EXPLORE THE ISSUE BEING INVESTIGATED

Why Do Some Genes Maintain More Than One Common Allele in a Population?

When Mendel did his crosses of pea plants, he knew what a pea plant was supposed to look like: a small plant with green leaves, purple flowers, and smooth seeds. But if all pea plants were like that, he would never have been able to sort out the rules of heredity—in a cross of green peas with green peas, there would have been no visible differences to reveal the 3:1 pattern of gene segregation. The variant alleles that Mendel employed in his studies—yellow leaves, white flowers, wrinkled seeds—were rare "accidents" maintained in seed collections for their novelty. In nature, such unusual kinds of peas had never been encountered by Mendel.

By the time Mendel's work was rediscovered in 1900, Darwin had provided a ready explanation of why alternative alleles seemed to be rare in natural populations. Natural selection was simply scouring the population, cleansing it in each generation of less fit alternatives. While recombination can complicate the process in interesting ways among sexual organisms like peas, asexual organisms like bacteria were predicted to be very sensitive to the effects of selection. Left to do its work, natural selection should crown as winner in bacterial population the best allele of each gene, producing a uniform population.

Why do populations contain variants at all? In 1932 the famous geneticist Herman Muller formulated what has come to be called the "classical model," explaining gene variation in natural populations of asexual organisms as a temporary, transient condition, new variations arising by random mutation only to be established or eliminated by selection. Except for the brief periods when populations are undergoing this periodic cleansing, they should remain genetically uniform.

The removal of variants was proposed to be a very straightforward process. During the periodic cleansing periods envisioned by Muller, his classical model operates under a "competitive exclusion" principle first proposed by Gause: whenever a new variant appears, it is weighed in the balance by natural selection, and either wins or loses. There are no ties. One version of the gene becomes universal in the population, and the other is eliminated.

Muller's classical model thus makes a very straightforward prediction: in nature, most populations of asexual organisms should be genetically uniform most of the time. However, this is not at all what is observed. Natural populations of most species, including asexual ones like bacteria, appear to have lots of common variants—they are said to be "polymorphic."

So where are all of these variants coming from? Variation in the environment, either spatial or temporal, can be used to explain how some polymorphisms arise. Selection favors one form at a particular place and time, a different form at a different place or time. In a nutshell, varying selection can encourage polymorphism.

Is that all there is to it? Is it really impossible for more than one variant to become common in a population, if the population lives in a constant uniform environment, an environment that does not vary from one place to another or from one time to another? Theory says so.

Biologists that study microbial communities have begun to report that bacteria are not aware of Muller's theory. Bacterial cultures started from a single cell living in simple unstructured environments rapidly become polymorphic.

There is a way to reconcile theory and experiment. Perhaps the variant individuals in the population are interacting with one another. Muller's theory assumes that every individual undergoes an independent trial by selection. But what if that's not so? What if different kinds of individuals help each other out? Stable coexistence of variants in a population might be possible if interactions between them contribute to the welfare of both (what a biologist calls mutualism) or favors one (what a biologist calls commensalism). In essence, cooperation would be counterbalancing the effects of competition.