AGC Refresher

- Loci and Zygotes -

A long time ago in a galaxy far, far away…

No, sorry, this isn't the start of a new sci-fi story about Loci and his trusty pal, Zygotes. This is about something much closer to home, yet quite possibly, more fascinating. Inside the core of each cell in every living thing is deoxyribonucleic acid (DNA), the very complex molecule that provides genetic codes such as:

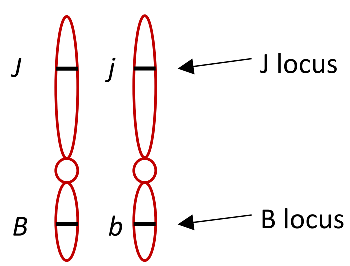
. . . T – G – A – T – **T** – C – G – G – G – T – G – A – T – T – C . . .

or

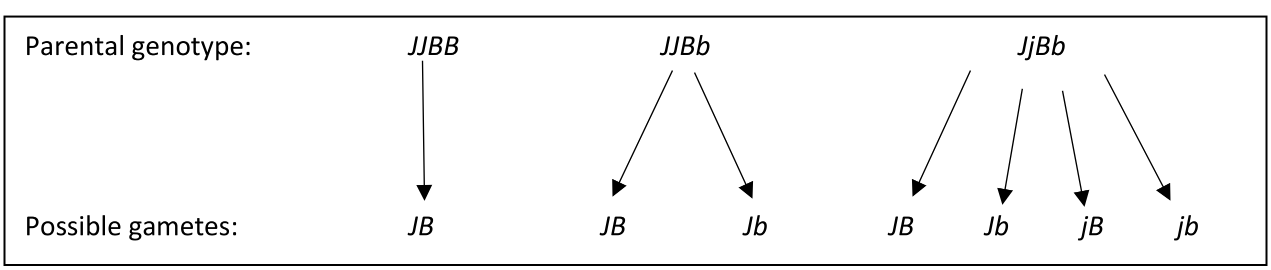
. . . T – G – A – T – **C** – C – G – G – G – T – G – A – T – T – C . . .

Three of the letters in a row are codes for a specific amino acid. For example, T-G-A codes for threonine, T-T-C codes for lysine, and T-C-C codes for arginine. In the top strand of DNA, threonine and lysine will be called up and join together. Proline (G-G-G) will then join the chain, followed by another threonine and lysine. A chain of hundreds of thousands of amino acids will then fold and twist together to form a particular protein. The bottom strand of DNA is identical except for one letter. Arginine will replace lysine in this particular segment of the protein. As a result, the protein will have a slightly different structure and may function differently or not work at all.

Swine DNA is about 2.7 billion "letters" long and is divided into 19 pairs of chromosomes. One set of chromosomes originate from the sire and the other from the dam. Somewhere on one of those chromosomes, we might find a sequence like the example above. This location, or *locus*, denotes the site of a particular gene.



The figure above is a representative pair of chromosomes with two *loci*, J and B. Each locus can have two or more forms of the same gene. An alternative form of a gene is called an *allele*. The top strand of DNA in the earlier example could be one allele such as *J* and the bottom strand could be another allele denoted as *j*. The two-locus genotype of the above animal is *JjBb*. When sperm cells in boars and eggs in gilts (gametes) develop, the paired chromosomes split into separate cells. Thus, each gamete will have a subset of alleles from the parent.



The probability of each gamete from say the *JjBb* genotype is actually equal even with the J and B loci on the same chromosome. During the split, paired chromosome will crossover with each other and exchange segments of their DNA. Only if the loci are very close together will they often "travel" together. These linked loci are the basis for genetic markers, a subject for another *AGC Refresher*.

When two gametes unite (one sperm and one egg), each chromosome gets a brand new partner and a *zygote* is formed (genetic term for an embryo). If a boar with a *JjBb* genotype, (a *heterozygote*), mates with a sow that is also heterozygous at both loci, we get the following possible genotypes in their offspring:

♂ \ ♀	*JB*	*Jb*	*jB*	*jb*
JB	*JJBB*	*JJBb*	*JjBB*	*JjBb*
Jb	*JJBb*	*JJbb*	*JjBb*	*Jjbb*
jB	*JjBB*	*JjBb*	*jjBB*	*jjBb*
jb	*JjBb*	*Jjbb*	*jjBb*	*jjbb*

For only two loci with two possible alleles each, we can have nine different genotypes. Consider a boar heterozygous at 100 loci. He can produce over 1.2 x 10^{30} uniquely different gametes. If he mates with a sow just like him, over 5 x 10^{47} unique zygotes would be possible. That's >500,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000! In fact, the number of heterozygous loci in swine is into the thousands. This is the main source of genetic variability, whereas the combination and interactions of alleles is another.

Animal breeding is almost like a card game that involves a lot of chance and a little luck too. Sometime you get a good hand, sometimes not. Mating your best sow to an excellent boar will usually produce great offspring, but there will always be a few outliers. There are tools and strategies to get the cards in your favour, and we at AGC can help you implement them. Genomics is one impressive new tool we are implementing in our breeding program. Genomics is essentially an endeavor to crack the genetic code and determine which alleles are favourable for our breeding objectives and select for them. What once seemed like a sci-fi story is now coming true!

-Brent DeVries, MSc.

agc
Alliance Genetics Canada

Trusted genetics.
Count on us.