Hormones

ALMOST every function of the animal organism is influenced by hormones produced within the body. Hormones act together; the secretion from one gland often affects the secretion of another gland. Hormones are the major chemical integrators of the many reactions involved in growth and development; the production of meat, milk, and eggs; and reproduction. Scientists have made many studies of the role of hormones in reproductive processes and control, the growth of the udder and lactation, and the growth and fattening of livestock. The function of certain organs, notably the thyroid gland, the ovaries and testes, and the pancreas, as sources of substances that produce profound physiological effects was known in the latter part of the 19th century, but most of our information about them has accumulated since 1910. Nine have been identified as endocrine organs, some of which produce more than one hormone. The pituitary gland, for example, produces eight separate and distinct hormones. Several substances of differing chemical composition but of similar functions may be produced within a gland. The substances that have hormone activity thus are more numerous than the glands that produce them. Most of the hormones have been isolated in pure form, and most of the steroid hormones can now be synthesized in the laboratory. Most nonsteroid hormones are obtained by extracting tissues obtained at slaughter, but thyroxine may be produced by laboratory procedures. Chemists have likewise synthesized a number of compounds—stilbestrol, hexestrol, and dienestrol—which are unrelated chemically to estrogenic hormones but have similar actions to the naturally occurring estrogens.

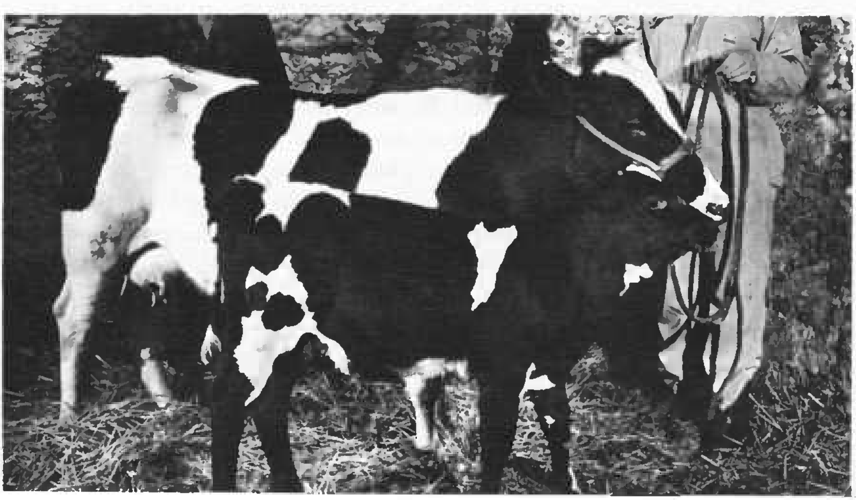
The hormones produced by the ovary—estrogens and progesterone—cause the udder to develop from simple ducts or tubes to a complex duct-secreting cell system capable of secreting milk. The pituitary gland hormones also participate in this development, but they are concerned more directly with the initiation and stimulation of lactation in the fully developed udder. The use of hormones now makes it possible to grow udders and induce lactation in nonpregnant cattle and goats. Some lactations, comparable to those that may be expected naturally, have resulted, but they have not been obtained consistently. Until more consistency is obtained, such results are primarily of experimental interest.

The anterior pituitary hormone, prolactin, promotes the secretion of milk from a fully developed udder. Growth hormone, another anterior pituitary hormone, increases yields of milk and the percentage of fat in milk. Thyroxine and thyroprotein, the latter an iodinated casein product that contains thyroxine, also have been used to stimulate the production of milk. While daily milk yields are increased for some time when thyroprotein is fed, the total production for the whole lactation seldom has been increased. Efficiency of production is not increased, and increases in consumption of feed are required to provide for the thyroprotein-stimulated increase in yield. Oxytocin, a posterior-pituitary hormone, is concerned in the milk letdown process. Its secretion causes milk to be squeezed from the depths of the udder into the milk cisterns and facilitates the removal of milk from the udder. Interference with the letdown process makes rapid milking difficult. Nervous reactions control the secretion of oxytocin. Proper preparation of the udder at milking, regular milking, and avoidance of fright or unusual situations at milking time facilitate the letdown.

The practical application of the use of the hormones probably will remain limited because of the expense of the hormonal preparations, the limited supply of pituitary hormone substances, and the lack of effectiveness of some of the material when given by mouth. The application of hormones to increase milk production is a useful research technique to study the endocrine processes involved in normal development of the mammary gland and lactation.

Research relating to reproduction in livestock has centered around a determination of the role of hormones in controlling the estrus—heat—cycle of mammals and the egg-laying cycle in birds. The use of hormones to manipulate the heat cycle, to increase production of germ cells, and to treat reproductive abnormalities has been studied extensively. Early work was concerned with use of the chick in hormone assays, the occurrence of prolactin in the pituitary glands of

This calf resulted from an ovum that was produced and fertilized in another cow and then transplanted into the cow shown here.



fowl, and the effectiveness of posterior pituitary preparations in causing hens to lay their eggs prematurely. Work at Beltsville has stressed the processes controlling ovulation in the hen. Ovulation is the shedding of the yolk from the ovarian follicle, within which it developed. Ovulation was known to be induced in mammals by a hormone (luteinizing hormone, which is secreted by the anterior pituitary gland) for some years before the same fact was established experimentally in 1942 for birds. As in mammals, ovulation was induced most effectively by preparations containing the luteinizing hormone.

Soon after these basic relationships had been established, it was discovered that progesterone, a hormone long thought not to occur in birds, is effective in causing premature ovulation in the hen. The substance (or substances with similar physiological properties) later was found to be present in the blood of chickens. Scientists succeeded in identifying progesterone itself in extracts of ovarian follicles and in blood. The essential pituitary and ovarian hormones therefore may be much the same in birds and mammals, however different their reproductive processes may be.

The use of supplemental lights to control seasonal egg production of chickens and turkeys is well established. The importance of the central nervous system and the hypothalamus in transmitting the effects of light to the pituitary and thus to the ovary has long been recognized. Newer investigations have been directed toward the elucidation of nervous pathways in the hen's brain. Small lesions in certain regions of the hypothalamus—the paraventricular nucleus, for example—prevent nervous stimulation of the pituitary and thus prevent the secretion of hormones for growth of ovarian follicles and their ovulation. Such lesions also prevent the ovulation-inducing action of progesterone systemically administered, an indication that this steroid acts over nervous pathways. The injection of minute amounts of progesterone directly into the same sites of the brain as were the lesions induces ovulation, but injection into some other regions of the brain are likewise effective, and the actual nervous mechanism of progesterone action is unknown.

Similar physiologic work with the larger farm animals has been extended in several directions. Now we can control several phases of the reproductive process experimentally with the aid of hormones. Hormones can be used to treat certain reproductive disorders, such as nymphomania due to cystic ovaries. They can be injected or fed to stimulate various phases of reproductive function or to slow down reproductive activity for a desired length of time. For example, heat in farm animals can be controlled to a high degree of predictability. Feeding certain substances similar to the natural hormone progesterone, which maintains pregnancy, results in cessation of the heat cycle. If a large number of animals in various stages of the estrus cycle are fed the proper hormone for a time, usually about 2 weeks, no heats will be observed until about 4 days after the hormone feeding is stopped. By this procedure, a whole herd of cattle could be brought into heat on the same day. This technique would be an advantage to many animal breeders, particularly ranchers. Artificial insemination often becomes more practicable when a large number of animals can be expected in heat on a certain day. More efficient use could often be made of outstanding sires owned by breeders; semen could be collected, diluted, and used to inseminate several times the number of animals that could be bred naturally. Parturition occurring over a relatively restricted period may be an advantage of breeding a large number of animals in a similarly short period. Fertility at these controlled heats is high in sheep and swine. Breeding these species under controlled conditions may become common. Fertility at the induced heat in beef and dairy cattle is rather low, but perhaps it can be improved by further research.

Transplantation of fertilized ova—eggs—from one female to another is a possible means of improving production rapidly through control of reproductive processes. A female of high-producing ability can be made to shed large numbers of ova at one time by the use of hormones to stimulate development and rupture of follicles. Insemination results in fertilization of nearly all the ova. Each ova transplanted into another female, in which the embryo and fetus develop, retains the genetic characteristics of its donor dam. A high-producing female thus could have hundreds of offspring if her ova could be readily collected and transplanted into other animals. Before these techniques can be used efficiently, a method for collecting ova from live females and a method of transplanting the ova into recipient animals without surgery must be developed. By using these rather cumbersome techniques, scientists have transplanted ova in sheep and rabbits. We know of only one instance in which the transplanting of an egg resulted in the birth of a live calf. An interesting application of this technique has been accomplished by British scientists. They transported fertilized sheep ova in the body cavity of rabbits overseas, where the sheep ova were transplanted into native sheep, which became foster mothers to sheep of quite different ancestry. The procedure saved the costs of shipping the sheep if they had been born in England.

Scientists have tried to regulate growth and fattening in livestock and poultry by administering the thyroid hormone or by reducing the activity of the animal's own thyroid gland by feeding goitrogenic substances. The results have been disappointing in cattle and sheep. In swine and poultry, small doses of thyroid hormone have increased the rate of gain at certain periods of the growth phase. Thereafter the use of goitrogens has increased the degree of fattening, but that frequently has been at the expense of gain in weight. At present, the use of these substances does not seem practical for use in livestock production. Some studies have shown that variation in the thyroid hormone status of animals may affect feather growth in birds, rate and quality of wool growth, and quality of fur in mink. Growth hormone from the anterior pituitary gland has been administered to pigs and cattle and has resulted in increased growth and increases in feed efficiency. Chickens have not shown growth responses to growth hormone of mammalian origin. The use of growth hormone is limited because of the expense of hormones and the small supply.

The most consistent results in the use of hormones to regulate growth and fattening have been obtained with the sex hormones. The synthetic estrogens, stilbestrol, hexestrol, and dienestrol, have been used. These substances, implanted in birds, improve carcass quality and fattening, but increases in rate of gain or in feed efficiency were not observed. Such implants were commonly employed in the poultry industry, but the presence of estrogen residues in tissues led to a discontinuation of the practice. These substances are still being used for cattle in the feedlot. Tissue residues do not seem to be a potential problem here. The implantation or feeding of stilbestrol is used extensively and results in increased rates of gain and increased feed efficiency. Androgenic hormones—for example, testosterone—and progesterone have likewise been tested. The results have been somewhat variable, and the hormones are not in general use. Sheep show similar responses to these substances as cattle. Rates of gain and feed efficiency are increased, although to a less extent. Carcass quality is reduced in some instances, particularly if estrogens are administered without administration of testosterone or progesterone at the same time. The practice of hormone fattening is less extensive for sheep than it is for cattle. The use of sex hormones has not yielded favorable results with swine.

Two other applications of endocrinology to problems of production deserve attention. Ketosis, a common disease of cattle and sheep, frequently causes marked decreases in production and loss of animals. Research has shown that the pituitary gland and the adrenal cortex are involved in the incidence of ketosis. The pituitary hormone, ACTH, and cortical hormones are commonly used in the treatment of the disease. Milk fever, a common disease of dairy cattle, is considered to be due to the inability of the parathyroid glands to maintain sufficiently high levels of blood calcium. The use of high doses of vitamin D to control this condition is reasonably successful and appears to function through stimulation of the parathyroid glands. A similar response of the parathyroid glands may also be involved in the use of the special low-calcium diets that have been proposed for treating milk fever. *(Joseph F. Sykes)*