

Reading 5.2 – Genetic Drift and Population Size

A **population bottleneck** (or genetic bottleneck) are when the size of a population becomes very small. This can happen when a significant percentage of a population or species is killed or otherwise prevented from reproducing. On a real bottle, the thin part of the bottle is called the neck. It is where the bottle is the smallest. For this smaller populations the effects of genetic drift can appear more quickly than on larger populations.

Questions 1 What are some events in the real world that might cause a significant percentage of a population or species to be killed or otherwise prevented from reproducing?

Thus populations that experienced a bottleneck at some point in the past typically end up having less genetic diversity in their gene pool than populations that never reached such small sizes. And they therefore have less variation in the traits of the individuals in the population.

Reduced genetic variation often also means that the population may not be able to adapt to new selection pressures (such as climate change or a shift in available resources, because the genetic variation that natural selection would have acted on may already have been eliminated from the gene pool). Therefore, changing selective pressures are likely to cause smaller populations or populations with less diversity in their gene pool to go locally extinct, instead of undergoing the effects of natural selection.

In the article below you will read about one species that encountered a population bottleneck about 10,000 years ago, and how that has affected the gene pool of the population as well mating behaviors of individuals now many years after the population bottleneck?

http://evolution.berkeley.edu/evolibrary/news/070701_cheetah

Cheating cheetahs prosper

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Philandering males, sneaking around behind their partners' backs or openly canoodling, are a stock character on Animal Planet. Male lions, male chimps, and male elephant seals (along with many others) play the Casanovas, pairing up with multiple females. But now researchers have revealed that cheetahs buck this sexual stereotype. According to the May 2007 study, female cheetahs seem to be at least as promiscuous as their male counterparts. Females frequently mate with several different males while they are fertile and are then likely to bear a single litter of cubs fathered by multiple males — making many of the cubs within a single litter only half-siblings. This discovery has important implications for the conservation of these endangered animals. Though it conflicts with the

idea that cheaters never prosper, evolutionary theory suggests that, in this case, cheating may be exactly what the doctor ordered.

How did biologist Dada Gottelli and her colleagues at the Zoological Society of London figure out that female cheetahs were fooling around with so many different suitors? Cheetahs seem to be modest about mating. Biologists have rarely caught cheetahs "in the act," but they *have* been able to pick up what cheetahs leave behind in their daily routine: poop. Feces contain traces of DNA. And cheetahs, like us, get half of their DNA from their mother and half from their father. So Gottelli's team collected feces from mothers, their cubs, and potential fathers and then extracted and analyzed the DNA to perform paternity tests on the cubs

Conservation biologists are interested in cheetah cheating because it impacts the cheetah [population's](#) level of [genetic variation](#). Loosely, genetic variation is a measure of the genetic differences within a population. A population in which every individual has the same [gene](#) version (i.e., [allele](#)) at a particular location in the [genome](#) has less genetic variation for that gene than a population in which many individuals carry different gene versions at that location.

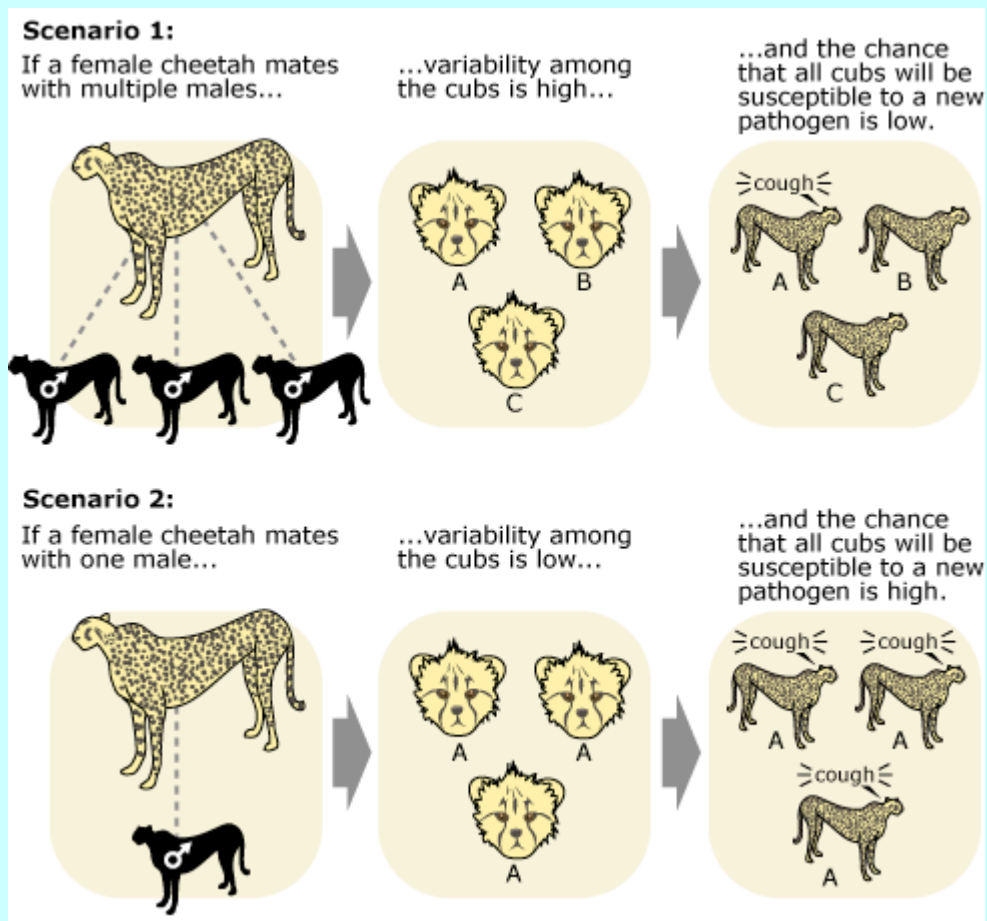
Genetic variation is a key ingredient of [evolution](#). [Natural selection](#) acts on the genetic variation present in a population to remove those variants that fail to produce offspring in a particular situation and spread those variants that are particularly good at producing offspring. A population with no genetic variation (in which every individual is genetically identical) cannot evolve in response to environmental or situational changes. If, for example, a genetically uniform population were exposed to a new pathogen and did not carry the gene versions necessary to fend off the disease, the population could face complete [extinction](#). On the other hand, a population with high levels of genetic variation is much more likely to include at least a few individuals carrying the gene versions that provide protection from the pathogen — and, hence, to evolve in response to the new situation instead of going extinct. A population with low genetic variation is something of a sitting duck — vulnerable to all sorts of environmental changes that a more variable population could persist through.

And unfortunately, those are exactly the circumstances faced by cheetahs today. As a [species](#), cheetahs have famously low levels of genetic variation. This can probably be attributed to a population [bottleneck](#) they experienced around 10,000 years ago, barely avoiding extinction at the end of the last ice age. However, the situation has worsened in modern times. Habitat encroachment and poaching have further reduced cheetah numbers, consequently snuffing out *even more* genetic variation and leaving cheetahs *even more* vulnerable to extinction.

Nevertheless, conservation biologists may have reason to hope that this genetic variation will not drain away as quickly as was thought — now that researchers from the Zoological Society of London have laid bare female cheetahs' cheating hearts. The scientists have found that not only do female cheetahs bear single litters with multiple fathers, but those fathers are rarely near neighbors. Females seem to mate with individuals from far-flung regions, meaning that the cubs' fathers are only distantly related to one another. Furthermore, female cheetahs don't even return to the same males year after year: consecutive litters from the same mother all had different sets of fathers. In short, female cheetahs' mating habits wind up getting genetic information from lots of different fathers into the next generation — and that helps preserve genetic variation!

In fact, the impact of multiple matings on genetic variation may help explain how the trait evolved in cheetahs in the first place. Biologists [hypothesize](#) that in an unpredictable environment, like the Serengeti, having variable offspring would have been advantageous to a female cheetah. Even if several of her cubs were killed by a new disease, succumbed to a novel environmental stress, or just didn't have what it took to make a living in the Serengeti, a female with a variable litter could still hope that one of her cubs would have "the right stuff" to survive (shown in Scenario 1 below). Biologists refer to this as "bet-hedging" — not putting all your eggs (or in this case, cubs) in one basket. On the other hand, a female with a more genetically uniform litter might not have any of her cubs survive their dicey environment (Scenario 2 below).

In this case the female who mated multiple times and had variable offspring would pass her genes on to the next generation, while the female who mated singly and had a more uniform litter would not. Over time, if this imbalance persisted, natural selection would favor females with genetically variable litters — and hence, females who engaged in multiple matings. So perhaps, what we humans perceive as promiscuity is actually an adaptation that allows female cheetahs to increase the odds of having at least one cub survive to pass on her genes.



While it's certainly possible that the multiple mating strategy spread because of its impact on the genetic diversity within litters, biologists have also come up with two main alternative hypotheses to

explain why multiple mating is common in cheetahs:

Perhaps, multiple mating is really a strategy to avoid expending extra energy fending off would-be suitors. In other words, maybe females mate multiple times not because it ensures genetic variation in offspring, but because it's so much easier than fighting off males right and left.

Or perhaps, multiple mating evolved as a way to deter infanticide. In some big cats (and in many other species), males try to kill cubs that are not their own — a phenomenon known as infanticide. However, if a mother mates with many different males, it is more difficult for a male to tell whether or not a cub is his own — and the male would likely be deterred from killing the cub. This third hypothesis suggests that multiple mating was favored by natural selection because it discouraged infanticide against a female's cubs, not because it increased the litter's genetic variation. This third hypothesis fits with the observation that wild cheetah males seem to rarely (if ever) commit infanticide, though it is common in lions and other big cats.

Figuring out which of these three hypotheses (if any) is the right one will require further research. But regardless of what we learn about the evolutionary origins of multiple mating in female cheetahs, its evolutionary consequences today are clear. The fact that female cheetahs bear young with many different fathers helps preserve what little genetic variation the species has left — and could even buy us some time in our efforts conserve these endangered animals

Question 2: Why would interbreeding with more mates likely increase the amount of genetic variation in the parent's offspring?

Endangered species are those whose population size is becoming so low, that scientists worry both about the immediate loss of the species, as well as the inability of the species to survive even if its numbers get very low, but does not immediately go extinct.

These are three species that are on the endangered species list: The California Condor, the Sea Otter, and the Loggerhead Sea Turtle.

Question 3: Even if a small number of individuals survive from each of these species for now, why might genetic drift in combination with the population bottleneck effect, hurt the long term chances of survival for all of these species?

Another type of event that also reduces population size and leads to an increased rate of genetic drift is called **the founder effect**. The founder effect occurs when a new isolated colony of individuals is started (or founded) by a few members of the original population. This small "founding" population size means that the colony is likely to have a smaller gene pool and less variation than the original population they migrated away from.

Such reduced genetic variation is apparent in colonists who have remained reproductively isolated from individuals outside their population for many generations. Many examples of such reduced genetic variation and some of the genetic diseases that can result from the founder effect can be found in isolated populations of people. In the article below you will read about how the founder effect has influenced the traits of a population of Amish people whose ancestors settled in Pennsylvania in the 1700s.

Genetic Drift and the Founder Effect: [text & image](http://www.pbs.org/wgbh/evolution/library/06/3/l_063_03.html)
http://www.pbs.org/wgbh/evolution/library/06/3/l_063_03.html

Eastern Pennsylvania is home to beautiful farmlands and countryside, but it's also a gold mine of information for geneticists, who have studied the region's Amish culture for decades. Because of their closed population stemming from a small number of German immigrants -- about 200 individuals -- the Amish carry unusual concentrations of gene [mutations](#) that cause a number of otherwise rare inherited disorders, including forms of dwarfism.

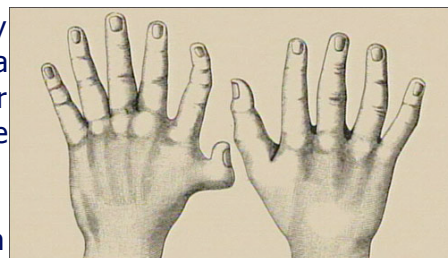
One form of dwarfism, Ellis-van Creveld syndrome, involves not only short stature but polydactyly (extra fingers or toes), abnormalities of the nails and teeth, and, in about half of individuals, a hole between the two upper chambers of the heart. The syndrome is common in the Amish because of the "[founder effect](#)."

When a small part of a population moves to a new locale, or when the population is reduced to a small size because of some environmental change, the genes of the "founders" of the new society are disproportionately frequent in the resulting population.

If individuals in the group tend to marry within it, there's a greater likelihood that the recessive genes of the founders will come together in the cells that produce offspring. Thus diseases of [recessive](#) genes, which require two copies of the gene to cause the disease, will show up more frequently than they would if the population married outside the group.

In the Amish, in fact, Ellis-van Creveld syndrome has been traced back to one couple, Samuel King and his wife, who came to the area in 1744. The mutated gene that causes the syndrome was passed along from the Kings and their offspring, and today it is many times more common in the Amish population than in the American population at large.

Polydactyly -- extra fingers or sometimes toes -- is one symptom of Ellis-



van Creveld syndrome.

The founder effect is an extreme example of "[genetic drift](#)." Genes occurring at a certain frequency

in the larger population will occur at a different frequency -- more or less often -- in a smaller subset of that population. As in the example of human diseases, genetically determined traits that would ordinarily be uncommon in the overall [gene pool](#) might crop up with distressing frequency in a small subset of that pool.

Question 4: How are both the founder effect and population bottle neck similar with regard to the sizes of populations they effect?

- a) They both are related to small populations
- b) They are both related to large populations
- c) Neither are related to population size

Question 5: How are both the founder effect and population bottle neck similar with regard to their effect on the diversity of the gene pool of the population?

Question 6: Why might islands be good ecosystems to study the outcomes of the founder effect?
