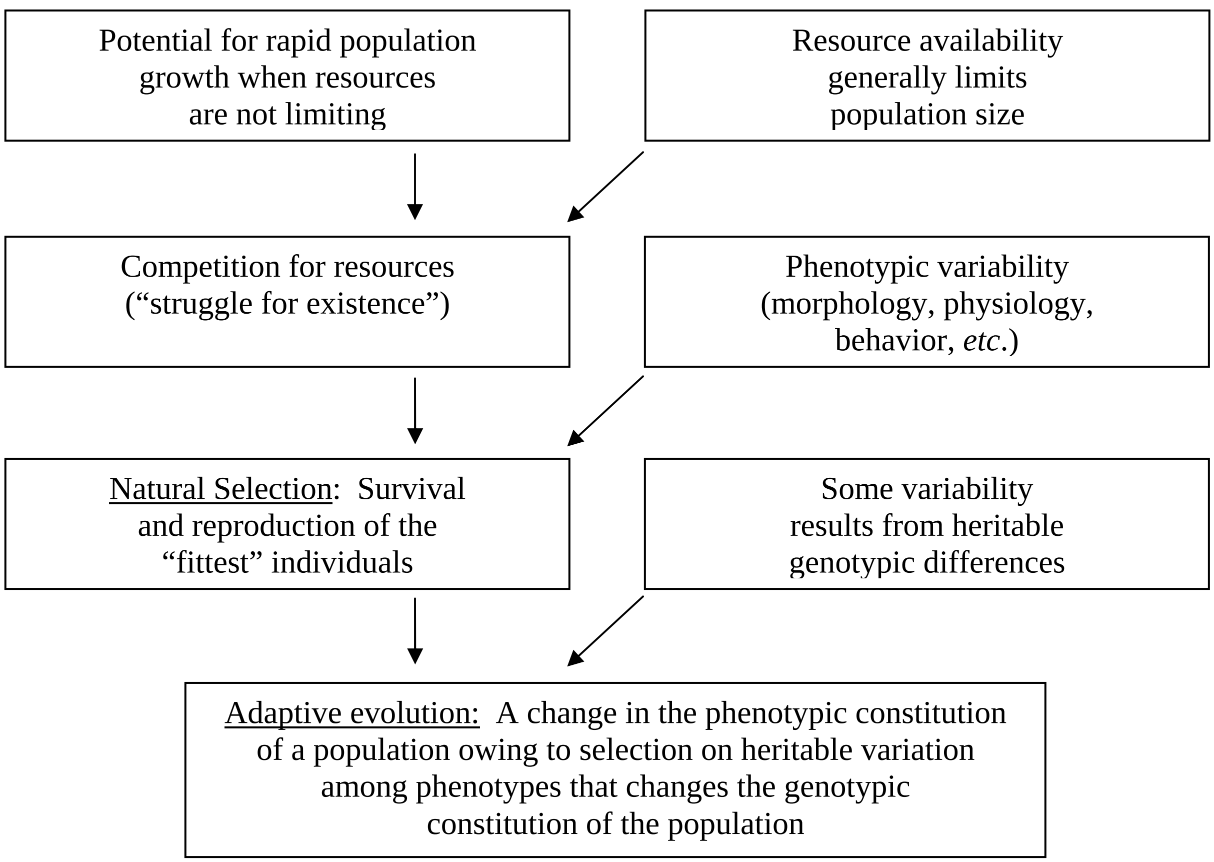
Chapt. 23 – The Evolution of Populations

Western Historical Context

Gregor Mendel (1822-1884)
Austrian monk whose breeding experiments with peas shed light on the rules of inheritance
Mendel was a contemporary of Darwin, but his work was overlooked until the 20th century

The Modern Synthesis (early 1940s)
A conceptual synthesis of Darwinian evolution, Mendelian inheritance, and modern population genetics



Phenotype – all expressed traits of an organism

Genotype – the entire genetic makeup of an individual (*i.e.*, its **genome –** it's full complement of **genes** and the two **alleles** that comprise each **locus**), or a subset of an individual's **genes**

Evolution

A change in **allele frequency** in a population (a change in the **gene pool**)

Population = all of the individuals of a species in a given area

Population Genetics

Examines the frequency, distribution, and inheritance of alleles within a population

Hardy-Weinberg Equilibrium [See Figs. 23.4 & 23.5]

The population genetics theorem that states that the frequencies of alleles and genotypes in a population will remain constant unless acted upon by non-Mendelian processes, *i.e.*, mechanisms of evolution

Allele Frequencies

Under strict Mendelian inheritance, allele frequencies would remain constant from one generation to the next (Hardy-Weinberg Equilibrium)

Hardy-Weinberg Equation

For a two-allele locus:

Let p = the frequency of one allele in the population (usually the dominant allele)

Let q = the frequency of the other allele (usually the recessive allele)

Notice that:

$p + q = 1$

$p = 1 - q$

$q = 1 - p$

Genotypes should occur in the population according to: $p^2 + 2pq + q^2 = 1$

p^2 = proportion of population that is **homozygous** for the first allele (*e.g.*, RR)

$2pq$ = proportion of population that is **heterozygous** (*e.g.*, Rr)

q^2 = proportion of population that is **homozygous** for the second allele (*e.g.*, rr)

Hardy-Weinberg Equilibrium

Is a null model… like Newton's first law of motion: Every object tends to remain in a state of uniform motion (or stasis), assuming no external force is applied to it

The **Hardy-Weinberg Equation** will be satisfied, as long as all the assumptions are met…

Hardy-Weinberg Assumptions:

1) Infinite population size

Because genetic drift affects smaller populations more than larger populations

Genetic drift = allele frequency change due to chance

Genetic drift reduces **genetic variability** **[See Fig. 23.7]**

Genetic drift often results from populations passing through a **population bottleneck**

The **founder effect** is an example of a population bottleneck **[See Fig. 23.8]**

2) No gene flow among populations

Gene flow = transfer of alleles among populations

Emigration transfers alleles out of a population and **immigration** transfers them in

3) No **mutations**

4) **Random mating** with respect to genotypes
E.g., imagine what would happen if RR males mated only with rr females; those particular matings would result in no RR or rr offspring, thereby altering population-wide genotype frequencies

5) No **natural selection**
E.g., imagine what would happen if rr flowers were the only ones that ever attracted pollinators (even though the population contains RR and Rr individuals as well)

Variation within Populations

Since selection acts on phenotypes, yet evolution requires population-level genotypic change, it is important to understand intraspecific variation

Note: If all individuals were phenotypically identical, there would be no opportunity for selection

Note: If all individuals were genotypically identical, there would be no opportunity for evolution

Phenotypic variation results from both environmental and genetic influences

Consider identical vs. fraternal twins

Phenotypic variation within populations is either **discrete** or **quantitative/continuous**

Discrete variation: polymorphism = mutiple phenotypes that are readily placed in distinct categories co-occur (*e.g.*, red and white flowers in our in-class example result from a single polymorphic locus)
E.g., a “bar graph” trait like ABO blood type

Continuous variation: quantitative characters = multiple loci produce a trait (*e.g.*, flower size), and the trait varies continuously in the population
E.g., a "bell curve" trait like human height

Phenotypic variation also exists **among populations**
E.g., **geographic variation**

How is genetic variation maintained?

1) **Diploidy** provides **heterozygote protection**

2) **Balanced polymorphism**
Heterozygote advantage
E.g., A locus for one chain of hemoglobin in humans has a recessive allele that causes sickle-cell anemia in homozygotes, but provides resistance to malaria in heterozygotes
Frequency-dependent selection

3) **Neutrality**

Fitness

Darwinian fitness = an individual's reproductive success (genetic contribution to subsequent generations)

Relative fitness = a genotype's contribution to subsequent generations compared to the contributions of alternative genotypes at the same locus

Effects of Selection [See Fig. 23.12]

1) **Directional selection** consistently favors phenotypes at one extreme

2) **Stabilizing selection** favors intermediate phenotypes

3) **Diversifying (disruptive) selection** simultaneously favors both phenotypic extremes

Sexual Selection

Intrasexual selection, usually male-male **competition**

Intersexual selection, usually female **mate choice**

Often leads to **sexual dimorphism** & **exaggerated traits**