Medical Academy named after S.I.Georgievsky of Vernadsky

CRIMEA FEDERAL UNIVERSITY

BOTTLENECK EFFECT

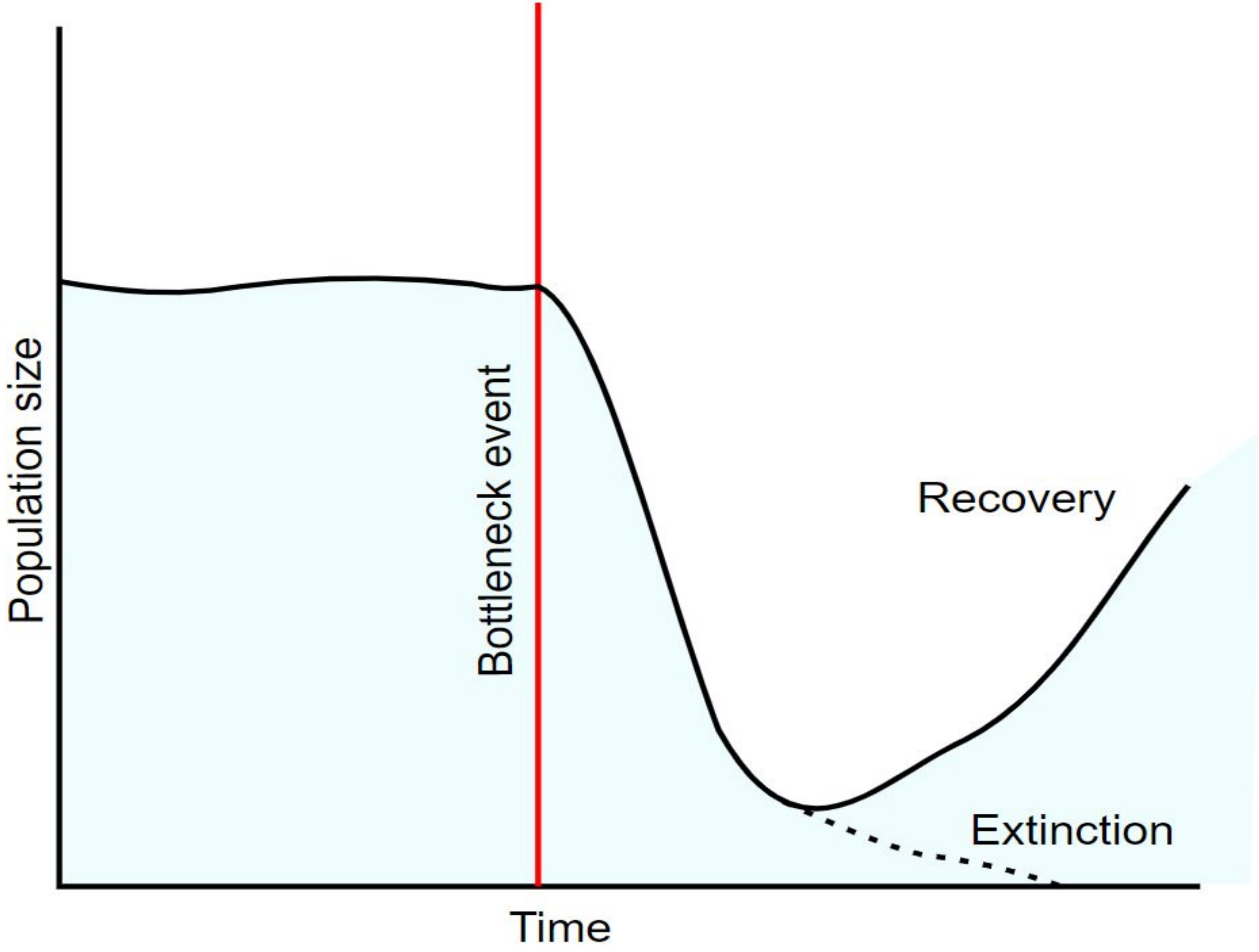
- TOPIC – EVOLUTION
- SUBJECT – MEDICAL BIOLOGY

NAME – MANIVEL PRAVEEN

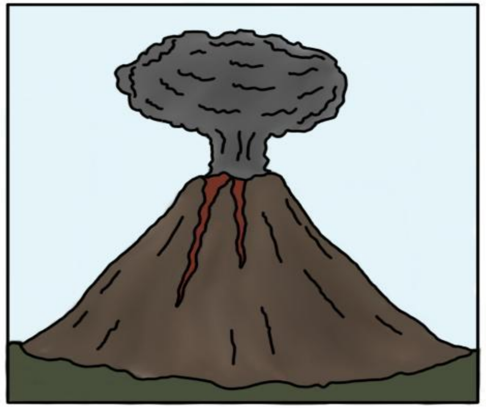
LA1-191 B

INTRODUCTION

A **population bottleneck** or **genetic bottleneck** is a sharp reduction in the size of a population due to environmental events such as famines, earthquakes, floods, fires, disease, and droughts or human activities such as genocide and human population planning. Such events can reduce the variation in the gene pool of a population; thereafter, a smaller population, with a smaller genetic diversity, remains to pass on genes to future generations of offspring through sexual reproduction. Genetic diversity remains lower, increasing only when gene flow from another population occurs or very slowly increasing with time as random mutations occur. This results in a reduction in the robustness of the population and in its ability to adapt to and survive selecting environmental changes, such as climate change or a shift in available resources. Alternatively, if survivors of the bottleneck are the individuals with the greatest genetic fitness, the frequency of the fitter genes within the gene pool is increased, while the pool itself is reduced.

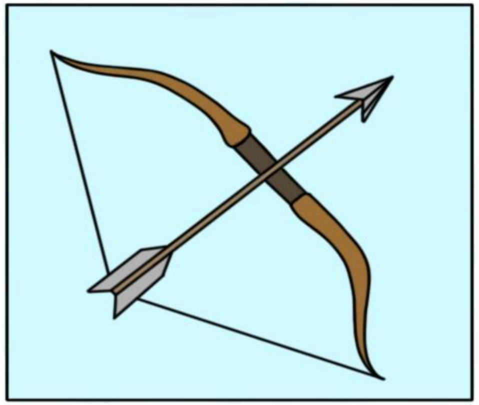

Population size
Bottleneck event
Recovery
Extinction
Time

CAUSES OF THE BOTTLENECK EFFECT

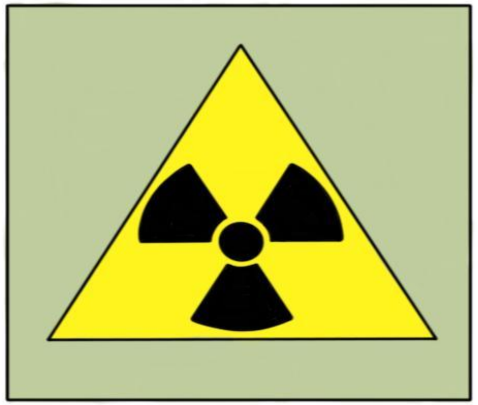


volcano eruption

earthquake



over-hunting



radiation poisoning

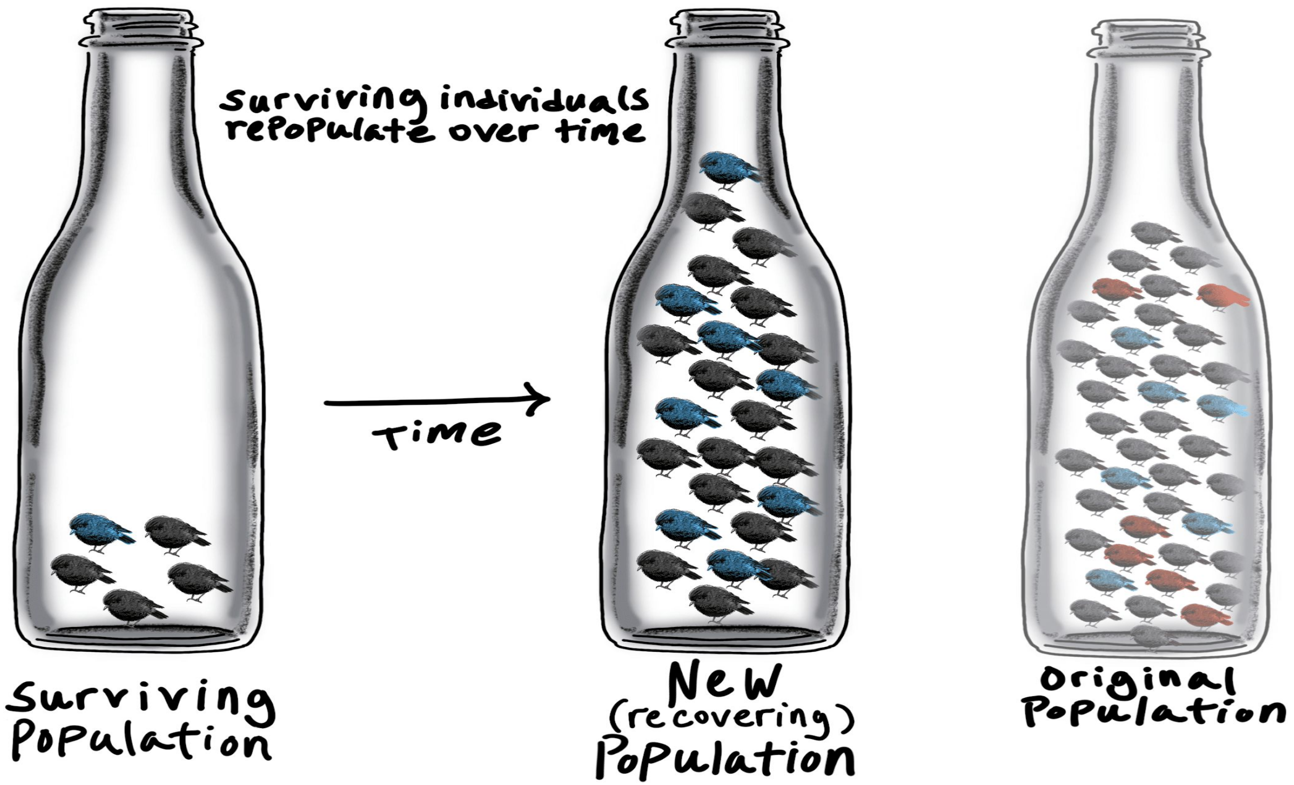
When disaster strikes, an ecosystem can change very quickly. When an event causes a drastic decrease in a population, it can cause a type of **genetic drift** called a **bottleneck effect**.
This can be caused by a natural disaster, like an earthquake or volcano eruption. Today, it is also often caused by humans through over-hunting, deforestation, and pollution.
When most members of a population die suddenly, **genetic variation** goes down and the frequencies at which different alleles are found in the population can change in a big way. Remember that alleles are different forms of a specific gene located in the same place on a chromosome.

Population size matters

Larger populations are unlikely to change this quickly as a result of genetic drift. For instance, if we followed a population of 100010001000 rabbits (instead of 101010), it's much less likely that the *b* allele would be lost (and that the *B* allele would reach 100\%100%100, percent frequency, or **fixation**) after such a short period of time. If only half of the 100010001000-rabbit population survived to reproduce, as in the first generation of the surviving rabbits (500500500 of them) would tend to be a much more accurate representation of the allele frequencies of the original population – simply because the sample would be so much larger.

EXAMPLES OF BOTTLENECK EFFECT

The original population of black robins on the left had genetic variation with the different "red" and "blue" genotypes. Humans caused a population bottleneck for these birds by introducing non-native predators and destroying their natural habitat. Over time, the black robin population shrank until there were only five birds left.



In the aftermath of the bottleneck event, and with the help of conservation scientists, the remaining few birds were able to reproduce and slowly increase their population size. But as you can see, because the new population is descended from just a few individuals, the genetic diversity of the species is greatly reduced.

The important detail that makes this an example of a bottleneck event and not just natural selection is that the birds survived at **random**. If there were some **heritable** traits that allowed some birds to survive better than others, then it would be an example of natural selection.

Toba catastrophe theory

The controversial Toba catastrophe theory, presented in the late 1990s to early 2000s, suggested that a bottleneck of the human population occurred approximately 70,000 years ago, proposing that the human population was reduced to perhaps 10,000–30,000 individuals when the Toba supervolcano in Indonesia erupted and triggered a major environmental change. Parallel bottlenecks were proposed to exist among chimpanzees, gorillas, rhesus macaques, orangutans and tigers. The hypothesis was based on geological evidence of sudden climate change and on coalescence evidence of some genes (including mitochondrial DNA, Y-chromosome DNA and some nuclear genes) and the relatively low level of genetic variation in humans.

However, subsequent research, especially in the 2010s, appeared to refute both the climate argument and the genetic argument

Recent research shows the extent of climate change was much smaller than believed by proponents of the theory. In addition, coalescence times for Y-chromosomal and mitochondrial DNA have been revised to well above 100,000 years since 2011

Finally, such coalescence would not, in itself, indicate a population bottleneck, because mitochondrial DNA and Y-chromosome DNA are only a small part of the entire genome, and are atypical in that they are inherited exclusively through the mother or through the father, respectively. Genetic material inherited exclusively from either father or mother can be traced back in time via either matrilineal or patrilineal ancestry.

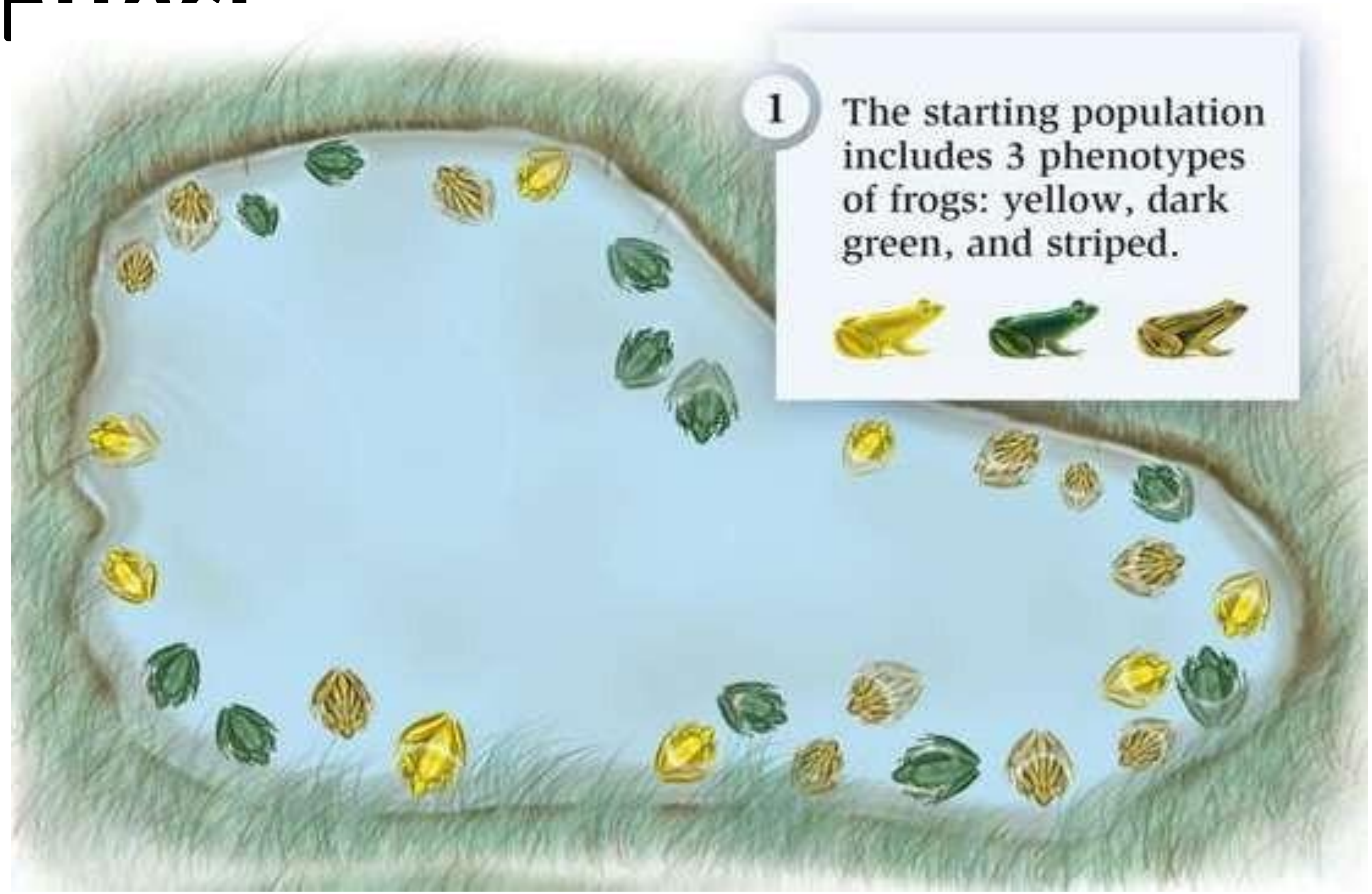
In 2000, a *Molecular Biology and Evolution* paper suggested a transplanting model or a 'long bottleneck' to account for the limited genetic variation, rather than a catastrophic environmental change. This would be consistent with suggestions that in sub-Saharan Africa numbers could have dropped at times as low as 2,000, for perhaps as long as 100,000 years, before numbers began to expand again in the Late Stone Age.

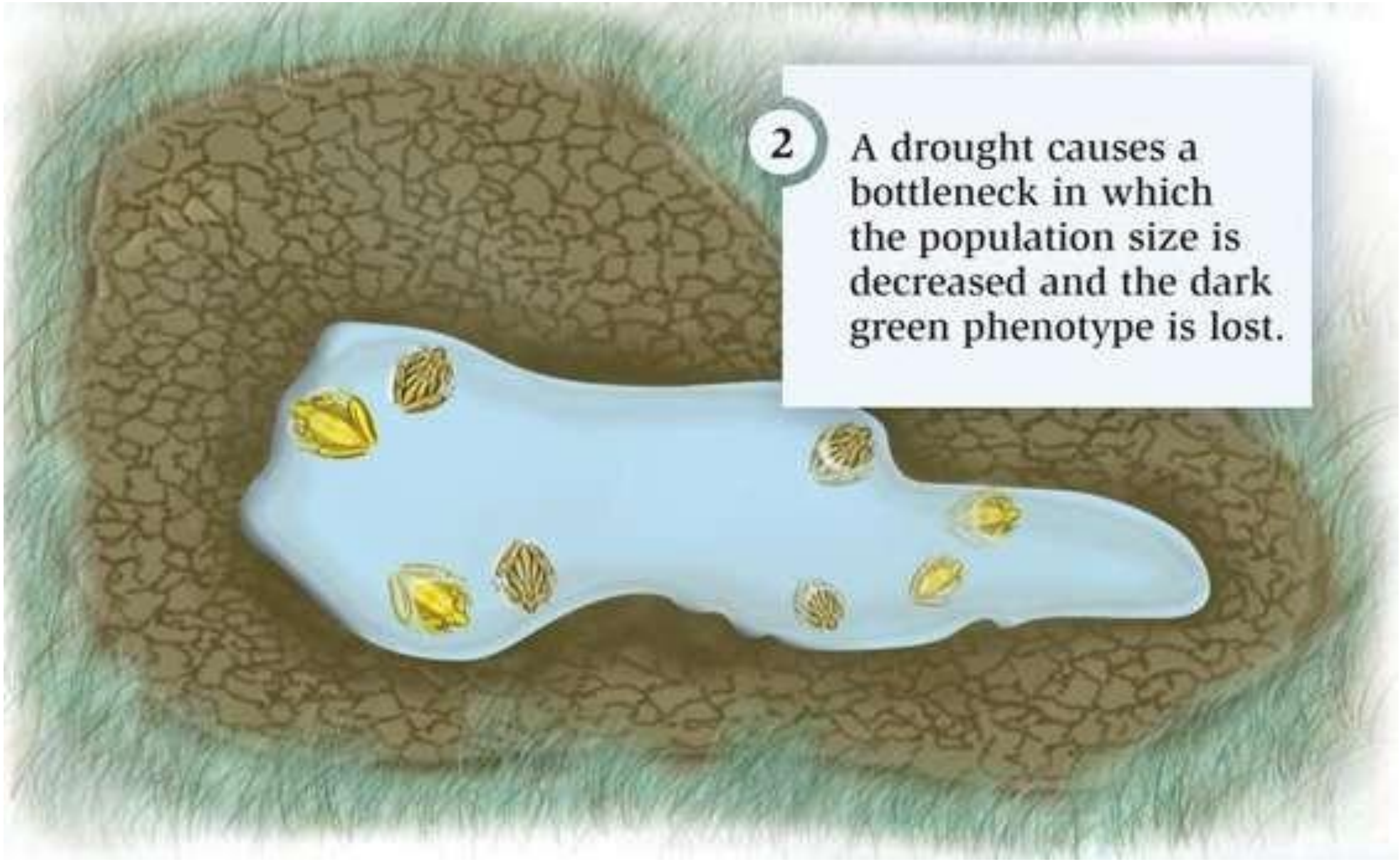
Bottleneck Effect

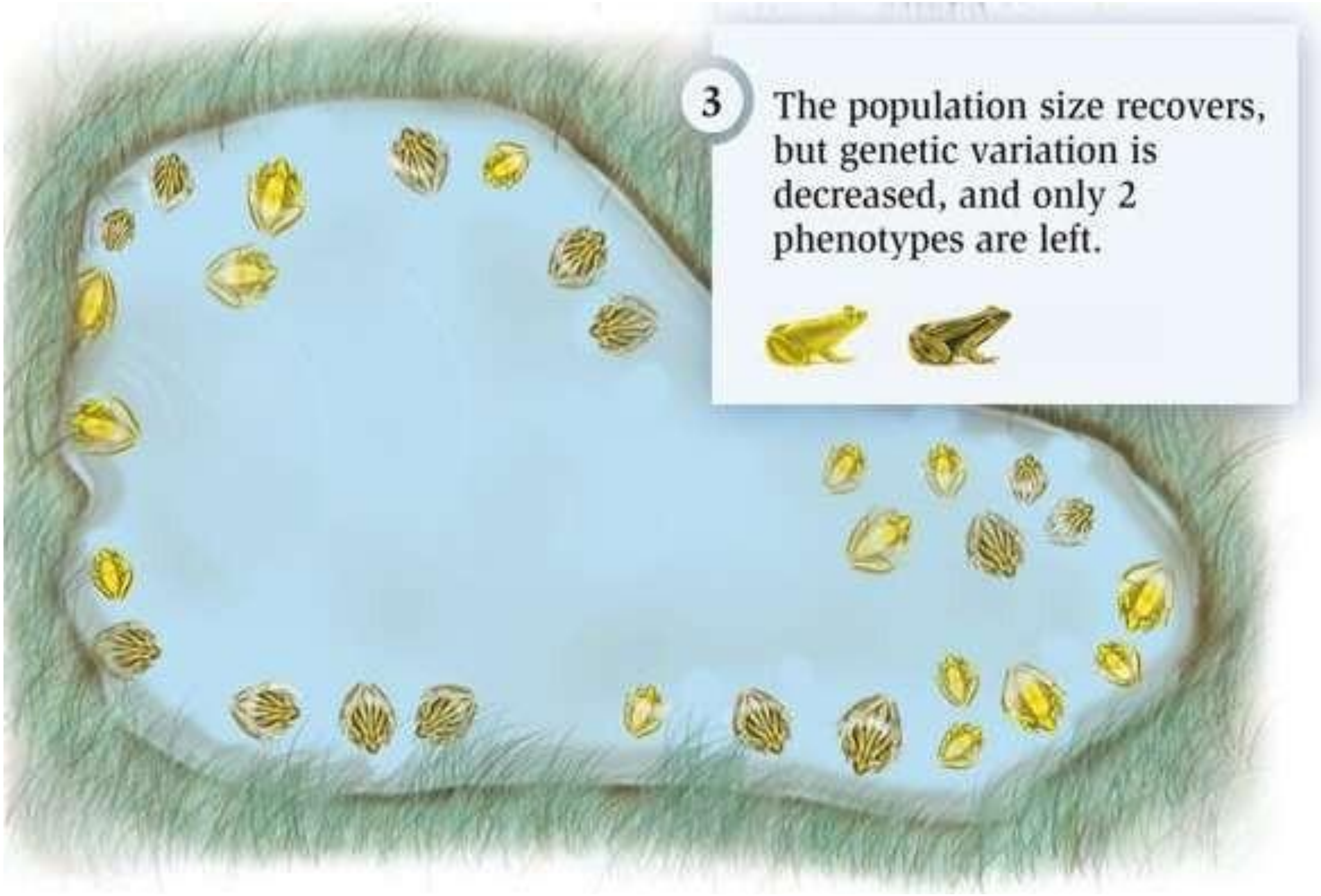
Two reasons for change:

1. Surviving population members have different allele frequencies than original population
2. When population is small, genetic drift reduces genetic variation faster, Alleles could even get eliminated

Examples of the Bottleneck Effect




2
A drought causes a bottleneck in which the population size is decreased and the dark green phenotype is lost.


3
The population size recovers, but genetic variation is decreased, and only 2 phenotypes are left.

Bottleneck effects v/s Founder effects

Bottleneck effect

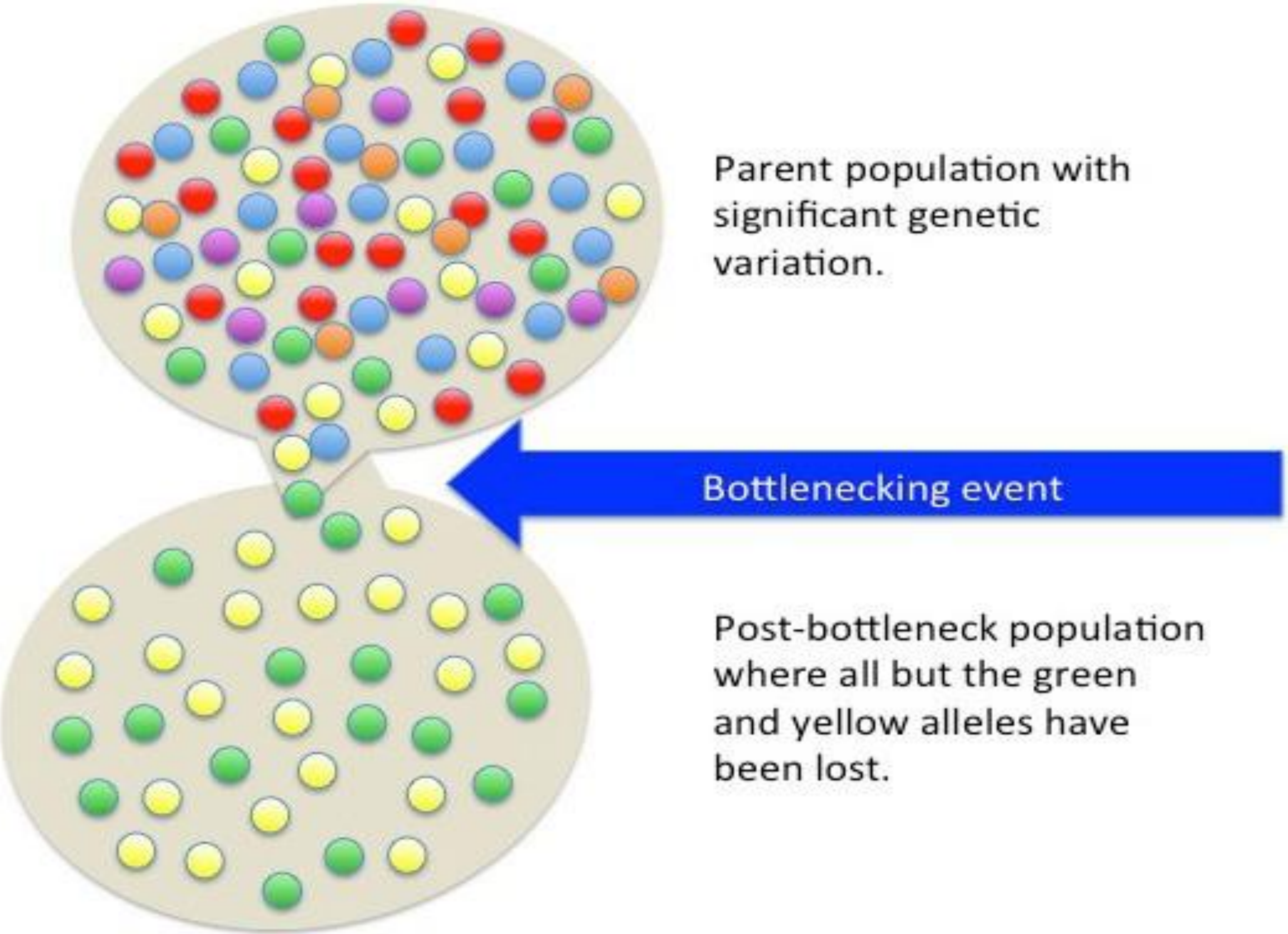
- Subpopulation caused when a natural disaster reduces the size of an original larger population.
- Result of habit fragmentation and/or overexploitation of the species.

Founder effects

- Founder establishes a subpopulation as a new colony drawn from a larger population.
- Result of migration .

A population bottleneck can be split into three unique stages:

1. **Before it occurs:** Before a chance event occurs, there is genetic diversity in the population. Different members of the population have different alleles for different traits.
2. **A chance event occurs:** The effect is prompted by some kind of chance event. Usually, this is a natural disaster like a forest fire or an earthquake. The event severely decreases the size of the population. Which members survive is based on chance.
3. **Decreased genetic diversity:** Because only some members of the population survive, only their alleles survive as well. The chance event leads to a loss of genetic diversity in the population. While the population can grow back to its original size, it will not have the same genetic diversity that it did before the event.


Parent population with significant genetic variation.
Bottlenecking event
Post-bottleneck population where all but the green and yellow alleles have been lost.

Selective breeding

Bottlenecks also exist among pure-bred animals
(e.g., dogs and cats: pugs, Persian) because breeders limit their gene pools by a few (show-winning) individuals for their looks and behaviors. The extensive use of desirable individual animals at the exclusion of others can result in a popular sire effect.

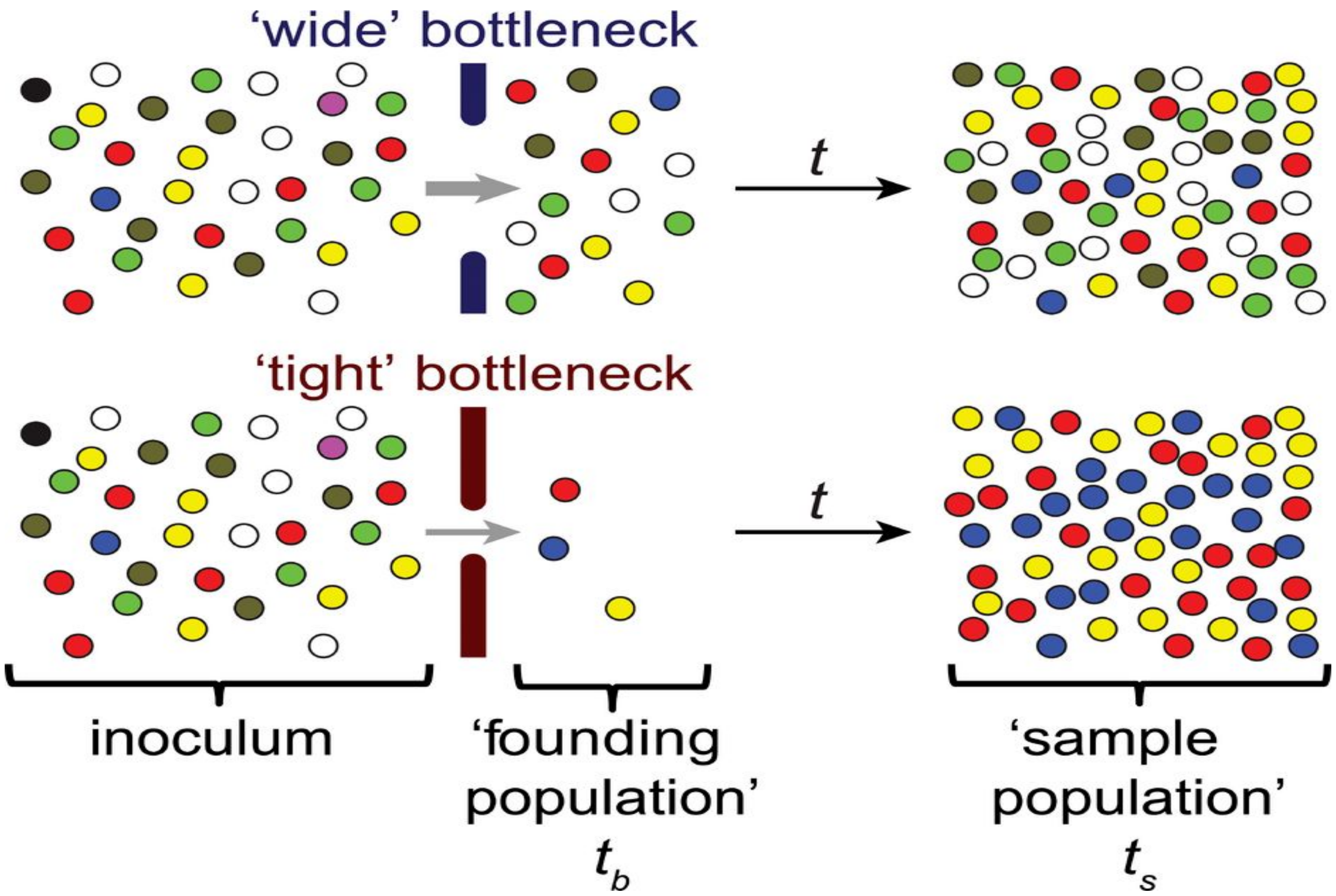
Selective breeding for dog breeds caused constricting breed-specific bottlenecks. These bottlenecks have led to dogs having an average of 2-3% more genetic loading than gray wolves. The strict breeding programs and population bottlenecks have led to the prevalence of diseases such as heart disease, blindness, cancers, hip dysplasia, cataracts, and more.

Selective breeding to produce high-yielding crops has caused genetic bottlenecks in these crops and has led to genetic homogeneity. This reduced genetic diversity in many crops could lead to broader susceptibility to new diseases or pests, which threatens global food security.

Disaster Events and Allele Frequency

Genetic drift can be separated into two types. The founder effect is defined as a new population breaking apart from an existing population. The bottleneck effect, on the other hand, is an event which sharply reduces a population's size. This decreases genetic diversity.

An event which could cause this effect on a population varies. It could be hunting, an environmental disaster, or even a disease. The important distinction between this effect and natural selection is that the bottleneck decreases a population **at random**. Natural selection is based on specific traits.



An example of this in the real world happened to northern elephant seals. In the 19th century, humans hunted these seals to near-extinction. By the time the hunting of these animals was made illegal, there were only 20 seals left. Since then, their population has increased to nearly 30,000. However, those northern elephant seals have very low genetic diversity among them when compared to the southern elephant seal that was not hunted.


Thank You