The structural changes observed in the testicles of aged persons ; The structural changes in the testicle of the dog when it is replaced within the abdominal cavity / by Joseph Griffiths.

With the Author's Compliments

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Changes in the Testicles of Aged Persons

by

Joseph Griffiths

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THE STRUCTURAL CHANGES OBSERVED IN THE TESTICLES OF AGED PERSONS.

By JOSEPH GRIFFITHS, M.A., M.D., F.R.C.S., *Assistant to the Professor of Surgery in the University of Cambridge.* (PLATE XXIII.)

DURING the last two years I have collected and examined microscopically numerous testicles removed from persons of different ages between fifty and eighty years.

This was done with the object of determining, if possible, what, if any, are the changes that this organ undergoes in the aged, and whether it is naturally subject to a regular process of decay similar to that affecting the mammary gland after the cessation of the menstrual function.

Such structural changes as would indicate a natural process of decay arise in the testicles; but the time at which such changes begin to manifest themselves varies within wide limits. For in some men the testicles show the initial changes of this decay and loss of secreting function soon after the age of fifty years, while in others, at the age of seventy or more, the testicles are in full vigour and actively producing and reproducing spermatozoa. Therefore, there is no such fixed date beyond which the testicle may be said to be in its natural process of decay, as can be said of the mammary gland in the female. Hitherto but little attention has been paid to this subject, although anatomists have, from time to time, established by measurement and weights the fact that the organ tends to diminish in old age; and, besides the researches of Arthaud,[1] there is no account of the histological changes that arise in the testicle and epididymis in old age.

Curling[2] seems to have been the first to give a definite description of the changes that occur in the testicle during and as a consequence of old age. These are his words:—

"And that as old age advances and the generative functions

[1] *Étude sur le testicle senile*, Paris, 1885.

[2] *Diseases of the Testis*, 4th ed.

cease to be called into action, they [testicles] undergo a diminution in size, their vessels grow less, and the seminiferous tubules become small, contracted, and partially obliterated, their place being supplied by fatty matter." In a foot-note he makes the following additional remark:—"In the testicles of old men the tubules are commonly found loaded with a dark granular substance, the result of fatty degeneration."

No other person seems to have paid much attention to this subject until Arthaud, who, in 1886, published a thesis on the senile changes in the testicle. After describing briefly the changes that arise in the testicle during old age, he devotes his attention chiefly to the cystic formations that are found in many old persons in the globus major, or head of the epididymis. I may return to these and the like cysts in this neighbourhood in a subsequent paper.

The changes that I have found in the testicles are the following:—The bulk of the organ is in most cases not much altered, though in some it is so considerably, and I have now under my care a man above ninety whose testicles are of quite the usual size. They usually become softer and more flaccid, and their tunics tend to become wrinkled as if too large for their contents. The internal structure, in those instances that are not much reduced in size, is either soft and yellowish, or granular and somewhat more firm than natural, the seminal tubules being less easily disentangled;—those instances in which the body of the testicle is much reduced in size there are large irregular-shaped fibrous patches here and there, apparently containing no seminal tubules. The epididymis retains its normal size to the testicle; but commonly, in small well-defined areas, its tubules (coni vasculosi) are of a yellowish colour, like those of the seminal tubules; and occasionally in these altered patches, and also in other tubules of the head of the epididymis, are minute, translucent cysts, holding clear fluid devoid of spermatozoa. This yellowish appearance in the tubules of both testicle and epididymis is due to fatty degeneration of the epithelial contents of the tubules; and when the fatty change is observed in the one part it is usually present in the other. Thus the chief and commonest change met with in the testicles of the aged, so far as can be determined by the naked eye, is fatty transforma-

tion of the epithelial contents of the seminal tubules, and this applies equally to the epididymis; but occasionally testicles are found that show transformation of their internal structure into patches of fibrous connective tissue, which are of irregular shape and size, and sometimes these replace the greater part of the tubular structure.

Before describing the microscopic changes in the testicle of the aged, it may be well to give an account of the minute structure of the tubules as they may be usually found in the normal human adult testicles; for purposes of comparison with the other figures a section has been drawn to illustrate this (see fig. 1).

The normal seminal tubules are surrounded by a thin layer or tissue, "tunica propria," which is composed of two or more layers of flattened connective-tissue cells with rod-like nuclei, or in some instances, of several layers of such cells with a small amount of intervening fibrous connective tissue. The epithelium within this tunica propria is arranged thus:—

Lining the "tunica" is a continuous layer of small cubical cells with round nuclei, and not much protoplasm; several of these nuclei may be seen in the process of division, or of having divided into two nuclei which still remain side by side; within this outer layer there are at least two strata of much larger cells that have large nuclei which are occupied with a network of thread-like filaments; the protoplasm is large in amount, and often finely granular. In many of the nuclei of the innermost stratum of these cells the heads of the spermatozoa are clearly visible, and these are arranged with their long axes towards the lumen. Occupying the lumen of the tubule are numerous spermatozoa scattered irregularly, and between them granular débris and a few partially degenerated free cells.

Connecting these tubules together is a small amount of delicate, loose, fibrous connective tissue, in which there are a few interstitial cells, and in which the vessels and nerves lie. The connection of this tissue with the tunica albuginea on the one hand, and with the tissue of the rête testis on the other, is quite familiar, and therefore needs no comment.

A microscopic examination of that variety of the testicles of the aged which is the commonest, and in which the organs are

not much reduced in bulk, indicates two distinct stages in the retrogressive or involution changes in this organ. The accompanying drawings (figs. 2–5) have been selected with a view to illustrating these stages.

In the earlier of these two stages the changes in the tubules, both of the testicle and of the epididymis, are but slight, except that fatty degeneration of the epithelial cells filling the seminal tubules, or as in the epididymis lining them, is more or less pronounced. In fig. 2, transverse sections of a seminal tubule and a part of another are shown, in which there is entire absence of the formation of spermatozoa in the cells and of spermatozoa in the interior; and there is a diminution in the number of the layers of cells lying within the continuous peripheral one. The most central cells are large and irregular in shape; in some of these there is a large, clear, ring-like space around the nucleus, which is large and highly granular, but not showing the threads of division. The protoplasm of the cells is ill-defined and slightly granular, the granules being composed of fat. The degree of this fatty degeneration is most pronounced in the cells lying just within the outer peripheral layer, in which latter degenerative changes are very slight (see fig. 2). In the more central cells the degeneration is also not so marked, but this may be due to the fact that more complete disintegration of the protoplasm of the cells has taken place, and that the granules of fat have either escaped into the lumen, from where they would have fallen out in the preparation of the section, or have been absorbed. In addition to this change, which is universal throughout the gland, there is another which accompanies it. It is the thickened and convoluted state of the tunica propria. In the normal testicle the tunica propria is a very thin membrane, composed as a rule of a single, or at most two, layer of cells, with a slight amount of intervening fibrous connective tissue; whereas, in the testicles of old men, this membrane becomes several times thicker than its original, and also becomes more fibrous in character. The convoluted disposition of this membrane corresponds with the diminution in the epithelial contents of the seminal tubules. There seems to be no increase in the intertubular connective tissue, but there is fatty degeneration of a few of the connective-tissue cells, and of those cells that

may be regarded as the remains of the peculiar *interstitial* cells of this organ.

In the epididymis the tubules are smaller than natural, and are bound together by intertubular connective tissue, which is here denser and more fibrous than natural. Most of the tubules are empty, a few containing a mass or plug of granular and fatty débris, in which there may be seen a few heads of persistent spermatozoa. The columnar epithelium, naturally lining the tubules at this part, has lost its regularity of form and arrangement, as well as its cilia; and the cells are reduced in size, and partially filled with fat granules which are mainly disposed towards the attached or basal part of the cells, and which, in consequence, obscure the nucleus (see fig. 3). The walls of the tubules, which, unlike those of the seminal tubules, are in the normal state mainly composed of layers of non-striped muscular fibres, are transformed in part, if not wholly, into fibrous connective tissue—the muscle cells having disappeared, while the connective tissue increased and replaced them. This altered wall of the tubule merges without any line of distinction into the intertubular connective tissue, which is in all these cases dense and fibrous, and very unlike the loose connective tissue found in this situation earlier in life.

The next, or second, stage of degeneration is well illustrated in figs. 4 and 5. The changes are mainly confined to the testicle, the structural alterations of this stage in the epididymis being but an exaggeration of those described in the first stage. In the testicle the seminal tubules are much reduced in size, the epithelium having in great part disappeared, while the tunica propria has acquired considerable thickness; the intertubular connective tissue is relatively increased, and it often presents numerous cells, and is loose in texture. In fig. 4 the changes that the tubules have undergone may be studied. There is only a single layer of cells which appear to be long columnar cells, arranged in a somewhat radial fashion, converging towards the centre of the tubule. These cells, which evidently represent the single layer of cubical cells lying on the inner surface of the tunica propria of a normal tubule, have large roundish nuclei, which are, almost without exception, surrounded by a clear ring-like space, and are placed near the

attached end of the cells. The protoplasm is delicately fibrillated, the fibrils corresponding with the long axis of the cell, *i.e.*, running from the periphery towards the centre of the tubule. Among these cells the remains of a few further degenerated cells, of which the nuclei still remain the protoplasm having disappeared, may be seen. The tunica propria is much thickened, but not much convoluted. It is several layers in thickness, and is composed of dense fibrous connective tissue, arranged in concentric lamellæ.

The fibrillated protoplasm of the epithelial cells in the interior of the tubule often appears at first sight, as if it were a continuation, or rather a prolongation, inwards of the fibrillated matrix of the tunica propria; but a careful examination will not fail to detect a sharply-defined line between the bases of the epithelial cells and the inner layer of that tissue.

The intervening intertubular connective tissue is, as has been said above, relatively increased, is cellular and loose. The cells it contains are large connective-tissue cells, with highly granular protoplasm which is in large measure transformed into fat granules. These cells are often grouped together in clusters in the angles left between the tubules.

Between these two stages there is every gradation, as may be expected.

The external appearance of the testicles is no sure guide to the state of the seminal tubules; and even when the organs are not much reduced in size, the structural changes in their essential constituents may be profound.

The changes that arise in the testicle of old men are chiefly, as one would expect, confined to the epithelium of the seminal tubules. It diminishes in amount from fatty and other disintegrative degenerations of the cells which in great part disappear, leaving only a single layer of columnar cells occupying the lumen. This layer of cells, there can hardly be any doubt, represents the outer cubical layer seen in the normal tubule; but why the cells should assume columnar shape, and their protoplasm show such distinct fibrillation, is more than I can even attempt to explain. Similar structural alterations occur in the testicle in other atrophic conditions, which I hope shortly to describe, and which may be found in the undescended organ.

Besides the above, I have found among the testicles of the aged, one in which the testicles are much reduced in size and their tunics much wrinkled. Both organs are usually affected, though not to an equal degree. If these be first hardened in alcohol and then sliced, it will be observed that the internal structure of the organ is replaced, in patches of irregular size and shape, by fibrous connective tissue which appears to contain no seminal tubules. These patches are not, so far as I have noted, confined to any particular area, but are scattered throughout the substance of the gland. Rarely is the greater part of the gland thus altered. The minute structure of these patches of fibrous connective tissue is well depicted in figs. 6, 7. The seminal tubules contained in them are reduced to their minimum size, and the intertubular connective tissue is increased, dense and fibrous. In each tubule the lumen is narrow and fissure-like, with many radiating branches; in some of these fissures remains of the epithelial cells still persist, as seen in fig. 7. The tunica propria of the tubules is thickened, fibrous, and wavy. Between this and the fissure-like lumen is a thick layer of almost transparent, delicately fibrillated matrix of fibrous connective tissue, in which there are interposed, here and there, a few flattened connective-tissue cells. It is the manner in which this latter has formed that gives the peculiar branched, fissure-like lumen to the tubule.

The parts of the gland that are not thus transformed into patches of fibrous-looking tissue, contain seminal tubules that present the characters of the tubules found in either the first or second stage in the commoner variety of testicle met with in the aged.

Such is the change observed in the small and atrophied testicles of old men. They so much resemble the changes met with as the result of chronic inflammation, that I have sometimes felt disposed to attribute them to that cause.

Further, the vessels in the stroma of the testicles of the aged have been carefully examined, but they show no other than the sclerotic changes so commonly found in the vessels of other organs and tissues in elderly persons.

Conclusions.

In the testicles of the aged, two distinct stages may be recognised in the process of involution or decay to which they are liable.

In the *one*, the epithelium of the seminal tubules, and also that of the tubules of the globus major of the epididymis, undergoes, more or less, complete fatty degeneration and partly disappears, the tunica propria of the tubules of the testicle becomes somewhat thickened, but the intervening intertubular connective tissue remains practically unaltered. In the epididymis the muscular wall of the tubule is replaced by fibrous connective tissue, and the intertubular connective tissue is increased, dense, and fibrous. In the *other*, or *second* stage, the seminal tubules are much reduced in size, the epithelium having in great part disappeared, leaving only, in many instances, a single layer of long, tapering, columnar cells, lining and filling the tubule, the central spermatozoa-producing cells having completely disappeared, while the tunica propria is greatly thickened from proliferation of its own connective-tissue cells and the formation of a fibrous matrix. The intertubular connective tissue is in this *second* stage relatively increased, owing perhaps to the diminution in the size of the seminal tubules, but it still remains of loose texture, and contains, as in the normal, many connective-tissue cells. The epididymis shows no other changes than those incident to the *first* stage.

Besides the above, there is a *third* change, which is more partial, and much resembles the result of the inflammatory process. It is usually observed in the small or shrunken testicles of old men, and affects both organs. In the altered patches, the seminal tubules, in the majority of instances, are completely transformed into fibrous rods or cords; but in some there still remain in the central fissure that represents the original lumen, traces of epithelial cells derived from the degenerated cells of the seminal tubes. The intertubular connective tissue is increased in amount, and converted into a dense fibrous variety.

EXPLANATION OF PLATE XXIII.

Fig. 1. Section of a portion of a natural seminal tubule from the testicle of a middle-aged man. Outside is the tunica propria, composed of fibrous tissue, in which there are a few flattened connective-tissue cells; within this a continuous layer of more or less cubical cells, with large, highly granular nuclei and clear protoplasm; within this layer two or more layers of large irregular-shaped cells, the nuclei of which are in the process of division, preparatory to the formation of spermatozoa; and still within these, groups of developing spermatozoa between cells which are evidently breaking down and passing into the lumen with the spermatozoa. × 450.

Fig. 2. Section of one seminal tubule and part of another taken from an aged person, and stained with osmic acid. It shows the first stage of the changes characteristic of the degeneration accompanying old age, namely, disappearance of most of the spermatozoa-producing cells and fatty degeneration of the remaining cells, especially those lying within the outer peripheral layer of cells, which show as yet but little change. The tunica propria is slightly thickened. × 120.

Fig. 3. A section of the tubules of the epididymis from the same person. The epithelium lining the tubules has lost its regular columnar appearance as well as its cilia, the cells having become small, less distinct, and in many instances filled with fat granules, which are so numerous as to obscure the nucleus.

Fig. 4. A section of testis showing the *second* stage in the changes that occur in old age. The seminal tubules are much reduced, the epithelium being only represented by a few cells, the tunica propria much thickened, and an increase of the intertubular connective tissue which is in the main cellular. × 100.

Fig. 5. One of the above tubules highly magnified. It shows the thickened tunica propria, the complete disappearance of the central or spermatozoa-producing cells of the tubule and the formation of columnar fibrillated cells from the continuous peripheral layer lining the tunica propria, the lumen being occupied by the prolongations of these cells. × 400.

Fig. 6. Section of a fibrous patch in the testicle of an aged person. The tubules are greatly reduced; their lumen reduced to a chink, and the tunica propria much thickened. The intertubular connective tissue somewhat increased and fibrous. × 40.

Fig. 7. One of the tubules seen in fig. 6 more magnified. The tunica propria is composed of an outer dense thin layer and of an inner transparent layer of wavy fibrous tissue, in which there are no connective-tissue cells: the lumen which radiates, contains a single atrophied epithelial cell.

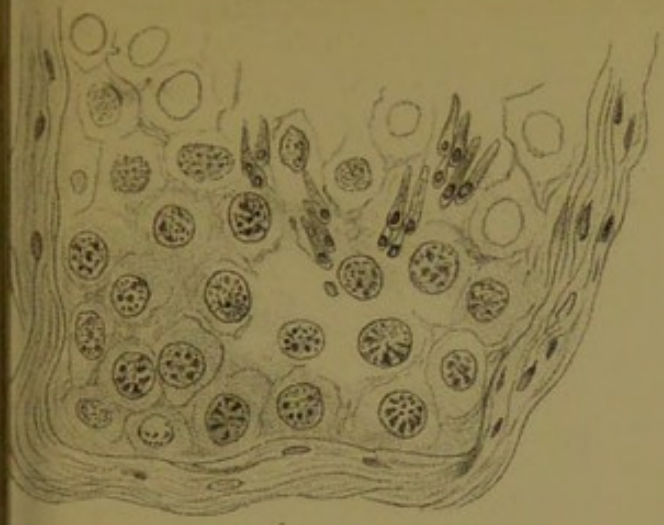

Fig. 1.

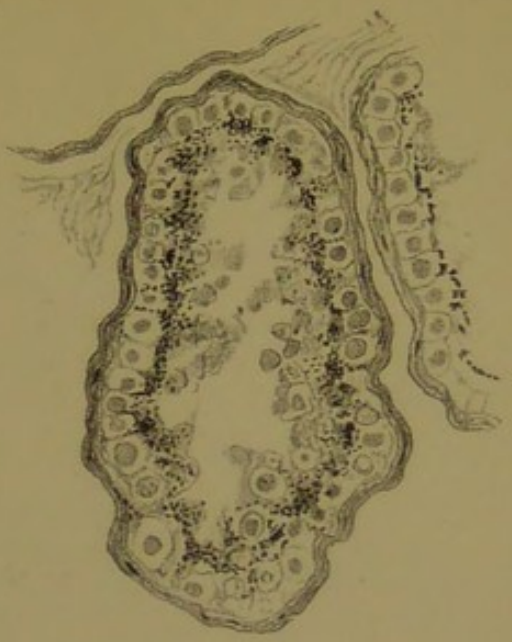

Fig. 2.

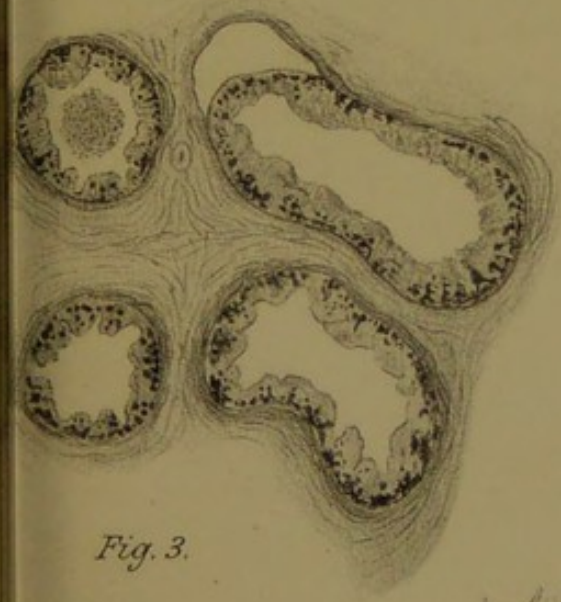

Fig. 3.

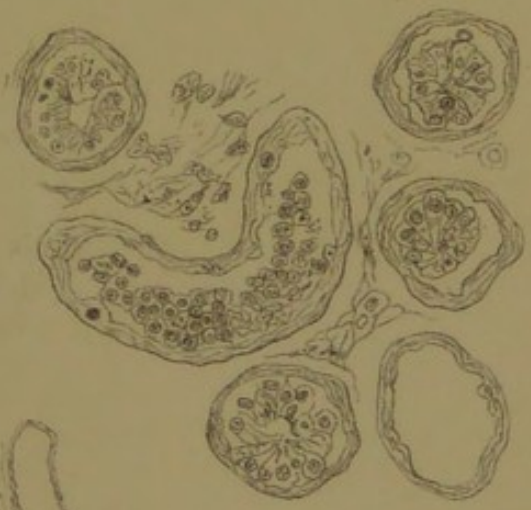

Fig. 4.

Fig. 6.

Fig. 5.

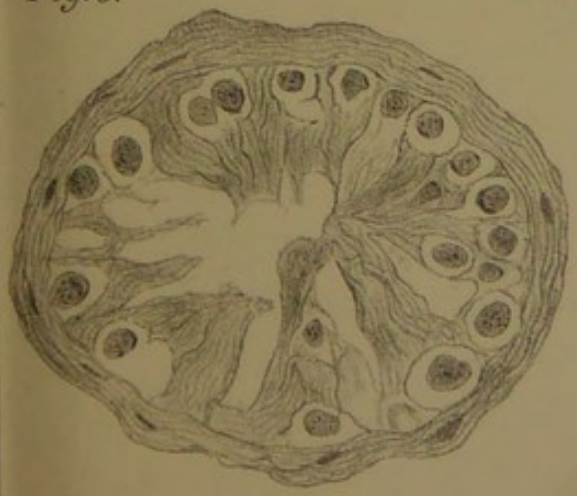

Fig. 7.

Griffith del. F. Huth, Lith^r Edin^r

TESTICLE IN OLD PERSONS.

THE STRUCTURAL CHANGES IN THE TESTICLE OF THE DOG WHEN IT IS REPLACED WITHIN THE ABDOMINAL CAVITY.

By Joseph Griffiths, M.A. Cantab., M.D. Edin., F.R.C.S. Eng., *Assistant to the Professor of Surgery in the University of Cambridge.* (Plates XXIV. and XXV.)

Since the publication of John Hunter's[1] observations upon the state of the testicle when retained within the abdomen, many investigations of a similar nature have been conducted in Man and in some of the domesticated animals, both in this country and in France; but so far as I am aware, no attempt has ever been made to determine, by means of experiments, (1) whether, when the testicle is replaced within the abdomen in young animals, it is capable of attaining its full size and mature structure and of producing spermatozoa; and (2) whether, when replaced within the abdomen in a full-grown animal, a dog for instance, in which the testicles have reached their full and mature size, it is capable of maintaining that full size and its powers of producing spermatozoa.[2]

It was with the object of determining these two points that the following experiments were conducted. Dogs were chosen, being easily procurable.

Before a detailed account of each experiment is given, it would be well to review briefly the opinions and observations of the more important writers on this subject.

Hunter, in the monograph to which reference has already been made, states as his opinion, that "when the testicle fails to descend from the abdomen, the organ is imperfectly formed, and that, in consequence of this imperfection in development, it is incapable of giving the necessary stimulus to the mechanism by means of which it descends." Accordingly, Hunter regards the undescended testicle as imperfectly formed, even during early embryonic life. He also considers, as may be gathered from another part of the same monograph, such a testicle incapable of producing spermatozoa, and a man

[1] Hunter, *Obs. on certain parts of the Animal Œconomy.*

[2] I find Curling suggests this method as one likely to lead to good results, in his 4th edition of the *Diseases of the Testis.*

whose testicles remain undescended as sterile. Hunter, it will be remembered, was the first to describe the mechanism of the descent of this organ, and to point out that when the mechanism failed in its appointed duty, the testicle was at fault, as shown by the smallness in its size, and the absence of spermatozoa in it, and in the corresponding *vesicula seminalis*.

Sir Astley Cooper [1] agrees with Hunter, and found nothing in his extensive experience to throw any doubt upon the accuracy of these observations. But not many years after the publication of Cooper's *Diseases of the Testis*, Curling [2] took up this subject, and after much labour came to a totally different conclusion, namely, that when the testicle is undescended and remains in the abdomen, it is not *ab initio* imperfectly formed or developed, but simply fails to reach beyond a certain stage in its development, and that its structure is perfect for that stage which is obtained prior to puberty; further, he attributes failure in descent to some defect in the mechanism itself, and not to any want of stimulus from an imperfectly formed testicle. As it is not my intention to enter into a discussion upon the prime mover in the mechanism of descent, nor upon the various causes of partial or complete failure in its action, I shall make no further references to that subject here.

Curling, however, agrees with Hunter and Cooper, inasmuch as he considers the testicle incapable under these conditions of producing its special secretion.

He, however, mentions an instance in which he understood that spermatozoa were found by a colleague in a testicle which had been retained in the inguinal canal.

Soon afterwards Godard,[3] in France, published a communication in which he showed that the testicle, when retained within the abdomen in Man, is capable of producing spermatozoa; and he cited instances which he had met with, and in which, after careful examination with the microscope, he found spermatozoa.

Just at the same time Follin and Goubaux [4] made extensive investigations both in Man and in horses; and they collected between them numerous instances of retained testicles, in none of which could they find any trace of the formation of spermatozoa, spermatogenesis, or of spermatozoa themselves. In spite of the observations of Godard, it has been generally accepted for many years that when the testicle fails to reach the scrotum and is detained in or near its original position below the kidney, in the iliac fossa, or in the inguinal canal, it is not fully developed; that is, it is smaller and softer than natural, and its internal structure differs from that of a natural organ in so far that the seminal tubules cannot be easily distinguished; that they are atrophied, and that they show no trace of

[1] Cooper, *On the Structure and Dis. of the Testis.*

[2] Curling, *Diseases of the Testis*, 4th ed.

[3] Godard, *Recherches sur la Monorchidie et la Cryptor. chez l'Homme.*

[4] Goubaux et Follin, "De la Cryptorch. chez l'Homme, et les principaux animaux domestiques," *Mem. d. la Soc. de Biol.*, 1855.

the formation of spermatozoa, these being also absent from the tubules of the epididymis, and the corresponding *vesicula seminalis.*

Although the above view of the state of the testicle when retained within the abdomen is the one most generally accepted, yet the observations of Godard have recently received considerable support from the researches of Monod and Arthaud,[1] who in 1887 published a conjoint paper. They maintain that the detained testicle does acquire its full and mature spermatozoa-producing structure; and that, owing to its abnormal position which in some obscure manner prevents it carrying out its function, the testicle soon shows signs of atrophy of the seminal tubules. This atrophy is progressive, and ultimately leads to a more or less complete transformation of the tubules into fibrous cords, and the intertubular connective tissue into a fibrous stroma.

There are therefore three views held regarding the state of the testicle when detained within the abdomen, namely, (1) that the testicle is imperfectly formed from the beginning (Hunter); (2) that the testicle is natural, but that at puberty it fails to reach its full size and mature structure (Curling), and thus remains in the pre-puberty stage; and (3) (Monod and Arthaud) that the testicle does acquire its full size and spermatozoa-producing powers at the time of puberty, but that, owing to its abnormal position, it soon undergoes retrogressive changes, which sooner or later end in complete atrophy of the seminal tubules.

In the following experiments the testicle in all instances, whether in young puppies or in full-grown dogs, was of natural size (natural to the age of the animal), shape, and consistency; and the greatest care was exercised in the handling requisite for its replacement within the abdomen, for anything like an attack of inflammation of the body of the testicle from rough handling at the operation, or from any other damage, would render the results of the experiment valueless. In no instance have I had any trouble either from inflammation or other cause, and the dogs have usually been running about in a pretty lively manner on the third or fourth day after the operation. In all the experiments morphia and chloroform were used, and anæsthesia throughout maintained; and all antiseptic precautions were adopted in order to ensure an aseptic state of the peri-

[1] Monod et Arthaud, "Contrib. a l'étude des alterations du testicule ectopique, etc.," *Arch. Gen. de Med.*, 1887.

toneal cavity into which the testicles were replaced. In the greater number of the dogs the testicle acquired new adhesions, and this, at its lower end, in the iliac fossa. The vas deferens was found coiled, but the spermatic vessels did not seem to be in any way interfered with. In one or two the testicle could be freely moved, and must have changed its position with the movements of the neighbouring bowel.

The experiments naturally divide themselves into *two* groups, namely, (1) those conducted on young animals, in which the testicles were immature and undeveloped; and (2) those conducted on full-grown animals, in which the testicles were of their full size and mature structure.

Accordingly, the following experiments are collected together under these two groups:—

I. Experiments on Young Animals (Dogs).

Experiment I.—A black-and-tan terrier, about nine to ten months old. The testicles were still of small size, and not fully developed. On December 3, 1891, the *right* testicle, which measured 15 mm. in length by 12 mm. in breadth (from the dorsum, exclusive of the epididymis, to the ventral border), was replaced in the abdominal cavity. The dog did well, and was soon running about.

On December 10, seven days after replacement of the organ, the animal was killed. The *right* testicle was somewhat smaller in size than the left, and it appeared as if its vessels were more turgid and congested, though the average size of the spermatic veins was decidedly smaller than normal. The *left* testicle measured 17 mm. in length by 12 mm. in breadth, and was of natural appearance.

Under the microscope the seminal tubules of this, the *left*, testicle were seen to be in an early stage of transition between the state of the organ before the onset of puberty, and that when it has reached maturity and is capable of producing spermatozoa. The tubules, that is to say, were somewhat larger than they are in the quite immature state, and they contained more small round cells; besides, in the majority of them, a central lumen had already made its appearance, but as yet there were no evidences of the formation of spermatozoa.

In the *right* testicle, that which was replaced in the abdominal cavity, the seminal tubules were solid rods of small polygonal cells, just as they are in the testicle before the occurrence of growth at puberty. In this organ no trace of the further development which the tubules undergo at puberty could be detected.

In this instance, therefore, the testicle which had been replaced in the abdomen remained in the state in which it probably was before

being replaced, while the one left undisturbed in the scrotum began to grow, and show distinct signs of active cell proliferation. I would here remark that I have found it not unfrequently happens that the testicles attain their full size during a short period of three to four weeks from the time at which the impulse to growth originates.

Experiment II.—A fox-terrier, three months old. On May 22, 1891, the *left* testicle, which measured 15 mm. in length by 12 mm. in breadth, was replaced in the abdominal cavity by the same method as in the former experiment. At the beginning of October in the same year the *right* testicle, which had not been interfered with, began to show signs of growth, and by the beginning of March it had reached its full size. The dog was killed on March 9, 1892, when the *right* testicle measured 30 mm. in length by 20 mm. in breadth, this being the usual size for a grown-up dog of this breed. The *left* testicle was found attached to the peritoneum at the brim of the pelvis, and hanging down into that cavity; the vas deferens was coiled, but the spermatic vessels, though somewhat smaller than those of the opposite side, were normal, and not in any way interfered with in their course. The body of the testicle measured 17 mm. in length and 13 mm. in breadth, was small and roundish, but of natural appearance, though softer than its fellow (see fig. 1, Plate XXIV.). The epididymis was small, though relatively larger than the testis, as is usually the case in young animals.

The *left* testicle showed under the microscope that the seminiferous tubules were only about one-half of the size natural in a full-grown organ. The tunica propria of each tubule was somewhat thickened, and the tubules were widely separated from one another (fig. 1, Plate XXV.).

The epithelium lining these tubules was composed of a single layer of columnar cells resting upon the inner surface of the tunica propria. These cells contained large, round, clear nuclei, which were found near the basal or attached ends of the cells; their protoplasm was delicately fibrillated in the long axis of the cells, and was comparatively free from granules (fig. 2, Plate XXV.).

The cells themselves were prolonged to the centre of the tubule in fine radiating processes composed of the delicately fibrillated protoplasm of the cells. There were no spermatozoa, nor any trace of their formation, in any of the tubules. The tunica albuginea of the testicle, together with the septa and the intertubular connective tissue, were not changed beyond a relative increase from diminution in the size of the seminal tubules. In the epididymis the tubules were small and contracted, but they were all lined by the usual single layer of columnar epithelial cells bearing fine long cilia.

In the central lumen which was correspondingly small, there were no spermatozoa, but in their place a few coarse clear granules.

The *right* testicle and epididymis were normal. In the seminal tubules of this testicle there was abundant evidence of the formation of spermatozoa, the tunica propria being lined by cubical cells, and

the cells nearer the lumen, which were altogether absent in the left testicle, showed the division of their nuclei preparatory to the formation of spermatozoa; and in the tubules of the globus major of the epididymis there were numerous spermatozoa.

It may be here noted that in this experiment the testicle that was replaced in the abdomen increased somewhat in size while in the abdominal cavity.

It will be further observed that the testicle that was left undisturbed in the scrotum had just attained its full size and functional powers when the animal was killed, whereas the replaced testicle had not undergone this change, but was found small and ill-developed, with altered seminal tubules which showed no indication whatever of the formation and production of spermatozoa. This is contrary to the opinion expressed by Godard, Monod, and Arthaud, that the detained testicle does continue to undergo the changes incidental to on-coming puberty.

Experiment III.—A fox-terrier, about four months old. On June 21, 1891, the *left* testicle, which measured 15 mm. in length by 12 mm. in breadth, was replaced in the abdominal cavity. The wound healed quickly, and the dog was soon about and well. On Nov. 8, 1891,—before, therefore, the period at which the testicle would have acquired its full size,—the animal was killed, when the *left* testicle, which measured 18 mm. in length by 12 mm. in breadth, was found lying in the iliac fossa, and adherent by its lower end to the peritoneum of that part. Its body was somewhat flaccid and soft. The epididymis was also small, but relatively large to the body of the testicle.

The vas deferens was coiled, but the spermatic vessels, although small, were otherwise natural. The structure of this testicle, as well as that of the epididymis, was precisely the same as is described in Experiment II., of which a description immediately precedes. The *left* testicle of this animal was of the same size as that of the dog in Experiment II., both dogs being of the same litter.

The right (opposite) testicle could not be used for comparison, forasmuch as I had, on July 21, 1891, ligatured the spermatic vessels on that side.

In this experiment the replaced testicle grew while in the abdominal cavity; and although it had not undergone much change, yet the seminal tubules were altered in their structure.

Experiment IV.—A well-grown fox-terrier of about 9–10 months old, the testicles not being fully developed. On Sept. 24, 1891, the *right* testicle was replaced in the abdominal cavity, and it then measured 15 mm. in length by 12 mm. in breadth. The wound healed quickly, and the dog was soon well and about.

During October and November the left testicle acquired its natural size (30 mm. in length by 20 mm. in breadth) and the normal histological structure of the functional testis. On Nov. 30, 1891, the animal was killed. The *right* testicle, which now measured 17

mm. in length by 12 mm. in breadth, was found in the iliac fossa, attached as usual to the peritoneum by its lower end. Its body was small, almost globular, and soft. The epididymis was also small. The vas deferens was coiled and shortened, but the spermatic vessels appeared natural. The histological structure of this *right* testicle and epididymis was precisely the same as that fully described in Experiment II.

There was no evidence whatsoever of the formation or presence of spermatozoa in any of the seminal tubules.

In this instance also the replaced testicle increased to some extent in size during the two months it lay in the abdominal cavity; yet it failed to keep pace in growth with its fellow the *left* testicle, which was left undisturbed in the scrotum and had during that time acquired its full size and spermatozoa-producing powers. It is further highly improbable that the replaced testicle acquired its full size and mature structure earlier than that left in the scrotum, and that it quickly underwent the degenerative changes which the full-grown organ, as will be presently shown, is liable to when replaced within the abdomen.

Experiment V.—A young black terrier, about six months old. On Dec. 10, 1891, the *left* testicle, which measured 12 mm. in length by 10 mm. in breadth, was replaced in the abdominal cavity. The wound did well. During February 1892 the right testicle grew normally, and on March 8, 1892, the animal was killed. The right testicle was of natural size, and measured 25 mm. in length by 20 mm. in breadth; whereas the *left* testicle, which was found attached to the peritoneum, and lying in the iliac fossa, measured only 16 mm. in length and 12 mm. in breadth. The left epididymis was also small; the vas deferens was coiled, but the spermatic vessels apparently natural.

In structure the left testicle was like that of the replaced organ in Experiment II., but the right was fully developed and capable of producing spermatozoa, which could be found in the seminal tubules as well as in those of the epididymis.

Here again the replaced testicle grew while in the abdominal cavity; and as the testicle was very small when replaced, the amount of growth is more apparent in this instance than in any other of the experiments. But although the animal was killed as soon as the right and undisturbed testicle reached its full size, yet the organ in the abdomen was small, and showed no signs whatever of producing spermatozoa.

We see, therefore, that when the testicle of a puppy is replaced in the abdominal cavity it undergoes but little change, being a little less plump than its fellow. It continues to grow with the body until the onset of puberty, but its growth is not so great as that of the undisturbed organ in the scrotum. At

puberty it, unlike its fellow, does not pass through the structural changes preliminary to the formation of the mature spermatozoa-producing tubules; nor does it remain stationary, retaining its pre-puberty structure, but it undergoes a change that is peculiar to a retained or replaced testis, the seminal tubules becoming altered. They are of small size, and in most instances a small central lumen; all being lined by a single layer of delicate columnar cells, which are derived from a modification of the single layer of the peripheral cubical cells seen before and after puberty, the central cells having disappeared.

Thus the seminal tubules are incapable of producing spermatozoa. They undergo, indeed, a degenerate change, being no longer like the tubules which characterise the pre-puberty state of the testicle, inasmuch as they no longer remain solid, but the central cells disappear, while the peripheral ones are converted into a layer of columnar cells which taper towards the centre of the tubule instead.

II. Experiments on Full-Grown Animals (Dogs).

Experiment VI.—A small full-grown fox-terrier. On December 7, 1892, the right testicle, which measured 22 mm. in length by 16 mm. in breadth, was replaced in the abdominal cavity. On December 14, 1892, the animal was killed. The testicle remained quite free in the abdominal cavity, and was found in the pelvis. It was reduced to 17 mm. in length by 13 mm. in breadth, and it appeared congested on the surface; the spermatic veins being if anything diminished in size, but in consistency the organ remained natural or nearly so. In none of the tubules could any trace be seen of the formation of spermatozoa, nor could any spermatozoa be detected, although only a week had elapsed since the replacement.

In some of the tubules, which were, without exception, reduced in size, the central canal or lumen was occupied in part by detached granular epithelial cells with ill-defined nuclei, and also by larger granular masses composed of fused degenerated cells (see fig. 3, Plate XXV.). These cells are the products of the cells which naturally occupy the circumferential part of the tubule, and which are derived from the peripheral layer of cells lining the tunica propria (see fig. 4). In other tubules these degenerated products of cells had entirely disappeared, the lumen being contracted and occupied by a single layer of slender columnar epithelial cells which line a somewhat thickened tunica propria, and which are the representatives of the single layer of the peripheral cubical epithelial cells of the normal tubule. There was no increase nor any alteration in the nature of the intertubular

connective tissue, except that where the tubules were much diminished in size it appeared relatively increased.

Experiment VII.—A full-grown fox-terrier. On August 13, 1892, the *left* testicle, which measured 30 mm. in length and 20 mm. in breadth, was replaced in the abdominal cavity. The animal soon got well and was running about as usual. On September 13, thirty-one days after the replacement, the dog was killed. The *left* testicle was found attached by its lower end to the peritoneum in the left iliac fossa. It was much reduced in size, measuring only 20 mm. in length by 15 mm. in breadth, was soft and flaccid. The epididymis was also reduced, but not so much as the body of the organ. On microscopic examination the seminal tubules were much reduced in size, and in many of them the epithelium was represented by a single continuous layer of small cubical cells with large nuclei lying on the inner surface of the tunica propria; within this layer were other less defined cells with granular protoplasm. The latter occupied the greater part of the lumen. In other tubules there was only a single layer of cells which had become columnar in shape. These lined the tunica propria, and were prolonged by delicate processes into the central part of the lumen. In this testicle the degenerative changes consequent upon replacement had in great part disappeared, so that the stages in the process could not be observed as in Experiment VI., in which the testicle had only been replaced for seven days.

It showed, however, that the inner cells of the tubules undergo degenerative changes and disappear, while the peripheral cells gradually elongate and become changed from a cubical to a columnar variety, and project into and fill the lumen.

The right testicle remained of natural size and of normal structure, and continued producing spermatozoa, which were found in great numbers in the seminal tubules after death.

Experiment VIII.—A small full-grown terrier. On December 1, 1891, the *left* testicle, which was of full size, and which measured 30 mm. in length and 20 mm. in breadth, was replaced in the abdominal cavity, the inguinal canal being enlarged, as in all the other cases, and afterwards carefully closed by numerous sutures. The wound quickly healed, and the dog was soon about and well. On March 7, 1892, ninety days after the operation, the dog was killed.

The *left* testicle was small, having been reduced in its size to 18 mm. in length by 12 mm. in breadth, but it was otherwise healthy-looking (see fig. 3, Plate XXIV.); it had become attached by its lower end to the peritoneum covering the iliac fossa. The epididymis was diminished, though not in the same proportion as the testicle, and the vas deferens was coiled and short; but the spermatic vessels, though not so large as when the testicle was replaced in the abdomen, or as those of the opposite organ, were quite normal in their appearance; nor were they in any way interfered with in their course.

A section of the body of the testicle revealed to the naked eye

nothing abnormal beyond a certain degree of compactness in its structure. For a comparison between the two testicles see the drawing (fig. 3, Plate XXIV.) taken from the specimen, after being hardened in alchohol.

The seminal tubules of the *left* (replaced) testicle were reduced to one-half their natural size. The tunica propria of the tubules was somewhat thicker than natural; but the chief changes that could be seen were in the epithelium, which was much altered. It had in great part disappeared, leaving only a single layer of cells with large round nuclei placed near the attached ends of the cells; some of these nuclei (fig. 4, Plate XXV.) contained nucleoli, as if they were in process of division, whereas others had become vesicular or vacuolated.

The cells were of columnar shape, with tapering inner free ends, the delicate filamentous processes of which passed into and filled the lumen.

The protoplasm of each cell was delicately fibrillated in its long axis. There seemed to be no remains of other cells between the filamentous processes, nor could spermatozoa, or traces of their formation, be found anywhere.

In the epididymis of this testicle, which was somewhat diminished, though not in the same proportions as the body of the organ, the only change observable was that of contraction of the tubules at the upper end, or globus major, with a diminution of the lumen. No spermatozoa were to be found but only a few clear granules. The columnar epithelium lining these tubules appeared natural, and the cilia were normal.

Neither in this specimen nor in any of the preceding were there any signs, either in the intertubular connective tissue nor elsewhere, of the inflammatory process having accompanied or preceded this atrophic change in the seminal tubules; and the tunica albuginea, together with the supporting connective tissue of the organ, showed no further changes than would result from the general diminution of the size of the seminal tubules.

The *right* testicle, which had been left undisturbed in the scrotum, was quite normal in size and structure, and showed the usual presence of spermatozoa in its tubules.

From the last series of experiments it will be gathered that when a full-grown testicle is replaced within the abdominal cavity with due care, it undergoes definite changes, and dwindles to a considerable extent.

The testicle after a period of a month or so becomes reduced to two-thirds or half its original size, but the epididymis not nearly to the same extent. The organ is of a somewhat darker colour, and the blood-vessels, especially the small venules on the surface of the testicle, appear as if they were engorged or congested; but the remaining spermatic vessels, although

they seem smaller than those of the normal side, appear natural, and in no way disturbed in their course. The seminal tubules are much reduced and contracted—in most instances to about half their natural size; and they are lined by a single layer of columnar cells, which are prolonged into fine filamentous processes, converging towards the centre of the tubule, there being no trace of the formation of spermatozoa in any of the tubules. The central cells—namely, those which give origin directly to the spermatozoa in a natural tubule—disappear completely by means of a peculiar granular degeneration of the protoplasm, which shows no tendency to fatty transformation. All the above changes take place without the slightest evidence of the inflammatory process accompanying them.

Judging from the last specimen (Exp. VIII.) which had been replaced in the abdomen for ninety days, I should infer that the testicles do not undergo further change.

In order to illustrate this subject still more, I will introduce here two observations I recently made upon dogs, in one of which the right testicle was retained in the groin, and in the other within the abdomen, by some failure in the mechanism of descent.

Undescended Testicles in the Dog.

The *first* was a small fox-terrier, of about two and a half years old. The *right* testicle was found to have been retained in the groin, just outside the external ring. It was of small size, measuring 16 mm. in length by 11 mm. in breadth, (the *left* being 20 mm. in length by 15 mm. in breadth,) and it could neither be pulled into the scrotum nor pushed into the inguinal canal. It appeared natural, except in its size. Under the microscope the seminal tubules were undistinguishable from those already described and figured as occurring after replacement of the fully-developed organ, and therefore there is no need for further comment.

The *second* was also a fox-terrier, of about eighteen months old. The *right* testicle was found in the right iliac fossa, freely movable, and attached by a slender cord, which passed into the same side of the pelvis. The organ was small, measuring 15 mm. in length by 10 mm. in breadth, (the *left* being 25 mm. in

length by 18 mm. in breadth). The epididymis was correspondingly small.

Under the microscope the seminal tubules of this organ were precisely the same as those in the above instances, and in none of them could any trace of spermatozoa or of their production be detected.

Thus, in each of the above instances—the testicle retained in the groin in the one and in the abdominal cavity in the other—the organ was small, of about $\frac{2}{3}$–$\frac{1}{2}$ size of the healthy and descended testicle; and under the microscope the seminal tubules presented histological characters, undistinguishable from those found in the testicles, whether young or of full size, that were replaced in the abdominal cavity.

It would seem, therefore, that the experimentally replaced testicle behaves in precisely the same manner as one retained by imperfections in the mechanism of descent or transition.

Answers to Questions set forth at the beginning of this Paper.

From the results of the following experiments, the two questions which induced me to make them may now be answered.

The *first* question was, *Whether, when the testicle is replaced within the abdomen in a young animal, it is capable of attaining its full size and mature structure, and of producing spermatozoa?*

It is clear from the results of the first set of experiments that the testicle of a young animal, when replaced in the abdominal cavity, does neither acquire its full size or its mature structure, nor does it acquire the power of producing spermatozoa. Though it does to some extent partake of the general growth of the body, it does not do so to the same extent as the organ which acquires its natural position.

The *second* question was, *Whether, when the testicle is replaced within the abdomen in a full-grown animal, it is capable of maintaining its full size and mature structure, and its powers of producing spermatozoa?*

Again, it is pretty obvious from the results of the second set of experiments that the testicle of a full-grown dog, when replaced within the abdominal cavity, dwindles to $\frac{2}{3}$–$\frac{1}{2}$ its natural

size, and remains in this state for some time at least. It loses its powers of producing spermatozoa and the seminal tubules are much degenerated in their structure.

The Views held regarding the State of the retained Testicle.

These views, already referred to, have special reference to Man, and some would perhaps think them inapplicable to the Dog, the animal selected for the preceding experiments. Hunter first pointed out that a retained testicle was imperfect in its development, and that it was incapable of producing spermatozoa, and that when both organs were retained the person was sterile. This imperfection in development was regarded by him as the result of a fault in the organ itself, a fault that had arisen, at any rate, before the commencement of the process of descent, for it was this he conceived to be the cause of the failure in that process.

Curling, indeed, recognised this, and pointed out that the retained testicle presents the same structure as that of the descended organ before the onset of puberty, and simply that at this period it does not participate in the growth that takes place in the properly descended organ.

In Experiments II.–V. it may be seen that the retained, or rather replaced, organ not only does not participate in this natural growth at the time of puberty, but that the seminal tubules lose their what may be called infantile character, and acquire a structure that is peculiar to the replaced and also the undescended organ; that is to say, the seminal tubules during early life are solid rods of small polygonal cells (fig. 5, Plate XXV.), whereas those of the retained testicle at and after puberty are lined by a single layer of delicate columnar cells, which project as fine processes into and fill the lumen, the central cells of the tubule having disappeared.

Therefore Curling's view of the state of the seminal tubules in an undescended testicle falls short of correctness, for they are not like those found in the organ of the young, but have acquired features and characteristics of their own.

All I need say with regard to the view maintained by Godard, Monod, and Arthaud, that the retained testicle does

acquire its full size and powers of producing spermatozoa at and soon after puberty, is that I have not found any evidence in its support; and all my own results in the foregoing experiments, and observations made on Man—which are but few, it is true—show the contrary to be the case. There has never been brought forward an indisputable case of the detection of spermatozoa in retained testicles; and what Monod and Arthaud have depicted in their conjoint paper as a section of the testicle in which the seminal tubules are said to be in the act of producing spermatozoa is indeed, without the text, unrecognisable even as a section of that organ at all.

I would, in addition, remark that the results of the experiments related coincide so entirely that I have not thought it worth while to make further experiments of a similar kind.

No wonder the idea that the retained testicle would be functional should have arisen, seeing how varied is its permanent position. In the Monotremes, Cetacea, Sirenia, and Proboscidia it is permanently abdominal, in some Perissodactyla it descends so far as the abdominal ring; in other animals it enters the scrotum which may be inguinal or perineal. In some of these latter Rodentia and Insectivora the cavity of the tunica vaginalis freely communicates with that of the peritoneum, so that the testis may pass to and fro between the abdominal cavity and the scrotum, while in the remainder the canal of communication becomes very narrow, as in Carnivora and most of the Anthropoid Apes, or completely obliterated as in Man. Yet in all these different positions the testicle acquires perfect structure and function. In some animals, such as Rodents, Insectivores, the testis descends into the scrotum during the period of rut, but in others, as the elephant, it remains at all times in the abdominal cavity. What, then, can be the reason that in some, a limited number of animals, the scrotal position is essential to structure and function?

Why should the testicle be required to depart from its comfortable quiet position in the abdominal cavity to a more turbulent region where it is of some inconvenience, and during its transit causes a weakening of the abdominal wall so serious in the erect attitude? Can it be that the very turbulence of this

region is requisite for its perfect development and the maintenance of its functions in certain animals?

Furthermore, its corresponding organ, the ovary in the female, remains in all animals in the abdominal cavity.

So far as I am aware, no satisfactory answer has ever been offered to this most interesting question.

It is possible that the cremaster muscle might, by its compression of the organ, exercise some obscure influence upon the testis, and thus keep it in a state of functional activity, but the complete removal of this muscle, which I carried out in one experiment, seemed to make no difference whatever to the efficiency of the organ, for after a period of thirty-one days, this being ample time for the testicle to show signs of atrophy, the organ was of the same size as before; it was quite normal, and actively producing spermatozoa: the details of the experiment are as follows:—

The Testicle deprived of its Cremaster Muscle.

A fox-terrier three to four years old. On August 15, 1892, the right testis was deprived of its cremaster muscle by exposing the organ and carefully dissecting the muscular fibres off the parietal layer of the tunica vaginalis. The testis was then measured, and was found to be about 27 mm. in length by about 17 mm. in breadth. Exact measurements could not be taken, as the tunica vaginalis was not laid open. The organ was replaced in the scrotum, and all the parts healed quickly, the animal running about on the day, and no changes were afterwards observed in the testicle. On Sept. 15, 1892, thirty-one days after the operation, the dog was killed. The right testicle—namely, that deprived of its cremaster muscle—was of the same size as before, that is, 27 mm. in length by 17 mm. in breadth, and it looked quite healthy and natural.

On microscopic examination the seminal tubules were of natural size, the formation of spermatozoa could be seen in most of them just as under normal conditions, and the organ was in every way similar to its fellow on the left side, which had not been disturbed.

Conclusions.

The following are the chief conclusions from the foregoing experimental investigations and observations:—

1. When the testicle of a young animal is replaced within the abdomen it undergoes but little change, growing somewhat, but not so much as the undisturbed organ, until the onset of puberty.

2. A testicle so replaced after the onset of puberty continues to grow to some extent, though but little; the seminal tubules are seen to be lined by a single layer of columnar epithelial cells lying upon the tunica propria, with delicate prolongations extending into and occupying the lumen of the tubules; the central cells, from which in the normal state spermatozoa are produced, do not exist, and spermatozoa, accordingly, are not forthcoming.

3. The testicle remains in this state; at least, we have no evidence that it undergoes further change.

4. The testicle of a full-grown animal, when replaced in the abdominal cavity, soon dwindles to two-thirds or one-half its natural size, and after a short time presents precisely the same structure as that which is found in the replaced testicle of a young animal above noted.

5. The testicle, the descent of which has been arrested in the dog, either in the groin or in the abdominal cavity, shows the same histological characteristics as the organ which has been replaced by experiment.

6. Replacement of the testicle can, with ordinary care, be effected without injury to the organ, and without setting up inflammation in its structure, the occurrence of which would be detrimental to an experiment.

DESCRIPTION OF PLATES XXIV., XXV.

Plate XXIV., fig. 1. Testes, epididymes, vasa efferentia, &c., of a dog one year old (Exp. II.), showing the *right* organ of natural size, and the *left*, which was replaced when the animal was three months old, small, and hardly half the size of its fellow. The left epididymis is also small, and the vas deferens shorter (nat. size).

Fig. 2. Testes, epididymes, vasa efferentia, &c., of a dog ten to twelve months old (Exp. V.).

The *right* testicle is of full size, this size having been attained during the month preceding the day on which the animal was killed. The *left* testicle, which was replaced three months previously, and which was then of small size, remains small, having grown but little, as was the case with that in Plate I. (Exp. II.). The animal was killed as soon as the *right* testicle had attained its natural size, in order to determine whether the replaced organ had undergone the same changes as that which was left undisturbed in the scrotum. Obviously these changes had not taken place (nat. size).

Fig. 3. Testes, epididymes, vasa efferentia, &c., of a full-grown dog (Exp. VIII.). The *left* testicle had been replaced in the abdominal cavity for a period of three months. At the time of replacement the organ was of the same size as its fellow, which was left undisturbed in the scrotum. The left testicle very small in comparison with the *right*, and so is the epididymis (nat. size).

Plate XXV., fig. 1.—A section of the replaced (left) testicle seen in fig. 1, Plate XXIV. The seminal tubules are small and atrophied, but the intertubular connective-tissue is not increased. × 45.

Fig. 2. Transverse section of one of the seminal tubules seen in fig. 1, showing the absence of the central cells, elongation and fibrillation of the cubical cells at the periphery, the lumen being chiefly occupied by the prolongation of these cells. × 300.

Fig. 3. A transverse section of an atrophied seminal tubule taken from the replaced testicle (Exp. VII.), which was replaced thirty days before death, and which was then of full size. It shows the large granular masses formed by the degeneration of the central cells of the tubule prior to their ultimate disappearance ; also the elongation and fibrillation of the cells at the periphery; also the total absence of spermatozoa-producing cells and spermatozoa. × 450.

Fig. 4. A transverse section of a seminal tubule taken from the left testicle (Exp. VIII.), fig. 3, Plate XXIV., which was replaced in the abdomen about three months before death, and which was then of full size. The central or spermatozoa-producing cells have completely disappeared, the peripheral cells having become elongated into a columnar variety projecting into and filling the lumen, the protoplasm of the cells is much fibrillated in the long axis of the cells. × 350.

Fig. 5. Sections of the tubules of the testis of a boy four to five years old, longitudinal and transverse ; each is seen to be composed at this time of life of solid rods or columns of cells, which all present much the same appearance. In process of development these cells would differentiate themselves into circumferential cubical cells and central polygonal spermatozoa-producing cells.

Table of Results of Experiments.

No.	Description of Dog.	Date.	Nature.	Date of Death.	Size of Testicle before Experiment.	Size of Testicle after Death.	No. of Days Dog kept Alive.	Observations.
1	Fox-terrier puppy, about 9 mons. old	3. xii. 92	Replaced right testicle in abdomen	10. xii. 92	15 mm. × 12 mm.	15 mm. × 11 mm.	7	Soon about, and well.
2	Fox-terrier puppy	21. vii. 91	Replaced left testicle in abdomen	8. xi. 91	15 mm. × 12 mm.	18 mm. × 12 mm.	139	Remained quite well and lively.
3	Fox-terrier puppy, 3 mons. old	22. v. 91	Replaced left testicle in abdomen	9. iii. 92	15 mm. × 12 mm.	17 mm. × 13 mm.	293	Ditto.
4	Full-grown fox-terrier (Testicles small)	24. ix. 91	Replaced right testicle in abdomen	30. xi. 91	15 mm. × 12 mm.	17 mm. × 14 mm.	67	Soon well and running about.
5	Black terrier, about 6 mons. old	10. xii. 91	Replaced left testicle in abdomen	8. iii. 92	12 mm. × 10 mm.	16 mm. × 12 mm.	89	Soon running about.
6	Full-grown fox-terrier (Small)	7. xii. 92	Replaced right testicle in abdomen	14. xii. 92	22 mm. × 16 mm.	17 mm. × 13 mm.	7	Wound healed quickly.
7	Full-grown fox-terrier	13. viii. 92	Replaced left testicle in abdomen	13. x. 92	30 mm. × 10 mm.	20 mm. × 15 mm.	31	Remained well.
8	Small terrier	1. xii. 91	Replaced left testicle in abdomen	7. iii. 92	30 mm. × 20 mm.	18 mm. × 12 mm.	90	Quickly recovered, and as lively as ever.
9	Fox-terrier	15. viii. 92	Removed cremaster muscle	15. ix. 92	27 mm. × 17 mm.	27 mm. × 17 mm.	31	Dog was soon lively and well.

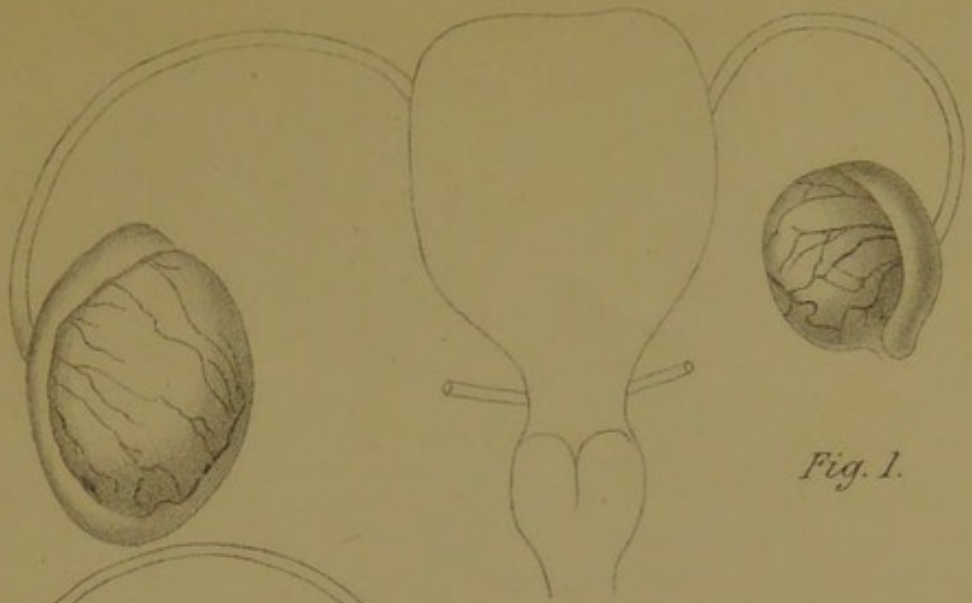

Fig. 1.

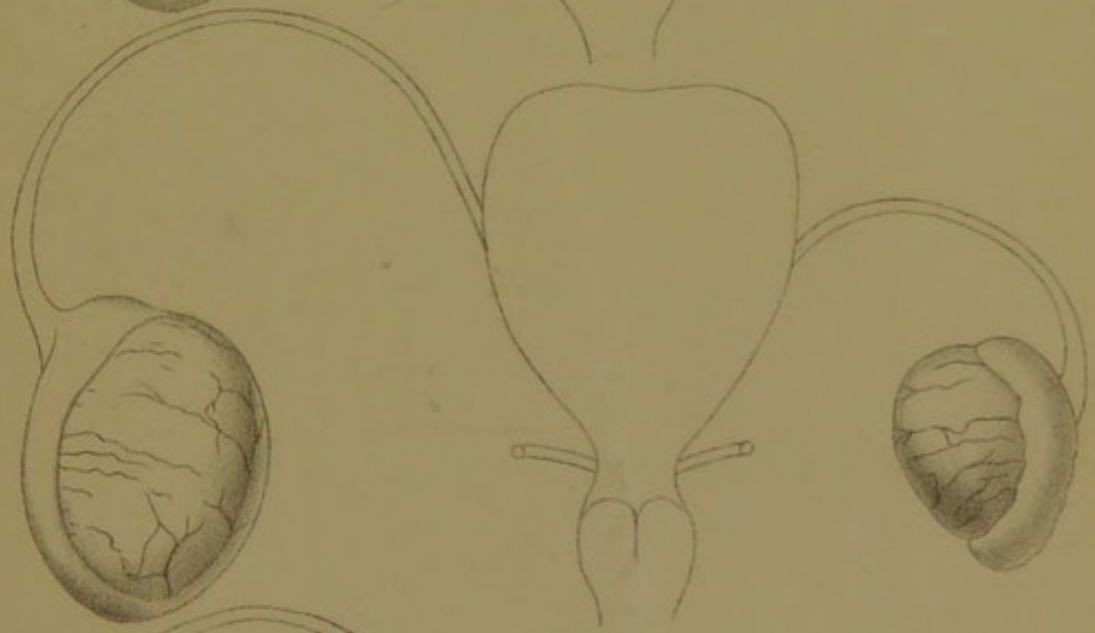

Fig. 2.

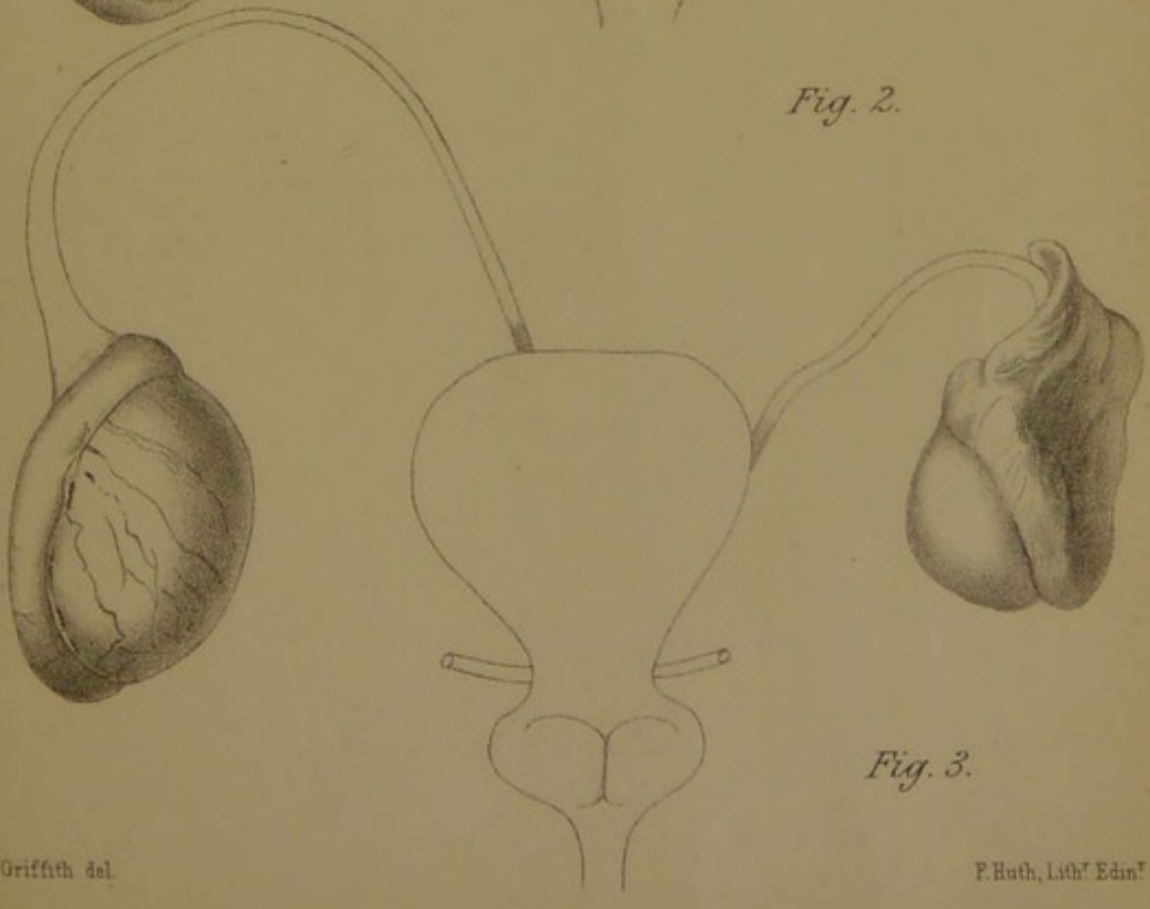

Fig. 3.

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TESTICLES OF DOG.

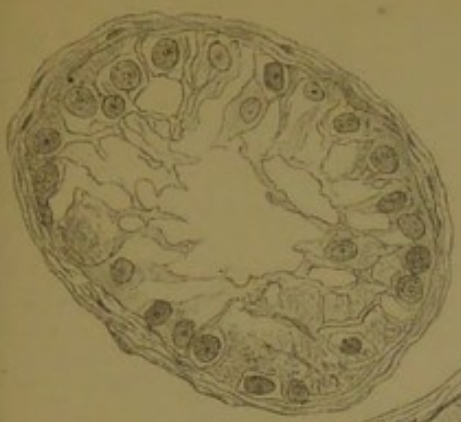

Fig. 1.

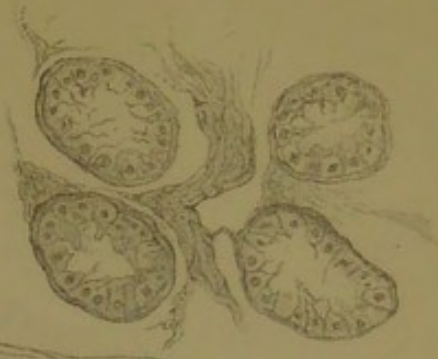

Fig. 2.

Fig. 3.

Fig. 4.

Fig. 5.

J. Griffith del.

F. Huth, Lith.r Edin.r

TESTICLES OF DOG.