Microevolution – Population Genetics

Microevolution is a change in a population's alleles over a period of time.

- **It is very difficult to detect changes that occur on the microscopic level. These changes must manifest themselves in the organism's phenotype.**
- **Since individuals do not evolve, one must keep a close eye on the individual's population to detect any change in genotypic modification.**
- **Biologists have a way to help them detect such changes; it is called the Hardy -Weinberg theorem.**

Hardy-Weinberg Theorem:

This idea was developed to determine if a population was evolving.

The authors of the theorem set up a series of parameters, which do not exist in nature, to be followed when determining the allele frequencies of any population. These guide lines are as follows:

- **The population must be very large in size.**
- **It must be isolated from other populations. (no gene flow)**
- **No mutations.**
- **Random mating.**
- **No natural selection.**

As one can see, these characteristics cannot be eliminated from nature. So what is the purpose of these restrictions? To answer this question let us take a look at the mathematics behind this idea.

- **Let us take a look at a population with alleles for large and small ears.**
- **Let us use L for the dominant allele, large ears, and l for the recessive allele small ears.**
- **If we look at that population of people, we can determine the number of individuals with large and small ears.**
- **Since each group is a result of the following genotypes: LL, Ll, and ll, we have three groups of possible combinations.**
- **These alleles make up the gene pool for that trait. The Hardy -Weinberg theorem states that : $p + q = 1$**

p = the dominant allele

q = the recessive allele

1 = the gene pool of that trait.

So all the L alleles added to all the l alleles = 100% of the genes for that trait in that population.

If we expand that formula by multiplying it by itself we produce the expanded formula:

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

- **p^2 = the homozygous dominant genotype LL,**
- **$2pq$ = the heterozygous genotype Ll**
- **q^2 = the homozygous recessive genotype ll**

- **If the large ear allele (L) has a .8 frequency in the population, the small ear allele (l) must have a .2 frequency since .2 + .8 = 1.**
- **If we substitute these frequencies into the expanded formula we can determine the percent of each of the three phenotypes in a given population.**

p2 = .64, 2pq = .32, and q2 = .04 = 1

kkk64%kkkk 32% kkkkkk jj4% jjj= 100%

- **If we know the percent of the homozygous recessive organisms, we can take the square root of the decimal value and determine the frequency.**
- **With that value we can determine the frequency of the dominant allele by subtracting it from 1.**
- **So as one can see, the formula can be used if the % is given or the frequency.**
- **This first calculation will act as a base and any changes that occur to the frequencies of further calculations may indicate that evolution is occurring in that population.**
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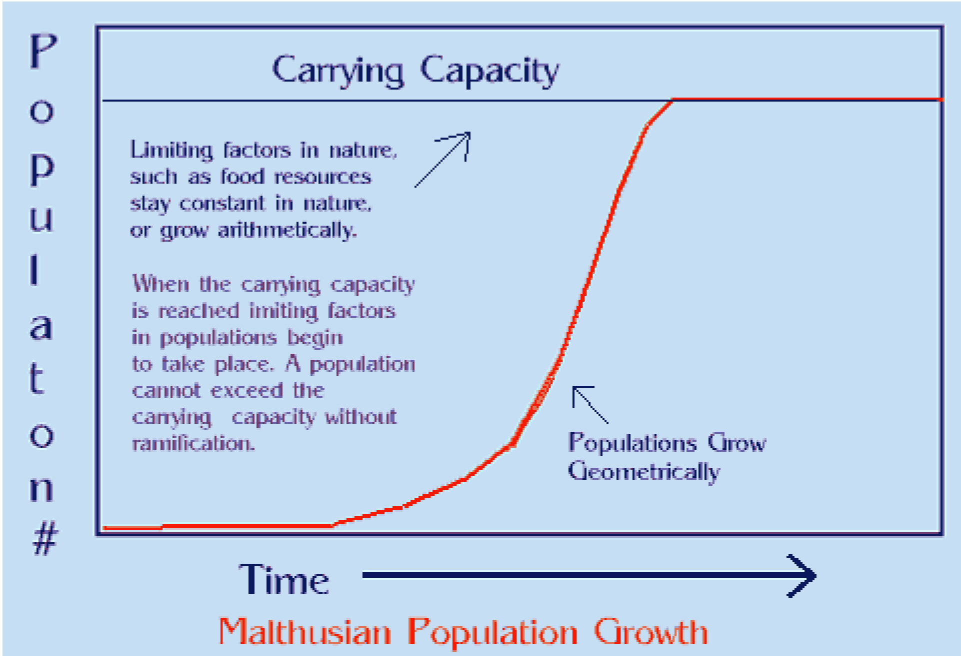
There are 5 basic causes of microevolution:

1. **Genetic Drift: This represents random changes in small gene pools due to sampling errors in propagation of alleles. The bottleneck effect and founder effect are prime examples of genetic drift. In either case the number of individuals in a population is drastically reduced distorting the original allelic frequencies.**
2. **Gene Flow: The movement of alleles into and out of a gene pool. Migration of an organism into different areas can cause the allelic frequencies of that population to increase. Most populations are not isolated, which is contrary to the Hardy-Weinberg Theorem.**
3. **Mutations: These changes in the genome of an organism are an important source of natural selection.**
4. **Nonrandom mating: Inbreeding is a popular form of nonrandom mating. Individuals will mate more frequently with close individuals than more distant ones. Assortive mating is another form of nonrandom mating. Here the individuals will mate with partners that closely resemble themselves in certain characteristics.**
5. **Natural Selection: Populations vary in the types of individuals and their reproductive success. Those individuals that leave more offspring behind than others pass on more of their alleles and have a better success rate in dominating the population.**

Darwin's Theory of Evolution:

- An adaptation is a trait that helps an organism be more suited to its environment
- Darwin decided adaptations develop over time
- Natural selection was proposed by both Alfred Russell Wallace and Darwin as a driving mechanism of evolution
- Darwin and Wallace both read an essay by Thomas Malthus that proposed that human populations outgrow resources so there is a constant struggle for existence



- Fitness is a measure of an organism's reproductive success
- Organisms most fit to reproduce are selected by environment which results in adaptation of the population
- Natural selection is also called "survival of the fittest"
- *Conditions for natural selection include:*
    a. Variations exist among members of a population
    b. Many more individuals are produced each generation than will survive
    c. Some individuals are better adapted so they survive & reproduce
    d. Members of a population compete for food, space, mates...
- Variations that make adaptation possible are those that are passed on generation to generation
- Extinction occurs when previous adaptations are no longer suitable to a changed environment

Biochemical Evidence:

- Almost all living organisms use the same basic biochemical molecules, e.g., DNA, ATP, enzymes ...
- Similarities in amino acid sequences, DNA codes, etc. can be explained by descent from a common ancestor

Examples of Evolution in Modern Times:

- Peppered moth -- light colored vs. dark colored (industrialization influence) Manchester, England
- Insect resistance to insecticides
- Bacterial resistance to antibiotics

Three ways (modes of selection) in which natural selection can affect the contribution that a genotype makes to the next generation.

a. **<u>Directional</u> <u>selection</u>** favors individuals at one end of the phenotypic range. Most common during times of environmental change or when moving to new habitats.

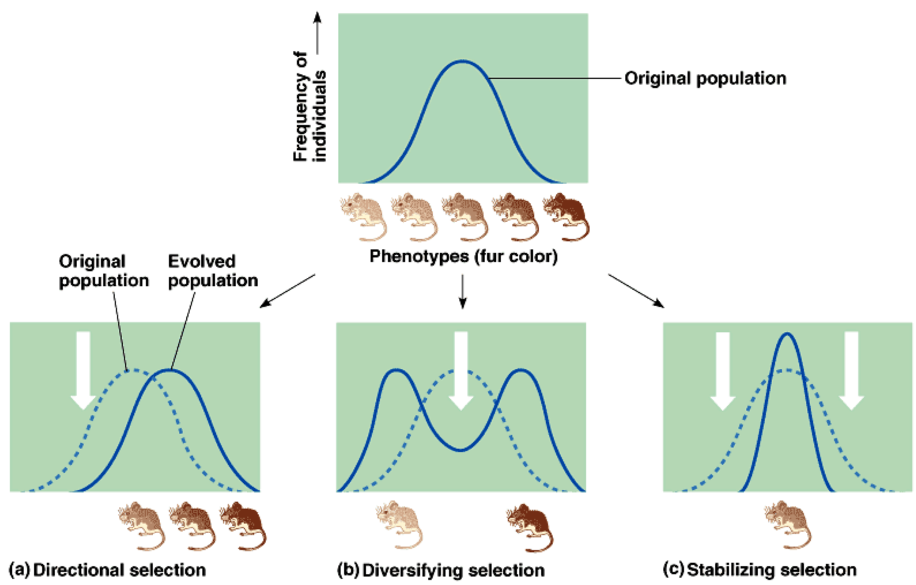
b. **<u>Diversifying</u> <u>selection</u>** favors extreme over intermediate phenotypes.

- Occurs when environmental change favors an extreme phenotype.

c. **<u>Stabilizing</u> <u>selection</u>** favors intermediate over extreme phenotypes.

- Reduces variation and maintains the current average.

- Example = human birth weights.



<u>Genetic drift</u>

Genetic drift = the alteration of the gene pool of a small population due to chance.

<u>Two factors may cause genetic drift:</u>

1. <u>Bottleneck effect</u> may lead to reduced genetic variability following some large disturbance that removes a large portion of the population. The surviving population often does not represent the allele frequency in the original population.
2. <u>Founder effect</u> may lead to reduced variability when a few individuals from a large population colonize an isolated habitat.