PRODUCTION OF OESTROGENIC SUBSTANCE
BY THE BIRD TESTIS

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Oestrogenic substances are now known to be elaborated and excreted by the males of various species of mammals. The testes and urine of the stallion (Zondek, 1934), in particular, and the testes of the hog and bull (Courrier, 1934) contain notable amounts of oestrogenic compounds. In the case of the horse, the urine is relatively inactive in castrates (viz. geldings), so that it may be assumed that the testis is the origin of this oestrogenic material. Oestrone is isolated from stallion's urine after mild chemical treatment, and it would appear that, whilst oestrone may not occur as such in the urine, the primary oestrogenic material in the stallion is a simple derivative of oestrone.

There is no clear evidence, however, that oestrone performs any essential function in the male mammal. It is probable that androsterone, the so-called male hormone isolated from urine, does not as such account for the whole androkinetic activity of the testis (David and Freud, 1935; Callow and Deanesly, 1935); but, although Freud (1933) has shown that oestrone stimulates growth of the fibrous tissue of the seminal vesicles of castrate rats, there is no proof that the normal development of these organs is dependent on oestrone as an accessory substance. On the contrary, we have the definite evidence provided by the experiments of Lacassagne (1933) and Burrows and Kennaway (1934) that excessive amounts of oestrone cause abnormal metaplastic changes in the prostate of mice.

The condition observed in birds is of interest. In the ordinary domestic fowl, castration of the male has no effect on the plumage, whereas ovariotomy of the female results in the assumption of the plumage of the normal cock. Thus a hen is hen-feathered because the male, or neutral, plumage is suppressed by the activity of the ovarian secretion, i.e. by oestrin or a closely related compound. A more complex condition occurs in the Sebright Bantam, in which the normal cock, as well as the hen, is hen-feathered. The same phenomenon occurs with less regularity in the Campine. Removal of the gonads of either the hen or the cock Sebright results in the appearance of normal cock feathering, with the characteristic structure and arrangement of display feathers which are common to cocks of other breeds (Morgan, 1919). It must be assumed that in this case the internal secretion of the testis has the same action on the plumage as that of the ovary. Certain other facts bearing on this problem are known. If the testis of a breed, in which the cock is normally cock-feathered, say the Leghorn, is transplanted into a Sebright capon, the usual hen-feathering of the Sebright cock is restored; if the Sebright testis is
transplanted in the Leghorn capon the plumage is unaffected (Roxas, 1926). On the other hand, Leghorn cock skin transplanted to hen-feathered cocks still bears cocky feathers, whilst the skin of hen-feathered cocks transplanted to the Leghorn cock still bears henny feathers (Danforth and Foster, 1929, and Danforth, 1930). The conclusion from these two series of experiments is that the peculiarity of the Sebright lies not in its testis, but in the reaction of its skin. Further, Freud, de Jongh and Laqueur (1930) have shown that the Sebright capon, like the capons of cock-feathered breeds, becomes hen-feathered after the administration of oestrin, although the amounts required to effect the change are much less than in the Leghorn (Champy, 1935).

In the present state of knowledge the possibility cannot be excluded that the gonads of either sex may produce, as by-products or intermediates, compounds which have both male and female hormonal activities. As we have seen, however, the characteristic endocrine activity of the Sebright testis does not differ from that of other fowl testes, and a sufficient explanation of the observed facts may be given on the basis that the only essential hormones are oestrone and androsterone (or closely related compounds differing quantitatively but not qualitatively from these two in activity). On this basis two hypotheses of the Sebright phenomenon are possible: (a) that the testes of Sebrights and other fowls produce oestrone in sufficient amount to affect the plumage of the sensitive Sebright, but insufficient to affect the less sensitive Leghorn, or (b) that the male hormone, either directly, or indirectly by way of the thyroid, has the same effect on plumage as oestrone, provided that the plumage is sensitive enough to respond. Of these two hypotheses the latter seems the more likely (Greenwood and Blyth, 1929; Gallagher, Domm and Koch, 1933).

The recent availability of androsterone in pure form has made it possible to decide between these two hypotheses. A Sebright capon, with fully developed cock feathering, was given daily injections of an oil solution of crystalline androsterone for more than two months, the daily amount being first 0.5 mg., then 2.5 mg., then 1.0 mg. At the beginning of the injections patches of neck hackles, wing coverts, and saddle hackles were plucked. In the course of the injections the comb, previously small and shrivelled, grew to an exceptional size and the bird started crowing and acquired the typical male stance, showing that the amount of hormone administered was fully up to the amount produced by the normal cock. The feathers regenerated on the plucked patches were, however, exactly as before, typically cocky. In other words, androsterone had restored the head furnishing, carriage, etc., of the normal Sebright cock, but had quite failed to evoke the henny feathering. One is left, therefore, with the theory that the testes of the Sebright, and of other birds, produce oestrin, or an oestrin-like substance, in addition to the male hormone, and that the essential difference between henny-feathered and cocky-

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1 \*Note added 21. ix. 35.\* Butenandt, A. and Hanisch, G. (Ber. dtsch. chem. Ges. (1935), 68, 1860) state that androstenedione and dehydroandrosterone, both of which have male hormone activity, have oestrogenic action on the immature rodent. Unsaturated compounds of this type are conceivable intermediates in the formation of the triply unsaturated oestrone from saturated aetiocholane compounds.
feathered cocks is purely one of the sensitivity of plumage to oestrin. Experiments carried out in this laboratory show that the Sebright capon saddle hackles will respond to 1–2 gamma of oestrin daily, about one-twenty-fifth of the amount required to cause a comparable response in the Leghorn capon. Even allowing for the lower weight of the Sebright (about 1/5th) this difference in sensitivity is still considerable and undoubtedly significant. It should be pointed out that this conclusion is not in conflict with the classical Darwinian theory of secondary sexual characters, which deals not with the physiological mechanism by which the character is produced, but with its survival value; not does it conflict with the genetical observations (Morgan, 1919; Punnett and Bailey, 1921; Pézard and Caridroit, 1927) that the hen-feathered character behaves as a Mendelian character. In fact it is now possible to quote these experiments as an interesting demonstration of the inheritance of variation in sensitivity to a hormone.

We thus have a clear demonstration that the avian testis produces both male hormone and oestrogenic substances and that in at least one breed of fowl both hormones are concerned in producing the typical external ensemble, a state of affairs not yet known in mammals. Two points of interest are raised. Leghorns naturally vary in their response to the injection of a given amount of oestrone, and the sensitivity of any particular bird can be ascertained by injection of the hormone. It should thus be possible to select and breed for high sensitivity to oestrone, and, in the course of several generations, to produce a strain of Leghorns in which the plumage of the cocks is as sensitive to oestrone as that of the Sebright cock, i.e. to produce a strain of Leghorns in which the cocks are hen-feathered. The second point is that, as a result of the work of Juhn and Gustavson (1930) and Greenwood and Blyth (1935) a good deal is now known about the amount of oestrin required to feminise the plumage of the Leghorn capon. If the normal bird testis is producing a certain amount of oestrin, then the cock should require less by injection to feminise the plumage than the capon. A careful comparison of the relative amounts required by the cock and the capon should enable an estimate to be made of the amount of oestrin produced by the normal cock.

SUMMARY.

Crystalline androsterone does not affect the cocky feathering of the Sebright Bantam capon, and the henny feathering of the normal Sebright cock must therefore be due to the elaboration by the testes of some other substance than androsterone, probably oestrin.
REFERENCES.