ENDOCRINOLOGY AS APPLIED TO LIVESTOCK

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Endocrine Glands

The endocrine glands are a group of glands located in various parts of the trunk, neck and head, and they seem to play a very important part in the entire functioning of the body. All higher animal bodies seem to require such a nice state of balance that one small organ can throw the whole organism completely out of balance. Endocrine glands or ductless glands are found in all vertebrates. Some of the glands are only endocrine or ductless, while some of them can be called compound in that they are in part ductless but also give off some other secretion through ducts as do the other body glands. Those that are listed by H. H. Dukes (1934) as being only endocrine are thyroid, parathyroids, pituitary, adrenals, pineal and thymus. The ones listed by the same author as both endocrine and ordinary are the pancreas, testicles, ovaries, gastric epithelium and intestinal epithelium. The study of endocrine glands has occupied one of the foremost places in the field of physiology during the last ten or fifteen years. The interrelationship between these organs and the high correlation between their functions and other body organs indicates that the endocrine glands may be an important way of accounting for a large part of the variations found among livestock. Since variation is the raw material with which a livestock breeder works, it is essential that he become acquainted with the different types of variation. Most of the literature found on endocrine glands has been interpreted in terms of humans rather than livestock.

In trying to draw conclusions from available information on these glands, it is very apparent that the older authors either knew much more about the subject than present day authors, or that they drew their conclusions from insufficient evidence. For example, Louis Berman (1921)

describes one adrenal type as "hairy, dark, masculinity marked, with a tendency toward diphtheria and hernia." Also "an adrenal person is one dominated by the ups and downs of his adrenal glands. In the large, the curve of his life is the curve of secretion by this gland. It has been stated that most red haired persons are of this type; such persons also have well marked canine teeth, which is another adrenal trait. They also have a low hair line, and we may say then that the adrenal type is a quick, alert, and successful one. Pugnacity and sexual instincts are obviously intimately bound together; and it appears likely that the cement which binds them together will be found in the adrenal cortex."

Two tables copied from the same author, Louis Berman, seem to have accepted facts that the more modern authors are still hesitant to accept.

"Pituitary sufficient and dominant
Large, spare bony frame
Eyes wide apart
Broad face
Teeth broad, large and unspaced
Square protruding chin and jaws
Large feet and hands
Early hair growth on body
Thick skin, large sex organs
Aggressive, precocious, calculating, self contained
Pituitary inferior
Small, sometimes delicate skeleton
Rather adipose, weak muscles
Upper jaw prognathous
Dry flabby skin
Small hands and feet
Abnormal desire for sweets
Subnormal temperature
Subnormal blood pressure
Subnormal pulse
Poor control of lower vegetative functions, mentally sluggish, dull, apathetic, backward, loses self control quickly, cries easily, discouraged promptly, psychic stamina insufficient."

Contrasted with this very definite information is offered an extract from a more modern author as printed in the 'Encyclopedia Britannicia'.

"The successful use of thyroid extracts for myxoedema and oretinism, the use of pituitary extracts in obstetrical practice and to raise blood pressure in case of surgical shock, the use of adrenaline in haemorrhage and insulin in diabetes represent positive genuine achievements of great value.
But the manufacture and sale of many commercial preparations by individuals and doctors who have not sufficient information to sift the wheat from the chaff, must be without beneficial results because these preparations seem to be prepared with no proper information concerning the nature and function of the component.
Side by side with these abuses, descriptions of clinical manifesta-

> tions, uncontrolled by critical experiment, has led to a large amount of speculation about the role of ductless glands in determining differences in temperment. Much of this may belong to the fields of psychological and sociological work. Much of this may be useful in that it stimulates further inquiry, but for the most part it is entirely premature to draw too many definite conclusions from the unknown speculations."

It will be observed that the more recent scientific authors draw fewer conclusions and make fewer definite statements regarding the influence of endocrine secretion than did the earlier writers, although the later writers have many times more experimental data than the earlier ones on which to base their conclusions. From this it must be inferred that the experiments have not been consistent in their results or that the early writers were too ready to accept theories as proven facts.

In either case, the result is the same. Although there is a great mass of experimental data, mostly gathered from animal experiments and observations, and it is generally accepted that endocrine disorders cause disasterous results, there is as yet not much beneficial knowledge that can be used either to remedy or prevent such disorders.

It is believed by some that different endocrine glands are dominant in different individuals, thus causing various types such as an adrenal type, a gonad type or a thyroid type. The older writers have gone so far as to describe each type in detail, but the later authors do not seem so sure that these types are caused by the glands.

The different types and combinations of types are very interesting and at the same time it is appalling to think of the uncontrollable influences that may be determining not only the physical welfare, but the entire mental balance as well.

Most of the animal experiments of course, are carried on for purely physical results, but since the physical and mental systems are so closely interrelated it is probable that one cannot be greatly changed

without having some effect on the other.

Hormones

Endocrinology is called "the science that deals with the structure and function of the organs of internal secretion." Hormonology is the science which deals with the hormones or chemical messengers within the body.

> A hormone is defined by Hoskins as "a substance produced in one part of the body and distributed by the blood or lymph to other parts, the structure or function of which is thereby modified."

According to H. H. Dukes, a hormone or autocoid means 'to stir up' and he lists two kinds, one which excites and one which inhibits. He suggests the name hormone for the excitatory secretion and the name chalone for the inhibitory secretion.

The ductless glands give off their secretions directly into the lymph or blood without the use of any tubes or ducts. It is not probable that all of them are yet known, but physiological chemists have isolated various potent substances such as adrenin, thyroxin, pituitrin, antuitrin, lutein, insulin, diiodotyrasin, prolactin, theelin, cortin, oestrin (folliculin), amniotin, menformon, progynon, adrenotropic and thyrotropic from the secretions and have analyzed and even been able to produce some of them synthetically. Others have been taken from healthy animals effectively. The diseases of the ductless glands seem to be of two types. The ones caused by too much secretion and the ones caused by too little or no secretion.

The glands do not seem to respond very well to treatment to increase their secretion. So in case of too little secretion the hormone lacking must usually be supplied from without the body as in the case of diabetes and endemic goitre.

In case of too much secretion it is possible sometimes to check this

by the use of X-ray, by removal of part of the gland or sometimes by tying off temporarily one of the blood vessels in order to lessen the amount of secretion reaching the blood.

Thyroid Gland

The thyroid gland is an H shaped organ located in front of the trachea immediately below the larynx. Its hormone thyroxin has long been known and the later authors have added another diiodotyrosin (information is not available on this new hormone). The hormone thyroxin has the formula HO O Ch_2CHNH_2COOH and is a complex compound relatively rich in iodine. It has been isolated and prepared artificially. According to Marine (as quoted by Barrows, 1931) it provides for maintaining a higher rate of metabolism than would otherwise occur, and also provides a means for varying the rate of metabolism to meet changing physiological needs.

Under normal conditions, the thyroid needs no control but if the secretion is excessive or insufficient the general metabolism is seriously disturbed. Thyroid disorders can be diagnosed by doctors by performing the basal metabolism test.

Thyroid deficiency, due to degeneration or removal of the glands, in adults gives rise to dullness and general sluggishness. A person becomes very stout although his appetite may be diminished. This disease is called myxedema. If in a young child the thyroid wastes away, the head and face usually become enlarged and look deformed and his abdomen becomes swollen. Both the mental and physical characters show lack of development and often the individual becomes an idiot. This disease is called cretinism and children suffering from it are called cretins. When thyroid extract is fed to persons suffering from myxedema or cretinism, they usually improve and are sometimes completely cured,

providing no essential organs have been affected. The treatment must be kept up indefinitely because the glands will remain inactive.

An overdeveloped thyroid gland produces a speeding up of the metabolic processes. The body burns itself up. Exophthalmic goitre (Graves disease) or hyperthyroidism is the name given to the malady caused by excessive thyroid secretion. It is characterized by bulging eyes, loss of weight and nervousness. This may be treated by X-ray, removal of part of the gland, or tying off part of the blood vessels that lead from the gland.

In certain sections distant from the seaboard where there is little or no iodine in the water or vegetative growth, a growth of the thyroid known as simple goitre is often present. This excessive growth is thought to be due to an attempt of the gland to overcome iodine insufficiency. Common goitre is very susceptible to treatment with iodine or thyroid extract.

Gudernatch (1912) of Columbia University fed thyroid glands from different animals to young tadpoles and they promptly went through metamorphosis and changed to frogs. In some cases the frogs were no larger than a beetle. He removed the thyroids from other tadpoles and they never became frogs although they grew larger than the usual size of tadpoles. From this it can be concluded that thyroxin must have some effect on the growth and development of organisms.

According to M. Campbell (1935), folliculin inhibits the thyroid gland and the oestral cycle is suppressed by feeding dried thyroid extract.

Craft and Orr (1924) observed a grade Hereford calf which had a dwarf like appearance, short and irregularly curved legs, abnormally

large joints, short and thickened face and a nervous disposition. When this calf was slaughtered at the age of ten months, it weighed 350 pounds. The weight of a normal calf would have been about 700 pounds. Upon examination it was found that the thyroid, parathyroids and the pituitary were markedly underdeveloped. The authors were unable to determine whether the condition was due to degeneration or failure to develop but it seemed quite certain that the calf's condition was due to the improper functioning of the above mentioned glands.

Pituitary Gland

The pituitary gland, also known as the hypophysis cerebri, is located on a stalk at the base of the brain. It weighs only about 0.6 gram in man and is about as large as a small marble. It is divided into three parts known as the anterior, intermediate and posterior lobes. The anterior and the intermediate lobes secrete hormones and the posterior lobes seem to serve as a storage place for the intermediate lobe. The two parts secrete hormones that have different functions.

According to H. R. Barrows (1931), the secretion manufactured by the anterior lobe is concerned with growth and the inhibition of ovulation. Giantism is in most cases due to an excessive secretion from this lobe, while dwarfism is usually due to lack of this substance. The abnormal development of bones such as those of the lower jaw or hands (acromegaly) is due to an over abundance of this hormone. It also has the function of sex stimulation and effects the mammary glands.

> According to Peabody and Hunt (1927), "A certain part of the pituitary gland secretes a hormone called tethelin that promotes the growth of the skeleton. Therefore, if a baby is born with an abnormally large pituitary gland there will be an unusual amount of tethelin secreted. And as a result the child becomes a giant. If, on the other hand, this gland is deficient in size or in the amount of tethelin produced, the body fails to grow to anything like normal size and may remain very small indeed."

Experiments have been tried on young animals to show the effect of tethelin. The animals that were fed tethelin grew faster than those that were not fed the hormone. The experiments suggest that in the near future tethelin from animals may be used to promote the growth of babies that would otherwise become dwarfs.

According to Collip (1937), the pituitary gland has more to do with man's behavior than any other gland. Dr. Asdell (1936) published the information that the injection of daily doses of prolactin during the lactation period of goats increased the yield as much as 250 percent in some cases and the improvement was lost when the injections ceased. This experiment was interpreted to mean that injections of prolactin can compensate for the deficiency of the anterior pituitary hormone but cannot cause any improvement in the cases where the secretion is normal.

According to Geiling (1933), the secretion of the pasterior lobe or intermediate lobe, known as pituitrin, produces marked physiological responses. Among these are a sharp and sustained rise of arterial pressure, a quickening of the respiratory rate, stimulation of the uterus, intestines, gall bladder, urinary bladder, mammary gland, and inhibition of the salivary glands. The hormone seems to regulate fat formation and appears to be associated with the production of urine. In addition to this there is some evidence that it exerts some control over the physiology of the reproductive organs.

Data on treatment of disorders of this gland was not available although it appears to be one of the most important ones. A very interesting case of giantism which is being followed closely by scientists is the case of Robert Wadlow of Alton, Illinois, who is 19 years old and eight and one-half feet tall. More information concerning this gland is given under the sex glands.

Adrenal Glands

The adrenal glands, sometimes called suprarenal bodies, are located just above the kidneys. In the human embryo, they are larger than the kidneys, but by the time of birth the kidneys have outgrown them. They are proportionally larger in infants than in adults. There seems to be no connection between them and the kidneys although they are constantly in contact.

The outer portion is known as the cortex and the inner portion is called the medulla. The hormones secreted by the two parts have very different properties. The inner part has so specific a reaction to chromium compounds that it is called chromaphil or cromaffine tissue.

The cortex gives off a hormone called cortin. Chemically named Dihydroxymethylaminoethylolbenyene, CHOH CH_2NH CH_2 OH. The exact function of the hormone is not known, but an insufficiency seems to cause Addison's disease, and tumors located in the tissue of the cortex inhibit the normal development of secondary sexual characters. Its removal is followed by death except in some cases with rabbits in which no ill effects are manifested.

The hormone given off by the medullary portion is known as adrenalin, adrenin or epinephrin. It is known as the emergency hormone because it may shift the blood to the skeletal muscle needing it in an emergency. It tends to contract the arteries thereby raising the blood pressure. At the same time, the heart becomes strong and steady, the respiratory organs are aroused to unusual activity and a larger supply of glucose is made available for use by the muscles. This hormone also stimulates flow of secretions from the salivary glands, tear glands, gall bladder and sweat glands. It causes a relaxation of bronchi, stomach and intestine.

Adrenin has been isolated and the synthetic product adrenaline is used to check bleeding. Surgeons often spray the muscles and membranes with adrenaline and perform 'bloodless operations'.

The older authors believed that bravery or fear were determined by the amount of adrenin present in the blood and explained the timid and aggressive personalities by this. A lion was given as an example of an animal with a large medullary portion and a correspondingly large secretion of adrenin, while a rabbit was mentioned as a typical example of an animal with a small medullary portion.

The stimulus that regulates the amount of adrenin secreted seems to be the emotional condition of the individual and in periods of excitement, rage, or fear the larger amounts seem to be secreted. Cannon (quoted by Barrows, 1931) in his work indicates that there is a high correlation between the amount of this hormone in the blood and the emotional states of fear, pain and rage.

Parathyroid

Parathyroids, or near thyroids, are four very small structures, each about the size of a grain of wheat, with two on each side of the windpipe and very often embedded in the thyroids. According to Atwood and Heiss (1933), "the removal of the parathyroids by surgical operation is followed by death in twelve hours to fourteen days."

> According to Wheat and Fitzpatirck (1929), "their removal or atrophy gives rise to tetany, a sudden convulsive contraction of the muscles, which may result in death. The injection of small doses of parathyroid extract usually results in temporary relief."

Barrows (1931), in his College Biology, says that the function of the parathyroids is not well understood and their hormone has not been identified. Furthermore, it has been pretty well established that the parathyroids are concerned with the regulation and concentration of calcium in the blood stream.

The effect of too great activity of the parathyroids has not been fully ascertained although it has been shown by Collip (1936) that the injection of parathyroid extract into the blood of an animal will increase the calcium content of the blood while the removal of part of the parathyroid tissue will give rise to calcium deficiency.

Thymus

It seems rather difficult to obtain any definite information concerning the function of the thymus. The thymus is a small gland beneath the thyroid and so far down on the neck that it is beneath the upper end of the breast bone. It seems that it grows in the infant until about the second year of life, remains stationary until puberty, and then usually atrophies and is represented by a mass of fat. Experiments seem to prove that it checks for a time the development of the reproductive organs.

Pineal Gland

> The pineal gland according to Atwood and Heiss (1933) "is about the size of a grain of wheat, is located in the top of the brain and is an interesting structure from the standpoint of evolution. It is thought that millions of years ago the pineal was a third eye, because the extinct reptiles had a hole in the top of the skull for this 'pineal eye'. Most lizards have a pineal organ and above it a hole in the roof of the skull. Practically all of the vertebrates have a relic of this 'eye' and in man the relic is a vestige of an optic nerve. The function of the pineal gland in man is not understood and no hormone is known to be secreted by it."

> Wheat and Fitzpatrick (1929) say, "the pineal body is at the base of the brain behind and above the pituitary. Extracts from the gland do not have any noticeable effect. There is some evidence, however, that the injury or destruction of the gland is usually followed by abnormal development."

Sex Glands

The sex glands, testes and ovaries not only produce the male and female gametes, but they also act as endocrine glands and secrete very active hormones. Scattered through the reproductive parts of the testes

are interstitial cells which act as glands of internal secretion. The hormones of the sex glands influence the development of the secondary sexual characters. Their influence is particularly noticeable at the time of change from youth to maturity. The breaking of the voice and the appearance of hair on the face are common examples. In the female, no cells have been found which correspond to the interstitial cells of the male. There is a body known as corpus luteum found in the Graffian follicles after the liberation of ova which appears to determine certain activities associated with pregnancy.

Removal of the gonads brings about great changes in the development of the young animal which seem to be a reversion to the undifferentiated condition. The male seems to revert to the female and the female to the male.

Much experimenting has been done with animals and the common practice of castrating is well known to all. Capons, steers and geldings illustrate the changes by comparing with roosters, bulls and stallions. In humans the eunuch is an example and equally striking changes accompany the surgical removal of ovaries from the young women. As old age approaches, the glands become less active. There has been much speculation along the lines of postponing old age by grafts or extracts from the sex glands. Some think it possible to postpone old age by this method. Various experiments such as grafting glands of young monkeys on humans and feeding glandular extracts have been made. All of these are yet in the experimental stage and although some of the persons who received the grafted glands showed temporary improvement, the grafted gland was ultimately absorbed by the surrounding tissue. Some scientists attribute the temporary youthful effects to the optimism and enthusiasm of the subject rather than to a definite physiological effect.

The sex glands are very active at puberty and during maturity, but less and less thereafter so that the disappearance of its activity corresponds with old age.

The physical and intellectual qualities of man and other animals are as intimately conditioned by the hormone secreted by the testicles as are the secondary sexual characters. No organ can keep its vital energy and yield a full return if the cells are not stimulated by the other endocrine glands. Castration is followed by hypertrophy of the anterior lobe of the pituitary gland and by regression of the thyroid body.

It seems certain that if the genital glands would remain active, old age would be indefinitely delayed. Eunuchs in Cairo who had been castrated at an early age and therefore had never been exposed to the testicular hormone were never known to live longer than sixty years and they had the appearance of centenarians.

With the rich addition of the testicular hormone the cells acquire new energy, grow more rapidly and rejuvenate the whole system. But at the end of several years of beneficial action, the grafted gland is exhausted and the organism again shows the symptoms of old age.

The endocrine relations of the ovary are not fully known but it is known that their activity is influenced by the anterior lobe of the pituitary body, and there is some evidence that the activity of the lobe is modified by the ovary itself. Either pituitary implantation or pituitary extracts from mature animals will bring about temporary sexual maturity in immature animals. In mature animals, the same treatment will cause super-ovulation. This same sex stimulating principle seems to cause the maturing and rupturing of the egg and the production of the hormone oestrin. Oestrin causes mitosis and increased activity

in the tubular genital organs and is responsible for the state of these organs during oestrum. It also sensitizes the tubular organs and makes the action of progestin and relaxin possible. It seems possible that oestrin is secreted by the placenta during the development of the embryo.

The portion of the ovary responsible for the production of secondary sex characteristics is unknown. No specific hormone having this action has ever been isolated.

When a mature ovum is discharged from the ovary, its place is filled by a temporary endocrine body known as the corpus luteum. This corpus luteum seems to be very essential to the normal development of the foetus. It inhibits further ovulation and produces two hormones, progestin and relaxin. The action of the hormone progestin seems to produce a development of the uterine glands and to sensitize the endometrium so that it will produce a maternal placenta when irritated by the fertilized ovum.

Relaxin seems to cause decalcification of the pelvic girdle and relaxation of the pelvic ligaments. The hormones from the pituitary gland, the ovaries and corpus luteum all seem to combine to produce the normal mammary development.

The hormone oestrin has been given various names, such as folliculin, amniotin, menformon, prognon and theelin. Marker and Oakwood (1937) report the synthetic production of theelin at Pennsylvania State College. W. S. Murray (1937) reports that the luteal fraction of the ovarian hormone plays a role in the development of breast cancer in mice.

R. E. Marker(1937) reports the finding of three new male hormones, testosterone, androsterone and epiallopregnanolone. Dr. Marker believes that the sex hormones do not act primarily as physical stimulators of specific organs, but rather by chemical combination in the body.

S. A. Asdell (1936) reports that several apparently sterile cows were given injections of the sex hormone progynon B, oestrone benzoate, and about half of them became pregnant. Apparently the only factor being changed was the addition of the hormone, as the animals had been repeatedly bred before but had not become pregnant. A supposedly sterile mare was given the same treatment and upon breeding she too became pregnant. Dr. Cole, of Wisconsin, questioned the advisability of such procedure on genetic grounds. His contention being that by this means the tendency toward sterility would be perpetuated.

H. R. Catchpole (1936) assembles evidence that the pituitary body is intimately related to reproduction. He states that "by the use of pregnant mares' blood we have at our disposal a specific gonad stimulating therapeutic agent for man and animals. Work has been done and is continuing on the induction of heat in horses and cattle. In fact, all experiments looking toward the increase of fertility and libido must take increasing cognizance of the role of gonado-tropic hormones and of the possibilities of gonadotropic therapy."

Pancreas

The pancreas is a digestive gland secreting pancreatic juice which is emptied into the small intestine. The pancreas also acts as a ductless gland. Certain cells embedded in the pancreas, called the islands of Langerhans after their discoverer, produce a secretion called insulin. This hormone stimulates the liver to give up its glycogen. At the same time, it accelerates the oxidization of sugar in the tissue cells. Thus sugar is removed from the blood and the body. If the islands of Langerhans lose the ability to produce this secretion, the sugar is not used, some of the extra sugar remains in the blood and some is excreted in the urine. The individual develops a disease known as diabetes. Dr. F. G. Banting and Bert (1922) discovered that insulin obtained from the normal pancreas of animals would produce a marked decrease in

diabetic symptoms. Insulin is available as a treatment for the disease and is very effective in nullifying its effects, but its use must be continued and it in no way cures the patient, since no way has yet been discovered for stimulating the defective gland to produce its own insulin. Removal of the pancreas was considered fatal until Banting and Bert showed that the fatal results following its removal could be prevented by specially prepared extracts from the pancreas of animals. Unlike the thyroid treatment which consists of oral additions of thyroid extract, the insulin is injected into the patient in any convenient place such as the arm or leg.

Dragstedt and Van Prohaska (1937) report a new hormone 'lipocaic' which originates in the pancreas and controls the use of fat in the same way that insulin controls the use of sugar. They state that judging from its effects on animals, it may prove a useful supplement to insulin in the treatment of diabetes.

Discussion

Knowledge of the endocrine glands is still incomplete. Almost daily there are results of new experiments published that may turn out to be as important as the insulin discovery. New hormones are suspected or found and new uses or effects of the known hormones discovered. It seems now that plants as well as animals have endocrine organs and thrive or wither according to their hormone supply. The differences in temperments and personalities are caused by something, and more evidence points to hormones than to any other possible cause. Perhaps the rate of growth can be speeded up or retarded by the proper use of pituitary extracts. Maybe the short people will be able to add to their stature and the runts of all kinds may be blessed with normal stature. A new method of charging the living body with vitality by transplanting adrenal glands

was reported June 18, 1937, by Dr's. Wyman and Suden of the Boston University medical school.

Sterility in humans is being partly overcome by the use of thyroid extract. From Vienna comes a substantiated report that insulin has cleared up the clouded minds of drug addicts and if rumors from Ohio State are true the use of cortin may produce super performance by the athletes. We may see a football game played at dazzling speed and the mile race run at sprinters speed.

It is too much to hope that any one discovery will be a panacea for all ills, since all of the body systems and secretions seem to be so intimately interlocked in one great mass of cooperation. This balance must not be disturbed. It seems that the best we can hope for is normality and that the best science can possibly hope to do is to repair the damages done by disease, misuse and accidents.

The vertebrate organism is being recognized as a very complex and complicated chain in which the endocrine glands are but one small indispensable link.

Farm animals are often classified as 'easy' and 'hard' keepers. In light of the foregoing discussion, it seems likely that the thyroid gland may be largely responsible for this variation. Some of the conditions which have been accounted for by diseases or parasites in the past, may really have been caused by hyper functioning of the thyroid. It seems likely that the hyper functioning or hypo functioning of the thyroid might be inherited and at the same time this characteristic may have to be added to the list of things for which livestock are selected.

Irregularities in breeding can often be accounted for by the lack of proper functioning of the pituitary glands and the ovaries. It is

often hard to tell which one is not functioning since the ovaries and the pituitary are so intimately related in their functions. It may be possible in the future to regulate the oestrous cycle. It may be possible to bring the animals in heat and successfully breed them at a desired time, thereby securing a more uniform group of offspring as far as age is concerned. Since pituitary extracts cause super ovulation, it might be that more twinning in lambs could be secured or larger litters of pigs. It is doubtful whether it will ever be practical to use these extracts on breeding animals which are to be saved for breeding in view of the fact that animals with poorly functioning pituitaries might be propagated.

If it is true that the adrenal hormone gives courage and added strength, it might be that aggressiveness and strength could actually be injected into an animal.

The parathyroids seem to have much to do with the regulating of mineral metabolism so it might develop that a little parathyroid extract would replace to some extent the vitamin D feeds.

The sex glands control a very long list of very evident secondary sexual characters, so when a little less or a little more of any one of these characters is desired it might be injected, grafted or fed into the animal.

Diabetes causes an excess of fat to be deposited on the animal giving rise to the thought that synthetically caused diabetes might be an economical way to fatten butcher animals. It seems possible that there might be some sentiment against eating the flesh of such animals.

Summary and Conclusions

1. Endocrine glands are defined as ductless glands which secrete substances called hormones.

2. The purely endocrine glands are thyroids, parathyroids, pituitary, adrenals, pineal and thymus.

3. The partially endocrine glands are the reproductive glands, pancreas, gastric epithelium and intestinal epithelium.

4. The thyroid gland secretes thyroxine. The efficiency of the thyroid depends to a large extent on the amount of iodine in the food. The thyroid seems to govern the rate of metabolism in the body. Its removal causes a stunting of physical, mental and sexual development.

5. The pituitary gland effects the rate of growth and regulates the activity of the reproductive organs; especially female.

6. The adrenal glands effect the personality and the muscles. Their output seems to be regulated by the individual's emotional condition.

7. The parathyroids seem to be connected with the mineral metabolism, especially that of calcium.

8. The thymus seems to effect the development of the reproductive organs.

9. The sex glands produce hormones which govern the secondary sexual characters and the functioning of the sex organs.

10. The isles of Langerhans in the pancreas secrete insulin, which controls the metabolism of sugar. A new hormone, lipocaic, secreted by the pancreas is said to control the metabolism of fat.

11. Diseased glands do not seem to respond to treatment. Synthetic hormones or extracts seem to do their work. Normal and not super performance seems to be all that can be expected of body parts, including the endocrine glands.

BIBLIOGRAPHY

Allen, E. Sex and Internal Secretions. William Wilkins Co., 1932.

Asdell, S. A. Some practical applications of endocrinology to animal husbandry. Proceedings of American Society of Animal Production for 1935. 235-237. 1936.

Atwood, W. H. and Heiss, E. D. Educational Biology. Maple Press Co. 362-369. 1933.

Banting, F. G. and Best, C. H. The internal secretion of the pancreas. American Journal of Physiology. 59:479. 1922.

Barrows, H. R. College Biology. Farrar & Rinehart. 178-186. 1931.

Berman, Louis. The Glands Regulating Personality. Macmillan Co., 1921.

Campbell, M. The effect of feeding thyroid on the anterior hypophysis of a female albino rat. Biological Abstracts 9:1531. No. 13845, August, 1935.

Catchpole, H. R. The role of the gonad stimulating hormones in reproduction. Proceedings of American Society of Animal Production for 1935. 217-222. 1936.

Cobb, Ivo Geikie. The Glands of Destiny. W. Herman, 1927.

Collip, I. B. Science Supplement. Science 84:9. September 11, 1936.

Craft, W. A. and Orr, H. W. Thyroid influence in cattle. Journal of Heredity. 15:255-256. 1924.

Curtis, Caldwell, Sherman. Biology for Today. Ginn & Co. 358-365. 1932.

Dragstedt, L. R., Prohaska, J. and Harms, H. P. Science Supplement. Science, 85:9, June 11, and 85:11, January 1, 1937.

Dukes, H. H. The Physiology of Domestic Animals. Edwards Bros. 249. 1934.

Encyclopoedia Brittannicia. Encyclopoedia Britannicia Co., London, 1936.

Geiling, E. M. K. The Hormones of the Pituitary Secretions. Chemistry

and Medicine. New York. 1928

Ginsburg, S. Temperature, Temperment and Thyroid. Hygeia. American Medical Association. 1066-1069. December, 1936.

Gudernatch, Zentr. Physiology. 26:323. 1912.

Hitchcock, F. A. and Grubbs, R. C. Science Supplement. Science, 85:9. April 30, 1937.

Hunter. Problems in Biology. American Book Co. 392-395. 1935.

Hunter. New Civic Biology. American Book Co. 166-168. 1926.

Keller, Morris D. The Eyes Have It. Hygeia. American Medical Association. 144. February, 1936.

Marker, R. E. and Oakwood, T. S. Science Supplement. Science. 85:10. January 1, 1937.

Marker, R. E., McGrew, R. V., Wille, E. L. and Jones, D. M. Science Supplement. Science. 85:9. April 23, 1937.

Murray, W. S. Science Supplement. Science. 85:12. April 2, 1937.

Peabody and Hunt. Biology and Human Welfare. Macmillan Co. 535-540. 1927.

Sakel, M. Science Supplement. Science. 85:8. May 21, 1937.

Wayman and Sudan. Homotransplantation of adrenal cortical tissue. Science Supplement. Science. 589. June 18, 1937.

Wheat and Fitzpatrick. Advanced Biology. American Book Co. 191-202. 1929.

Williams, E. H. Rest and Grow Strong. Bobbs Merrill Co., 1925.

Williams, E. H. How We Become Personalities. Bobbs Merrill Co., 1926.

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