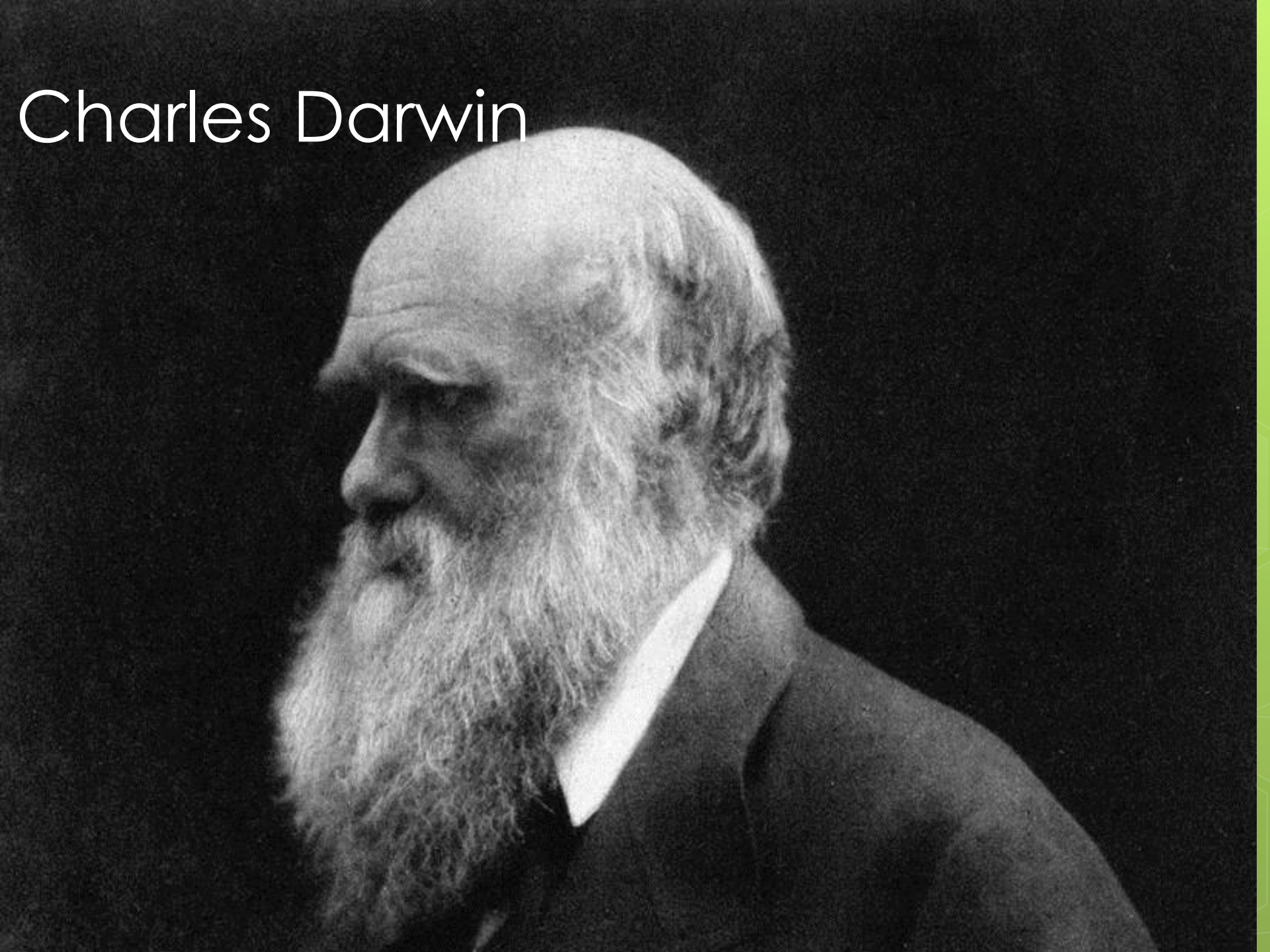
Domain 1: Evolution

1. Natural Selection

1.1: Natural selection is a major mechanism of evolution

Charles Darwin

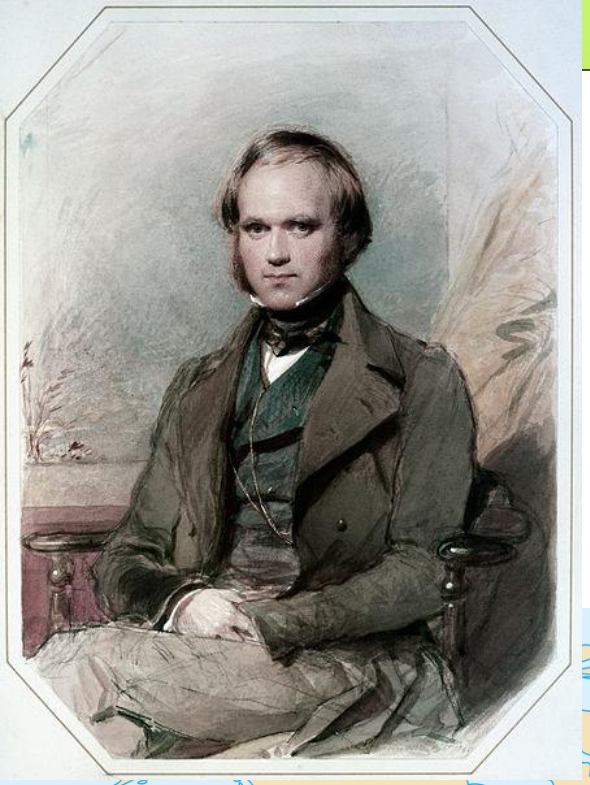


Pre-Darwin

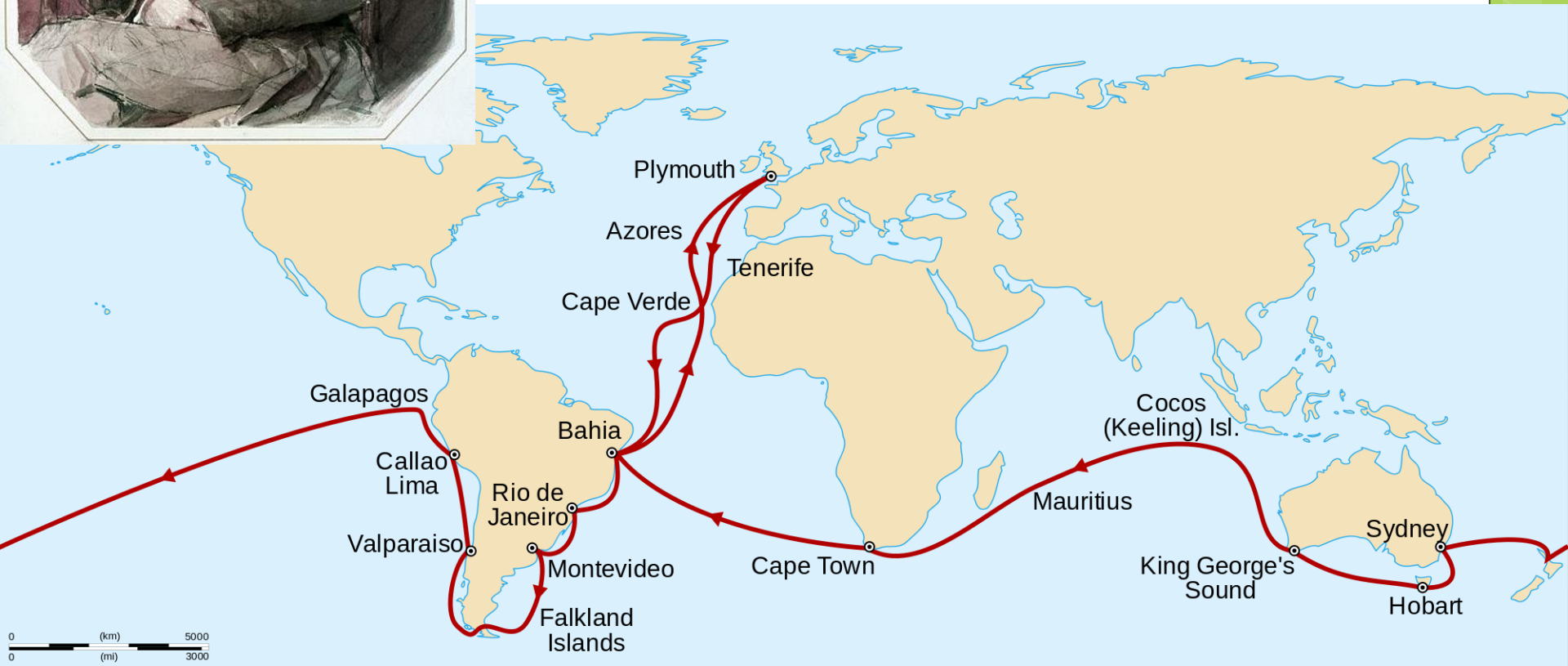
Lyell: Geology, Uniformitarianism→ very old earth.

Malthus: Exponential Population Growth

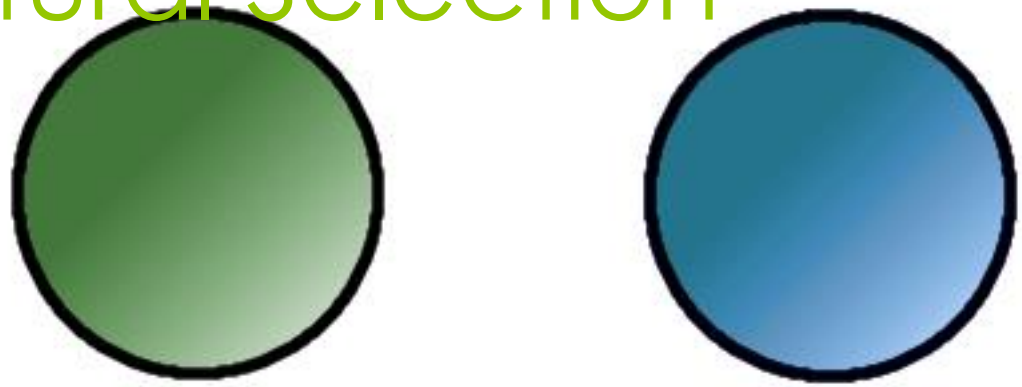
LaMarck: Evolution. Inheritance of acquired characteristics (wrong, but still evolutionary)



The Voyage of the *HMS Beagle*

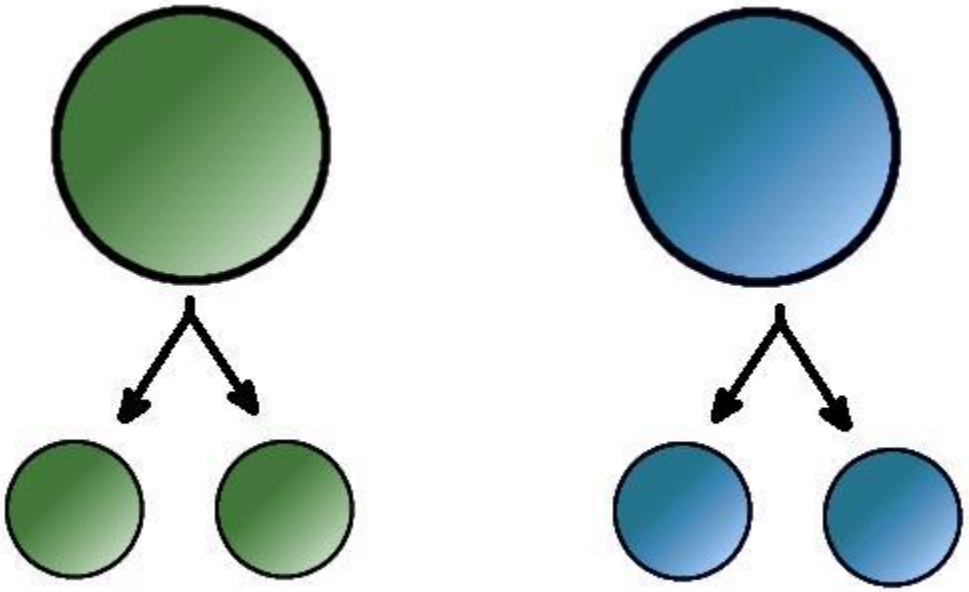


Natural Selection



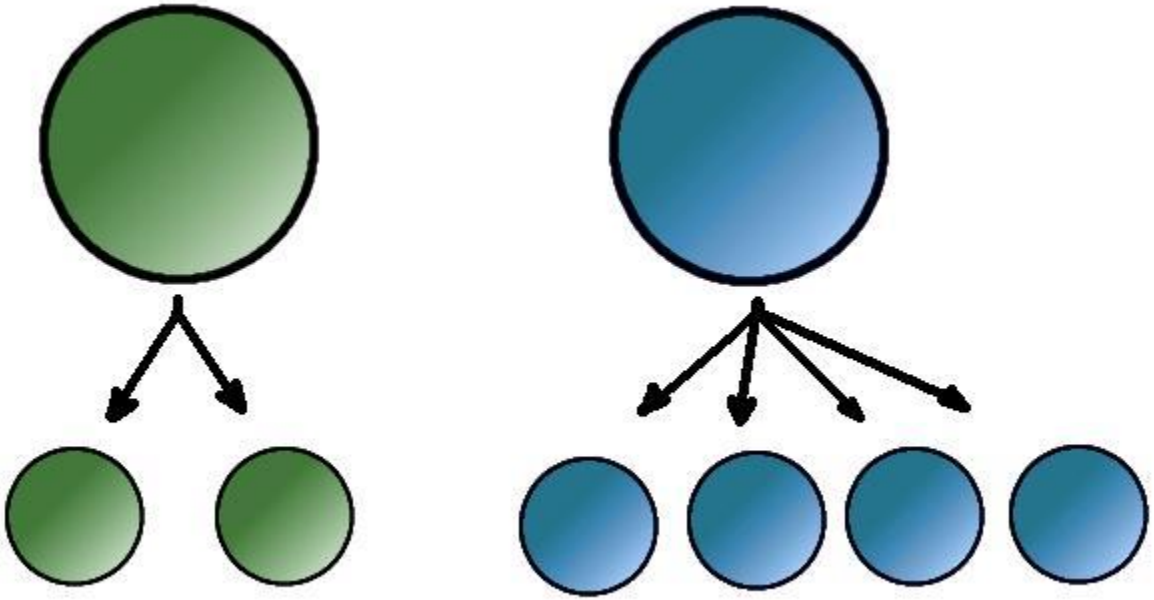
Observation 1: Variation

No two organisms are completely alike.



Observation 2: Reproduction…

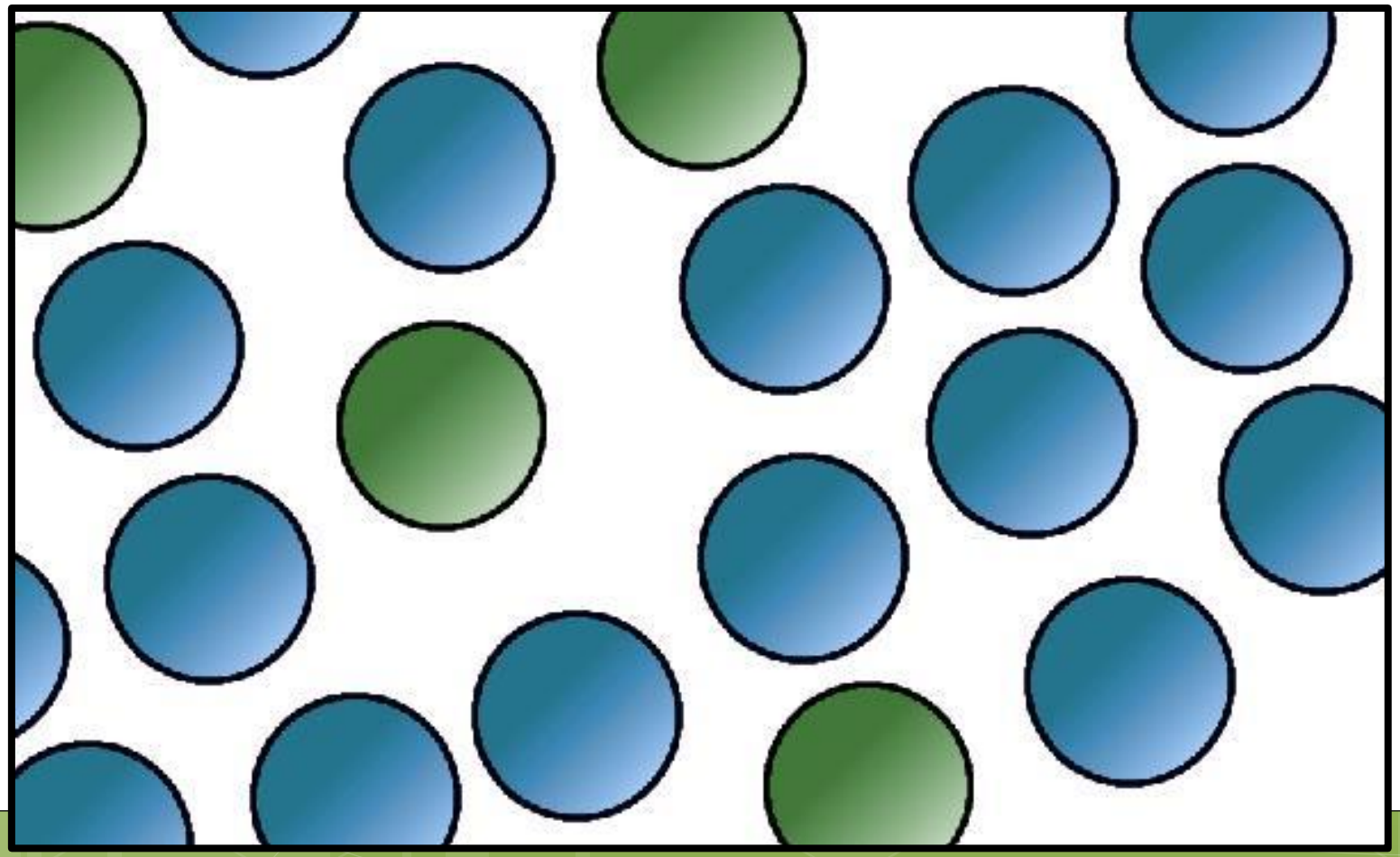
….And overproduction



Inference 1: Differential “fitness” in the environment due to variations.

The “struggle for existence”

Inference 2: Over the span of geological time (billions of years), inheritance of adaptations will lead to evolution of the population.

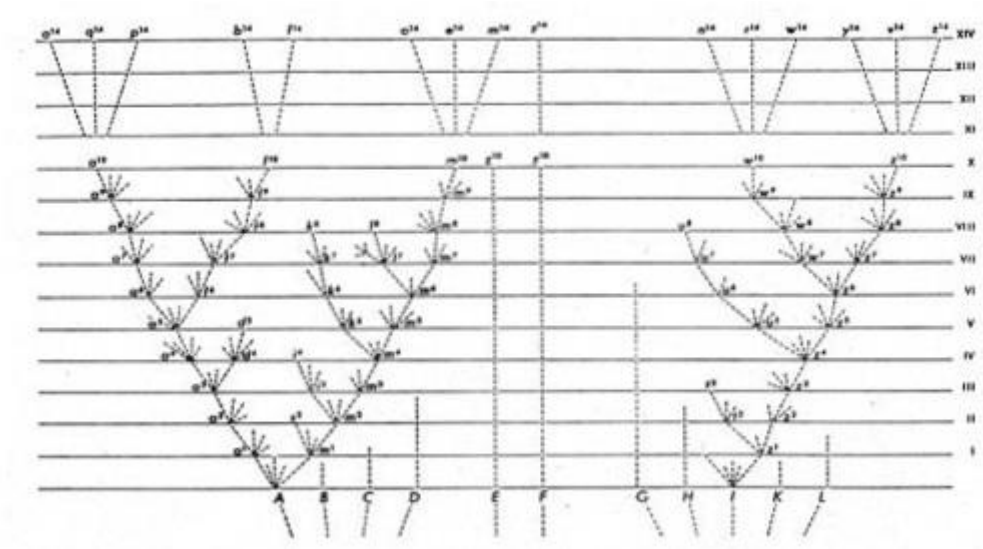


Fundamental Conclusions

1. To develop the diversity of life seen on the Earth today, the Earth has to be incredibly old.

2. If organisms evolve from pre-existing organisms, then all organisms should share a universal "**common ancestor**"

“tree thinking”



Unsettled by Darwin

1. Origin of Life

1. Origin of species

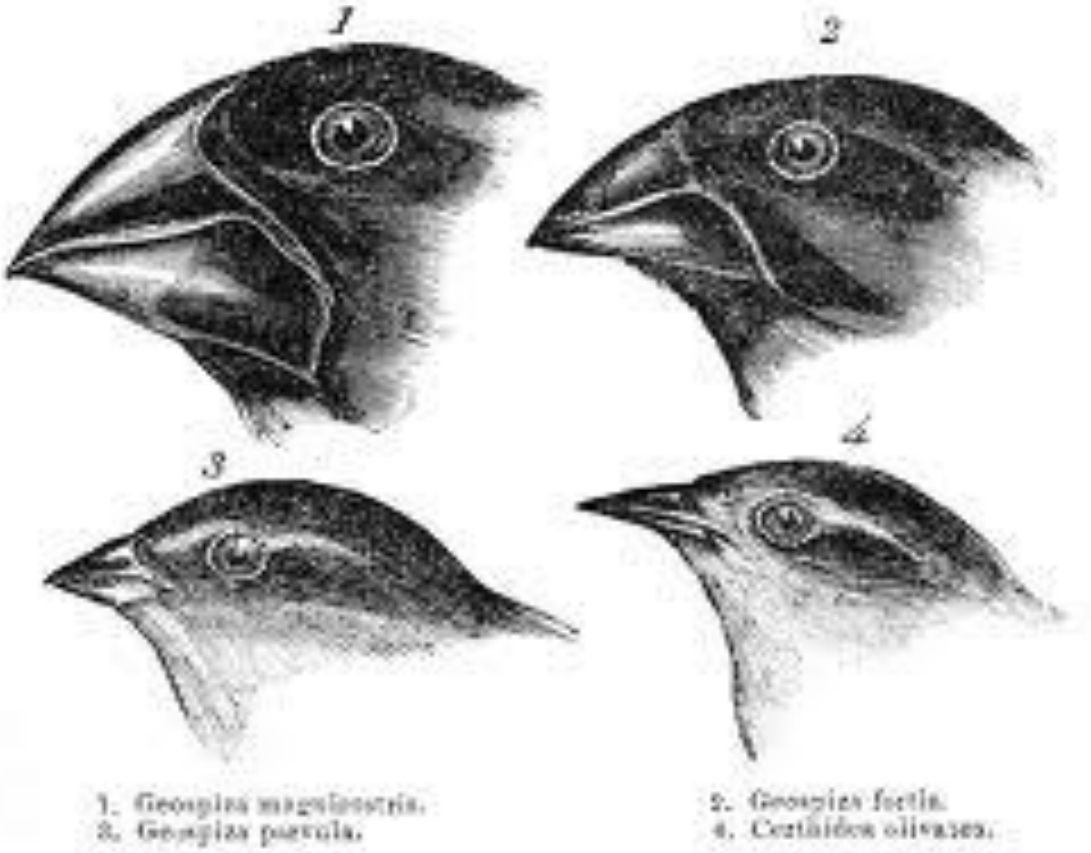
1. Nature of variation/inheritance

2. The Modern Synthesis

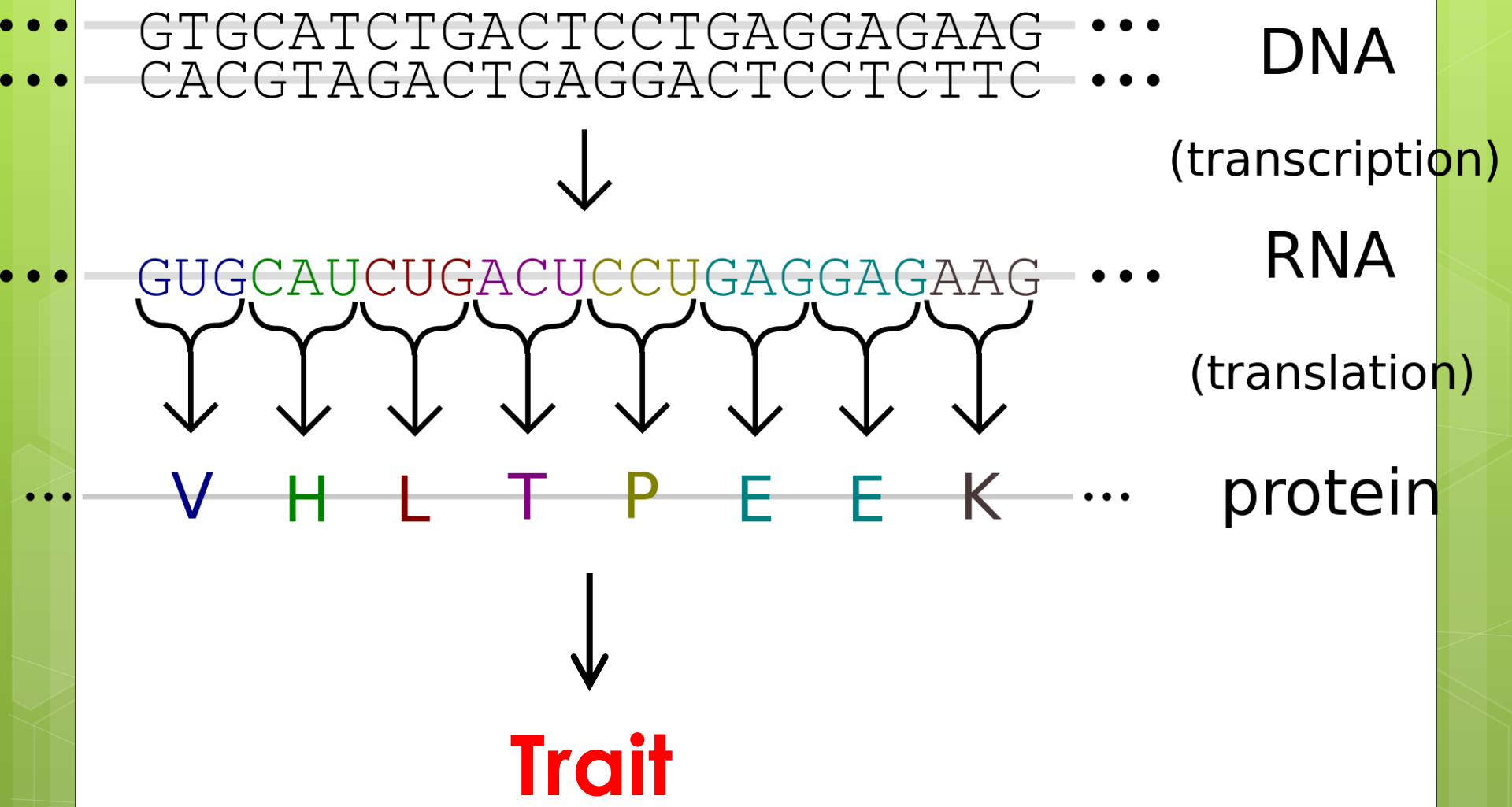
1.1: Natural selection is a major mechanism of evolution

The "Modern Synthesis"

Connects Darwinian evolution to genetics and modern understanding of inheritance.

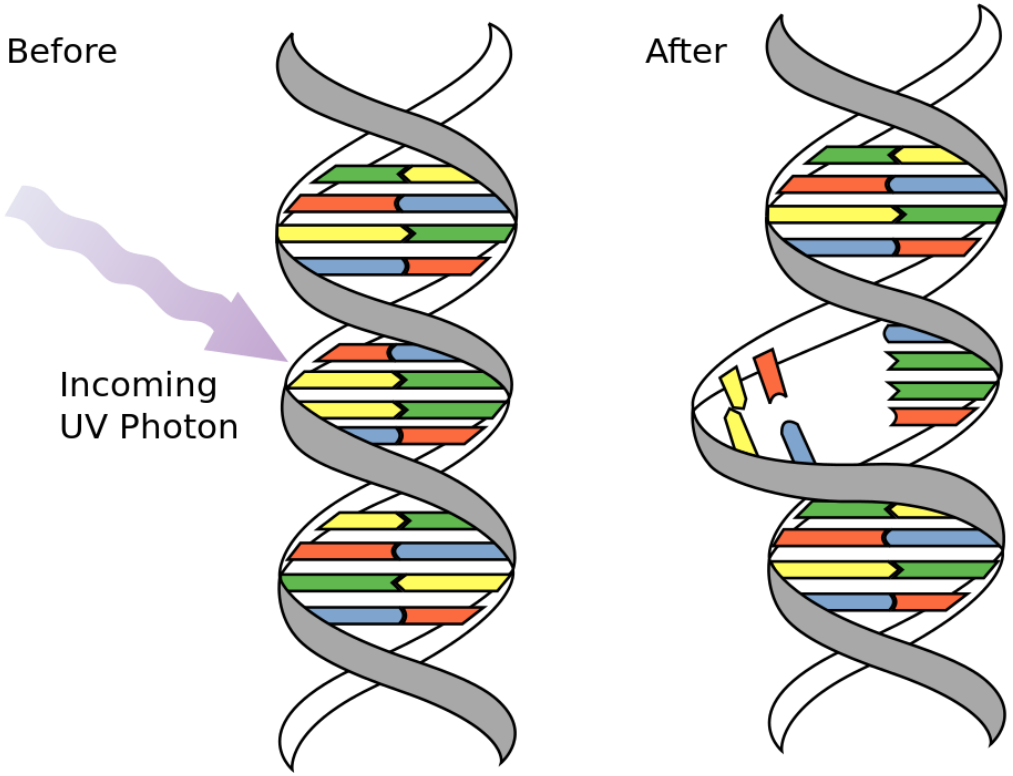


Where Traits come from:



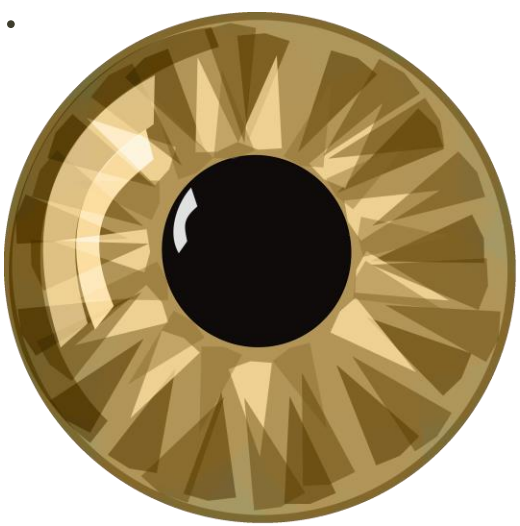
Variation comes from Mutation

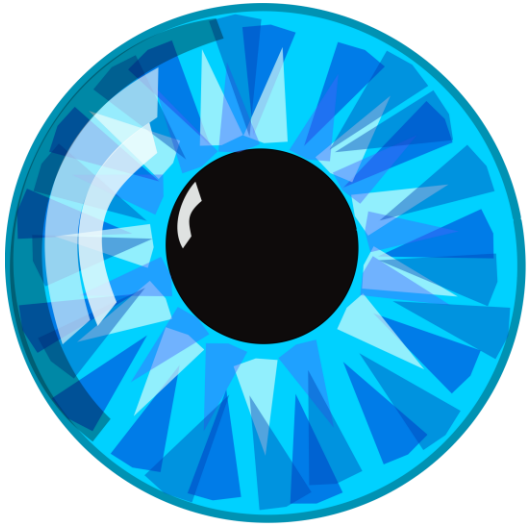
Mutation: A change in a DNA sequence. Happens spontaneously and unavoidably.



Mutations create "alleles"

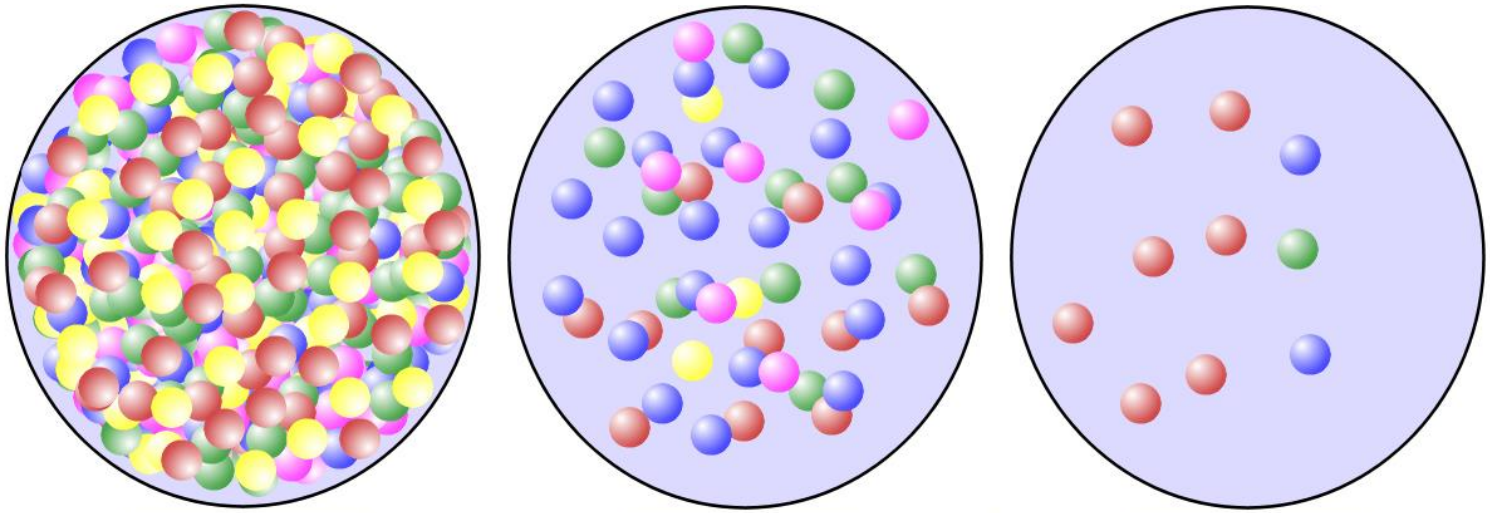
Alleles: Different versions of the genes for a trait.





Evolution Defined:

Evolution: Changes in allele frequencies over time.



Initial frequency distribution	
	0.20
	0.20
	0.20
	0.20
	0.20

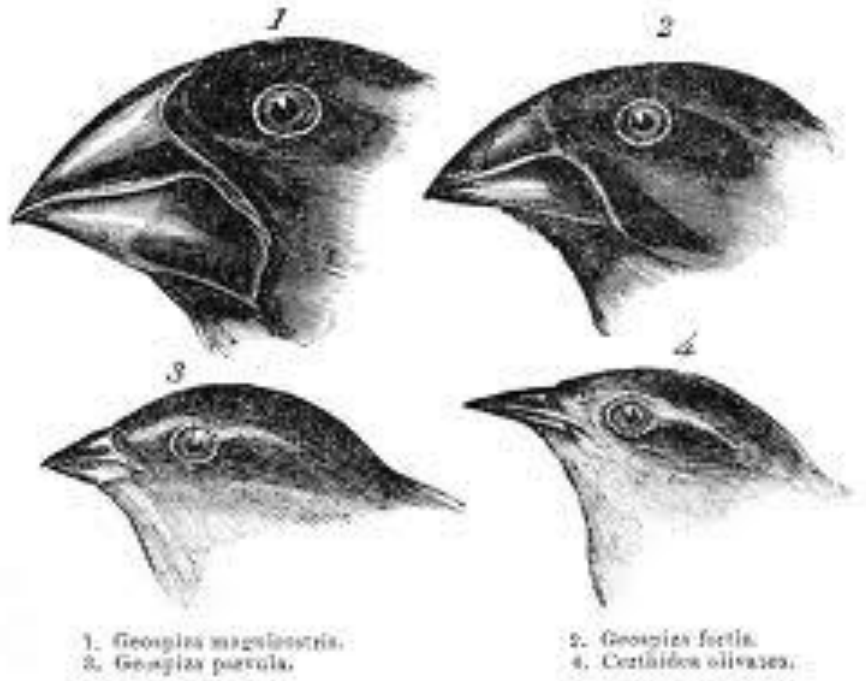
5th generation frequency distribution	
	0.40
	0.06
	0.20
	0.14
	0.20

10th generation frequency distribution	
	0.20
	0.00
	0.10
	0.00
	0.70

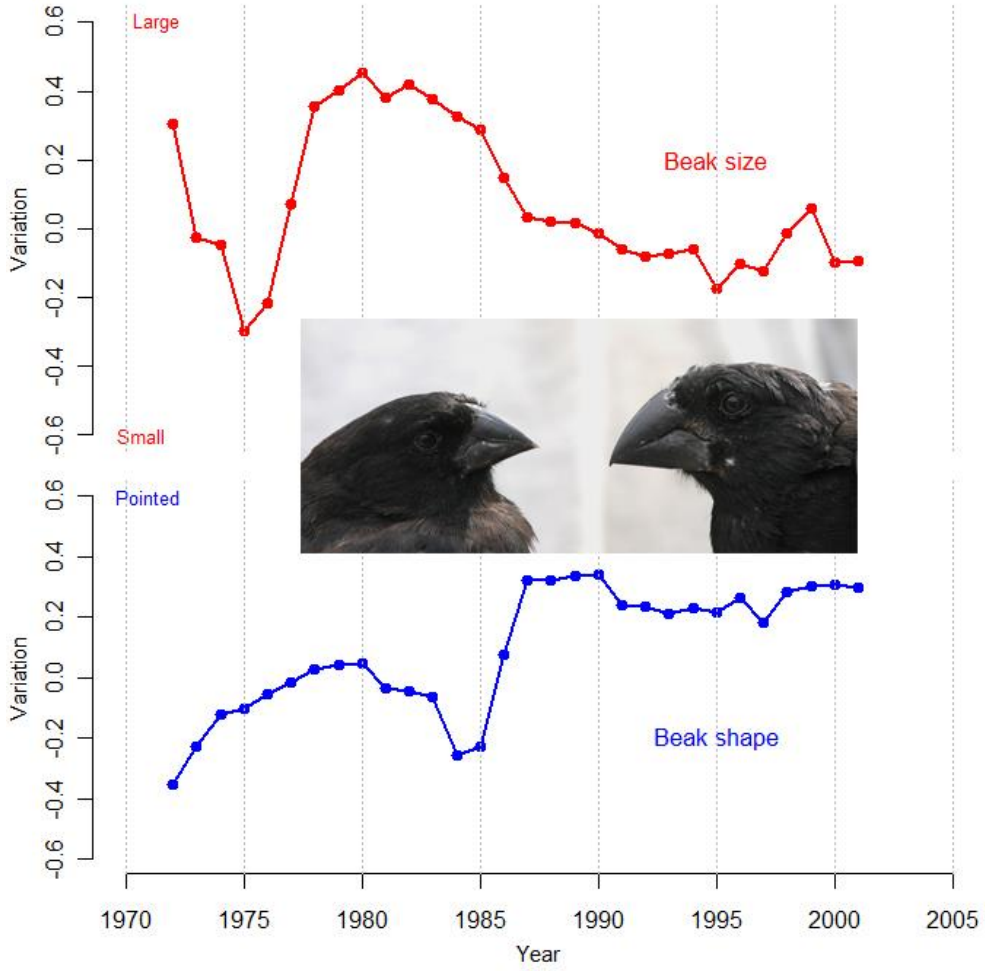
Ex. Galapagos Finches

Grant and Grant: Studied the finch population on an isolated island in the Galapagos.

Measured the beak dimensions of all birds on the island every year for decades.



Connected changes in beak dimensions to fluctuations in the environment (precipitation, seed sizes)



Evolution Misconception Alert!

Misconception: Individuals evolve.

Evolution is a "population level" phenomenon. Individuals DO NOT evolve!

The evolution of a population emerges from the individual fitness of members of that population.

As they survive and reproduce or not, the frequencies of alleles in the next generation will change accordingly.

1. How Natural Selection Works.

1.2: Natural selection acts on phenotypic variations in populations.

Genotype

The alleles that an individual has for a particular trait.

2 Types:

Homozygous: Two copies of the same allele.

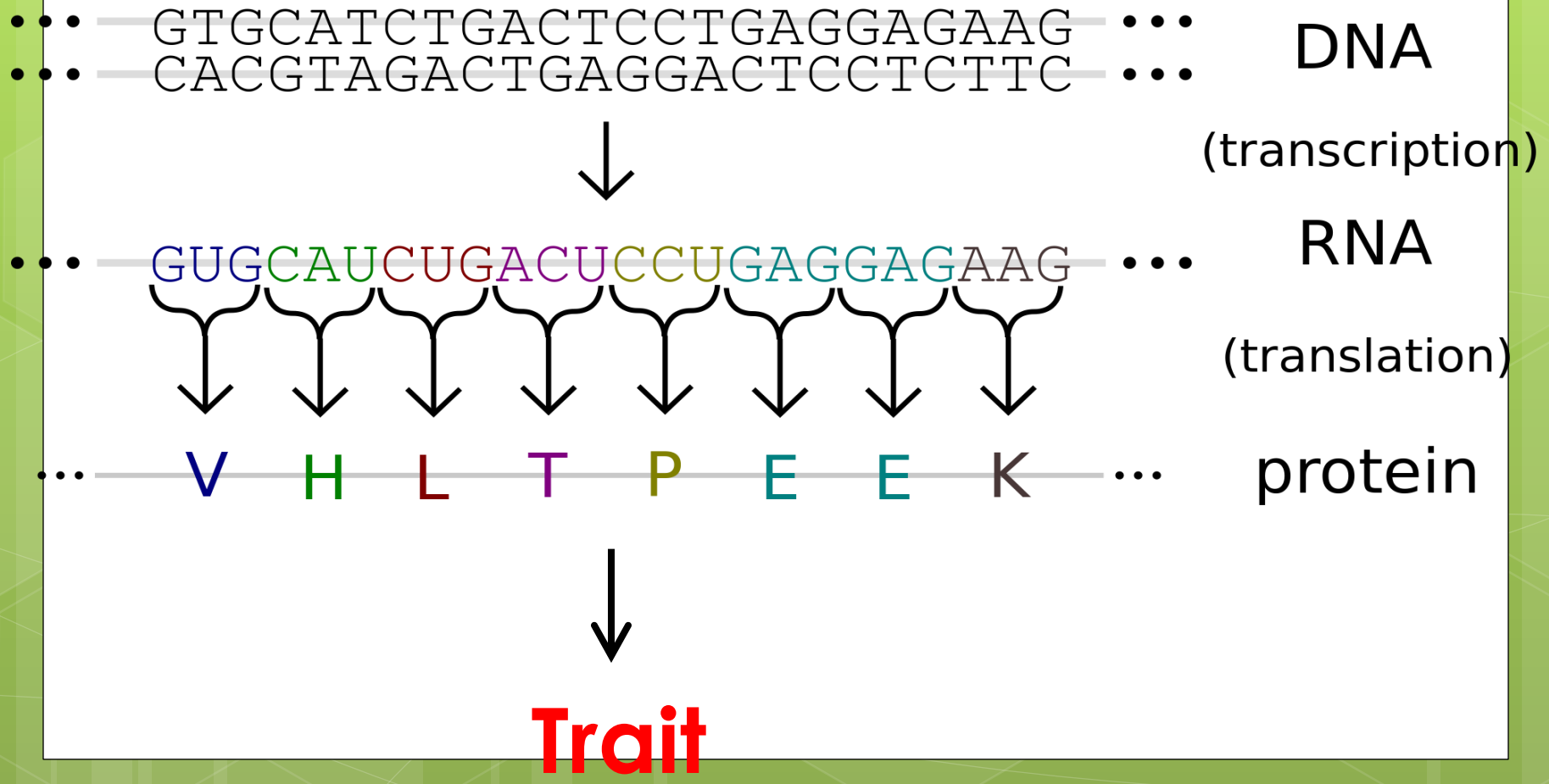
Heterozygous: Two copies of different alleles for each trait.

Phenotype

The trait that an individual shows.

Genotype determines Phenotype!

Alleles control the production of proteins and proteins determine traits.



Dominant & Recessive

Some alleles ("**dominant**") will control phenotype over other alleles ("**recessive**") when both are present.

Ex. Eye color (simplified)

Two alleles: B (dominant) and b (recessive)

Two phenotypes: Brown eyes and blue eyes

Eye Color Genetics:

3 possible genotypes:

BB Bb

bb

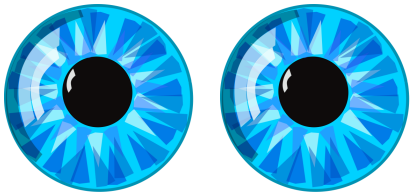
Homozygous **Heterozygous**

Homozygous

Dominant

Recessive

2 possible phenotypes:



Brown eyes **Blue eyes**

Heterozygotes have **BROWN** eyes.

Misconception: Dominant = "better"

Evolution Misconception Alert!

Dominant alleles are NOT "better" than recessive alleles

Dominant and recessive have nothing to do with their effect on fitness. They only refer to how they contribute to phenotype expression.

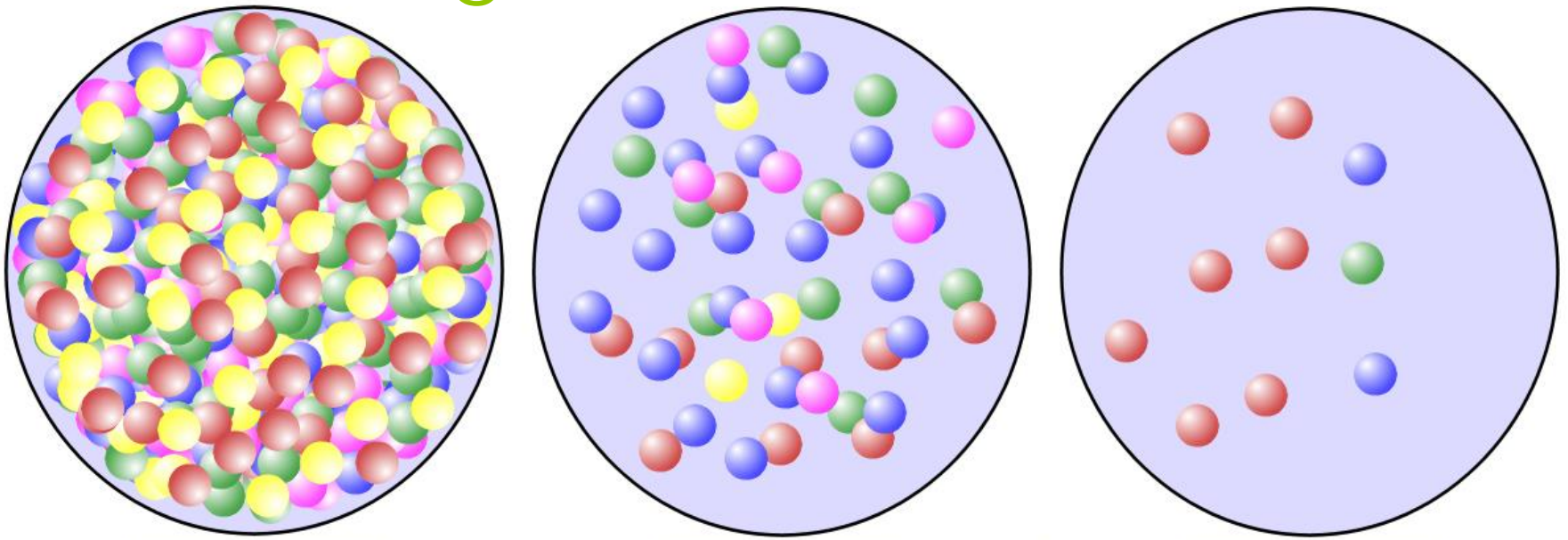
Phenotype and Fitness

Different phenotypes will be more or less fit, depending upon the requirements of the environment.

"Fitness": Ability to contribute genes to the next generation (reproduction).

The environment determines fitness.

Fitness changes with the environment



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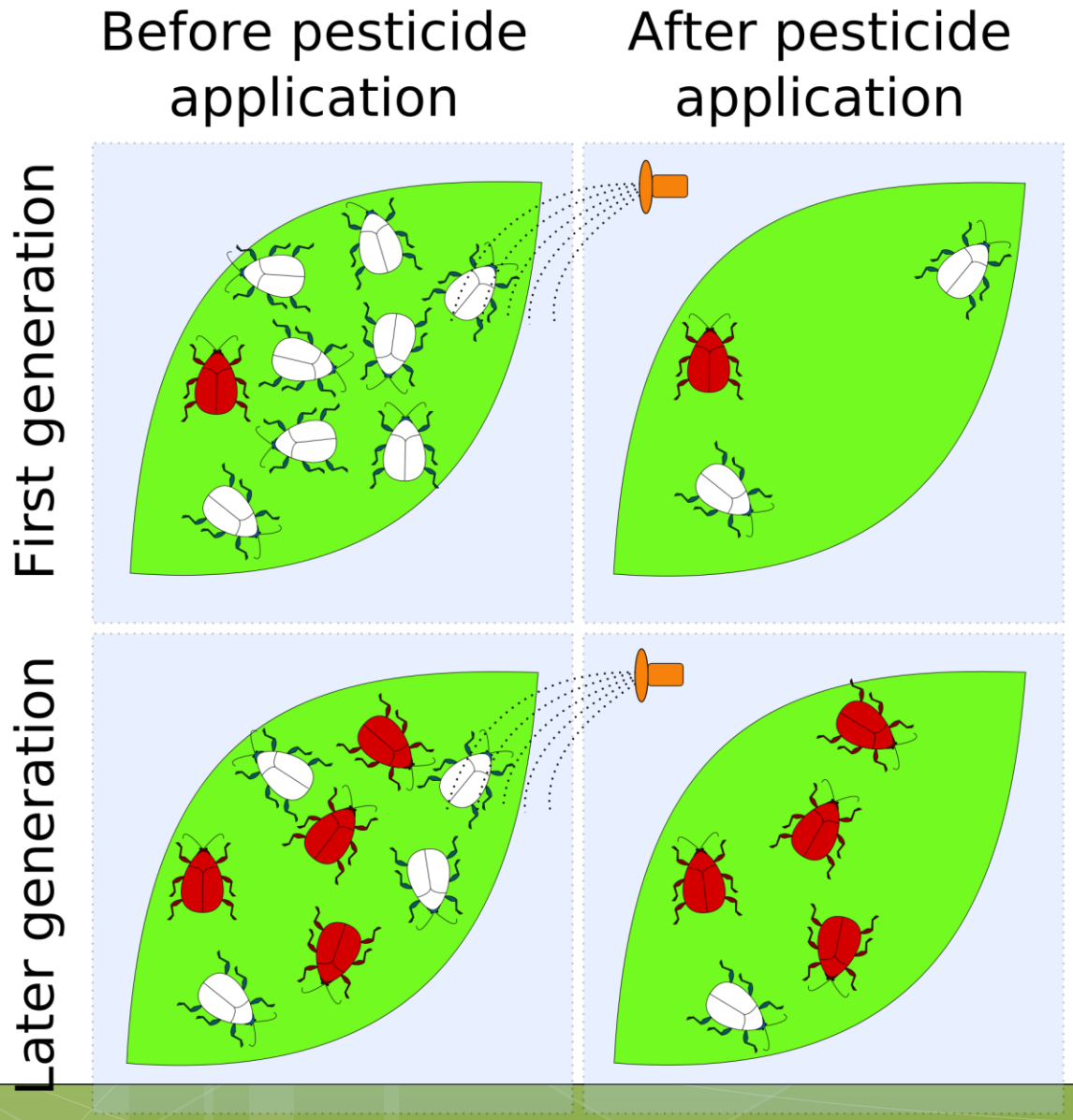
	0.14
	0.20

10th generation frequency distribution	
	0.20
	0.00
	0.10
	0.00
	0.70

Ex. Pesticide Resistance



Human Impact on Variation

Humans are able to impact variation in other organisms by controlling which individuals are able to reproduce.

Artificial selection: When reproductive success is determined by human requirements


Ex. Dog Breeds

Ex. Food Crops

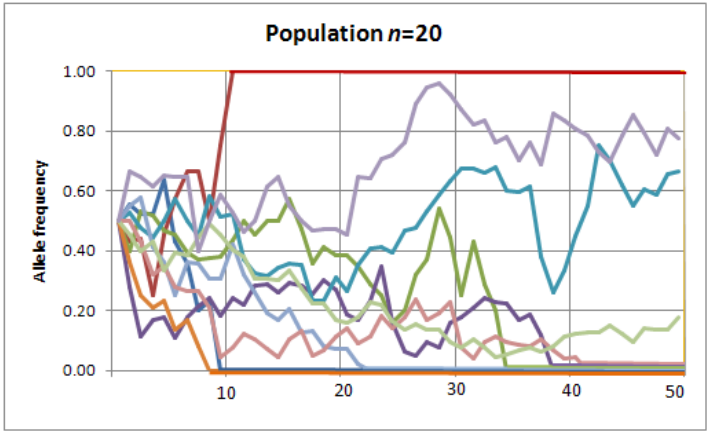
1. Other Evolutionary Forces

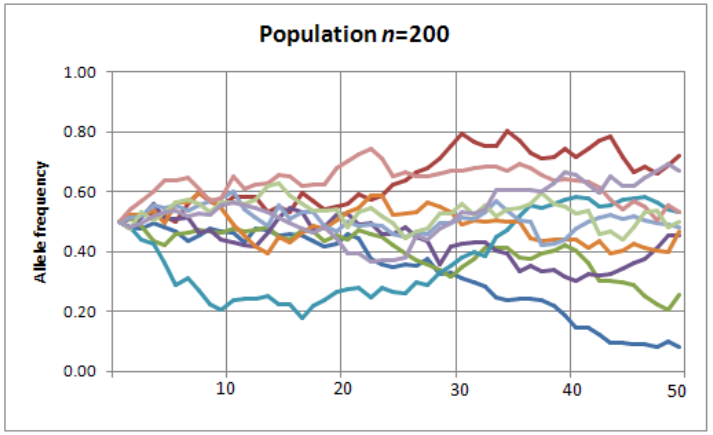
1.3: Evolutionary change is also driven by random processes.

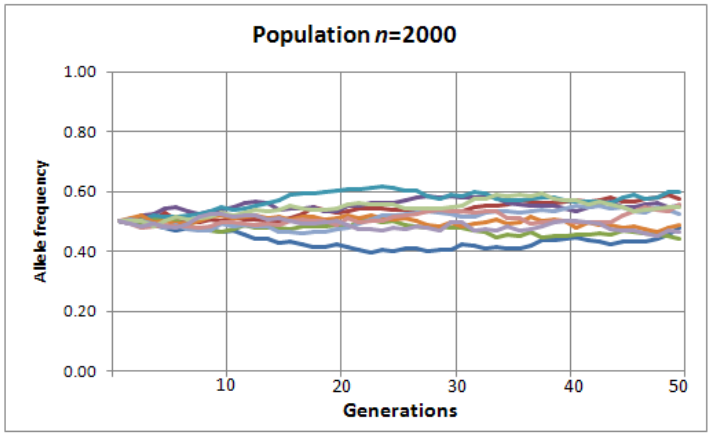
Genetic Drift

Random, non-selective, changes in allele frequency due to chance.

Has a larger effect on smaller populations, since each individual is more of the total alleles.

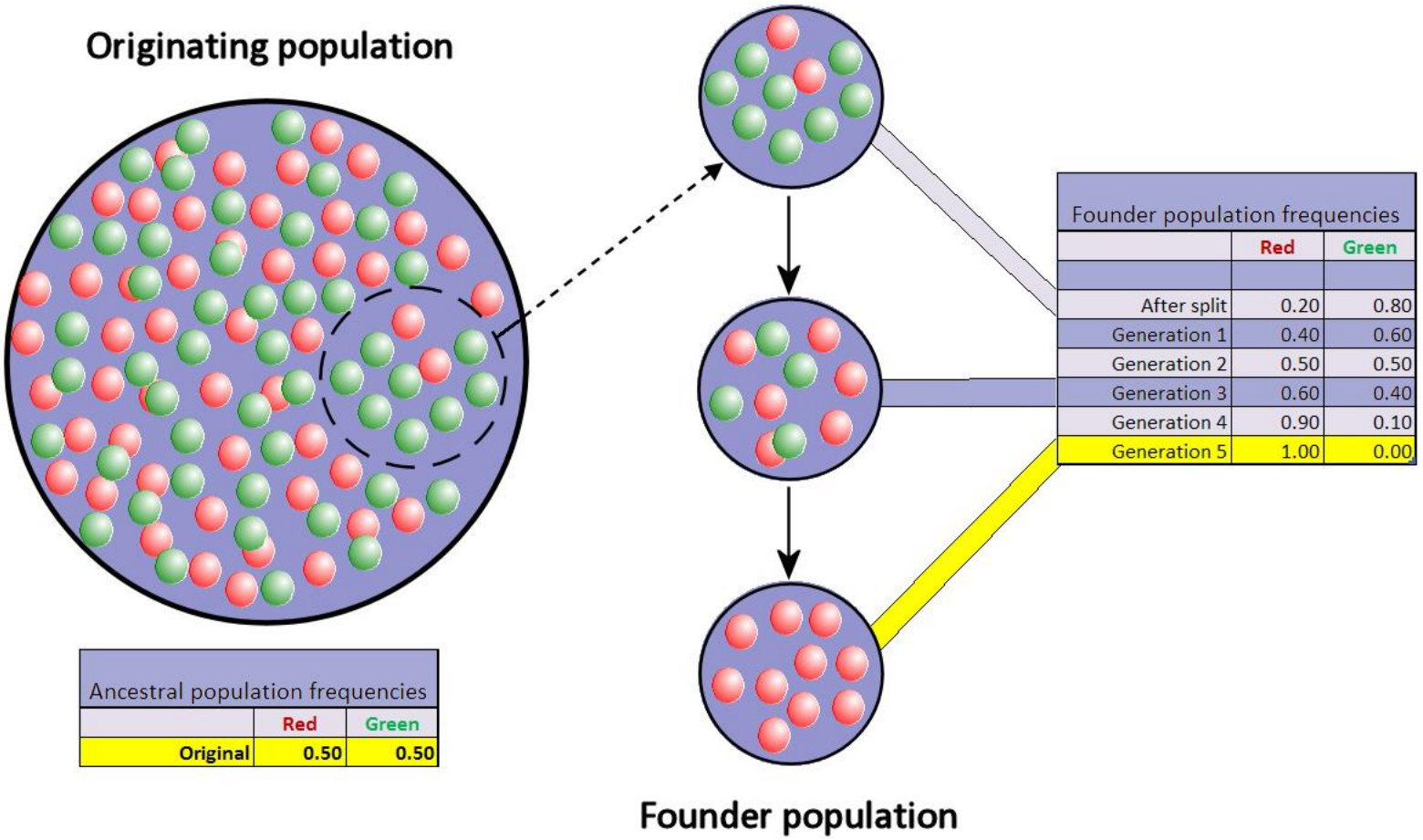






Founder Effect

The descendants of a small, founding population have different allele percentages than the population the founders came from.



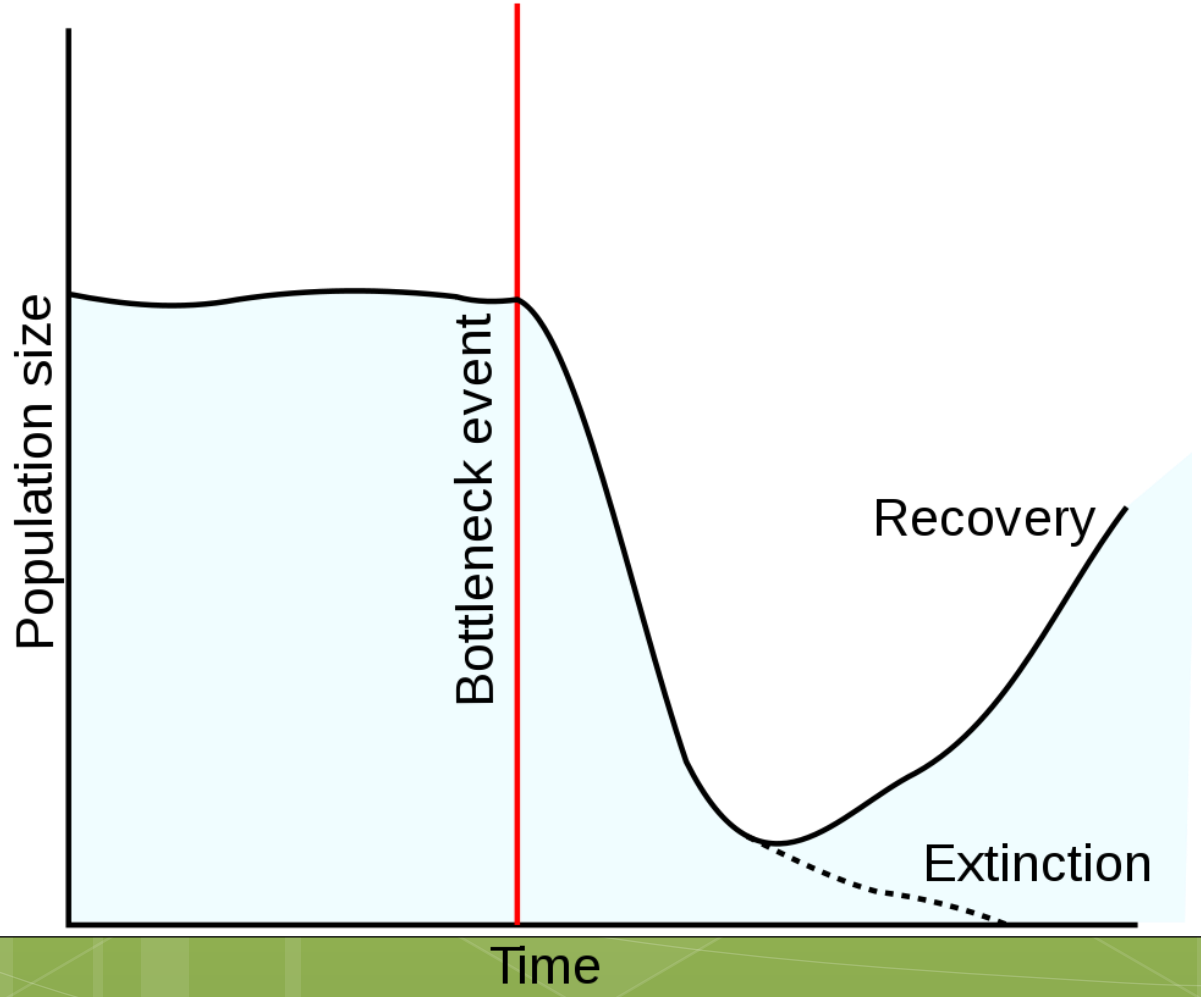
Ancestral population frequencies		
	Red	Green
Original	0.50	0.50

Founder population frequencies		
	Red	Green
After split	0.20	0.80
Generation 1	0.40	0.60
Generation 2	0.50	0.50
Generation 3	0.60	0.40
Generation 4	0.90	0.10
Generation 5	1.00	0.00

Ex. Amish Populations and polydactyly

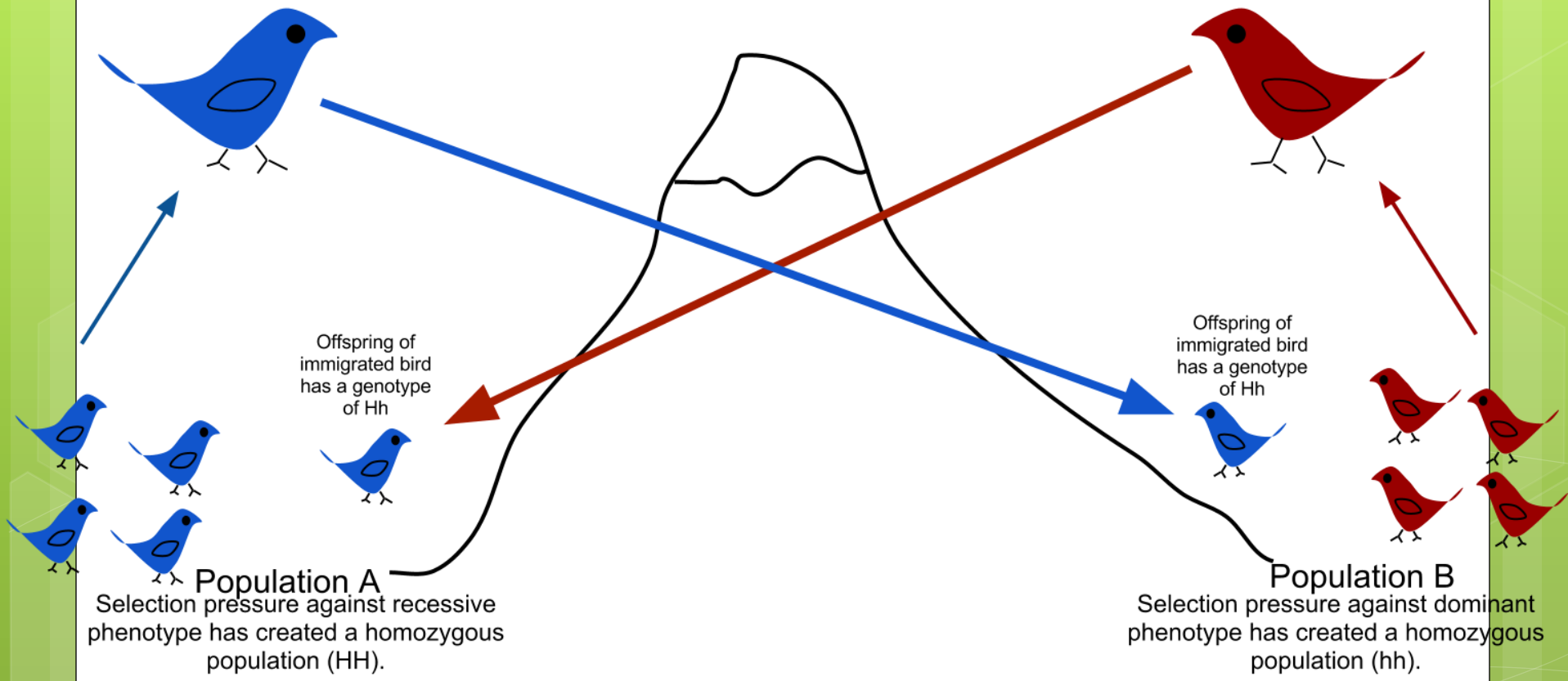
Bottleneck Effect

The survivors of a catastrophic decrease in a population may have a different allele frequency than the pre-bottleneck population



Ex. Modern Cheetahs are all genetically similar due to 2 bottlenecks

Gene Flow



Movement of alleles due to immigration and emigration

Example: Modern Human Migration

Sexual Selection

Persistence of traits that signify fitness and aid in reproduction

Ex. Peacocks are male.

Can be intersexual or intrasexual

Evolution Misconception Alert!

Misconception: Evolution is "random".

Evolution is a change in allele frequency in a population. That change involves random forces (ex. Genetic drift) and selective processes (ex. Natural selection).

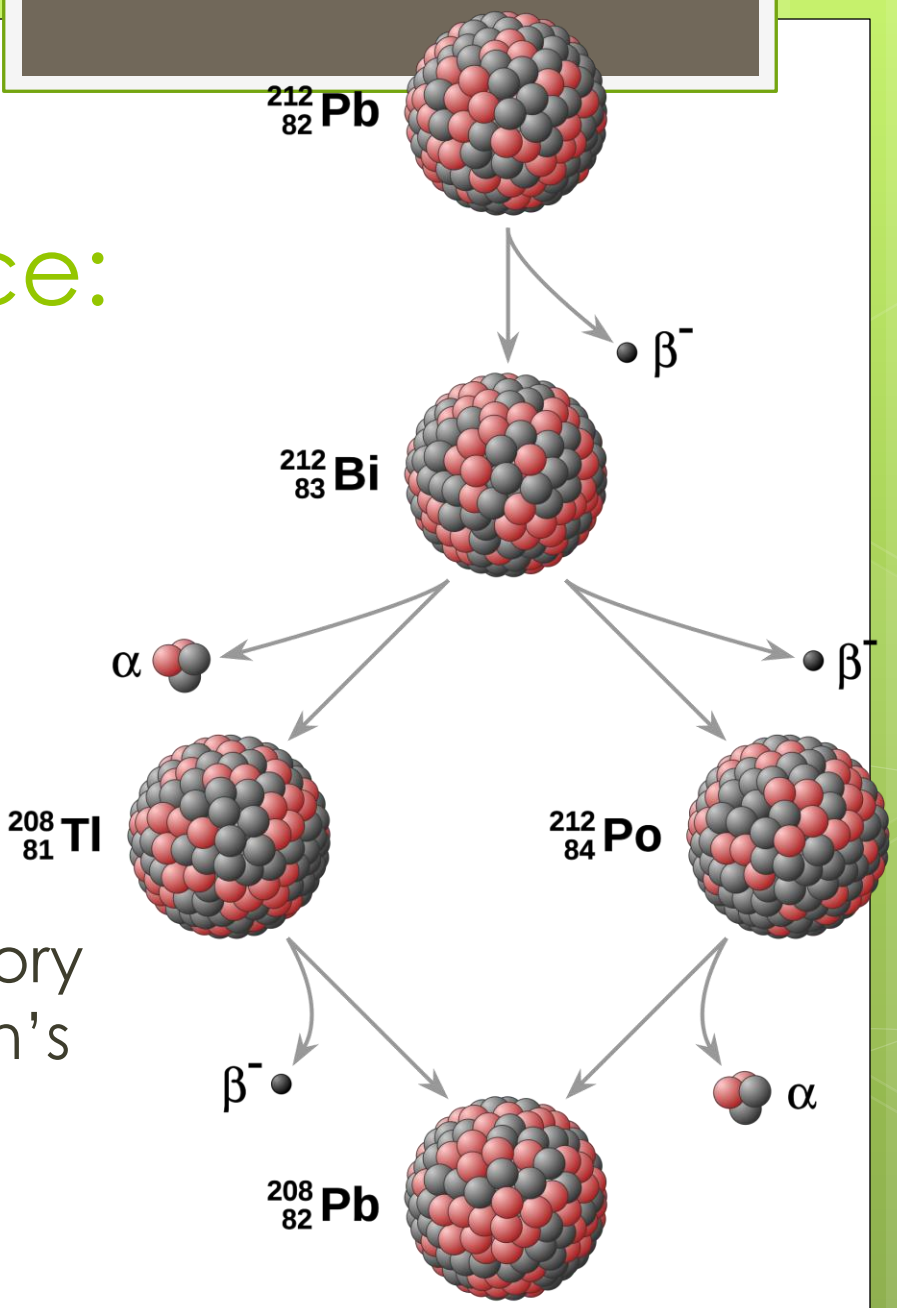
1. Evidence of Evolution

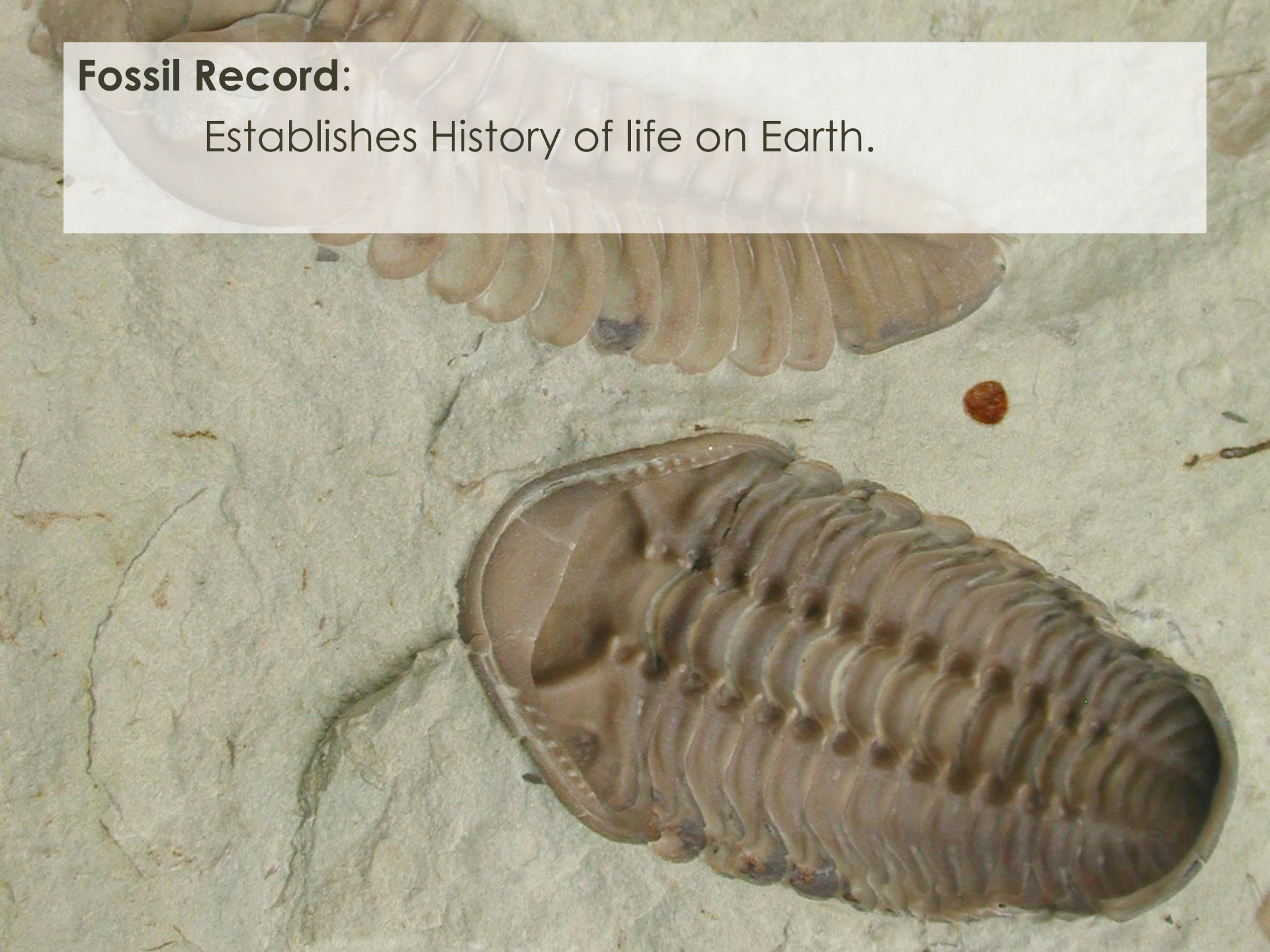
1.4: Biological evolution is supported by scientific evidence from many disciplines, including mathematics.

Geological Evidence:

Radiometric dating:
Used to date geological formations and fossils.

Establishes chronological history of Earth, and establishes Earth's age at **~4.5 billion years**.





Fossil Record:

Establishes History of life on Earth.

Living organisms resemble fossilized forms.

Transitional Fossils:

Show evolutionary progression between groups

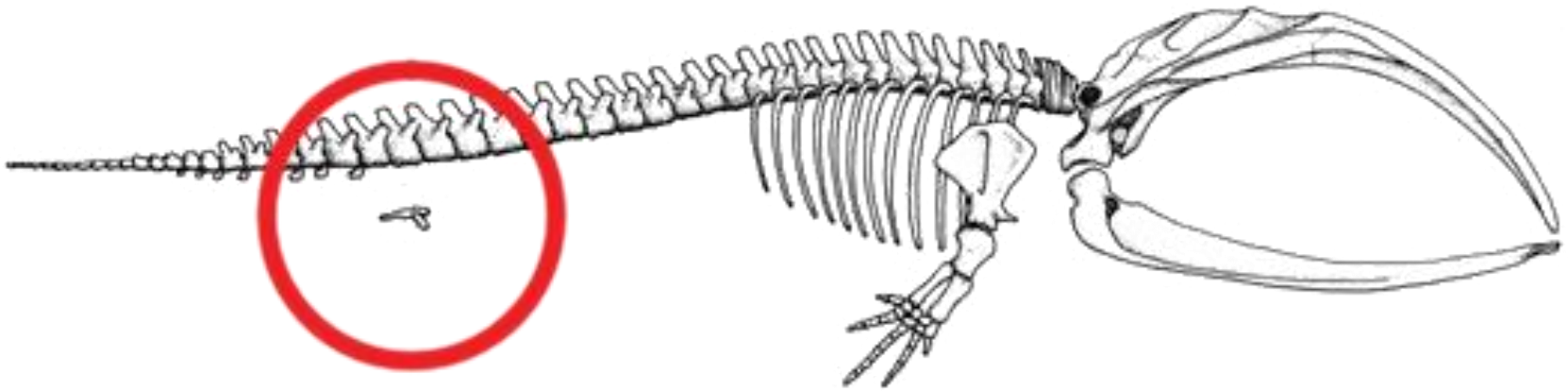
Ex. *Tiktaalik*

Anatomical Evidence

Similarities and differences in the anatomy (morphology) of organisms.

Vestigial structures: structures that have lost their primary adaptive purpose

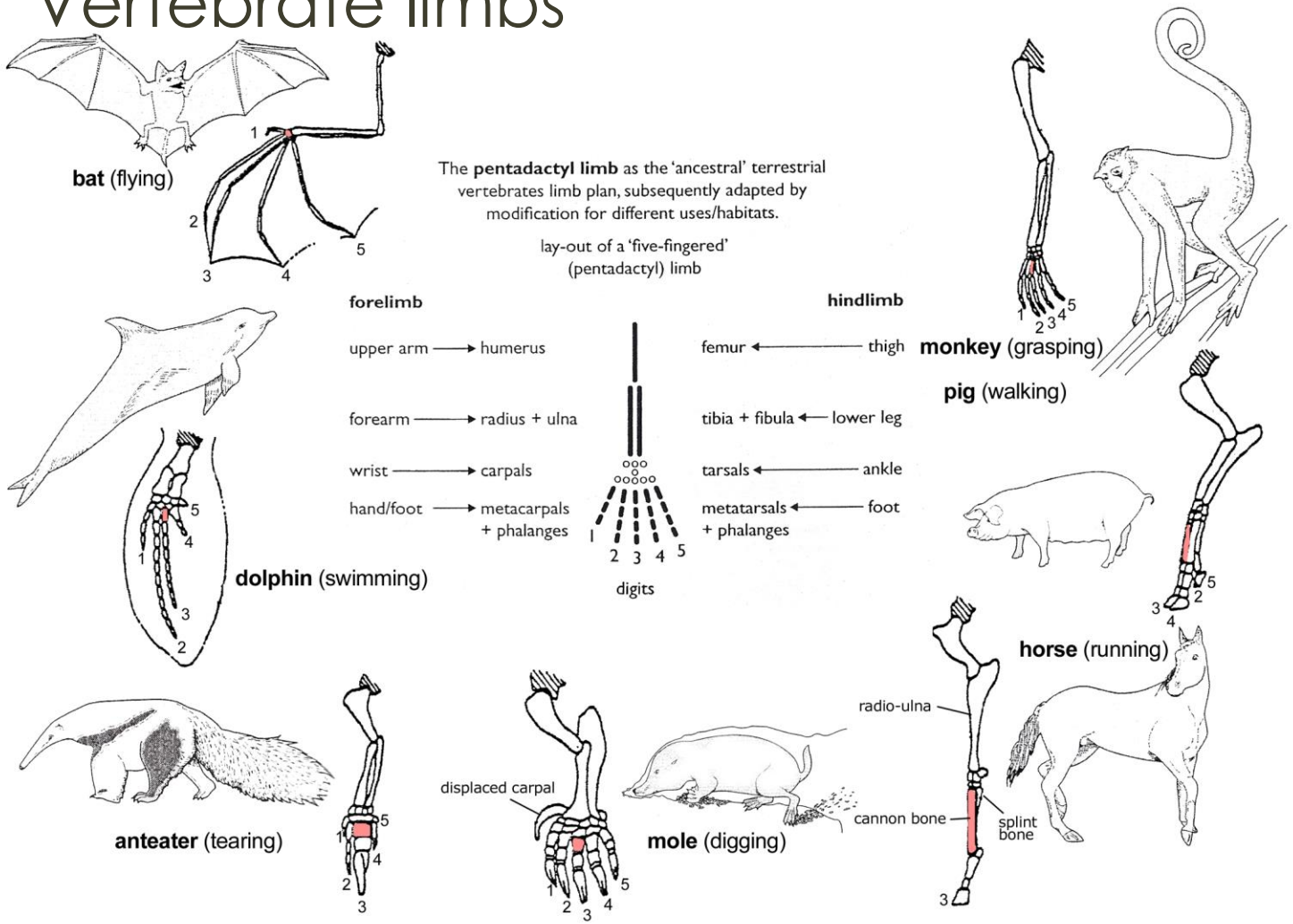
Ex. Whale hind-limbs



Homologous structures:

Structures present in a common ancestor, which have diverged during evolution.

Ex. Vertebrate limbs

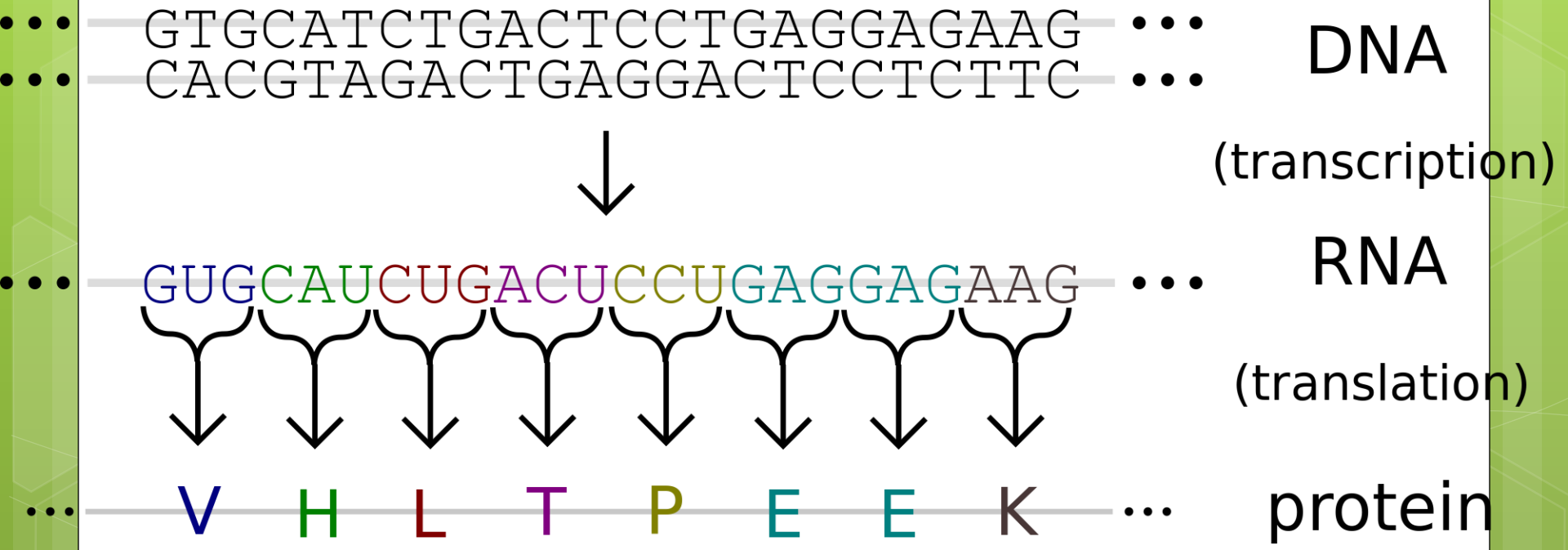


Analogous structures:

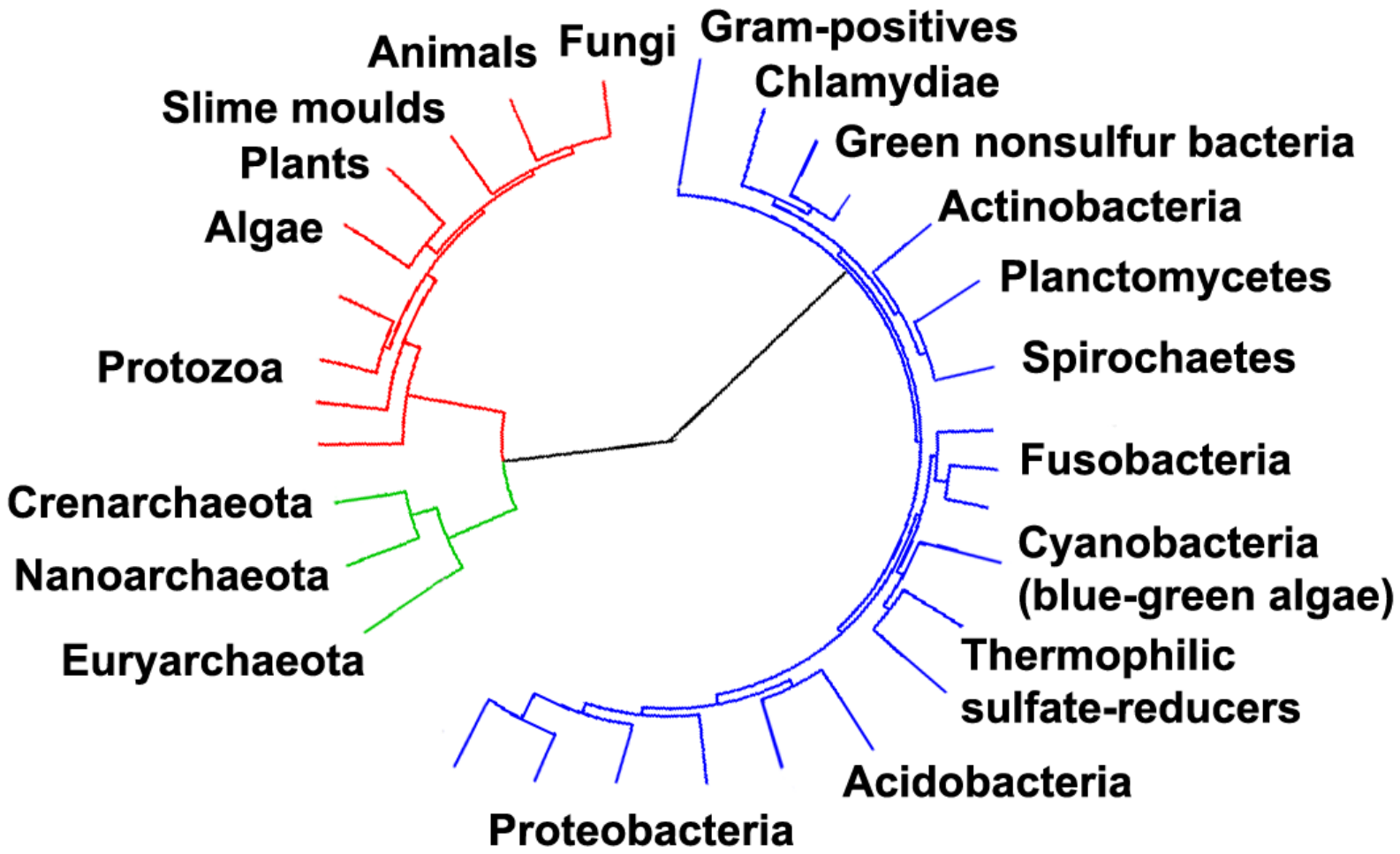
Structures that have evolved multiple times in different lineages to fill similar adaptive needs.
Ex. Wings

Chemical Evidence

Similarities and differences in DNA and protein sequences.



Chemical evidence has been used to establish the evolutionary relatedness ("**phylogeny**") of all life on Earth



Mathematical Modeling:

Computational analysis: The ability to analyze large amounts of chemical sequence data to establish evolutionary relationships among organisms.

Hardy-Weinberg Theory: The ability to quantify the amount of evolutionary change from generation to generation.

2. MATH Skills: Hardy-Weinberg Theory

1.4: Biological evolution is supported by scientific evidence from many disciplines, including mathematics.