

## Common Student Ideas about Variations in Plants and Animals

Common Student Idea(s)	Scientific Explanation
<p>1. All individuals in a population are the same. Any differences are too small to matter.</p> <p>Every difference between individual organisms of the same group has a purpose.</p>	<p>In some species, such as dogs or humans, variations among individuals are easy to see. In other species, variations may be harder to distinguish. For example, beans exhibit small differences in size, and insects have slight color variations. There are also behavioral variations within a species. Although these differences might seem inconsequential, they could confer an advantage that enables some individuals to survive better than others in their environment. In other cases, a variation might not confer such an advantage.</p>
<p>2. Individuals can change or adapt to their environment.</p>	<p>Common language usage regarding adaptation can contribute to student misconceptions. In everyday language, the word <i>adapt</i> means a change that makes something or someone suitable for a new use or purpose. Biological adaptations, however, are heritable. Over time, the characteristics of a population may experience shifts because of the selective environmental pressures on generations of individuals. Traits that become biological adaptations change within populations over the course of several generations in response to these selective pressures.</p>
<p>3. Individuals change their traits because they want to or need to.</p>	<p>Individual organisms don't change their traits simply because they want to or need to. For example, students may think that moths change their color because they don't want birds to eat them. But this isn't the case. Trait changes occur across generations of a species because of natural selection. Like many organisms, moths show trait variations for color. During the Industrial Revolution, pollution caused tree trunks to become darker, which enabled birds to see light-colored moths on the bark more easily. This led to a selective pressure that gave dark-colored moths a survival advantage because they blended into their environment (the dark tree trunks) much better. As a result, the dark-colored moths lived longer and passed their dark-colored trait to their offspring. After several generations, dark-colored moths vastly outnumbered light-colored moths. This trait change came about not because individual moths <i>chose</i> to become darker but as a result of random DNA mutations.</p>

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4. Individual organisms change because they copy the traits of successful organisms they see and like.	Variations in a population depend on the traits that future generations inherit from their parents. These traits must be encoded in DNA, a complex molecule that contains all of the biological instructions that make an individual organism and a species unique. Simply observing the traits of another individual and mimicking them doesn't encode them in an individual's DNA or pass them on to future offspring or generations.
5. Changes in a population happen because all individuals change gradually over time.	Natural selection means that individual organisms with traits that make them better adapted to their environment are more likely to survive long enough to reproduce and pass on these traits to their offspring. Not all individuals change, but if environmental conditions stay the same, their offspring will also be more likely to survive long enough to reproduce and pass on these traits to the next generation. This natural selection of traits means that some individuals in a population inherit and pass on traits that confer specific survival advantages. Over time, this leads to changes in the traits of a population, since individuals without traits that confer an advantage may not survive long enough to reproduce.
6. Changes in the environment don't lead to changes in the traits of populations living in that environment.	When environmental conditions change, individuals whose traits make them better suited to the conditions have a survival advantage over those without these traits. This natural selection of traits means that some individuals in a population inherit and pass on traits that confer specific survival advantages. Over time, this leads to changes in the traits of a population, since individuals without these traits may not survive long enough to reproduce.
7. The environment has to change suddenly for evolution to occur.	Some students think that sudden changes in the environment, such as volcanic eruptions, are the only way evolution occurs. But many environmental changes that cause selection for certain traits happen slowly over time.
8. Extinction is rare. Humans cause most extinction.	Extinction is the most dramatic change possible for a species. The fossil record shows that many species that once existed are now extinct. In fact, of all the species that ever existed on Earth, 99.9% are now extinct. Humans cause some species extinction, but there are also natural causes. As environments change, some species aren't able to adapt quickly enough for individuals to survive and pass on their traits to the next generation. At the same time, new species emerge and often take over roles in the environment that extinct species filled in the past.

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9. Species that survive because of natural selection are perfect.	Some of the language used to describe natural selection and evolution can be misleading. For example, descriptions such as “This species was better adapted and survived” or “This species evolved into a new species” may cause students to think that surviving species are perfect. This isn’t the case. Individuals of a species may simply have traits that help them adapt better to environmental conditions. As conditions change over time, the traits that helped an organism adapt and survive in one environment may no longer confer a survival advantage in the new environment.
10. Natural selection and evolution are the same thing.	<i>Evolution</i> refers to changes in genetic information and the traits encoded in that information across generations of a population or species due to the processes of mutation, natural selection, or genetic drift. These processes are <i>mechanisms</i> of evolution. Natural selection is one of the most powerful and well-documented mechanisms among these processes. However, natural selection can exist apart from evolution if the next generation doesn’t inherit the selected traits.
11. An example of variation within a species is that dogs look different from cats.	Dogs and cats are different species. The combined features of an individual organism determine which species it belongs to. Variation occurs among organisms of the same species when a trait has several possible variants. For example, color is a trait that shows variation in beetles, which means that green, white, black, and brown beetles are all members of the same species.
12. The environment on Earth has stayed mostly the same over time, except when volcanoes erupt and meteorites fall from the sky.	Conditions on Earth have always changed and will continue to change in the future. Some changes in the environment happen quickly, such as when volcanoes erupt, while others happen more gradually over time, such as when deltas or canyons form.
13. Models are exact copies of real phenomena.	Models are simplified <i>representations</i> of real-life phenomena that are useful for understanding the world; explaining or describing theories; visualizing things that are difficult to see or understand; summarizing features; and predicting outcomes, but they aren’t exact replicas. Students often struggle with the idea that models are deliberate simplifications of reality that aren’t completely precise and have limitations.