Microevolution- Examples

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Microevolution

- Microevolution: change in gene frequency that occurs over time within a population.
- **Population genetics:** provides the mathematical structure for study of the process of microevolution.
- **Ecological genetics:** concerned with observing microevolution in the wild.
- Macro and microevolution: Both describe fundamentally identical processes on different scales.
- Microevolution: emphasizes on changes occurring *within* a species or population.
- Macroevolutionary studies: emphasizes on changes occurring at or over the level of species.

Examples of microevolution

The size of sparrow

- House sparrows: introduced to North America in 1852.
- Therafter, sparrows have evolved different characteristics in different locations.
- Sparrow populations in northern regions: larger-bodied as compared to sparrow populations in south.
- Reason: Divergence in populations is partly a result of natural selection: larger-bodied birds survive lower temperatures than birds having smaller bodies.
- Colder weather in the north probably selects for larger-bodied birds.
- Result: sparrows in cold places are now generally larger than sparrows in warm areas.

Evolving resistance

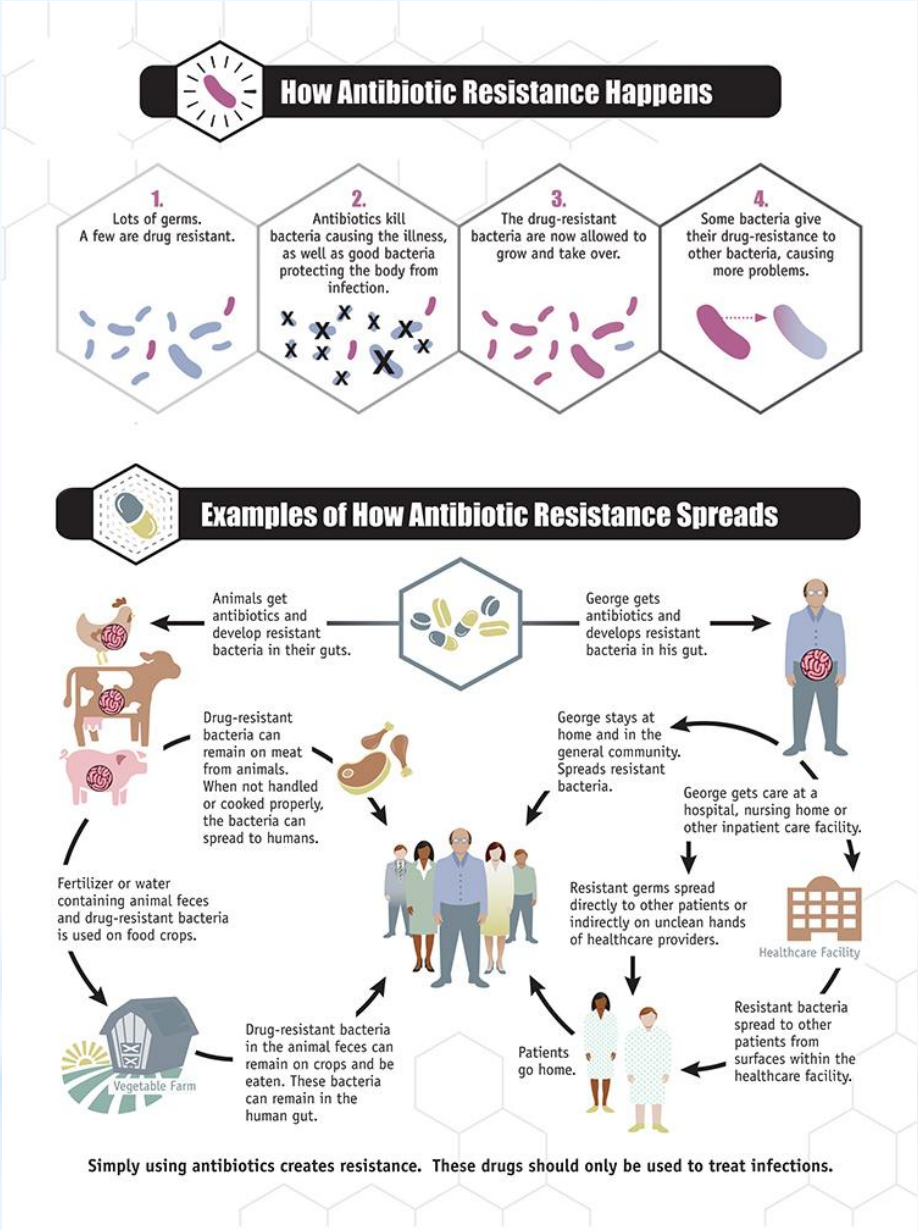
- Science has documented many examples of the evolution of resistance:
  - pests to pesticides
  - weeds to herbicides
  - pathogens to medicines
- All the abovementioned are cases of microevolution by natural selection.

<u>Specific examples</u>

- Insects developing resistance to Dichlorodiphenyltrichloroethane
- Hemipterans developing resistance to insecticides
- Bacteria developing resistance to antibiotics
- Viruses developing resistance to antiviral medicines

Antibiotic resistance in bacteria

- Antibiotic resistance: refers to bacteria becoming resistant to antibiotics.
- The enormous population structure and tiny generation time leads to rapid natural selection.
- In consecutive bacterial generations, novel mutations and genetic combinations are generated.
- If any of these provides resistance against a drug to which the bacteria were exposed, natural selection favors these gene variations.
- Accumulation over many generations leads to adaptability in bacteria against host defenses and resistance towards specific antibacterial agents.



A CDC infographic on how antibiotic resistance (a major type of antimicrobial resistance) happens and spreads. (Image courtesy: Wikipedia)

Mechanisms of microevolution

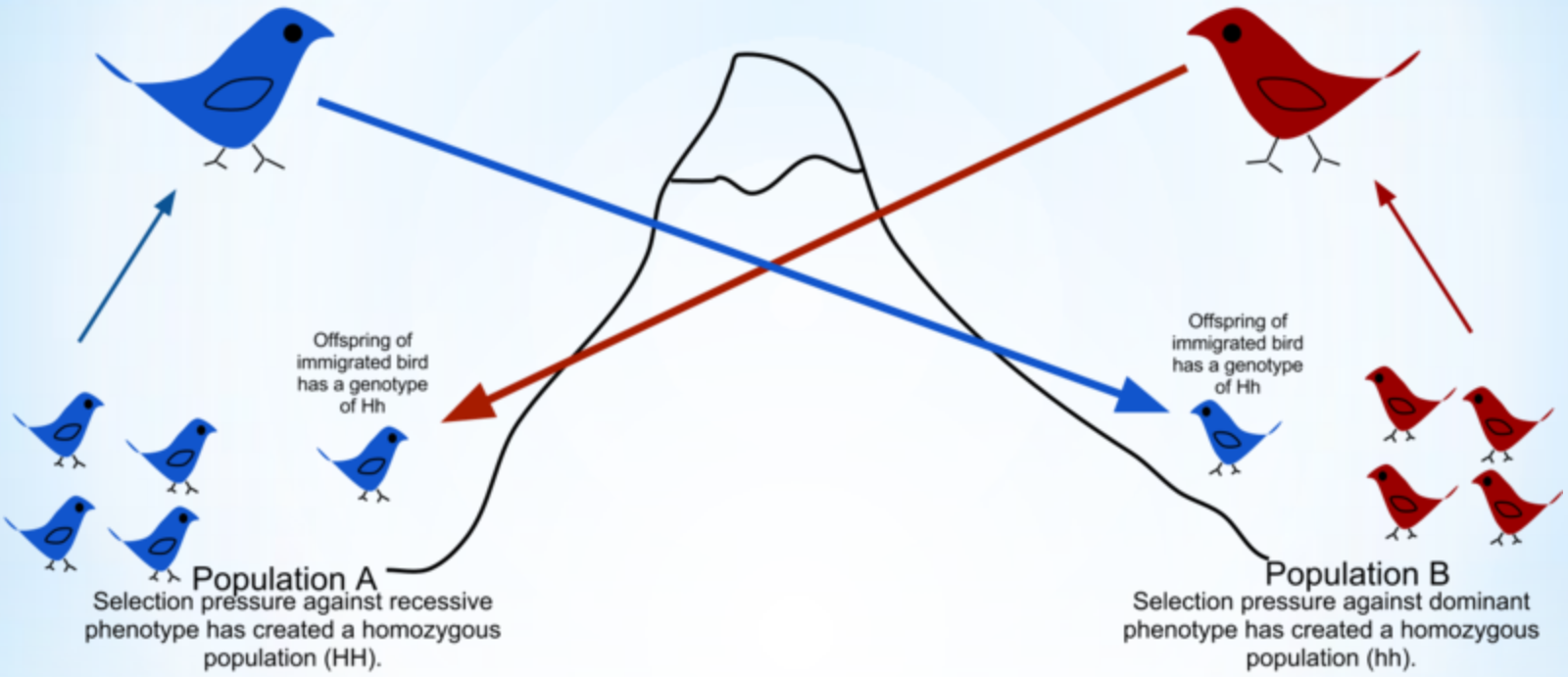
[I] Mutation

- Changes in DNA sequence; caused by irradiation, transposable elements, mutagenic agents, errors occurring replication.
- When an advantageous mutation arises spontaneously, the mutated gene can increase in frequency over generations if it confers an advantage to the organism.
- If a neutral mutation arises in a population, it can increase in population by genetic drift.
- If a deleterious mutation arises in an organism, it is likely to be selected against and will generally not increase in frequency.
- While recombination during meiosis can shuffle genes into new combinations, mutation is the only source of new genes.

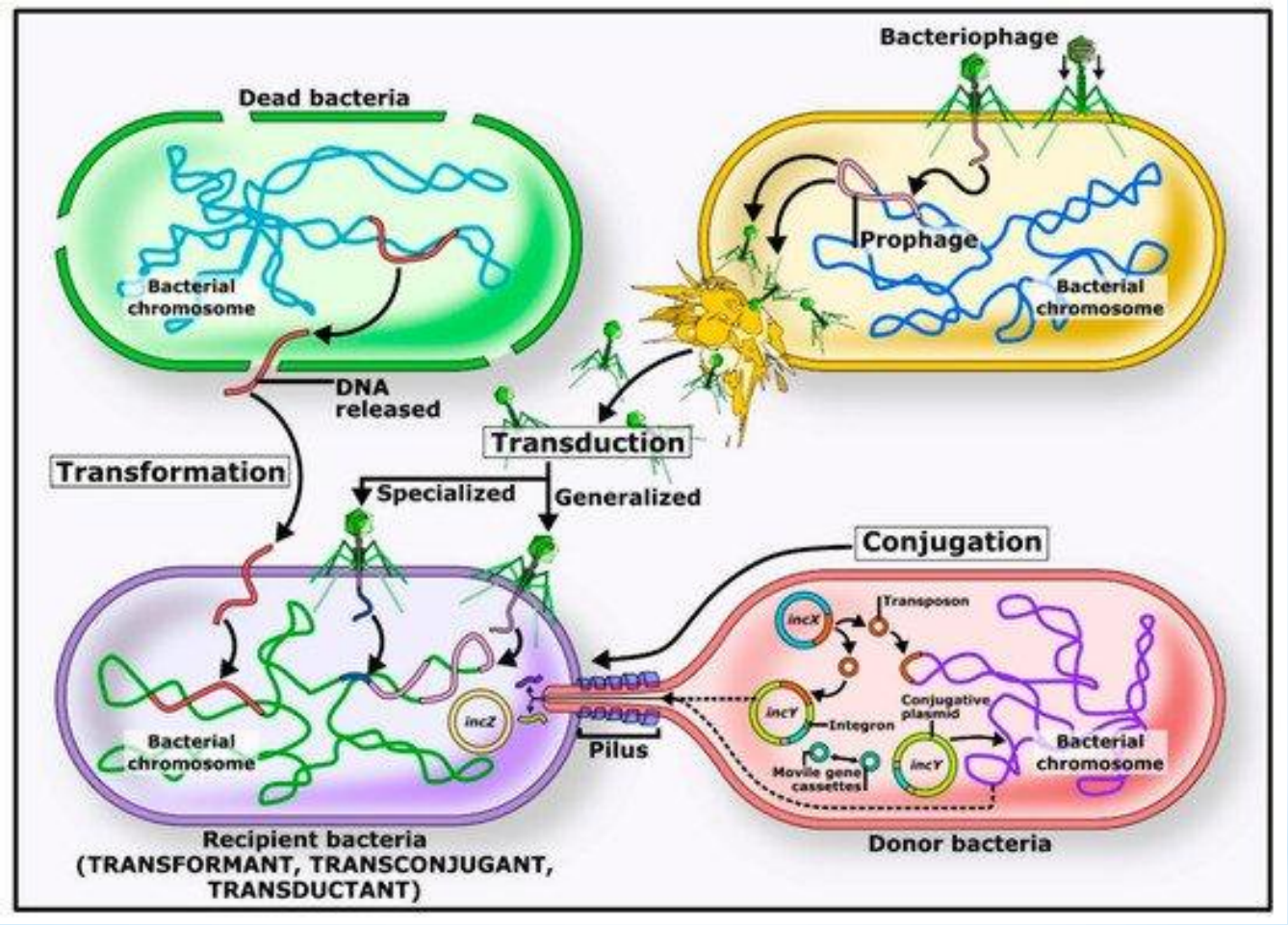
Mechanisms of microevolution

[II] Migration/Gene flow

- **Gene flow/gene migration: exchange of genetic material between populations.**
- **Intraspecific: migration and breeding of individuals.**
- **Interspecific: formation of hybrid individuals and horizontal gene transfer.**
- **Transfer of DNA between bacteria contributes to the evolution and adaptation as a result of new genes endowing resistance to antibiotics and/or metals, pathogenicity, symbiosis, and metabolism of new substrates.**



Gene flow: transfer of alleles from one population to the other through immigration of individuals. (Image courtesy: Wikipedia)



Horizontal gene transfer (Courtesy: Bello-López, et al., *Microorganisms* 2019, *7*, 363.

- Migration in and out of a population can significantly alter allele frequencies, and introduce variability into a population.
- Immigration may add new genes to the already established gene pool of a plant/animal/microbial population.
- Alternatively, emigration may alter gene pool by removing genetic material.
- Gene flow also takes place without migration. Eg: Alteration of local population during Vietnam War.
- Gene flow is hindered by
  - mountain ranges
  - oceans
  - deserts
  - man-made structures such as the Great Wall of China

Mechanisms of microevolution

[III] Genetic drift

Allelic drift *or* ***Sewall Wright effect***

- Alteration in the frequency of an existing allele in a population that takes place due to random sampling.
- Mechanism in which allele frequencies are altered from 1 generation to the next due to chance.
- Occurs in all populations but the effects are remarkable in miniscule populations.
- Result: loss of both beneficial and harmful alleles; **fixation**, or rise of other alleles.
- Genetic drift can have major effects:
  - **bottleneck effect**

    or
  - **founder effect**.

Mechanism of Genetic drift

Courtesy- https://evolution.berkeley.edu/evolibrary/article/evo_24

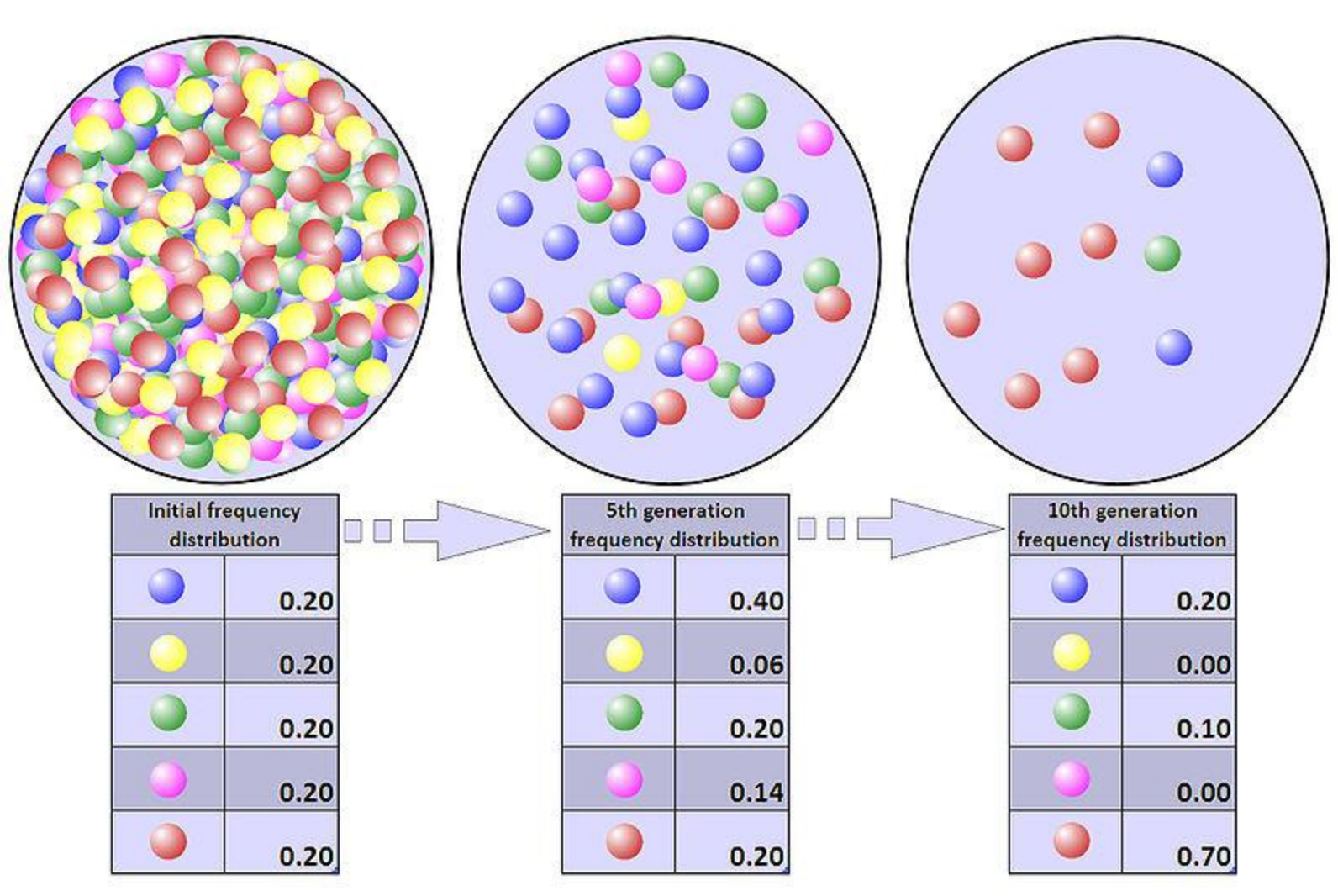
The Bottleneck Effect

- **Bottleneck effect:** ***extreme example of genetic drift that happens when the size of a population is severely reduced*****.**

- **Events like natural disasters (earthquakes/ floods/ fires) can drastically reduce a population, killing most individuals and leaving behind a small, random assortment of survivors.**

- **The allele frequencies in this group are bound to vary from those of the population prior to the event, and some alleles may be entirely lost.**

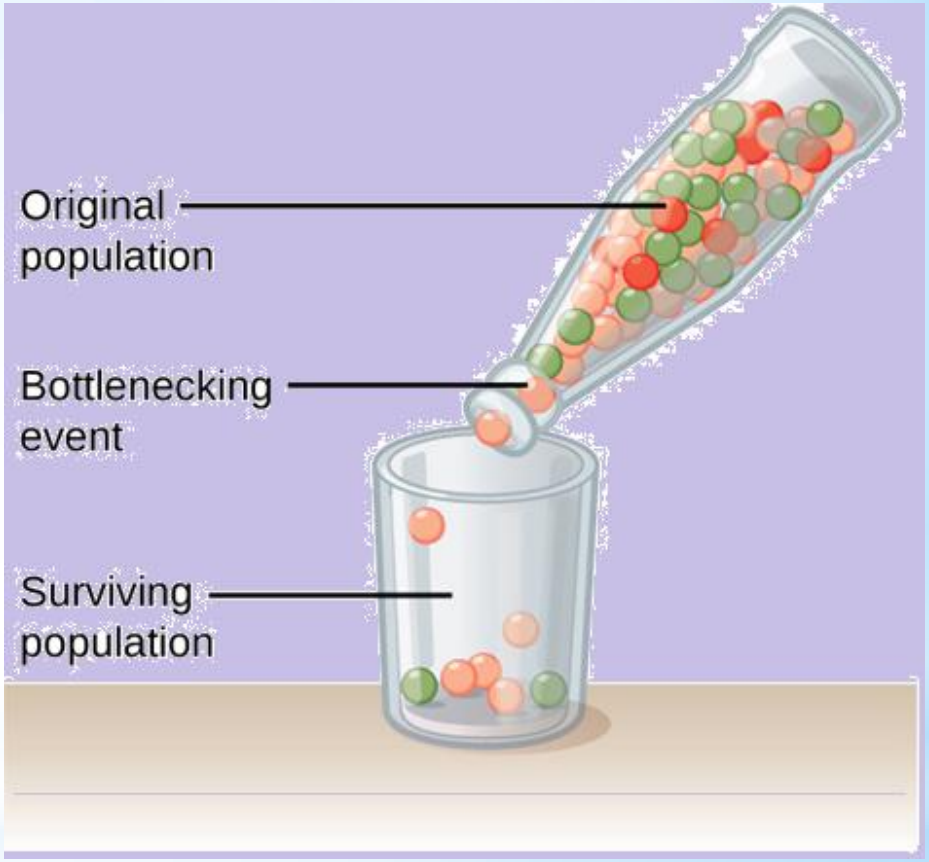
- **The smaller population will also be more susceptible to the effects of genetic drift for generations.**



Population bottleneck. (Image courtesy: Wikipedia)

How does bottleneck event reduce genetic diversity?

- Consider a bottle filled with small balls.
- Small balls: individuals in a population.
- When a bottleneck occurs: only some individuals survive and pass into the glass, while bulk of the population is destroyed.
- Result: Genetic composition of the population changes and the new population contains alleles of individuals that have escaped extermination.

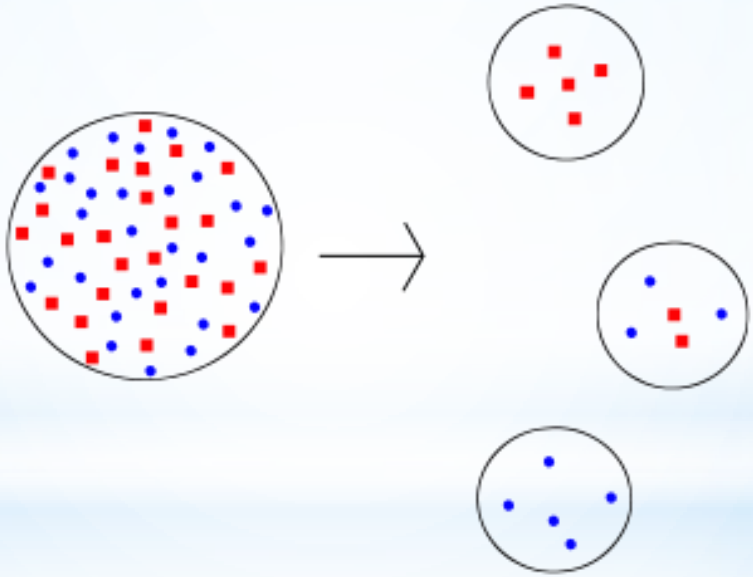


The founder effect

- Concept outlined by Ernst Mayr in 1942.
- Loss of genetic variation that takes place when a new population is established by a miniscule number of individuals from a larger population.
- **Founder mutation:** a mutation appearing in the genetic material of one or more individuals which are founders of a distinct population.
- Takes place when a small group of individuals breaks off from a larger population to establish a colony.
- New colony is isolated from the original population, and founding individuals may not represent the full genetic diversity of original population.

- Result: alleles in the founding population may be at different frequencies than in the original population, and some alleles may be missing.

- Similar in concept to the bottleneck effect, but it occurs via a different mechanism (colonization rather than catastrophe).

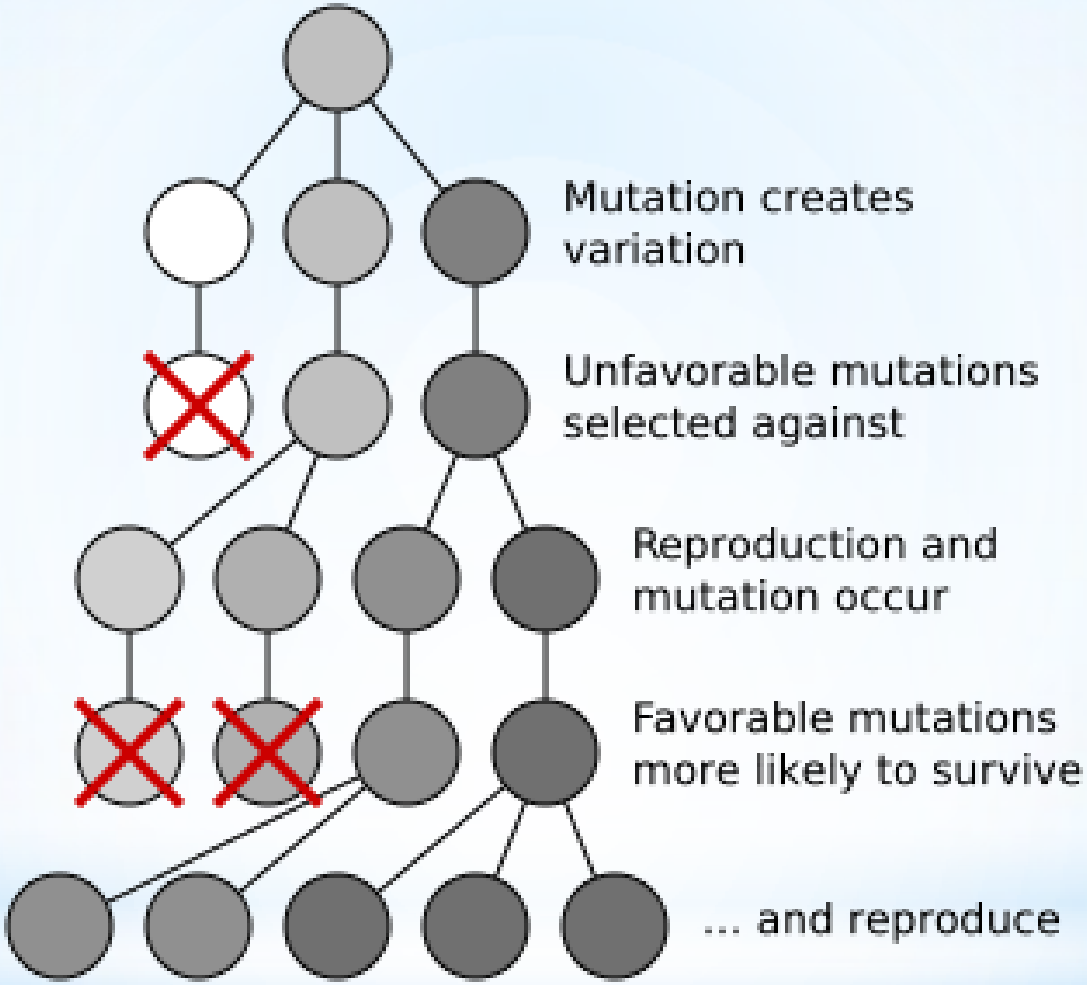


Founder effect: The original population (left) could give rise to different founder populations (right). (Image courtesy: Wikipedia)

Mechanisms of microevolution

[IV] Natural selection

- Process by which populations of living organisms adapt and change.
- Individuals in a population are naturally variable.
- Natural selection can lead to speciation: one species gives rise to a new and distinctly different species.
- NS is an important process driving evolution and helps to explain the diversity of life on Earth.
- Darwin chose the name natural selection to contrast with “artificial selection,” or selective breeding that is controlled by humans.
- This process like artificial selection occurred in nature without any human intervention.
- Darwin’s concept of natural selection explained how a wide variety of life forms developed over time from a single common ancestor.



Natural selection of a population for dark coloration. (Image courtesy: Wikipedia)

Summary

- Genetic drift does not depend on an allele's beneficial/harmful effects.
- Genetic drift changes allele frequencies purely by chance.
- Every population experiences genetic drift, but in small populations the effect is observed more strongly.
- Genetic drift: does not take into account an allele's adaptive value to a population, and it may result in loss of a beneficial allele or fixation of a deleterious allele in a population.
- Founder effect and Bottleneck effect: cases in which a small population is formed from a larger population.
- These "sampled" populations rarely represent the genetic diversity of the original population, and their small size means they may experience strong drift for generations.

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Thank you