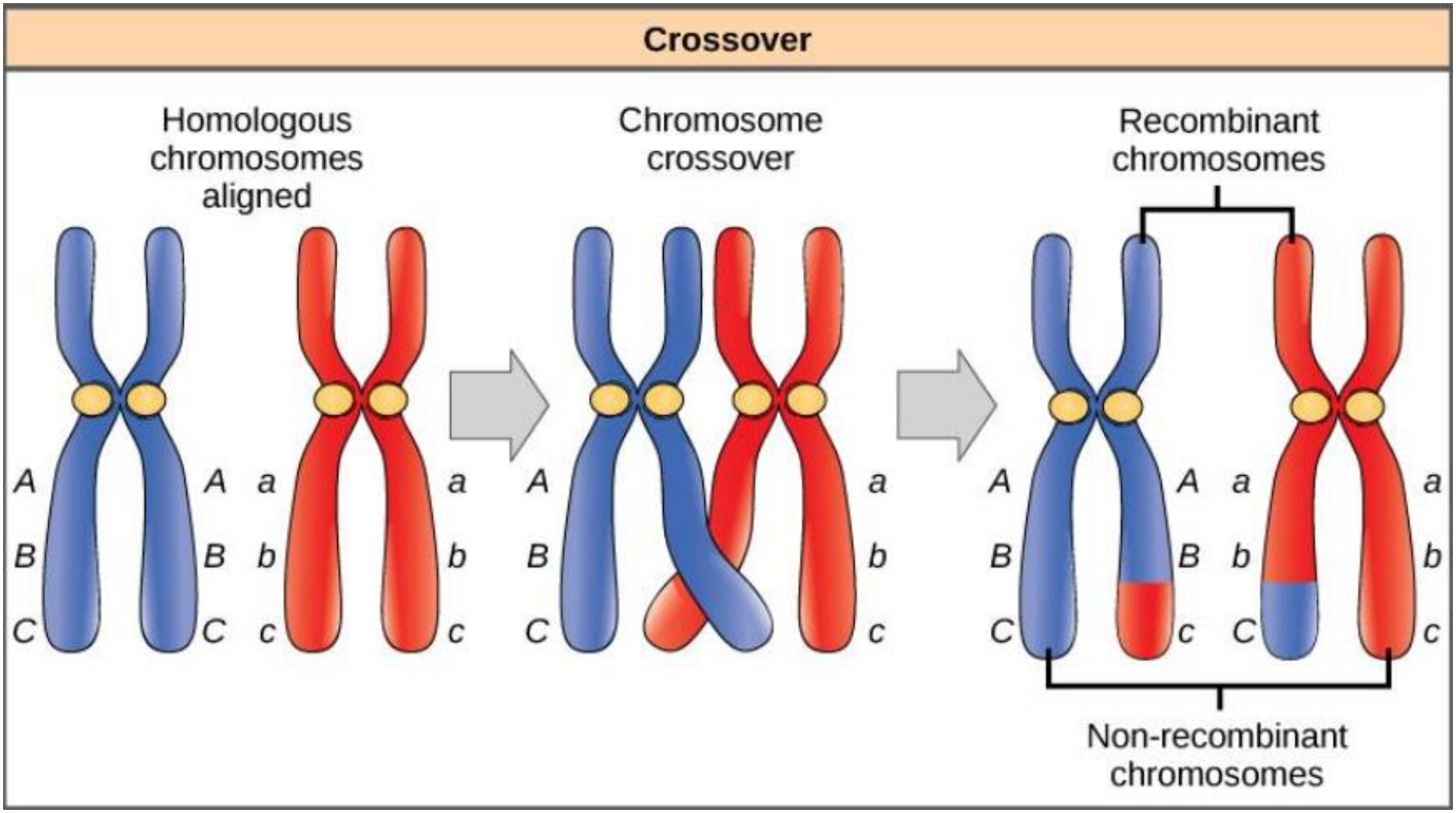


Types of Genetic Drift

- Founder effect:

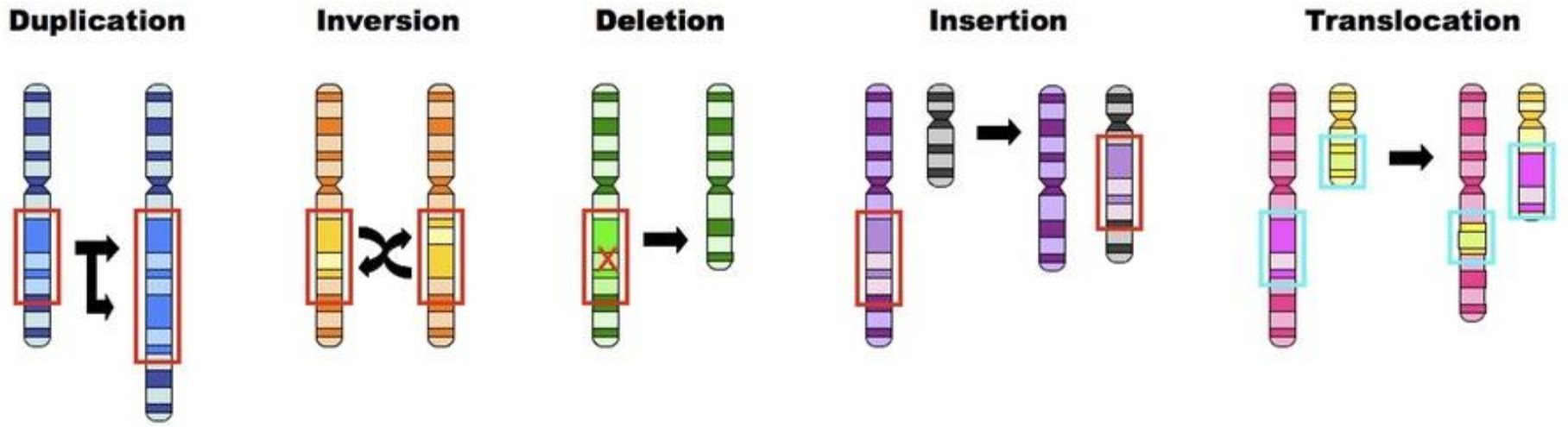


Genetic Recombination



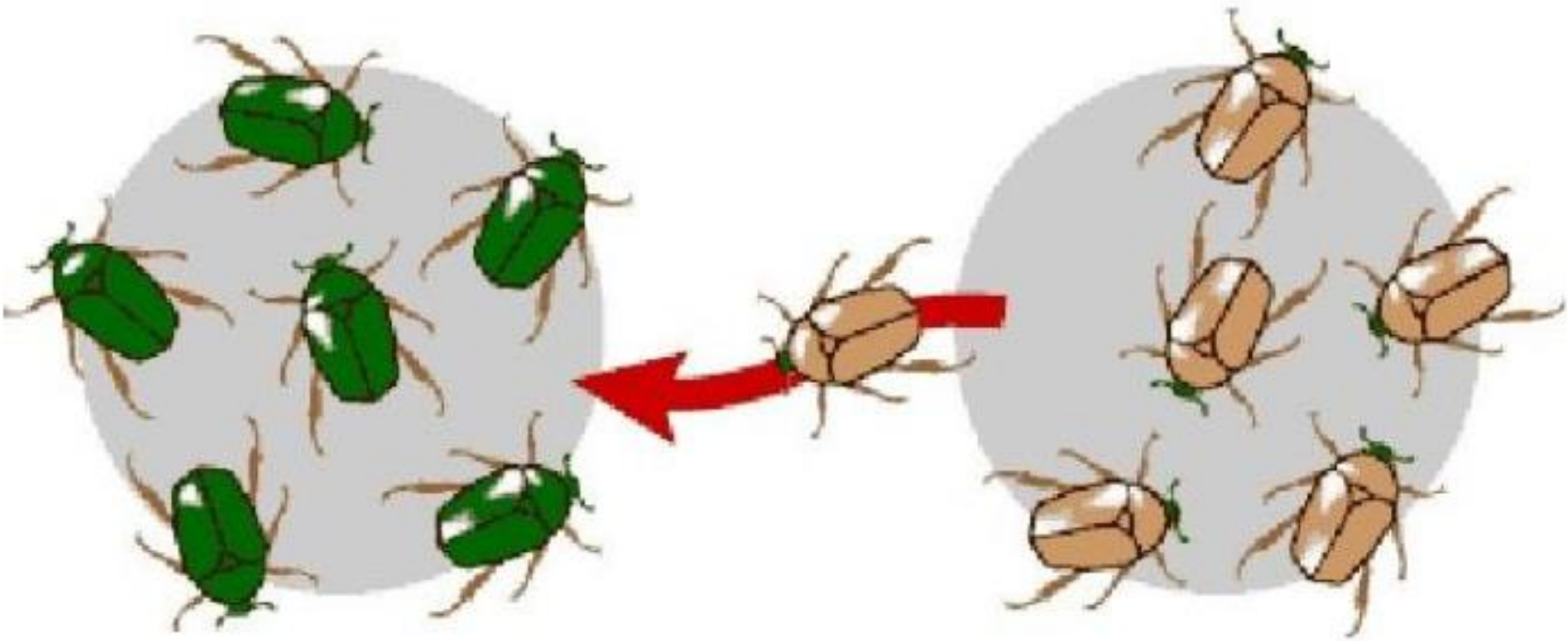
Mutation

- Change in DNA, the hereditary material of life



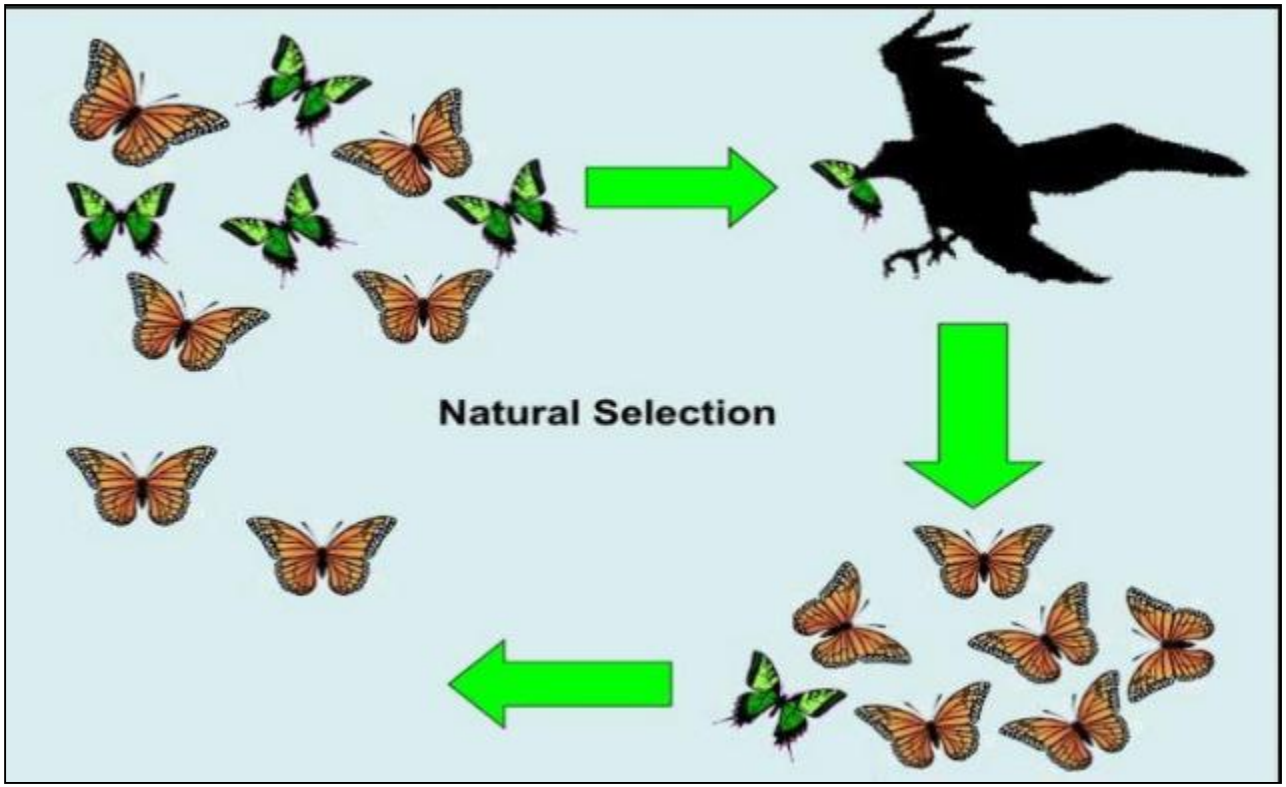
- mutations do not "try" to supply what the organism "needs; mutations are random.

Gene Flow / migration



Natural selection

- That results in the adaptation of an organism to its environment
- Determines the traits that allow organism to multiply and survive
- Evolution often occurs as a result of this process



Is Evolutionary Theory testable?

Karl Popper: "Science can only succeed if it can fail"