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*William Hansel*

# Big Milk Productivity Increases In Sight with More to Follow

The record is clear. American dairy farmers through good husbandry and breeding have achieved an impressive record of increased milk productivity per cow.

From 1955 to date, U.S. milk production per cow increased about 240 pounds per year. Merely maintaining this rate of increase will mean average production per cow per year of 17,000 pounds in the year 2000.

Traditional technology already available permits even larger production. Productivity of some large herds already exceeds 20,000 pounds per year. One herd in California milking 3,000 cows three times a day averages 20,000 pounds of milk per cow per lactation.

If all cows in the United States produced at this level, we would need only 6 million cows to produce the milk that 10.5 million cows now produce. Some expect this rate of increase to slow because of the biological limitations of the cow. However, there is, as yet, no hard evidence to support this view. In fact, a number of individual cows have produced over 50,000 pounds of milk per lactation.

MALCOLM W. EMMONS, OHIO COOPERATIVE EXTENSION SERVICE

*High school students in an Ohio State University dairy lab.*

### Large Increases Coming With BGH

Instead of slowing, I think that increases in production per cow will actually accelerate soon—during the next 15 years. This acceleration will be largely related to new advances in animal biotechnology and could result in a national average production of 24,000 pounds of milk per lactation by year 2000..

As described in the first issue of CHOICES, these advances are, to a large degree, dependent on our ability to manipulate the availability of the hormones of the anterior pituitary gland. This can be done by controlling the activities of a "happy hypothalamus," or by injecting or implanting the hormones produced by these organs directly into cows.

We've known for a long time that the major hormone responsible for stimulating milk production in the cow is the growth hormone. Workers at the National Institute for Dairying in England clearly established this fact in 1949. Until recently commercial exploitation of this finding was not possible because of limited supplies of the hormone.

Now advances in genetic engineering make it possible to produce large amounts of recombinant DNA bovine growth hormone (BGH) by fermentation processes. Workers at Cornell recently demonstrated that daily injections of either natural or recombinant DNA BGH produce marked increases in milk yield in high yielding cows at all stages of lactation.

An economic study conducted at Cornell by a group of economists and animal scientists suggests that productivity increases due to BGH treatments could be as much as 25% in well managed herds. The study also concluded that at least half of the dairymen in New York State would adopt the treatment during the first year of availability once approved by the Food and Drug Administration. Large herds would be the first to implement the practice.

It is difficult to estimate when BGH might become commercially available. Most estimates suggest its availability within 3-5 years. Some delay might be encountered because there is a need to develop foolproof systems for delivering the hormone under practical conditions. However, researchers are making progress on developing these systems and do not anticipate long delays for this reason.

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**More To Come After BGH**

Its likely that the use of BGH to increase milk production will be only the first of a series of new applications of growth hormone related technology.

**GHRH.** One potential new application is closely related to BGH technology and knowledge about how the hypothalamus works. Production of growth hormone by the pituitary gland is controlled by the hypothalamus. The hypothalamus secretes two peptides—one inhibitory and the other stimulatory.

The stimulatory peptide—growth hormone releasing hormone (GHRH)—has been isolated and can be produced in large quantities by either recombinant DNA techniques or by direct chemical synthesis. Thus, there is the potential of using GHRH to increase the secretion rate of the cow's own growth hormone. This would mean that injections of BGH would not be required in order to get the same effect. GHRH would be used instead.

**SS.** Conversely, inactivation of the inhibitory hypothalamic peptide called somatostatin (SS)—might also be used to promote higher milk productivity. This might be accomplished by immunizing the cow against somatostatin, thus removing its inhibitory influence on growth hormone secretion. The feasibility of this approach has already been demonstrated in an experiment in which lambs immunized against somatostatin had increased growth hormone secretion rates and grew at an accelerated rate.

**SM.** Furthermore, most of the physiological effects of growth hormone are accomplished by an intermediary substance called somatomedin (SM). It is synthesized in the liver under control of growth hormone. Blood levels of somatomedin (sometimes also referred to as "insulin-like growth factor," or IGF) always increase in animals after they have been given growth hormones.

This leads us to think that if SM or IGF could be increased artifically in the animal, such as by injection or with feed, it would have effects on milk production similar to BGH. Thus, SM becomes another candidate to use to increase milk production.

Like SS and GHRH, SM is a small molecule. Therefore, we anticipate it can probably be produced in large amounts at a relatively low cost. There is also a good chance that more potent long-acting analogs of each of these three compounds can be synthesized, as has already been done for other peptides of hypothalamic origin.

**Environment.** Ultimately, it should be possible to manipulate the environmental cues received by the hypothalamus in ways that cause it to increase the production of the GHRH, BGH itself, SM, and, perhaps other pituitary hormones involved in lactation.

Indeed, workers at Michigan State University have recently accomplished this by exposing dairy cattle in commercial herds to supplemental lighting (16 hours per day). The result was an 8 percent increase in milk production. In this case, however, the hypothalamus responded to the "long days" by causing the pituitary to secrete more prolactin, rather than more growth hormone. Other environmental cues, such as temperature, are known to affect hypothalamic functions, but more research is needed to pinpoint their effects.

**Imprinting.** Recently, scientists have shown that it is possible to "imprint" the hypothalamus of the newborn rat. This imprinting alters the growth hormone secretion pattern during adult life in ways that are reflected in increased growth rates.

The "imprinting" was accomplished by injections of the male sex hormone, testosterone, during a critical period, shortly after birth. If a corresponding critical period can be found in the development of the hypothalami of cattle, sheep and swine, it may become possible to program these animals with imprinting at, or before birth for a pattern of growth hormone secretion in adult life that is optimal for maximum milk production and/or growth. Possibilities of applications of this sort are particularly intriguing, since they would result in increased productivity without the necessity of any hormone treatments during the productive life of the animal.

**Genetic Engineering.** By the year 2000 it seems likely that we will be able, by genetic engineering techniques, to produce new strains of animals that contain and trasmit genes for high milk yield. Growth hormone genes from other species have already been introduced into mouse, pig and sheep embryos. In the case of the mouse, it is already known that animals that have the gene grow at an accelerated rate and that the gene is transmitted to offspring. Obviously, many difficult problems concerning the mechanisms involved in expression of these genes and the physiology of animals containing them remain to be solved.

Another genetic possibility is to engineer the microrganisms found in the rumen of the cow so that they become more efficient in converting forage consumed by the animals into energy and high quality milk protein.

Fifteen years may seem too short a time frame in which to accomplish these feats of genetic engineering. However, I would point out that in the past most of our predictions of this sort have been far too conservative. Advances have actually been made more rapidly than we had expected! C

## A Biotechnology Glossary

**BGH**—Natural or recombinant DNA bovine growth hormone.

**GHRH**—Growth hormone releasing hormone. The stimulating peptide secreted by the hypothalamus.

**SS**—Somatostatin. The inhibitory peptide secreted by the hypothalamus.

**SM**—Somatomedin. Substance synthesized in the liver under control of the BGH that mediates many BGH effects.

**Environment**—Atmospheric and other conditions affecting physiology of animals.

**Imprinting**—An example is to inject newborn rats with testosterone in order to alter the growth hormone secretion during adult life.

**Genetic Engineering**—Artificially altering the genetic makeup of an animal by adding, deleting or modifying genes that code for definable traits, such as those that control milk production.