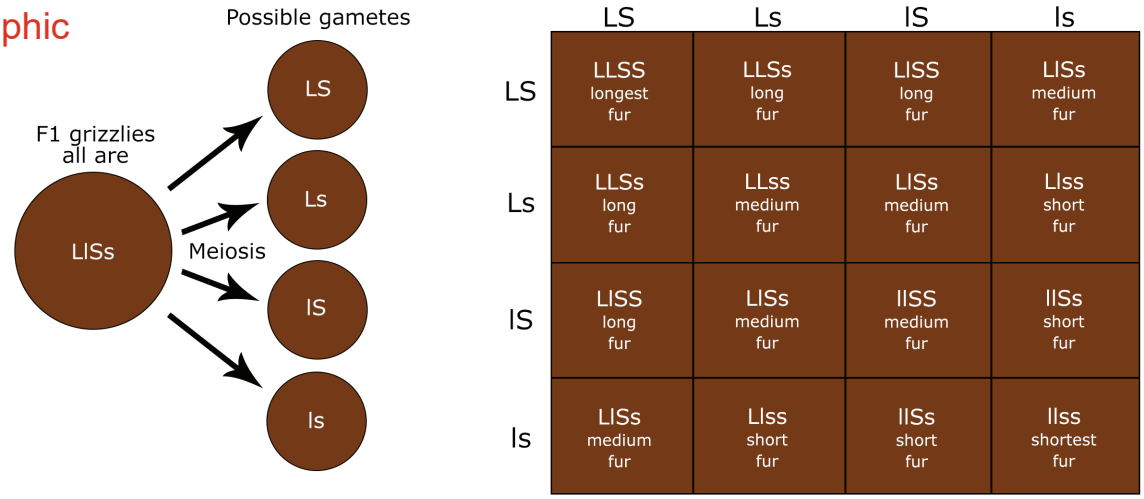
Figure 13.7.3

Hypothetical Dihybrid Cross in Grizzly Bears Resulting in Continuous Variation in Fur Length: F1 Cross

Continuing with our grizzly crossing, we now perform the F1 cross using the animals obtained in Figure 13.7.2. All of the F1 generation organisms have the genotype *LlSs*. During gene segregation of meiosis, the gamete genotypes for each F1 animal are *LS*, *Ls*, *lS* and l*s*, as shown. The Punnett square shows the gamete genotype for the F1 bear parents and the expected possible genotypes and phenotypes of the resultant F2 generation. The F2 generation grizzly bears have five different fur lengths: shortest, short, medium, long, and longest. As you may imagine, the presence of modifier genes which result in continuous variation is a difficult situation to predict until the exact relationships of the genes are understood. Modifier genes are one of the main reasons that geneticists have a difficult time in some cases accurately predicting heredity patterns.

New Graphic



13.8 INHERITANCE PATTERNS: EPISTASIS

Modifier genes cause what is referred to as **epistasis**. Epistasis occurs when one or more genes that do not code for a trait modify or change the way the trait is expressed. Modifier genes do not code directly for a trait, but influence how the gene or genes that do code for the trait are expressed. Modifier genes can make accurately predicting heredity patterns difficult for geneticists. This is because when epistasis is present, a gene which has been identified to code for a certain trait does not always completely control that trait. Modifier genes cause the phenotype to vary—sometimes a little and sometimes a lot—from what one would expect. Often times the epistatic relationship is that one gene which does not code for a trait suppresses the expression of a gene which does code for a trait. So even though an organism may have a gene coding for a trait, that trait may not be expressed because of the epistatic interaction causing suppression of the trait for which the gene codes.

Eye color is the classic example of epistasis. There are only two alleles for human eye color, *B* and *b*. The *B* allele codes for brown eyes and is dominant. The *b* allele codes for blue eyes. If eye color were determined by a simple dominant-recessive relationship, everyone would either have brown or blue eyes. If the relationship was incomplete dominance, everyone would have one of three eye colors—brown, blue, or a dark brownish color resulting from a blend between blue and brown. But there are many different eye colors that humans exhibit—brown, blue, green, gray, and others because of epistasis caused by modifier genes.

Geneticists learned long ago that "something else" influences the trait for eye color other than the *B* and *b* alleles. That "something else" is the presence of modifier genes. This means that the strict genotype does not always control the phenotype. Even though a person may have the genotype *bb*—so should have blue eyes—they may have the phenotype of green eyes because of modifier genes. Epistasis is a difficult area to study and is not completely understood. We still do not completely understand how eye color is determined, even though there are only two alleles that code for it.

Another example of epistasis is seen in the colors of mice. Mice have two coat colors: black and brown. Black is dominant to brown. A mouse that is homozygous for the black coat color, or heterozygous will have a black coat. A mouse that is homozygous for the brown color will have a brown coat. However, there is another gene which determines whether the pigment will deposit in the hair or not. The allele for pigment deposition the hair is dominant to the allele for no deposit of pigment in the hair. A mouse which is homozygous for the recessive non-deposition allele will appear white no matter what the genotype is for coat color. The gene for deposition of coat pigment is a modifier, or is said to be epistatic, to the gene which codes for coat color.

13.9 INHERITANCE PATTERNS: ENVIRONMENT

Finally, phenotypes can also be affected by the environmental conditions such as nutrition and temperature. For example, if a corn plant has genes that code for long ears of corn, they may not be able to grow long because of poor soil conditions. The genes of the corn plant did not undergo some kind of change which resulted in the genotype changing from one which coded for longer ears of corn to one which coded for shorter ears of corn. The ears of corn did not grow as long as the gene code instructed it to because of poor nutrition in the soil. The poor soil condition could not provide enough nutrients for the ears of corn to grow as long as the genes coded.

Or, if a person with the genotype for light-colored skin moves to the tropics and is in the sun all of the time, their skin will tan and turn much darker than their genotype codes for. The reason their skin becomes darker is not because their genes have changed. It is because of the environmental change they are exposed to. The more sun you are exposed to, the darker your skin gets (i.e., it tans).

Environmental factors can also result in changes in behavior. For example, a person's response to their environment and to those around them is in part determined by genes. If a person's genes code for them to be easygoing, then usually they are easygoing. Even the most genetically easygoing person can become grumpy if they are exposed to enough stress. That person's genes have not changed; their environment is simply causing their normally easygoing nature to temporarily change.

It is important to realize that environmental factors cannot change the genetic material. A genetically tall corn plant which is nutritionally short still contains the genes to be a tall corn plant. The genes do not change. When that corn plant reproduces, it passes along its genes to be tall to its offspring. The offspring do not inherit genes to be short because the parent plant suffered nutritional problems in the soil. The offspring will inherit the genes to be tall because that is the information contained in the genes. Likewise, a person who is genetically light skinned, but is tan because they are living in the tropics, does not pass genes to their children to be dark skinned. Rather, the genes for light skin are passed to the offspring because that is the genetic material of the parent. Inherited genetic material can only contain the genes which the parent organism has. Changes in an organism due to environmental factors are never passed from parent to offspring.

This chapter has helped to further identify patterns of inheritance and how they can be predicted. It is amazing to think that everything we have been discussing regarding phenotype—how something looks or acts because of their genes—is governed by molecules that direct the making of proteins. We will continue to explore the properties of genes and chromosomes in the next chapter, then apply that knowledge to human genetics.

13.10 PEOPLE OF SCIENCE

Thomas Morgan (1866–1945) was an American researcher who was born in Kentucky. He received his bachelor's and master's degrees from the University of Kentucky and his PhD from Johns Hopkins. Dr. Morgan utilized Mendel's principles to prove that chromosomes were the carriers of genes. He received the 1933 Nobel Prize for his work.