- Chapter 23
  The Evolution of Populations

Essential Knowledge

- 1.A.1 – Natural selection is a major mechanism of evolution
- 1.A.2 – Natural selection acts on phenotypic variations in populations
- 1.A.3 – Evolutionary change is also driven by random processes
- 1.A.4 – Biological evolution is supported by scientific evidence from many disciplines, including mathematics
- 3.C.1 – Changes in genotype can result in changes in phenotype

Evolution of Populations

- Population = a group of individuals in the same species that live in the same area and interbreed
- Gene pool = all of the alleles in the members of a population
  - A diverse gene pool is important for the survival of a species in a changing environment
  - Diploid organisms have 2 alleles for a gene
  - Homozygous dominant (AA), Heterozygous (Aa), and Homozygous recessive (aa)

Phenotypic Variation

- Environments change and act as selective mechanisms on populations
  - As environments become stable or fluctuating, this affects evolutionary rate and direction. Different genetic variations can be selected in each generation
- Phenotypic variations are not directed by the environment but occur through random changes in DNA and through new gene combinations

Phenotypic Variation

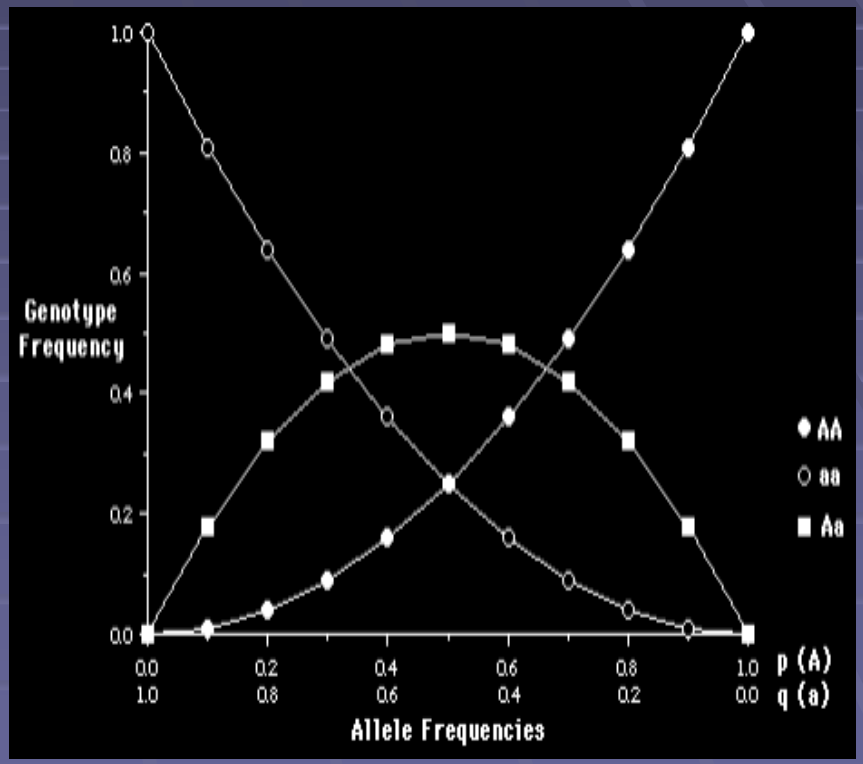
- Some phenotypic variations significantly increase or decrease fitness of the organism and the population
- Humans can impact variation in other species

  - **How have humans impact variation?**

Hardy-Weinberg Theorem

- *Serves as a model for the genetic structure of a non-evolving population* (equilibrium)

- <u>5 conditions for equilibrium:</u>
  1. Very large population size
  2. No migration
  3. No net mutations
  4. Random mating
  5. No natural selection



Hardy-Weinberg Equation

- p = dominant allele
- q = recessive allele

- For allele frequencies: p + q = 1 (or 100% of the population)

- For genotypic frequencies:

$p^2 + 2pq + q^2 = 1$

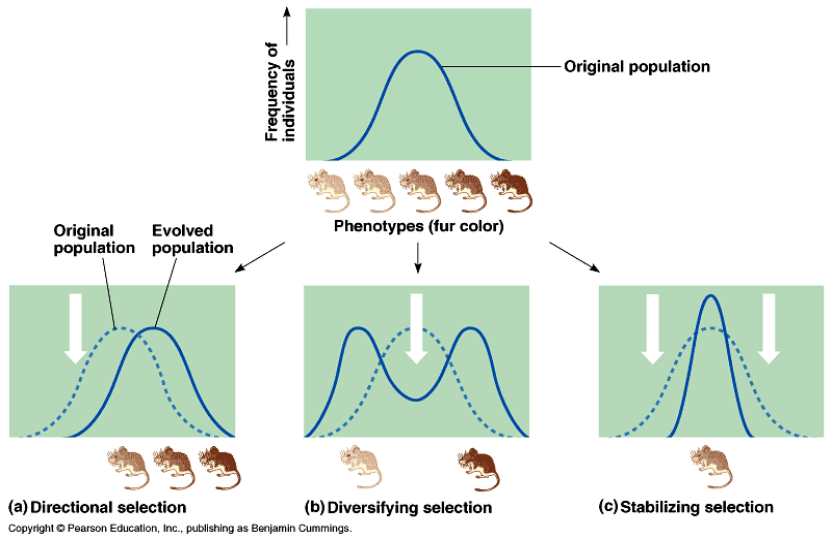
AA + Aa + aa = 1

Causes of Evolution / Changes in Allele Frequencies

1) Natural Selection:

- Results in alleles being passed to the next generation in proportions different from their relative frequencies in the present generation

- Fitness: *contribution an individual makes to the gene pool of* the next generation

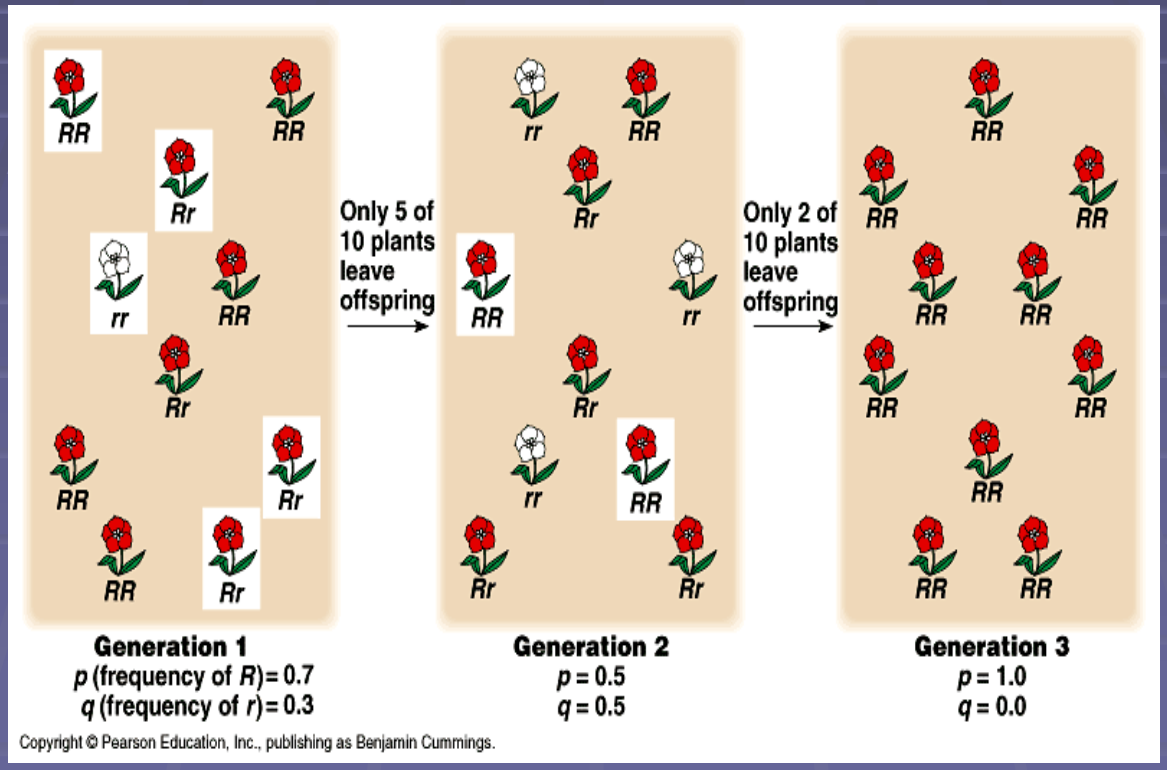


Survival of the “Fit Enough”

- Selection can only operate on the available genetic variation – can only edit
- Constraints due to history - genes predetermine body formation and development
  - You can only work with what you have at the time
- Adaptations are often compromises – as a body part gets bigger or faster it might bring some problems with it
- Chance, natural selection, and the environment interact

Causes of Evolution

2) Genetic drift: unpredictable, nonselective changes in the gene pool (usually reduces genetic variability)

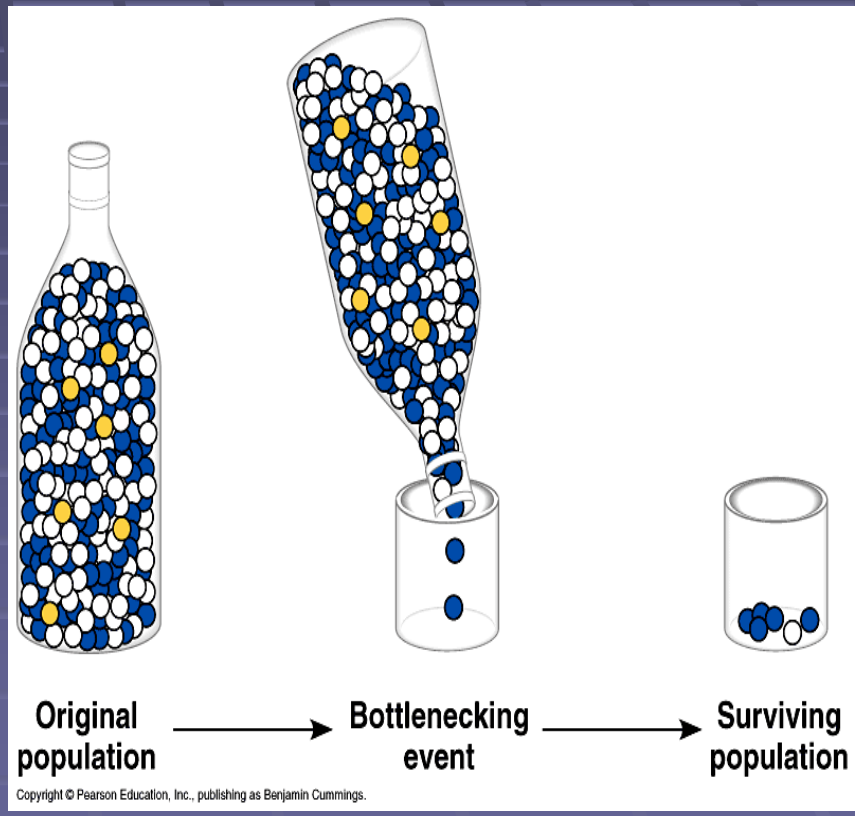


- Small population → greater the chance for genetic drift
- Allele frequencies can change at random
- Can lead to loss of genetic variation within a population
- Can cause harmful alleles to become fixed

- **Reduction of genetic variation within a given population can INCREASE the differences between populations of the same species**

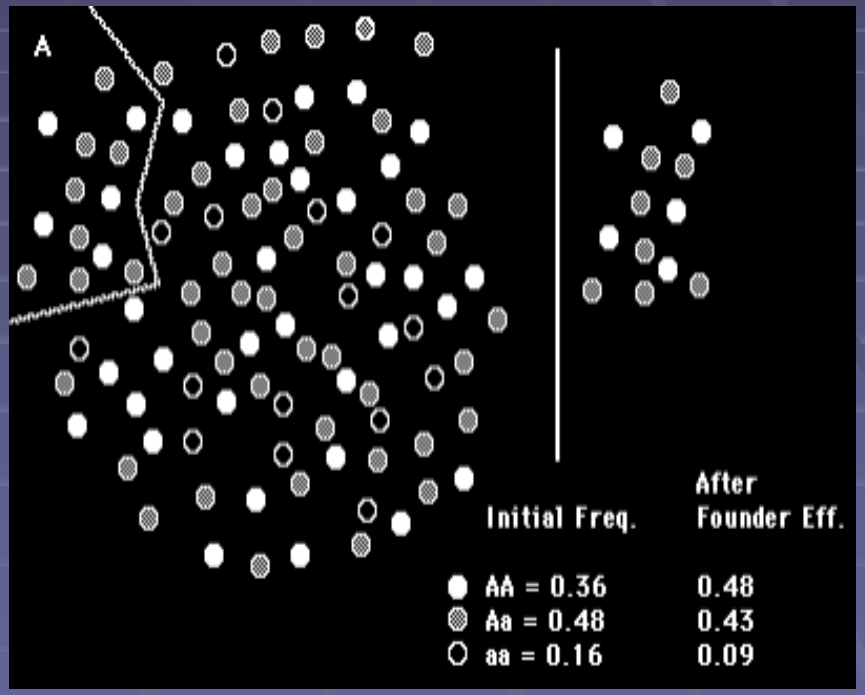
Examples of Genetic Drift

- The Bottleneck Effect:
  - Sudden change in the environment causes drastic reduction in population (natural disaster)
  - Surviving population is no longer genetically representative of the original population



Examples of Genetic Drift

- Founder Effect:
  - Isolation of a small group and establishment of a new population whose gene pool is not reflective of the source population
  - Ex: moving to an island



Causes of Evolution

3) <u>Gene Flow</u>:

- Genetic exchange due to the migration of fertile individuals or gametes between populations
- Tends of **REDUCE** the genetic differences between populations resulting in more similar populations

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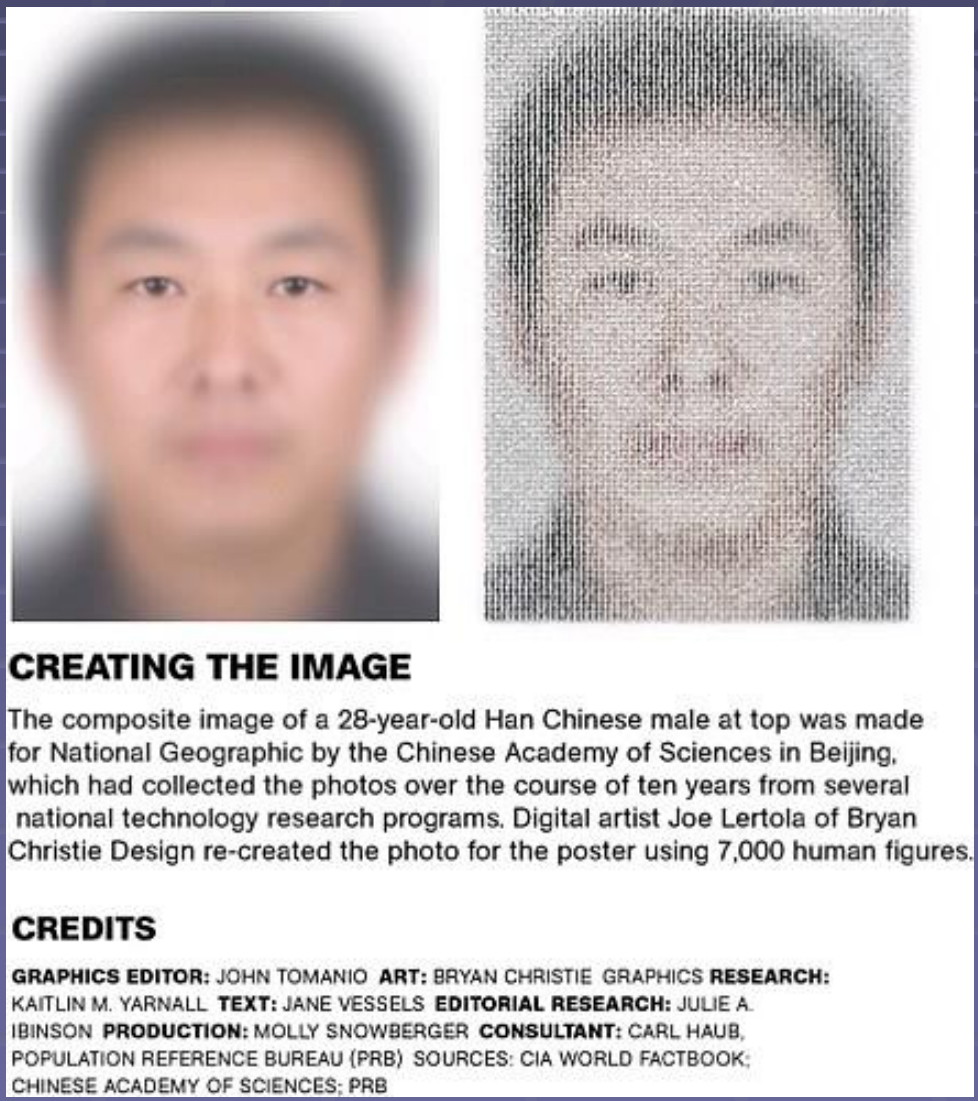
Gene Flow

- Most Common Face Video



CREATING THE IMAGE

The composite image of a 28-year-old Han Chinese male at top was made for National Geographic by the Chinese Academy of Sciences in Beijing, which had collected the photos over the course of ten years from several national technology research programs. Digital artist Joe Lertola of Bryan Christie Design re-created the photo for the poster using 7,000 human figures.

CREDITS

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Sources of Variation

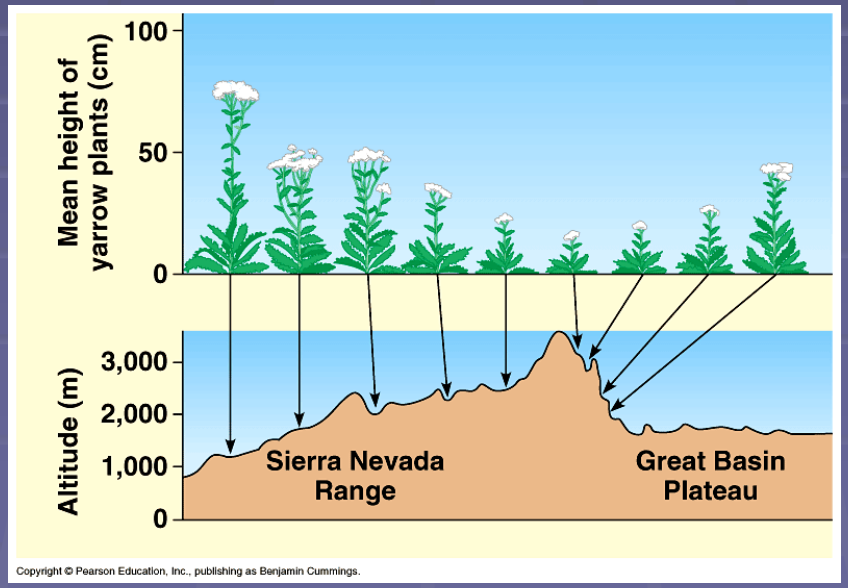
- **Mutations – change in DNA**
  - Only source of new genes and new alleles
  - Can be positive, negative, or neutral based on the environmental context

Sources of Variation

- Sexual recombination of alleles – how most of the variation occurs in a population
  - **Crossing over** – during meiosis
  - **Independent assortment** – random alignment of chromosomes in meiosis
  - **Fertilization** – random sperm and egg unite

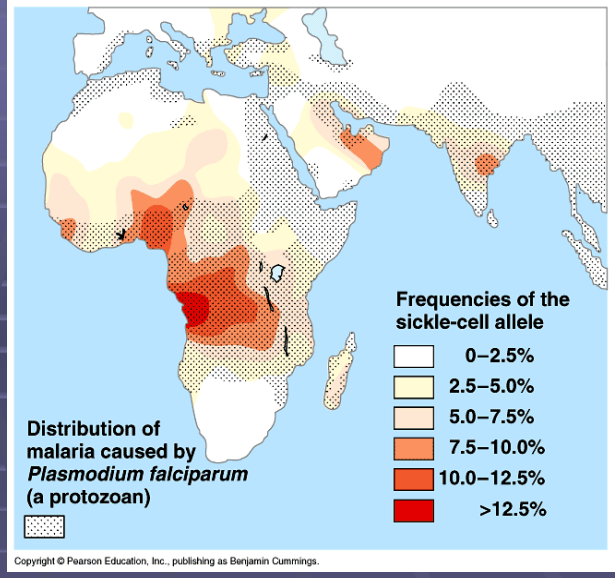
Sources of Variation

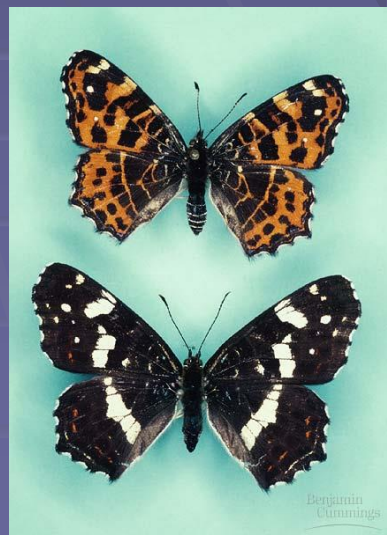
- Geographical variation: differences in genetic structure between populations
  - **Cline** = graded change in a character along a geographic axis
    - Ex: fur color in a species of rabbits from north to south



Preservation of Genetic Variation

- Balanced polymorphism = presence of 2 or more phenotypically distinct forms of a trait in a single population
  - One morph is better adapted for one area, while the other does better in a different area
  - Ex) shells of mollusks – different banding patterns





Preservation of Genetic Variation

- Outbreeding – mating of organisms that are not closely related

- Frequency-Dependent Selection – maintains variety by increasing the frequency of the less common allele
  - Due to predator-prey relationships

Preservation of Genetic Variation

- Diploidy – 2n condition that shelters a hidden gene pool of alleles
- Heterozygote advantage – hybrid state is selected for because of its increased reproductive success
  - Sickle cell anemia and malaria protection
- Evolutionary Neutral Traits – no selective value
  - Ex) fingerprints, blood type