

TEXTS AND DOCUMENTS

THE TRANSPLANTATION OF TESTES

ARNOLD ADOLPH BERTHOLD

TRANSLATED BY D. P. QUIRING

*Translator's Note*

Now and then the account of a basic research appears in the literature. More rarely, it is expressed with such clarity, with such concentration on essentials, that the described problem appears to have solved itself.

Some years ago I had occasion to refer to the short paper of Professor Berthold of Göttingen on the transplantation of the testes in six cockerels. The account was published in the *Archiv für Anatomie, Physiologie und wissenschaftliche Medizin*, pp. 42-46, 1849. Because of its inaccessibility in the original and because it is so frequently overlooked, it was thought worth while to translate the short four and a half page paper, the clearcut conclusions of which have become the foundation of modern endocrinology. Apparently Berthold was the first to indicate that the internal secretory products of the testis were taken up by the blood and thence transferred to the other systems of the body.

*Translation*

On August 2 last year, I caponized six young cockerels, *a*, *b*, *c*, each three months old, and *d*, *e*, *f*, two months old. Wattles, combs, and spurs were not removed from these animals. Both testes were taken from cockerels *a* and *d*; these animals later showed the characteristics of capons; they were not aggressive, they fought with other cockerels rarely and then in a half-hearted manner, and they developed the monotone voice of the capon. Comb and wattles became pale and developed but slightly; the head remained small. When these animals were killed on December 20, the former site of the testes showed but a small scar. The spermatid cords were recognizable only as delicate fibers.

Cockerels *b* and *e* were castrated in similar manner except that only one testis was removed from the body; the other remained isolated in the body cavity.\* In cockerels *c* and *f*, however, both testes were taken from

\* Apparently it was separated from its attachments and left lying loosely in the body cavity. (Translator's note.)

the body; one testis of cockerel *c* was placed in the body cavity of cockerel *f*, and one from *f* was placed in the body cavity of *c*, among the intestines.

These four cockerels (*b*, *e*, *c*, *f*) exhibited the normal behavior of uncastrated fowls; they crowed lustily, often engaged in battle with each other and with other cockerels, and showed the usual reactions to hens. Their combs and wattles developed as in normal fowls.

Cockerel *b* was sacrificed on October 4; the remaining testis had attached itself and healed in the original site. It had increased by more than half in diameter, was richly vascularized, and showed distinct spermatic tubules; upon section a whitish fluid with many large and small cells was extruded which failed to show any spermatozoa, however.

On the same day the well developed combs and wattles were removed from cockerels *c*, *e*, and *f*, and the body cavity was opened for examination of the testis. Cockerel *e* showed the testis in the usual site, as I had also found it in the sacrificed cockerel *b*. I removed this testis from the body cavity and found it similar to that of cockerel *b*. The abdominal wound, the comb, and the wattles soon healed in this fowl, but the comb and wattles did not regenerate. The fowl began to emit the typical voice of the capon, it no longer showed interest in hens, nor would it battle with other cockerels; in fact it remained at a distance from them and showed the nature of a true capon.

In cockerels *c* and *f* no sign of the testes was observed in the usual site. Combs and wattles regenerated; the creatures retained their cockerel nature, and continued to crow and to exhibit their former behavior toward hens and other cockerels. These two roosters were killed on January 30, 1849. No sign of the testes was found in the usual site; instead in cockerel *c* it had attached itself to the ventral surface of the colon and was bordered on both sides by intestinal caeca without, however, having become attached to them. I found the same conditions in cockerel *f*, except that the testis had become attached farther caudad at about the middle of the caeca. The testis was oval in both these animals, and had a length of 15, width of 8 and thickness of 6 lines (*linien*: mm.). Well developed branches of the mesenterial arteries approached and entered the testis at various points and could be followed to the spermatic tubules. When I opened the testes, a milky white fluid exuded which had the appearance and odor of normal cockerel semen. Under the microscope I recognized in this fluid many small and large cells of  $1/450$  to 150 line diameter, as well as many spermatozoa with active flagellar movements, which became much more active upon the addition of a droplet of water.

These experiments yield the following results for physiology:

1. The testes belong to the transplantable organs; they may become reattached after removal from the body; actually one may transplant them from one animal to another, and the attachment may occur at the original site of removal or in an entirely foreign location, for example, on the intestinal wall.

2. The transplanted testis continues its characteristic growth as a spermatogenic organ even in a foreign site; the tubuli expand and enlarge and carry on normal functions in that they secrete the typical semen characterized by spermatozoa. We find here conditions comparable to those in plants where the cion retains its specific characteristics and produces its own fruit after having been grafted into the stock.

3. It is a known fact that severed nerves may be rejoined and that parts whose nerves have been cut may have sensation and movement restored after healing. But it is evident that the same fibers are not always rejoined. This may be deduced from the behavior of a restored skin transplant. From the fact that the testis may attach itself to a remote body part, namely, to the intestine, and continue to develop and actually produce semen, it follows that no specific spermatogenic nerves exist.\* This is the chief argument against the existence of specific trophic nerves. The sympathetic nervous system has until recently been considered such a trophic system.

4. The remarkable sensuous (*consensuelle*) and antagonistic relation between the life of the individual and the life of the species, as it appears particularly at puberty and continues until advanced age, is not affected when the testes are removed from their original site and severed from their innervation and become attached to an entirely different part of the body. So far as voice, sexual urge, belligerence, and growth of combs and wattles are concerned, such birds remain true cockerels. Since, however, transplanted testes are no longer connected with their original innervation, and since, as indicated in paragraph 3, no specific secretory nerves are present, it follows that the results in question are determined by the productive function of the testes (*productive Verhältniss der Hoden*), i. e., by their action on the blood stream, and then by corresponding reaction of the blood upon the entire organism, of which, it is true, the nervous system represents a considerable part.

\* Apparently the author means in a secretory sense. (Translator's note.)