and whether phaophytin, obtained from chlorophyll, functions as a hemoglobin precursor in anemic rats, however this anemia may have been brought about. Rats kept upon such diets were systematically followed as to weight, blood hemoglobin and red blood cell count. The tentative conclusions arrived at as applied to rats are the following:

1. Synthetic rations containing 18 per cent casein and deficient in Vitamines A, B and E do not produce anemia but do produce an unusually high hemoglobin content.
2. Phaophytin may not be substituted for any one of the Vitamins A, B, or E.
3. Casein at a 10 per cent level produces a lower hemoglobin content than does casein at an 18 per cent level.
4. Casein extracted with acetic acid and aerated is less efficient in maintaining hemoglobin than is casein extracted with lukewarm alcohol.
5. Casein is much more efficient in the maintenance of hemoglobin than is gluten.
6. Experimental anemia may be produced on synthetic rations using wheat gluten as the protein and this anemia may be at least partially and temporarily alleviated by the addition of 0.2 to 1 per cent phaophytin to the ration.
7. It appears that proteins contain an important precursor of hematin and that since casein contains this in greater quantity than wheat gluten, the indications are that possibly tryptophane is involved.

3173

Gonad cross-transplantation in Sebright and Leghorn fowls.

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I. INTRODUCTION.

The main problem attacked was the question of a difference in the endocrine secretions of the testes of the Sebright and the Leghorn. The Sebright male is so-called "hen-feathered" as it has a feathering similar to that of the female, while the Leghorn

male is male-feathered. The work of Morgan[1] (and later of Eliot, unpublished) shows that the castration of the male Sebright is followed by the formation of capon feathers (usually called male feathers); thus the testis of the Sebright, like the ovary of the hen, and unlike the testis of the Leghorn, inhibits the formation of male feathers. Morgan concluded from this result and from later histological studies, in conjunction with Miss Boring,[2] that the Sebright and the Leghorn testes have different endocrine secretions, and that the Sebright testis contains cells indentical with the so-called luteal cells of the ovary, the presumed source of the internal secretion of the latter, which are responsible for hen-feathering of the male. Thus the Sebright was regarded as hermaphroditic in respect to its endocrine apparatus. The relation of the so-called luteal cells of the testis to hen-feathering, however, has been denied by M. S. Pease,[3] Goodale, and Nonidez,[4] who arrived at the conclusion that there is no morphological difference between the testes of different breeds to account for a presumed difference in their endocrine functioning. This led Prof. F. R. Lillie to suggest that the problem be attacked experimentally. The work was done on

10 Autotransplantation in the Leghorn,
2 Autotransplantation in the Sebright,
50 Cross-transplantation of Sebright testis into the Leghorn capon,
38 Cross-transplantation of Leghorn testis into the Sebright capon.

Autoplastic grafts grow readily in both breeds, and, when sufficiently developed, substitute completely, both physiologically and psychologically, for the normal glands. This confirms the results of previous investigators. In such grafts normal spermatogenesis may proceed indefinitely.

The birds retained the original feathering, prominent head furnishings, and male sex instincts during the time the grafts were intact. The removal of the grafts was soon followed by the regression of the size of head apparel, loss of sex instincts and, in

[1] Morgan, T. H., *Carn. Inst. Wash. Pub.* No. 286, 1919. *Endocrin.*, 1920, iv, 381-386.

[2] Boring, A. M., and Morgan, T. H., *J. Gen. Physiol.*, i, 127-131.

[3] Pease, M. S., *Proc. Camb. Phil. Soc.*, 1922, xxxi, 22-36.

[4] Goodale, H. D., and Nonidez, J. F., *Am. Nat.*, 1924, lviii, 91-92.

the case of the Sebright, change of plumage from the henny to the capon type.

II. EXPERIMENTS ON CROSS-TRANSPLANTATION.

To find out if the Sebright and the Leghorn testes are different from each other in their endocrine functioning, and especially if their secretions have specifically different effects on plumage, the following experiments were performed:

1. Leghorn cockerels were castrated and Sebright testis implanted into them.

2. Sebright cockerels were castrated and Leghorn testis implanted into them.

1. *Transplantation of Sebright Testis into the Leghorn.*

Fifty Leghorn males were used, all of which were successfully castrated and received Sebright testis grafts. These grafts "take" with great difficulty in Leghorns and only two successful cases out of 50 capons were secured. In these cases (L. 95 and 155) the Sebright testis caused in the Leghorn the formation of typical prominent head furnishings and sex and fighting instincts of the male. However, the feathers remained typical Leghorn male whether replaced by normal moult or after removal by plucking which was practiced several times. There was no tendency to the production of hen-type feathers caused by the Sebright graft, though this was active enough to induce the typical male characters of head furnishings and behavior. In the one case, the graft remained for 3 months and 24 days (No. 95) and in the other for 4 months and 14 days (No. 155). On internal examination, the original testicular sites were found clean and free from any growth, and growing grafts were found at the original sites of implantation. As soon as the grafts were removed, the head furnishings immediately receded and the male sex and fighting instincts disappeared. In L. 155 the graft recovered contained pigmentary cells which furnished additional evidence that the tissue recovered is the same as the tissue implanted.

2. *Transplantation of Leghorn Testis into the Sebright.*

This form of cross-transplantation succeeds much more readily than the reciprocal. Eleven out of the 38 cases were successful. Nevertheless, the grafts do not take so well as the

autoplastic grafts. Of these 11 birds, 9 developed capons feathers and the head furnishings regressed to the capon condition after complete castration and before grafting. Under the influence of the Leghorn testis grafts, the head furnishings developed again and the male sex and fighting instincts reappeared. The feathers, also, after plucking or molting, instead of being replaced by capon or cock feathers, developed as henny feathers, the animals reverting to the hen-feathering normal for the Sebright cock. In all except two (S. 3 and 12) no regenerated testicular tissue was found. But in these exceptions, also, the feathers remained the henny type under the influence of the Leghorn testis grafts after the regenerated tissue was removed.

After the grafts were removed, after being retained for from 3 months to a year or more, the sex instincts disappeared, and the feathers again developed to the capon type, the so-called male feathers in the Sebright.

c. Discussion of Results.

These experiments show that it is much more difficult to transplant Sebright testis into the Leghorn than it is to transplant Leghorn testis into the Sebright; that while the Leghorn testis will readily take in a Sebright, the growth of a Sebright testis in a Leghorn is an exception rather than the rule. This difference in the reciprocals is very striking. It has been found that of the two breeds, the Sebright is more hardy and less subject to infections, although it is the one more difficult to operate on. The question of blood differences in the breeds should receive attention.

These experiments clearly indicate that there is no difference in the endocrine secretions of the Leghorn and Sebright testes contrary to what has been postulated by some workers. A Leghorn testis in a Leghorn body is accompanied by the appearance of the usual male type feathering, while the same testis in a Sebright body is accompanied by the appearance of the Sebright henny feathering. A Sebright testis in a Sebright body provokes the production of the henny type of feathers, while the same testis in a Leghorn body is accompanied by the production of the usual Leghorn feathers. It seems safe to conclude then that there is no qualitative difference in the secretion of the two testes as far as their effect on plumage is concerned, both producing the same effect when placed in the same body.

Hen feathering in the Sebright has been shown by Morgan[1] to be dominant to cock-feathering in crosses and to behave in a general Mendelian fashion. It is natural to conclude, therefore, at least provisionally, that the difference in the feather reactions to the testis hormones in the two breeds is based upon such differences in their genetic constitution, though other possibilities remain to be considered elsewhere. This implies that while the male type of head furnishings and the development of male sex instincts are determined in all their extent by the testicular hormone, the plumage of the male is conditioned in both breeds by another factor or set of factors, presumably genetic, in addition to the influence of the testis.

The results, in any case, remove the necessity of assuming two kinds of endocrine secretions by the Sebright testis, which is inherent in Morgan's theory. It may also be incidentally noted that there is no noticeable racial influence of the heteroplastic testis.