Evaluating Epigenetics

Researchers consider potential effect on industry.

by ***Barb Baylor Anderson***

The world of genomics is a complicated one, and one the cattle industry is just beginning to explore. Within that world is the study of epigenetics, or learning why cells may contain the same DNA but not the same characteristics. Researchers are investigating the concept to determine its effect on heifers, and its use someday as a management tool.

"The area of epigenetics is on the radar with quite a few livestock researchers. It holds the potential of having an impact on management," confirms Mark Allan, research geneticist with the U.S. Department of Agriculture Agricultural Research Service (USDA-ARS) at the Roman L. Hruska U.S. Meat Animal Research Center (USMARC) in Clay Center, Neb. "It's still in a research phase prior to implementation. However, some producers are altering heifer management strategies because they believe 'roughing' the young female results in increased productivity over her lifetime."

PHOTO BY LYNN GORDON

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Just what is epigenetics? The textbook definition is the study of heritable changes in gene function that occur without a change in the DNA sequence. The differentiated cells are reprogrammed at some point and develop into the characteristics they will become.

During the process, "imprinting" determines whether or not the paternal or maternal copy of a gene is expressed, and the mRNA that is converted into a protein. Imprinting is another form of regulation of an animal's genome that differs from traditional genetic inheritance models. Researchers have shown where the maternal imprinted copy of the gene may suppress growth and the paternal copy of the gene may enhance growth.

Nutrient modulation

USDA-ARS research involving epigenetic mechanisms is evaluating nutrient-specific modulation of genetic networks. Researchers note, "A host of genomic interrelationships with the diet evidently exist and encompass the broad topic of nutrigenomics, or the interaction between nutrition and an individual's genome."

In the study, short-chain volatile fatty acids (VFA, including acetate, propionate and butyrate), especially butyrate, are involved in metabolism as a genomic regulator as well as a nutrient.

"Butyrate induces many significant changes in the expression of genes associated with regulatory pathways that are critical to cell growth, immune response and signal transduction — an example of epigenetic regulation of the genome at work and basis for understanding the full range of biological roles and molecular mechanisms that butyrate may play in cell growth, proliferation and energy metabolism," report USMARC researchers.

Reproductive implications

Rick Funston, University of Nebraska West Central Research and Extension Center at North Platte, Neb., is also following the body of epigenetics research. Studies show, he notes, that diet during development can partly control physiological changes needed for puberty.

"Previous research indicated rate of postweaning growth was thought to be an important factor affecting age of puberty, which in turn influenced pregnancy rates. The universal thought process had been that puberty occurs at a genetically predetermined size. Only when heifers reached their target weight could high pregnancy rates be obtained," he says. "Replacement heifers have always been fed to achieve 60% to 65% of expected mature body weight by the time breeding started in order to reach puberty."

In contrast, Funston says contemporary research shows the pattern of growth heifers experience prior to achieving target weight is varied. Heifers may be developed to lighter target weights without any negative effects on profitability or future productivity.

A review of studies conducted during the last several decades, along with new research, indicates the association among birth weight, puberty and heifer pregnancy rate appears to be changing over time. Several factors have likely contributed to this change.

"Initial research corresponds to the

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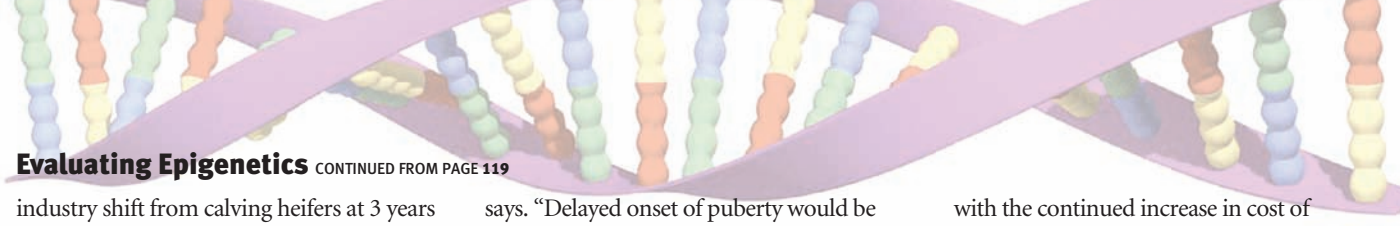

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industry shift from calving heifers at 3 years of age to calving at 2 years of age. Thus, selection pressure for age of puberty was probably minimal in the animals used in early studies," Funston says. "While selection intensity would have increased with the reduction in calving age of heifers, genetic progress would take time due to the long generation interval in cattle."

In the mid-1980s researchers identified the association between scrotal circumference in bulls and age of puberty in female offspring. Since then, Funston says that scrotal circumference has been used as an indicator trait for puberty. The change occurring in scrotal circumference from 1985 to the present indicates substantial progress has been made, and a similar response in age of puberty would be expected.

Yet another factor is the association between timing of puberty and subsequent pregnancy rate. "Early research indicated heifers should experience two or three estrous cycles before the onset of the breeding season, because fertility of the first estrus is lower than subsequent cycles," he says. "Delayed onset of puberty would be associated with lower pregnancy rates. But several studies have not shown strong associations between nutritionally related changes in age of puberty and final pregnancy rates."

Funston acknowledges that limited research has been performed to determine whether inherent differences in heifer development systems affect reproductive efficiency or future productivity. Some studies provide evidence such systems can influence reproductive performance, but do not offer evidence of the effects independent of energy intake and/or growth rate. He says producers have the opportunity to decrease feed costs by altering rate and timing of gain, creating periods of compensatory growth, and/or allowing producers to limit supplementation to critical periods of heifer development.

"Evidence for a genetic basis for differences exists and is reported as pregnancy rates greater in heifers AI (artificial insemination)-sired by bulls born after 1988 than bulls born between 1982 and 1984," he says. "These changes, combined with the continued increase in cost of harvested feedstuffs indicate the need for alternative development systems [that] allow heifers the opportunity to conceive early as yearlings at reduced cost."

Other researchers hope to explore nutrition during pregnancy and in calfhood and the potential effect on epigenetic control of genes regulating appetite or body condition. Glen Gentry, resident coordinator and assistant professor, Louisiana State University AgCenter's Reproductive Biology Center, is looking at serum leptin values at breeding in heifers and cows to determine if there might be some selection criteria that could be used chuteside to increase reproductive efficiency. He believes and is exploring whether epigenetics may play a role in the level of circulating leptin within an individual animal.

"It would be another selection tool," Gentry says. "The more parameters we can measure, the better control we can have of the reproductive efficiency of the herd."

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