

A Little About Evolution

Evolution FAQ

What is evolution?

Evolution is change over generations in the inherited characteristics found in a population or species. Evolution is often a slow and gradual process, but in the 3,500,000,000 years since life began on Earth, there has been plenty of time for it to produce the great diversity of life we see today from the ancient common ancestor shared by all living species.

What is natural selection?

Natural selection is the mechanism by which evolution can occur. It describes the situation when some individuals in a population or species are able to outcompete and out-reproduce other individuals based on the traits that they have. If these advantageous traits can be inherited and passed on, then natural selection can cause the population or species to evolve.

What is an adaptation? Is cyanogenesis an adaptation in white clover?

An adaptation is an inherited trait that is favored by natural selection. It improves the chance that an organism will survive and reproduce in particular circumstances or in a particular environment. In white clover, cyanogenesis (the ability to release cyanide when a leaf is damaged) is an adaptation in warm climates; in contrast, *not* producing cyanide (the acyanogenic phenotype) is an adaptation in colder climates. The reason probably has to do with the energetic costs vs. benefits of being cyanogenic in regions of high vs. low herbivore abundance. Cyanogenesis is known to protect plants from being eaten. Therefore, in warm climates, where there are many clover herbivores (such as snails, slugs, and insects), cyanogenesis is an adaptation that is favored by natural selection. On the other hand, the components required for cyanogenesis take energy to make, energy that could otherwise be spent on growth and reproduction. So, in colder climates, where herbivores are less abundant, acyanogenic plants have a competitive advantage, and most clover plants in a population will be acyanogenic. In moderate climates, both cyanogenic and acyanogenic plants can survive and reproduce, and so both phenotypes can be considered adaptive.

What is an adaptive polymorphism?

In a situation such as white clover, where natural selection favors two different forms of a trait and so maintains the polymorphism in the species, the trait is referred to as an *adaptive polymorphism*

Why is white clover (*Trifolium repens*) used for evolutionary study?

White clover (*Trifolium repens*) has been studied for the past 60 years with regards to natural selection and the environmental factors that maintain the cyanogenesis adaptive polymorphism in this species. Today's technology, such as DNA sequencing, allows us to now document the effect of natural selection at the DNA sequence level to understand the molecular evolution of this polymorphism. Usually, researchers study model plants such as *Arabidopsis* or tobacco to understand genetics. Those are species that are well studied in the lab but where very little is known about how natural selection acts on them in nature. With clover we have a system where we can look in detail at DNA sequence variation and at the same time have a thorough understanding of the plant's ecology. "The advantage of the clover cyanogenesis system is there's already so much known about its ecology," says Dr. Kenneth Olsen of Washington University in St. Louis, who studies the evolution of clover cyanogenesis. "What we're able to do now is get to the molecular level and look at the molecular basis of ecologically important variation."

What is the biochemical and genetic basis of the cyanogenesis polymorphism in white clover?

It's a bit complicated! The simplified version is as follows: The clover cyanogenesis polymorphism comes from two biochemical polymorphisms for the presence/absence of each of two required cyanogenic components, cyanogenic glucosides (sugar molecules containing cyanide), and an enzyme that can break down the sugars to release cyanide. A plant must produce both components to be cyanogenic. These two components are stored in separate parts of the tissue (cyanogenic glucosides in the cell vacuoles, and the enzyme in the cell wall), so cyanide release only occurs if there is tissue damage that ruptures the cells and causes the two components to mix. A plant that is lacking in either one of these two required components will be acyanogenic.

Two separate genes control the two biochemical polymorphisms; the *Ac* gene controls the presence or absence of cyanogenic glucosides, and the *Li* gene controls the presence or absence of the enzyme. For each gene, if a plant has two recessive alleles (*acac*, or *lili* genotypes), it will not produce the corresponding cyanogenic component. On the other hand, a plant only needs one dominant allele at each gene to make the component. So a plant with at least one dominant allele at both genes (*Ac_*, *Li_*) will be cyanogenic. A plant with two recessive alleles at either (or both) genes will be acyanogenic. At the DNA sequence level, the recessive alleles at each gene correspond to deletions of the gene from the white clover genome.

More details of the genetics are given in a project excerpt provided by Dr. Olsen. Link below:

[Dr. Kenneth Olsen-Background Genetics](#)