Common Student Idea #6

Dominant traits are more common in a population.

Students sometimes interpret the term *dominant* as being more prevalent in a population. However, *dominant* refers only to an allele's expression over another allele. There are a number of dominant traits that are quite rare in a human population. For example, polydactyly, or having more than the typical number of fingers or toes, is the result of a dominant trait. However, polydactyly occurs in only 0.31–6.18 births in 1,000, depending on ethnic background. This means it is very rare for a person to have the gene mutation that causes polydactyly, even though it is dominant. This may be an opportunity for students to calculate the prevalence of certain traits in the population compared to others that are less rare. This can lead to deeper understanding of what *dominance* means compared to *prevalence* while supporting students in using science practices.

Common Student Idea #7

Organisms have genes for particular traits, such as "disease genes."

This common student idea often persists because of imprecise language usage. We often make comments such as, "He has the cystic fibrosis gene" or "She had the gene for blue eyes." In fact, people have the same genes. They also have two alleles for each gene. The difference comes in the particular alleles that a person inherits from their parents. A person might inherit alleles that lead to cystic fibrosis or blue eyes, which leads to the particular expression of the trait.

Common Student Idea #8

If there is a one in four chance of having a particular trait and a couple's first child shows the trait, the next three have a reduced chance of showing that trait.

Having a one in four chance does not mean that one out of four children will show a particular trait. It means that each child has a 25 percent chance of showing that trait. The chance each child has is independent of the others. Similarly, every child has a 50 percent chance of being a boy and a 50 percent chance of being a girl. Even if a couple has seven boys in the family, the next child still has a 50 percent chance of being a boy.

If you choose to have students develop abilities related to the science and engineering practice "using mathematics and computational thinking," this is an opportunity to help them understand how to calculate probabilities. For example, students could consider a family who has three boys and is having a fourth child. That child has a 50 percent chance or ½ chance of being a boy. However, students can also develop an understanding of the chances of having four boys. To do this, they would multiply:

$$½ \times ½ \times ½ \times ½ = 1/16$$

For each pregnancy, there is a ½ chance of having a boy. Multiple together ½ for each of four pregnancies and you arrive at 1/16. This means that there is a 1 in 16 chance, or 6.25 percent chance, of having four boys.

Common Student Idea #9

All mutations are harmful.

A mutation is a change in the DNA of an organism. Many mutations are a change to a single nucleotide in the DNA that does not cause any harm to the individual. Some of these mutations occur in places along the DNA that do not code for proteins and as a result do not have any effect on the individual. In other cases, the mutation might occur within a gene but in the third position of a codon. This third spot in each codon is called the *wobble base* because in many cases there can be several different nucleotides at the position that code for the same amino acids. In this way, a change in a wobble base might not change the amino acid and therefore no differences would be expressed in the protein.

In other cases, a mutation can be beneficial. For example, a mutation might encode a change in a gene that leads to resistance to a disease. In this case, the particular allele could become "selected for" in a population over time. Individuals in the population who carry the mutation will survive and pass it on to their offspring. It is often the environment in which an organism lives that determines if a mutation is beneficial or harmful. As a result, mutations can be a way of helping organisms adapt to their environments. A discussion of mutations is an excellent time to make the crosscutting concept of "cause and effect" explicit to students. In addition, this is an opportunity to help students determine evidence that would support an explanation about the role of mutation in variation as well as considering whether mutations are positive, negative, or neutral.

It is also important to realize that mutations often represent preexisting variations in a population. Some of these are favored by changing environmental conditions. Over many generations, the favored variations become more prevalent in the population. However, if the environment changes, a particular mutation may no longer be favored and may disappear over time.

Precise Use of Genetic Terms

The use of precise language is important when teaching genetics to help students avoid some of the common student ideas addressed in this document. Students are often confused among terms, such as *gene*, *trait*, *allele*, *chromosome*, *DNA*, *amino acid*, and *protein*. By carefully using the words in reference to specific components and being precise about language, it will support students in understanding the different parts of genetic processes.

Furthermore, it can often be tempting to use the word *normal* in relation to a wild-type, or most common, trait. Avoid using this word as it implies that other traits are "abnormal." In general, it is useful to refer to particular alleles by carefully describing the trait, such as the eye color allele. In referring to diseases, one is affected or unaffected by the disease.