Evolutionary Theory

<u>Evolution</u>

In biology, **evolution** is change in the genetic material of a population of organisms through successive generations. Although the changes produced in a single generation are normally small, the accumulation of these differences over time can cause substantial changes in a population, a process that can result in the emergence of new species. Similarities among species suggest that all known species descended from a common ancestor (or ancestral gene pool) through this process of gradual divergence.

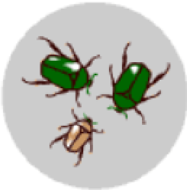
The basis of evolution is the passing of genes from one generation to the next. Genes are what produce an organism's inherited traits. These vary within populations, with organisms showing heritable differences (variation) in their traits. Evolution is the product of two opposing forces: processes that constantly introduce variation, and processes that make those variants become either more common or rare. New variation arises in two main ways: either from mutations in genes, or from the transfer of genes between populations and between species. New combinations of genes are also produced by genetic recombination, which can increase variation between organisms.

Two major mechanisms determine if variants will become more common or rare in a population. One is ***natural selection*** , a process whereby helpful traits (those that increase the chance of survival and reproduction) become more common in a population while harmful traits become increasingly rare. This occurs because individuals with advantageous traits are more likely to survive and reproduce, resulting in more individuals of the next generation inheriting those traits. Adaptations occur over many generations through successive, small, random changes in traits combined with natural selection of those variants best-suited for their environment. The other major mechanism driving evolution is ***genetic drift*** , an independent process that produces random changes in the frequency of traits in a population. Genetic drift results from the role that chance plays in whether a given trait will be passed on as individuals survive and reproduce.

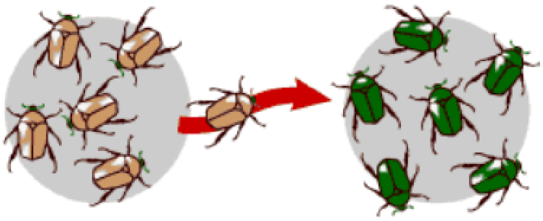
Mechanisms of Change

Each of these four processes is a basic mechanism of evolutionary change.

Mutation
A mutation could cause parents with genes for bright green coloration to have offspring with a gene for brown coloration. That would make the genes for brown beetles more frequent in the population.



Migration
Some individuals from a population of brown beetles might have joined a population of green beetles. That would make the genes for brown beetles more frequent in the green beetle population.



Genetic Drift
Imagine that in one generation, two brown beetles happened to have four offspring survive to reproduce. Several green beetles were killed when someone stepped on them and had no offspring. The next generation would have a few more brown beetles than the previous generation—but just by chance. These chance changes from generation to generation are known as genetic drift.

Natural Selection
Imagine that green beetles are easier for birds to spot (and hence, eat). Brown beetles are a little more likely to survive to produce offspring. They pass their genes for brown coloration on to their offspring. So in the next generation, brown beetles are more common than in the previous generation.

All of these mechanisms can cause changes in the frequencies of genes in populations, and so all of them are mechanisms of evolutionary change. However, natural selection and genetic drift cannot operate unless there is genetic variation—that is, unless some individuals are genetically different from others. If the population of beetles were 100% green, selection and drift would not have any effect because their genetic make-up could not change.

Genetic Drift

Genetic drift—along with natural selection, mutation, and migration—is one of the basic mechanisms of evolution.

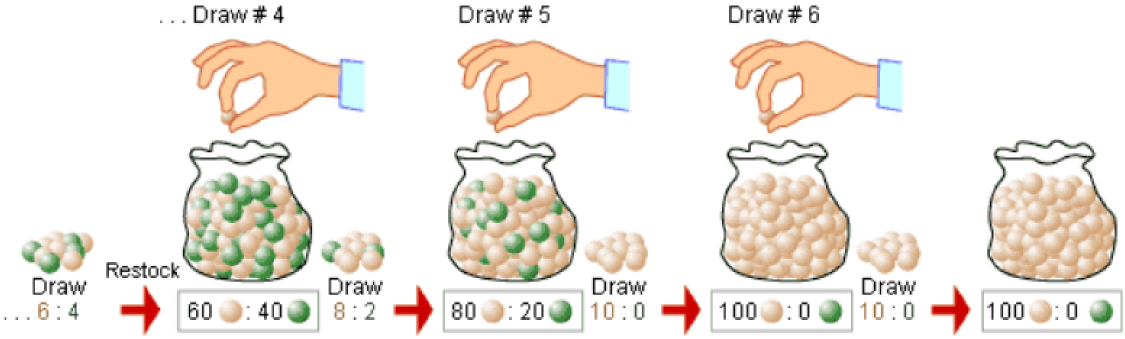
In each generation, some individuals may, just by chance, leave behind a few more descendents (and genes, of course!) than other individuals. The genes of the next generation will be the genes of the "lucky" individuals, not necessarily the healthier or "better" individuals. That, in a nutshell, is genetic drift. It happens to ALL populations—there's no avoiding the vagaries of chance.

Earlier we used this hypothetical cartoon. Genetic drift affects the genetic makeup of the population but, unlike natural selection, through an entirely random process. So although genetic drift is a mechanism of evolution, it doesn't work to produce adaptations.

Effects of Genetic Drift (1 of 2)

Through sampling error, genetic drift can cause populations to lose genetic variation.

Decreasing variation:
Imagine that our random draws from the marble bag produced the following pattern: 5:5, 6:4, 7:3, 4:6, 8:2, 10:0, 10:0, 10:0, 10:0, 10:0... Why did we keep drawing 10:0? Because if the green marbles fail to be represented in just one draw, we can't get them back—we are "stuck" with only brown marbles. The cartoon below illustrates this process, beginning with the fourth draw.



The same thing can happen to populations. If the gene for green coloration drifts out of the population, the gene is gone for good—unless, of course, a mutation or gene flow reintroduces the green gene.

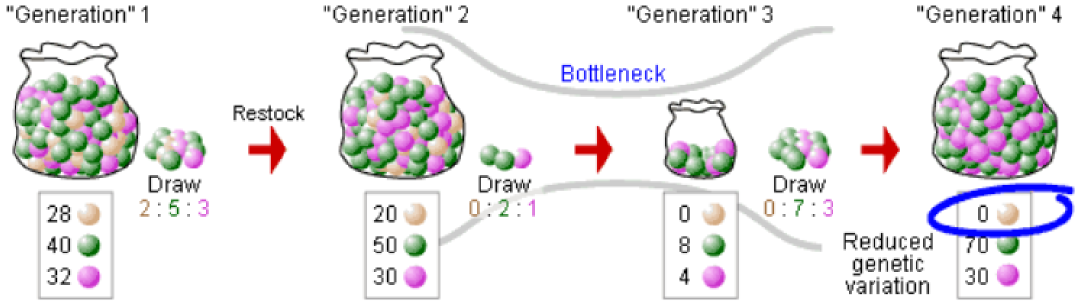
The 10:0 situation illustrates one of the most important effects of genetic drift: it reduces the amount of genetic variation in a population. And with less genetic variation, there is less for natural selection to work with. If the green gene drifts out of the population, and the population ends up in a situation where it would be advantageous to be green, the population is out of luck. Selection cannot increase the frequency of the green gene, because it's not there for selection to act on. Selection can only act on what variation is already in a population; it cannot create variation.

Bottlenecks and Founder Effects

Genetic drift can cause big losses of genetic variation for small populations.

Population bottlenecks occur when a population's size is reduced for at least one generation. Because genetic drift acts more quickly to reduce genetic variation in small populations, undergoing a bottleneck can reduce a population's genetic variation by a lot, even if the bottleneck doesn't last for very many generations. This is illustrated by the bags of marbles shown below, where, in generation 2, an unusually small draw creates a bottleneck.

Read more about the importance of **random genetic drift**.



Reduced genetic variation means that the population may not be able to adapt to new selection pressures, such as climatic change or a shift in available resources, because the genetic variation that selection would act on may have already drifted out of the population.

An example of a bottleneck:
Northern elephant seals have reduced genetic variation probably because of a population bottleneck humans inflicted on them in the 1890s. Hunting reduced their population size to as few as 20 individuals at the end of the 19th century. Their population has since rebounded to over 30,000—but their genes still carry the marks of this bottleneck: they have much less genetic variation than a population of southern elephant seals that was not so intensely hunted.

Founder effects
A founder effect occurs when a new colony is started by a few members of the original population. This small population size means that the colony may have:

- reduced genetic variation from the original population.
- a non-random sample of the genes in the original population.

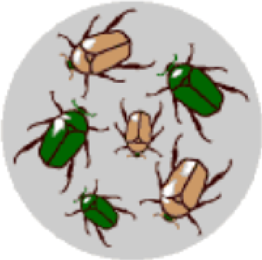
For example, the Afrikaner population of Dutch settlers in South Africa is descended mainly from a few colonists. Today, the Afrikaner population has an unusually high frequency of the gene that causes Huntington's disease, because those original Dutch colonists just happened to carry that gene with unusually high frequency. This effect is easy to recognize in genetic diseases, but of course, the frequencies of all sorts of genes are affected by founder events.

Natural Selection

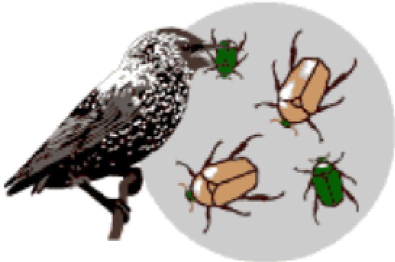
Natural selection is one of the basic mechanisms of evolution, along with mutation, migration, and genetic drift.

Darwin's grand idea of evolution by natural selection is relatively simple but often misunderstood. To find out how it works, imagine a population of beetles:

1. **There is variation in traits.**
   For example, some beetles are green and some are brown.



2. **There is differential reproduction.**
   Since the environment can't support unlimited population growth, not all individuals get to reproduce to their full potential. In this example, green beetles tend to get eaten by birds and survive to reproduce less often than brown beetles do.



3. **There is heredity.**
   The surviving brown beetles have brown baby beetles because this trait has a genetic basis.

4. **End result:**
   The more advantageous trait, brown coloration, which allows the beetle to have more offspring, becomes more common in the population. If this process continues, eventually, all individuals in the population will be brown.

If you have variation, differential reproduction, and heredity, you will have evolution by natural selection as an outcome. It is as simple as that.

Natural Selection at Work

Scientists have worked out many examples of natural selection, one of the basic mechanisms of evolution.

Any coffee table book about natural history will overwhelm you with full-page glossies depicting amazing adaptations produced by natural selection, such as the examples below.


Orchids fool wasps into "mating" with them.


Katydids have camouflage to look like leaves.

Non-poisonous king snakes mimic poisonous coral snakes.

Behavior can also be shaped by natural selection. Behaviors such as birds' mating rituals, bees' wiggle dance, and humans' capacity to learn language also have genetic components and are subject to natural selection. The male blue-footed booby, shown to the right, exaggerates his foot movements to attract a mate.

In some cases, we can directly observe natural selection. Very convincing data show that the shape of finches' beaks on the Galapagos Islands has tracked weather patterns: after droughts, the finch population has deeper, stronger beaks that let them eat tougher seeds.

In other cases, human activity has led to environmental changes that have caused populations to evolve through natural selection. A striking example is that of the population of dark moths in the 19th century in England, which rose and fell in parallel to industrial pollution. These changes can often be observed and documented.

Attachments

steps of non repulsion.ppt