BIOLOGY REVIEW

Biological Evolution

Biological evolution is more than just change over time. Many things change over time but are not examples of evolution. For example: trees lose their leaves, mountain ranges arise because of volcanic eruption but these are not examples of biological evolution because they don't involve descent through genetic inheritance.

The central idea of biological evolution is that all life on Earth shares a common ancestor, just as you and your cousins share a common grandmother.

The great diversity we see in living things came to be through the process of descent with modification. The fossil record provides documentation of the descent with modification.

Important concepts in evolution: **Variation:** All life forms vary genetically within a population. **Inheritance:** Genetic traits are inherited from parents and are passed on to offspring. **Selection:** 0rganisms with traits that are favorable to their survival and reproduction are more likely to pass on their genes to the next generation. **Time:** Evolutionary change can happen in a few generations, but major change, such as speciation, often takes many thousands of generations.

Biological evolution is descent with modification. This definition encompasses small-scale evolution (changes in gene frequency in a population from one generation to the next) and large-scale evolution (the descent of different species from a common ancestor over many generations). Evolution helps us to understand the history of life. *(http://evolution.berkeley.edu/evolibrary/article/0_0_0/evo_02)*

Process of Evolution

Fundamental to evolution is genetic variation upon which selective forces can act in order for evolution to occur. **Mutations** are changes in the DNA. A single mutation can have a large effect, but in many cases, evolutionary change is based on the accumulation of many mutations. **Gene flow** is any movement of genes from one population to another and is an important source of genetic variation. **Sex** can introduce new gene combinations into a population. This genetic shuffling is another important source of genetic variation.

Genetic variation refers variety in gene frequencies. Genetic variation can refer to differences between individuals or to differences between populations. Mutuation is the ultimate source of all genetic variation. Sexual reproduction and genetic drift can influence also contribute the genetic variation.

The potential for a new allele combination is increased with every sexual reproduction from: random union of sperm and egg, crossing over during meiosis I, and Independent assortment of homologous chromosomes.. Most genetic recombinations involving a recessive gene are biologically neutral, the potential for that gene to be expressed in the future still survives in that organism and therefore in that breeding population. Increasing genetic variation and the environmental effects on that variation form the basis for natural selection.

Resistance to antibiotics is increased though the survival of individuals that are immune to the effects of the antibiotic, whose offspring then inherit the resistance, creating a new population of resistant bacteria.

Red eyes Sepia eyes

In a certain population of 1000 fruit flies, 640 have red eyes while the remainder have sepia eyes. The sepia eye trait is recessive to red eyes. How many individuals would you expect to be homozygous for red eye color?

Hint: The first step is always to calculate q^2! Start by determining the number of fruit flies that are homozygous recessive. If you need help doing the calculation, look back at the Hardy-Weinberg equation.

Answer:
You should expect 160 to be homozygous dominant.
Calculations:
q^2 for this population is 360/1000 = 0.36
$q = \sqrt{0.36} = 0.6$
$p = 1 - q = 1 - 0.6 = 0.4$
The homozygous dominant frequency = $p^2 = (0.4)(0.4) = 0.16$.
Therefore, you can expect 16% of 1000, or 160 individuals, to be homozygous dominant.

Hardy Weinberg Equation

To estimate the frequency of alleles in a population, we can use the Hardy-Weinberg equation. According to this equation:

p = the frequency of the dominant allele (represented here by *A*)
q = the frequency of the recessive allele (represented here by *a*)

For a population in genetic equilibrium:
$p + q = 1.0$ (The sum of the frequencies of both alleles is 100%.)

$(p + q)^2 = 1$

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

The three terms of this binomial expansion indicate the frequencies of the three genotypes:

p^2 = frequency of *AA* (homozygous dominant)
$2pq$ = frequency of *Aa* (heterozygous)
q^2 = frequency of *aa* (homozygous recessive) lighter content inside.

Assumptions of HW Equilibrium

The Hardy Weinberg equilibrium only occurs when the population is at equilibrium, i.e. there is no evolution.

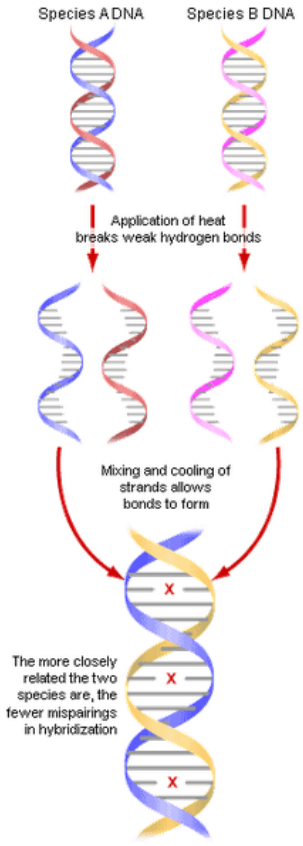
Assumptions: 1. No mutation 2. Natural selection is not occurring 3. Large population size. 4. All members breed. 5. Mating is random. 6. All individuals produce same number of offspring. 7. No migration in or out of the population.

The Hardy–Weinberg principle may be applied in two ways, either a population is assumed to be in Hardy–Weinberg proportions, in which the genotype frequencies can be calculated, or if the genotype frequencies of all three genotypes are known, they can be tested for deviations that are statistically significant..

DNA Hybridization and Evolution

Each DNA molecule is made of two strands of nucleotides. If the strands are heated, they will separate—and as they cool, the attraction of the nucleotides will make them bond back together again. To compare different species, scientists cut the DNA of the species into small segments, separate the strands, and mix the DNA together. When the two species' DNA bonds together, the match between the two strands will not be perfect since there are genetic differences between the species — and the more imperfect the match, the weaker the bond between the two strands. These weak bonds can be broken with just a little heat, while closer matches require more heat to separate the strands again.

DNA hybridization can measure how similar the DNA of different species is — more similar DNA hybrids "melt" at higher temperatures. When this technique was applied to primate relationships, it suggested that humans and chimpanzees carried DNA more similar to one another's than to orangutans' or gorillas' DNA.



Vocabulary

Adaption: structure, trait, or characteristic that enhances the fitness and survival of individuals

Balanced polymorphism: A system of genes in which 2 alleles are maintained in a stable equilibrium because heterozygotes are more fit than either homozygotes

Bottleneck effect: an ecological phenomenon in which the population of a species is drastically reduced to the point where the species is still able to carry on, but the genetic diversity of the species is severely limited

Common ancestry: a group of organisms share a recent common ancestor

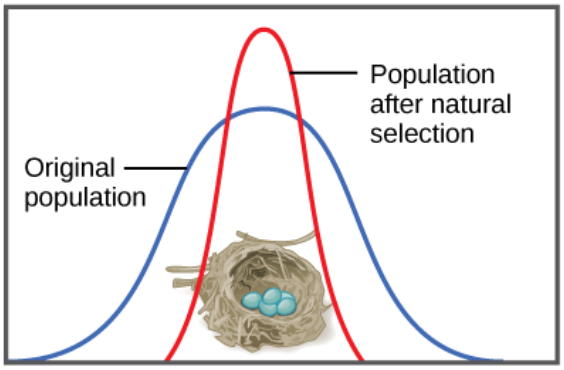
Convergent evolution: process whereby organisms not closely related independently evolve similar traits as a result of having to adapt to similar environments or ecological niches.

Destabilizing selection: selection which favors the intermediate variants; reduces phenotypes at either extreme

Directional selection: selection in which an extreme phenotype is favored over the other phenotypes causing the allele frequency to shift over time in the direction of that phenotype

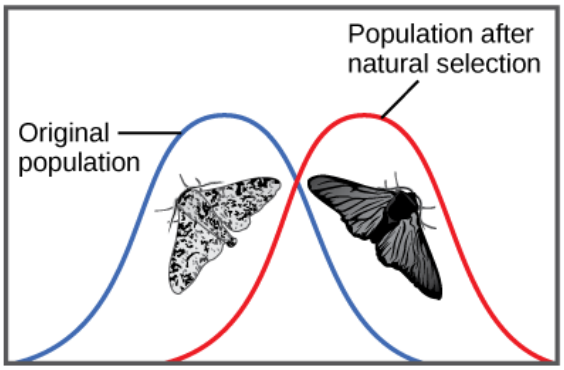
Divergenent evolution: accumulation of differences between groups which can lead to speciation; usually due to same species entering different and isolated environments which block gene flow

(a) **Stabilizing selection**



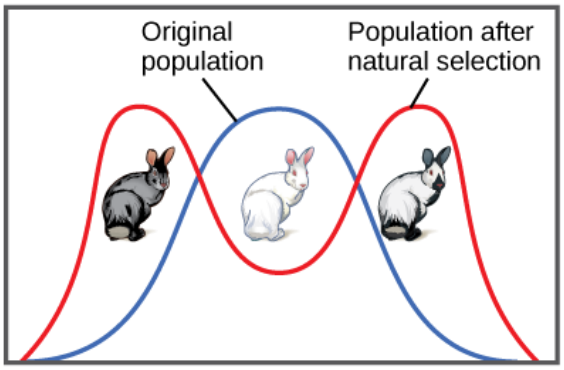
Robins typically lay four eggs, an example of stabilizing selection. Larger clutches may result in malnourished chicks, while smaller clutches may result in no viable offspring.

(b) **Directional selection**



Light-colored peppered moths are better camouflaged against a pristine environment; likewise, dark-colored peppered moths are better camouflaged against a sooty environment. Thus, as the Industrial Revolution progressed in nineteenth-century England, the color of the moth population shifted from light to dark, an example of directional selection.

(c) **Diversifying selection**



In a hyphothetical population, gray and Himalayan (gray and white) rabbits are better able to blend with a rocky environment than white rabbits, resulting in diversifying selection.

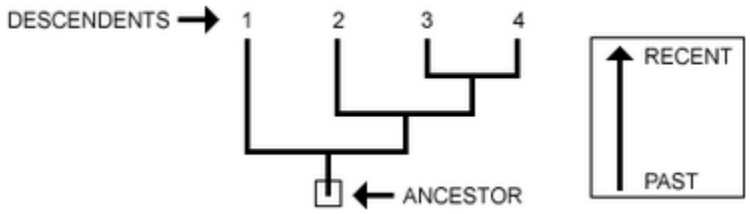
Molecular Aspects of Evolution

Traits are coded in genes— sequences of DNA nucleotides. Genes may appear in different forms, known as alleles. A diploid organism will possess two copies of each gene or allele. If the alleles code for the same instructions, the individual is **homozygous**. If the alleles provide different information about a particular trait, the individual is **heterozygous.** Dominant alleles are those that appear in the phenotype if present in the genotype. Recessive alleles appear in the phenotype only when in the homozygous condition.

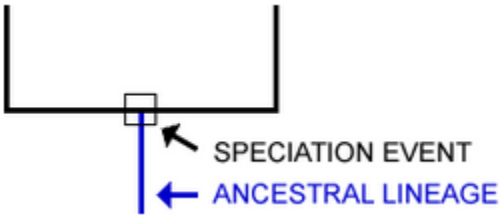
The sequence of nucleotides in DNA is transcribed into RNA, then translated into an amino acid sequence. The nucleotides are arranged into 3 nucleotide segments known as codons. These codons determine the type and sequence of amino acids in the polypeptides synthesized during translation. A mutation is an alteration in the nucleotide sequence of DNA.

Understanding Phylogenetic Trees

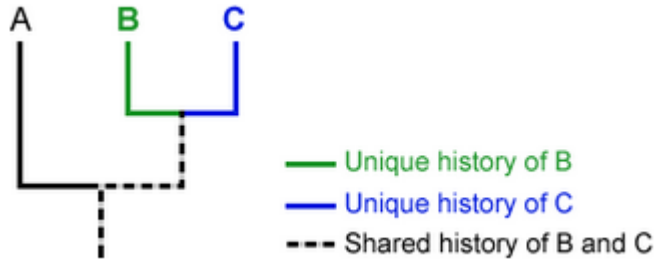
The root of the phylogenetic tree represents the ancestral line, the tips of the branches represent the descendents of that ancestor. The old part of the line is near the bottom of the tree, more recent at top.



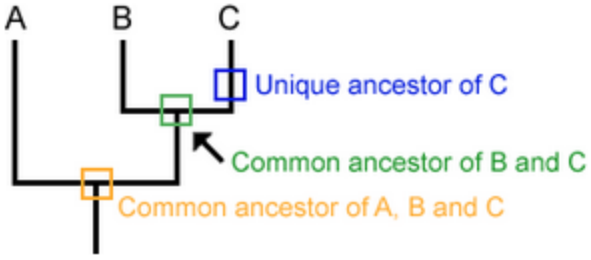
When speciation occurs, it is represented as a branching on the tree. A single ancestral lineage gives rise to two or more daughter lineages.



Phylogenetic trees show patterns of shared ancestry between lineages. Each lineage has a unique history and a shared history.



Each lineage has ancestors that are unique to that lineage and ancestors that are shared with other lineages— referred to as common ancestors.



Continued on next page —

Vocabulary

Fitness: ability to survive to reproductive agae, sucess at finding mates and producing offspring; generally more offspring = greater fitness

Homologous genes: genes which have a common ancestral gene

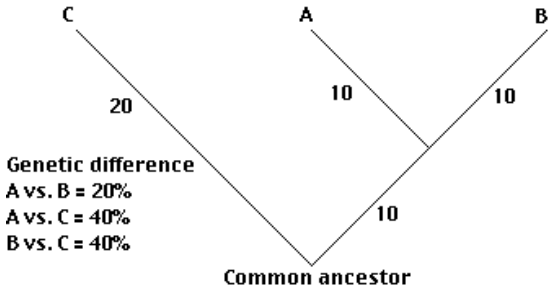
Mutation: a permanent change of the nucleotide sequence of a genome of an organism

Nucleotide sequences: a succession of nitrogenous bases within DNA or RNA

Sexual selection: the advantage which certain individuals have over others of the same sex and species solely in respect to reproduction.

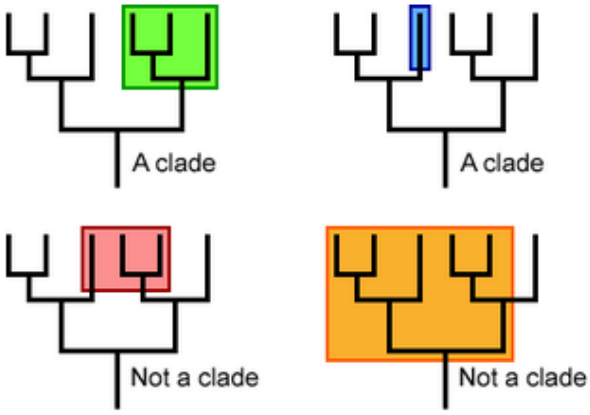
Stabilizing selection: favors the intermediate variants of the phenotype. It reduces phenotypic variation.

Genetic differences can be noted on a phylogenic tree. The numbers represent the percent differences among the species A, B, and C.

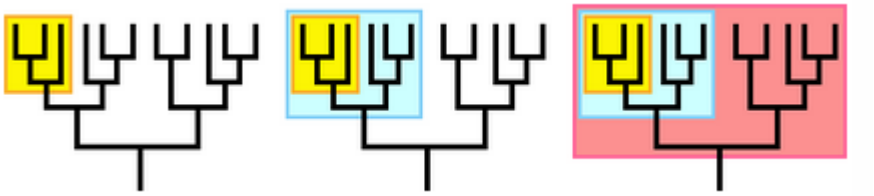


Understanding Phylogenetic Trees (continued from previous page)

A clade is a grouping that includes a common ancestor and all the desendents (extinct and extant) of that ancestior. To determine if a group of lineages in a clade— imagine clipping a single branch off the tree. All of the organism on that branch belong o a clade.



Clades are nested one inside another and form a nest hierarchy. A clade may include thousands of species or only a few.



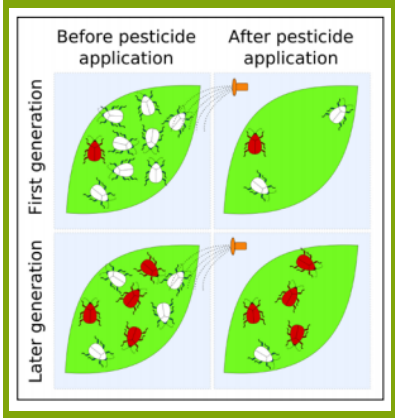
In many cases the tips of a phylogenic tree represent descendent lineages. Depending on how many branches of the tree you are including the descendents at the tips might be different populations of a species, different species, or different clades each composed of many species

(Adopted in large part from: http://evolution.berkeley.edu/)

Which of the following evolutionary trees illustrates a lineage in which species A is separate from other species present and where species A diverged to form another line. After the divergence, the other line diverged into two other species B and C.

Pesticide Resistance

Pesticide resistance is the ability of an organism to withstand a poison, is a predictable consequence of repeated pesticide use.



Insects are exposed to the chemical, those with resistant gene survive and reproduce. Resistant insects become more common. The pesticide did not cause the mutation for resistance. Natural selection acts upon the genetic variation that already exists in the population.

Caution: If you are unaware of all the evidence in an evolutionary series you can come to the wrong conclusion. For example, both birds and mammals have four chambered hearts. Based solely on this, one might conclude that the common ancestor for birds and mammals also had a four chambered heart. BUT– other evidence suggests the four chambered heart of birds and mammals evolved independently of one another. Take home: one must be care when assuming evolutionary relationships.

Fitness & Natural Selection

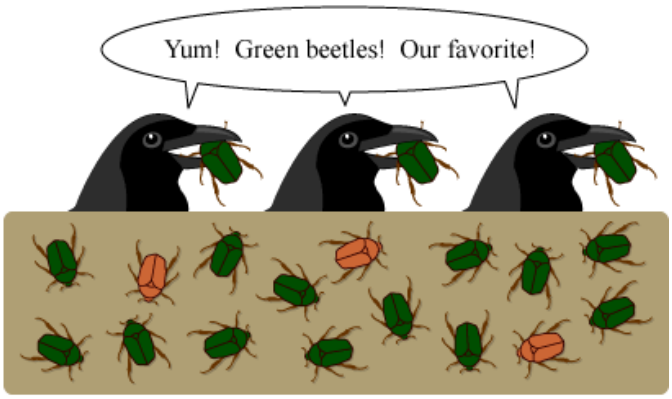
Fitness refers to how good a particular genotype is at leaving offspring in the next generation as compared to other genotypes. Of course, fitness is a relative thing. A genotype's fitness depends on the environment in which the organism lives. The fittest genotype in one particular environment, is probably not the fittest genotype in another different environment.

Fitness lumps everything that matters to natural selection (survival, mate-finding, reproduction) into one idea. The fittest individual is not necessarily the strongest, fastest, or biggest. A genotype's fitness includes its ability to survive, find a mate, produce offspring—and ultimately leave its genes in the next generation.

Producing and caring for offspring, producing feathers, producing vocalizations, engaging in courtship behaviors — are all a burden to the health and survival of parents. These strategies increase fitness because they increase the ability of the parents to produce successful offspring.

It might be tempting to think of natural selection acting exclusively on survival ability—but, as the concept of fitness shows, that's only part of the story. When natural selection acts on mate-finding and reproductive behavior, it is known as sexual selection. Sexual selection is often powerful enough to produce features that are harmful to the individual's survival. For example, extravagant and colorful tail feathers or fins are likely to attract predators as well as interested members of the opposite sex.

Natural selection, in a nutshell:



Predation can be a powerful influence in natural selection. Here, the lighter colored beetles (tan vs. green) will have a selective advantage. The darker (green) beetles will be selected against.

Evolution tidbits

In many species males are larger and brighter colored this is an example of **Sexual selection**.

Convergent evolution can be used to explain why the Giant Panda and the Lesser Panda have such similar body morphology (look so much alike) but DNA hybridization data place the Giant Panda in the bear family and the Lesser Panda in the raccoon family.

Mutations are often responsible to the sudden appearance of novel characteristics in a population.

Natural selection is limited to acting upon (selecting for or against) structures that are present in previous generations. Recall also that natural selection favors those traits that improve survival and reproduction. Although natural selection can produce amazing adaptations, and it's tempting to think of it as an all-powerful force, urging organisms on, constantly pushing them in the direction of progress — but this is not how natural selection operates. It does not produce perfection. If your genes are "good enough," you'll get some offspring into the next generation — you don't have to be perfect. You can see this by looking at the populations around us: people may have genes for genetic diseases, plants may not have the genes to survive a drought, a predator may not be quite fast enough to catch her prey every time she is hungry. No population or organism is perfectly adapted. Natural selection is the simple result of variation, differential reproduction, and heredity — it is mindless and mechanistic. It has no goals; it's not striving to produce "progress" or a balanced ecosystem.

Selection acts upon an individual (it reproduces or not), but evolution applies to the population (it changes gene frequencies).