

Understanding Evolution

(http://evolution.berkeley.edu/evolibrary/article/evo_25)

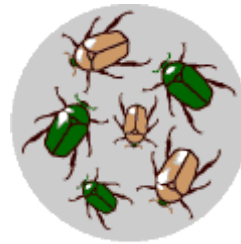
Natural selection

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:

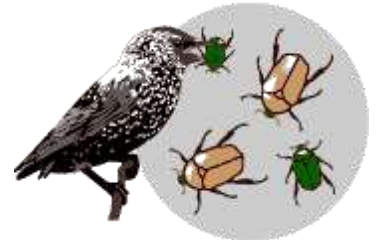
1. **There is variation in traits.**

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.



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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' wobble 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.

What about fitness?

Biologists use the word fitness to describe how good a particular [genotype](#) is at leaving offspring in the next generation relative to how good other genotypes are at it. So if brown beetles consistently leave more offspring than green beetles because of their color, you'd say that the brown beetles had a higher fitness.

		
Number that survive compared to total	95 %	33 %

The brown beetles have a greater fitness relative to the green beetles.

Of course, fitness is a relative thing. A genotype's fitness depends on the environment in which the organism lives. The fittest genotype during an ice age, for example, is probably not the fittest genotype once the ice age is over.

Fitness is a handy concept because it 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.



Caring for your offspring (above left), and producing thousands of young — many of whom won't survive (above right), and sporting fancy feathers that attract females (left) are a burden to the health and survival of the parent. These strategies do, however, increase fitness because they help the parents get more of their offspring into the next generation.

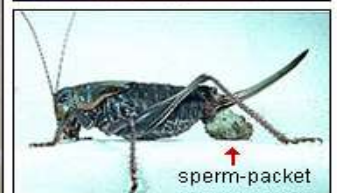
It might be tempting to think of natural selection acting exclusively on survival ability — but, as the concept of fitness shows, that's only half the story. When natural selection acts on mate-finding and reproductive behavior, biologists call it **sexual selection**.



Sexual selection

Sexual selection is a "special case" of natural selection. Sexual selection acts on an organism's ability to obtain (often by any means necessary!) or successfully copulate with a mate.

Selection makes many organisms go to extreme lengths for sex: peacocks (top left) maintain elaborate tails, elephant seals (top right) fight over territories, fruit flies perform dances, and some species deliver persuasive

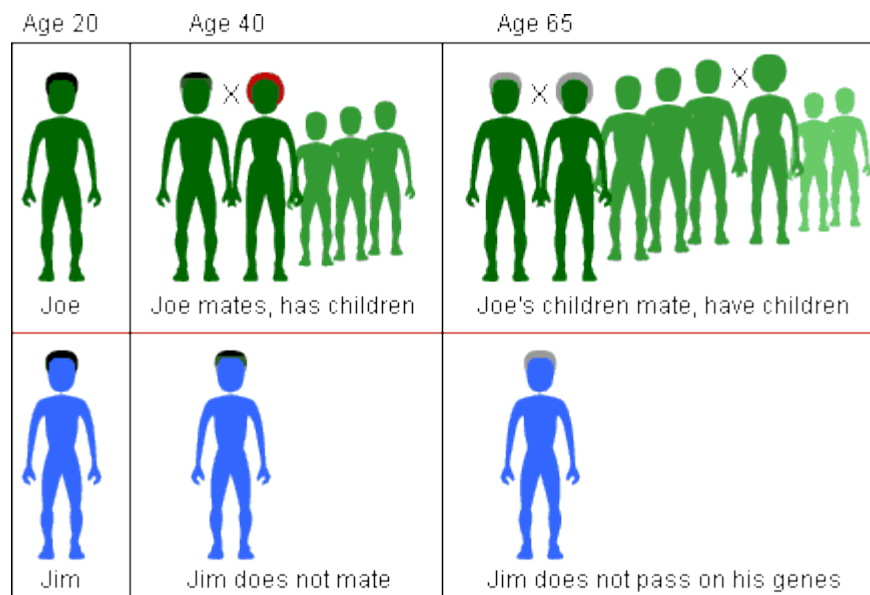


gifts. After all, what female Mormon cricket (bottom right) could resist the gift of a juicy sperm-packet? Going to even more extreme lengths, the male redback spider (bottom left) literally flings itself into the jaws of death in order to mate successfully.

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.

Sexual selection (2 of 2)

It's clear why sexual selection is so powerful when you consider what happens to the genes of an individual who lives to a ripe old age but never got to mate: no offspring means no genes in the next generation, which means that all those genes for living to a ripe old age don't get passed on to anyone! That individual's fitness is zero.



Selection is a two-way street

Sexual selection usually works in two ways, although in some cases we do see sex role reversals:

- **Male competition**

Males compete for access to females, the amount of time spent mating with females, and even whose sperm gets to fertilize her eggs. For example, male damselflies scrub rival sperm out of the female reproductive tract when mating.

- **Female choice**

Females choose which males to mate with, how long to mate, and even whose sperm will fertilize her eggs. Some females can eject sperm from an undesirable mate.

Adaptation

An adaptation is a feature that is common in a population because it provides some improved function. Adaptations are well fitted to their function and are produced by natural selection.

Adaptations can take many forms: a behavior that allows better evasion of predators, a protein that functions better at body temperature, or an anatomical feature that allows the organism to access a valuable new resource — all of these might be adaptations. Many of the things that impress us most in nature are thought to be adaptations.

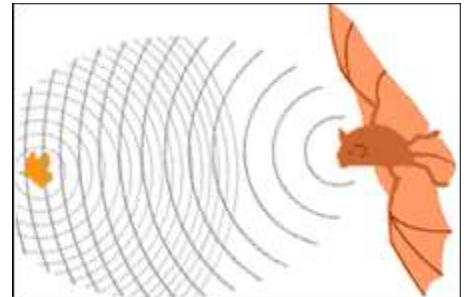
Mimicry of leaves by insects is an adaptation for evading predators. This example is a katydid from Costa Rica.



The creosote bush is a desert-dwelling plant that produces toxins that prevent other plants from growing nearby, thus reducing competition for nutrients and water.



Echolocation in bats is an adaptation for catching insects.



So what's not an adaptation? The answer: a lot of things. One example is [vestigial structures](#). A vestigial structure is a feature that was an adaptation for the organism's ancestor, but that evolved to be non-functional because the organism's environment changed.

Fish species that live in completely dark caves have vestigial, non-functional eyes. When their sighted ancestors ended up living in caves, there was no longer any natural selection that maintained the function of the fishes' eyes. So, fish with better sight no longer out-competed fish with worse sight. Today, these fish still have eyes — but they are not functional and are not an adaptation; they are just the by-products of the fishes' evolutionary history.



In fact, biologists have a lot to say about what is and is not an adaptation.

Misconceptions about natural selection

Because natural selection can produce amazing adaptations, 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 what natural selection is like at all.

First, natural selection is not all-powerful; 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. This should be pretty clear just 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.

Second, it's more accurate to think of natural selection as a process rather than as a guiding hand. 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.

$$\text{variation} + \text{differential reproduction} + \text{heredity} = \text{natural selection}$$



Evolution does not work this way.