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Why Every Good Bull Has a Few Poor Daughters and Every Poor Bull Has a Few Good Daughters

Cooperative Extension South Dakota State University

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WHY EVERY GOOD BULL HAS A FEW POOR DAUGHTERS AND EVERY POOR BULL HAS A FEW GOOD DAUGHTERS.

COOPERATIVE EXTENSION SERVICE
SOUTH DAKOTA STATE UNIVERSITY
U.S. DEPARTMENT OF AGRICULTURE

WHY EVERY GOOD BULL HAS A FEW POOR DAUGHTERS AND EVERY POOR BULL HAS A FEW GOOD DAUGHTERS

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Extension dairyman

The test

Table 1 lists the first lactation milk production of the first four daughters of two bulls in a herd averaging 14,100 pounds of milk per cow per year. Which bull is more capable of transmitting milk to his daughters?

Table 1. First lactation records for daughters of two bulls in a herd averaging 14,100 pounds of milk per cow per year (2x, 305-day, ME milk records*).

Sunnyview Criss Fred	Sunnyview Chief Tom
18,699	12,128
17,939	11,619
17,240	11,600
16,879	10,187

*2x = milked twice a day; 305-day = days of lactation; ME = mature equivalent. These are adjustments for age and length of lactation of individual cows so their records can be compared.

This question is easy to answer, right? Anyone can see that Fred is transmitting more milk production than Tom.

You did not pass

Table 2 gives the production of **all** daughters of these bulls in this herd. Considering all daughters, Tom really is the better bull. The first four daughters with records happened to be Fred's best, but were Tom's poorest.

This test is given in dairy herds all the time. The dairyman uses a high PD (predicted difference) milk bull, and gets two or three daughters below herd average. He uses a low PD milk bull, and gets two or three daughters that are above herd average. One may be the best cow in the herd.

Because only a few daughters are involved, incorrect conclusions are made about the bull's ability to transmit milk production. The dairyman also incorrectly concludes that sire summaries are worthless.

Genetic variation

If you got the wrong answer to the test question, it's because of genetic variation, which is often diagramed as a bell-shaped curve (Figure 1).

Table 2. Distribution of first lactation records for all daughters of two bulls in a herd averaging 14,100 pounds of milk per cow per year (2x, 305-day, ME milk records).

Sunnyview Criss Fred
PD* milk = +15, R** = 98%
30 daughters averaged 14,124 pounds

					14,977				
					14,965				
				13,888	14,900	15,991			
				13,872	14,301	15,900			
			12,818	13,561	14,260	15,219			
	10,140	11,373	12,825	13,100	14,221	15,150	16,879	17,939	
9,372	10,069	11,058	12,638	13,020	14,111	15,100	16,138	17,240	18,699

Sunnyview Chief Tom
PD milk = +1,224, R = 96%
31 daughters averaged 15,243 pounds

						15,995			
						15,912	16,608		
					14,433	15,854	16,599	17,116	18,991
				13,341	14,210	15,587	16,575	17,110	18,477
		11,619	12,590	13,261	14,166	15,154	16,372	17,106	18,075
	10,187	11,600	12,128	13,169	14,121	15,109	16,021	17,024	18,022

* PD = predicted difference.
** R = repeatability. R indicates the reliability of the proof; 99% is the highest. So, 98% on Fred and 96% on Tom indicate that their proofs are accurate estimates of these bulls' ability to transmit milk production.

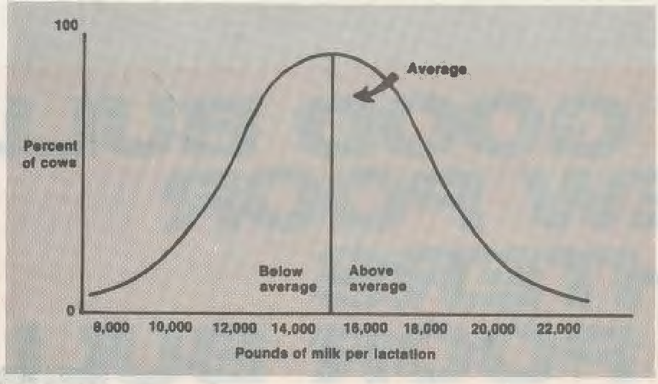

Figure 1. Bell shaped curve showing a normal population of cows.

In all biological traits (milk production of cows, height of people, etc.) higher percentages of the population are closer to the average than are at the low or high extremes. For example, more of Fred's daughters (Table 2) produced 13,000 through 15,000 pounds than produced 9,000 or 10,000 pounds and 17,000 or 18,000 pounds.

A bull's PD milk indicates how much more or less milk his daughters average compared to breed average cows (daughters of zero PD milk bulls). Figure 2 shows how daughters of a +1,000 PD milk bull compare to breed average females.

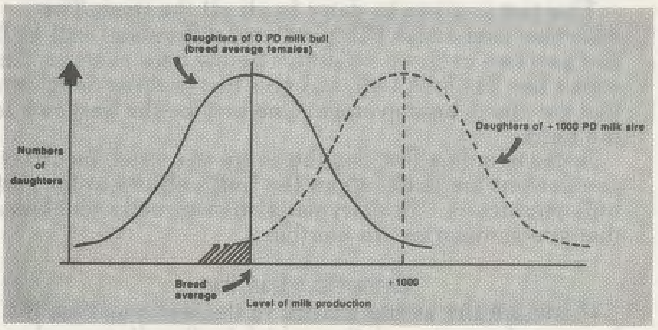

Figure 2. Population distribution for daughters of +1,000 PD milk and zero PD milk (breed average) bulls.

Figure 3 shows how daughters of a -1,000 PD milk bull compare to breed average females.

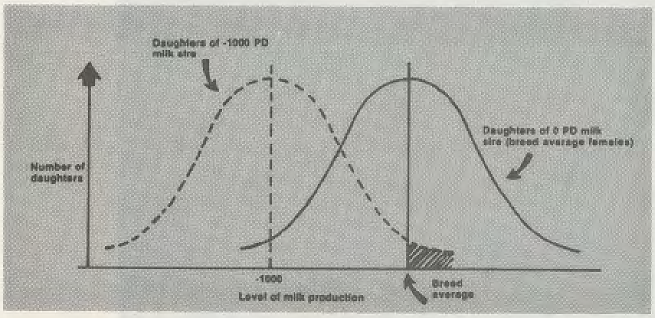

Figure 3. Population distribution for daughters of -1,000 PD milk and zero PD milk (breed average) bulls.

Figure 2 shows that most daughters of the +1,000 pound PD milk bull will produce above breed average. A few, represented by the shaded area, will produce below the breed average. Figure 3 shows that most daughters of a -1,000 PD milk bull would produce below the breed average. A few, represented by the shaded area, would be above.

If a dairyman has two or three daughters of a +1,000 PD milk bull, and they all happen to fall in the shaded area (Figure 2), he concludes that the bull does not work for his herd and that bull proofs are worthless. If he uses a -1,000 pound PD milk bull and the two or three resulting daughters all fall in the shaded area of Figure 3, or produce above herd average, he concludes that the bull works in his herd and that bull proofs are still worthless.

Continued use of the +1,000 or -1,000 pound bull would convince the dairyman that he has been fooled by small numbers in reaching his initial conclusions.

Figures in Table 2 further illustrate these facts. Tom (PD milk = +1,224) and Fred (PD milk = +15) both have daughters that produced 10,000 pounds, and daughters that produced 18,000 pounds. However, most of Tom's daughters produced between 14,000 and 18,000 pounds, whereas most of Fred's daughters produced between 13,000 and 16,000 pounds.

Differences in performance

Performance of a dairy cow is comprised of her ability (genetics) plus her opportunity (environment). Variations in both of these areas determine how much milk a cow will produce.

Environmental variations are easily understood because they can be seen. No two herds are housed, fed, milked, and managed exactly the same. Genetic variation is hidden; it is complex and not easily understood. This fact sheet explains why there is genetic variation, and why daughters of the same cow and bull are not the same genetically.

Genes and cell division

The basic genetic unit is the gene. Genes are located on chromosomes, and chromosomes come in pairs in every body cell except for the sperm and egg. The cow has 30 pairs of chromosomes. Every time a new cell is formed the 30 chromosome pairs duplicate themselves exactly. Thirty chromosome pairs stay in the parent cell, and the duplicate 30 chromosome pairs go to the new cell (Figure 4). This method, called mitosis, assures that every cell is like the one it came from, and is capable of performing the same function.

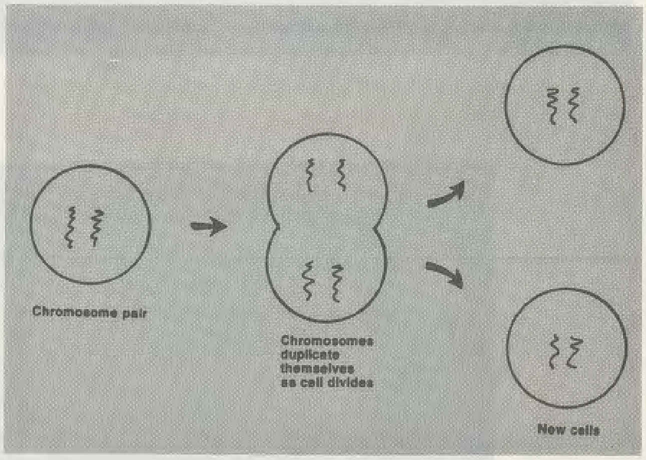

Figure 4. Mitosis or cell division.

One member of each chromosome pair is from an animal's dam and the other is from the sire. Therefore, a cow receives ½ of her genetic material from her dam and ½ from her sire (Figure 5).

If this is the case, it would seem that all cows with the same dam and sire would be genetically equal. Actually they differ genetically because of four random events or chance factors that occur during sex cell formation and fertilization.

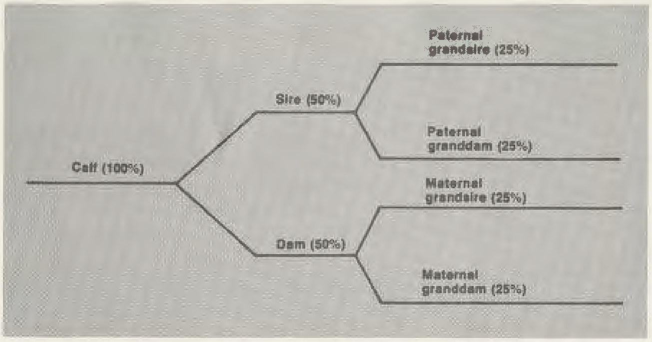

Figure 5. Pedigree chart showing percent of genetic material received from each ancestor.

Sex cell formation and fertilization

The first reason for genetic difference is the random separation of chromosomes during sex cell formation. To illustrate, the top of Figure 6 shows cells from a male and female with 3 chromosome pairs (remember the cow has 30 pairs). Consider A, B, C, a, b and c chromosomes as those received from the animal's dam, and A', B', C', a', b' and c' as those received from the sire.

When sex cells are formed, only one member of each chromosome pair goes to each sperm or egg. The direction a chromosome goes is strictly a chance event. If it happens to line up on the left, it goes left. If it happens to line up on the right, it goes right. Chromosome A' in the male cell of Figure 6 could have been on the left as easily as on the right.

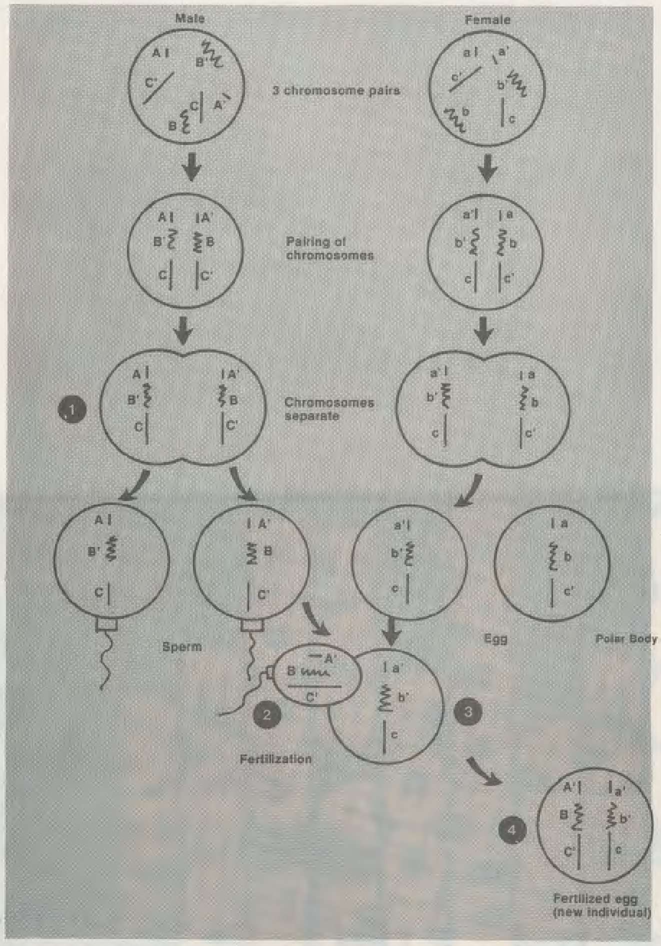

Figure 6. Meiosis and fertilization. The dairyman cannot control the way the chromosomes split (1), which sperm (2) will fertilize what egg (3), or the way genes will recombine in the new individual (4).

In Figure 6 the chromosomes received by the fertilized egg are A', a', B, b', C', and c. If by chance the left sperm instead of the right had fertilized the egg, the chromosome combination would be A, a', B', b', C, c, and a completely different individual would have resulted.

This is the second reason why cows with the same parents differ genetically. There are millions of sperm available for each fertilization, but only one sperm by virtue of being in the right place at the right time fertilizes the egg.

The third reason for genetic difference is that you cannot select the egg to be ovulated. In addition, for every egg ovulated many degenerate in regressing follicles in the ovaries.

The fourth reason why cows with the same dam and sire differ genetically is that after fertilization the genes do not recombine in the same order as they were in the parents.

The recombined genes are the blueprint for development of the new individual. The number of gene pairs that are the blueprint for milk production are not known, but are guessed to be in the thousands. Table 3 shows the number of possible combinations (genotypes) when only a few gene pairs are involved.

Table 3. Number of gene pairs and number of possible genotypes.

Pairs of genes	Possible kinds of genotypes
1	3
2	9
3	27
4	81
5	243
10	59,049
20	3,486,784,401

There are over three billion different combinations for a trait influenced by 20 gene pairs. With milk production influenced by thousands of gene pairs, it is little wonder that two animals from the same dam and sire differ in their genetic ability to produce milk.

Summary

In the face of all these chance events, your one sure fact is that you will breed a better animal if you start with superior parents.

You cannot control the randomness of chromosome separation; you cannot decide which sperm will fertilize what egg; and you can't direct the recombination of genes at fertilization. However, you can control the quality of genetic material that is subjected to this randomness.

Dairymen who combine superior genetics with excellent environment will be rewarded by their cows' superior performance.

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