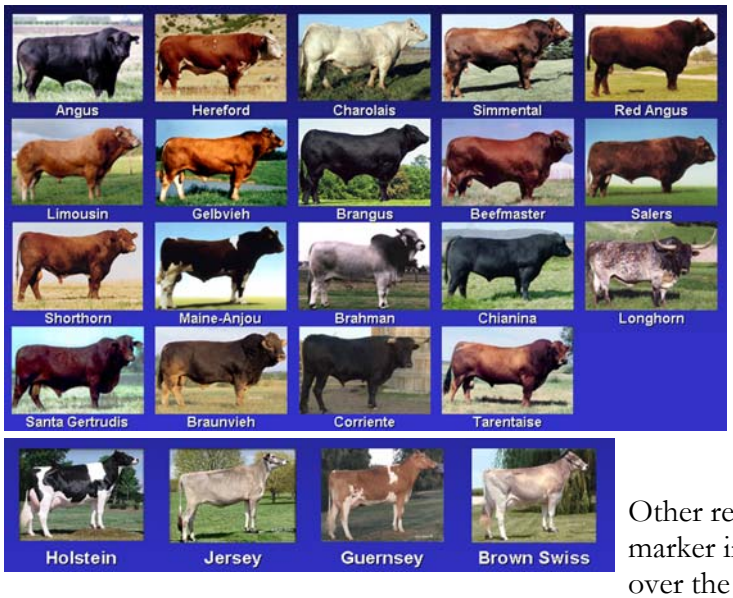
The best DNA markers pennies can buy

a specialized set of cattle markers for improving food safety and beef quality

by Michael P. Heaton, PhD

Researchers at the U.S. Meat Animal Research Center (USMARC) in Clay Center, Nebraska are developing a set of 100 DNA markers that will provide essential genetic information for improving food safety and beef quality in North American beef and dairy cattle. This powerful set of markers has been thoroughly screened to accomplish both DNA fingerprinting and parentage testing in essentially all U.S. beef and dairy populations, an ability that only a small fraction of known DNA markers have.

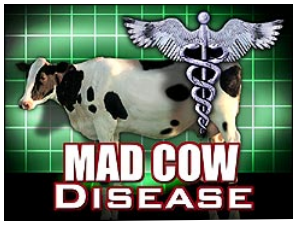


One key to success has been the careful sampling of U.S. beef and dairy populations to create a test panel representing the vast majority of U.S. cattle. A group of 216 diverse sires from 19 beef breeds and 4 dairy breeds was selected for marker testing. Their DNA is being sequenced in selected regions and markers are chosen that work well for the entire group. The rationale is this: if the markers perform well in this diverse group of 216 sires, they will work well in most U.S. cattle herds and beyond.

Other researchers tend to agree and requests for marker information have been received from all over the world including: North America, Europe, Asia, Australia, and South America. All of the information is being made freely available on the internet through the National Center for Biotechnology Information (***www.ncbi.nlm.nih.gov***).

Accuracy counts

Surprisingly, there is so much genetic diversity in U.S. cattle that creating universal DNA marker tests that will work in every animal becomes problematic. The many DNA differences between animals interfere with the chemistry of the DNA testing process. To overcome this problem, USMARC scientists sequence key DNA regions from the group of 216 sires described above. Scientists then document the DNA diversity and use this information to design each DNA test so it will be accurate in more than 99.9% of the cattle to be tested.



Accuracy is important when using DNA markers to trace the origin of a diseased animal—such as the December 23, 2003 Washington State bovine spongiform encephalopathy (BSE) case. This Holstein dairy cow was the first reported U.S. case of BSE (also known as mad cow disease). Scientists at USMARC designed and analyzed the DNA testing for this case and confirmed its Canadian origin by parentage analysis. In situations like this it is critical that DNA tests are as accurate as possible because one error can cause enormous confusion and raise potential doubts about the results. For that reason, scientists have gone the extra mile in developing a surplus of the best DNA markers possible.

How it works

A small amount of any tissue may be used as a source of DNA including: whole blood, skin, semen, hair follicles, or meat. First the DNA is extracted by technicians at a testing company. Next the DNA tests are run and simultaneously scored for all markers. The DNA test scores (i.e., genotypes) are assigned to the individual and become part of its permanent genetic record. This information can be used both as a unique DNA fingerprint and as a tool to determine parentage. The ultimate goal is to get the cost of DNA testing down to less than a penny per marker and the whole test less than the cost of a cheeseburger. At present, the lowest fees for high-volume testing are in the range of $0.03 to $0.05 per marker and $10 per animal. Like computer technology, the price and availability are expected to improve with time and increased demand.

An essential tool for improving food safety

If the time and place of the animal's tissue sample collection are carefully recorded, its DNA marker information provides a unique genetic record that stays with the animal and its products throughout the food chain. Thus, the identity of a beef product can be determined at any point in the food chain, including cooked products. The markers developed by USMARC scientists currently have enough power to uniquely identify all cattle in the United States. This allows one to verify which carcasses test positive for disease at slaughter and to confirm a diseased animal's origin by parentage. More importantly, it allows DNA-based verification of carcasses that have been certified as safe and healthy.

A bonus tool for improving beef quality and production

The same set of genetic information used for DNA fingerprinting can also be used to determine parentage in settings where DNA from only one parent is available. For example, in multiple-sire matings one can determine: 1) which bulls sired the best calves, 2) which bulls sired the most calves, 3) which calves were produced by artificial insemination, and 4) which calves were raised by the wrong mother. Assigning parentage is considered to be the foundation of genetic evaluation on commercial ranches. So whether it is beef improvement, food safety, or disease traceback, these new markers are available and expected to perform well in any population of U.S. cattle.

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This project is in collaboration with scientists at the ARS, Bovine Functional Genomics Laboratory in Beltsville, MD, the University of Alberta's Beef Genomics Laboratory in Edmonton Canada, the Center for Genetics and Molecular Medicine at the University of Louisville, KY, and Cogenics in Morrisville, NC.