

**The mechanism of the gubernaculum testis : with an introductory sketch of the development of the testes, and an appendix on the purpose of their descent from the abdomen. Prize thesis / by John Cleland.**

### **Contributors**

Cleland, John, 1835-1925.  
Royal College of Physicians of Edinburgh

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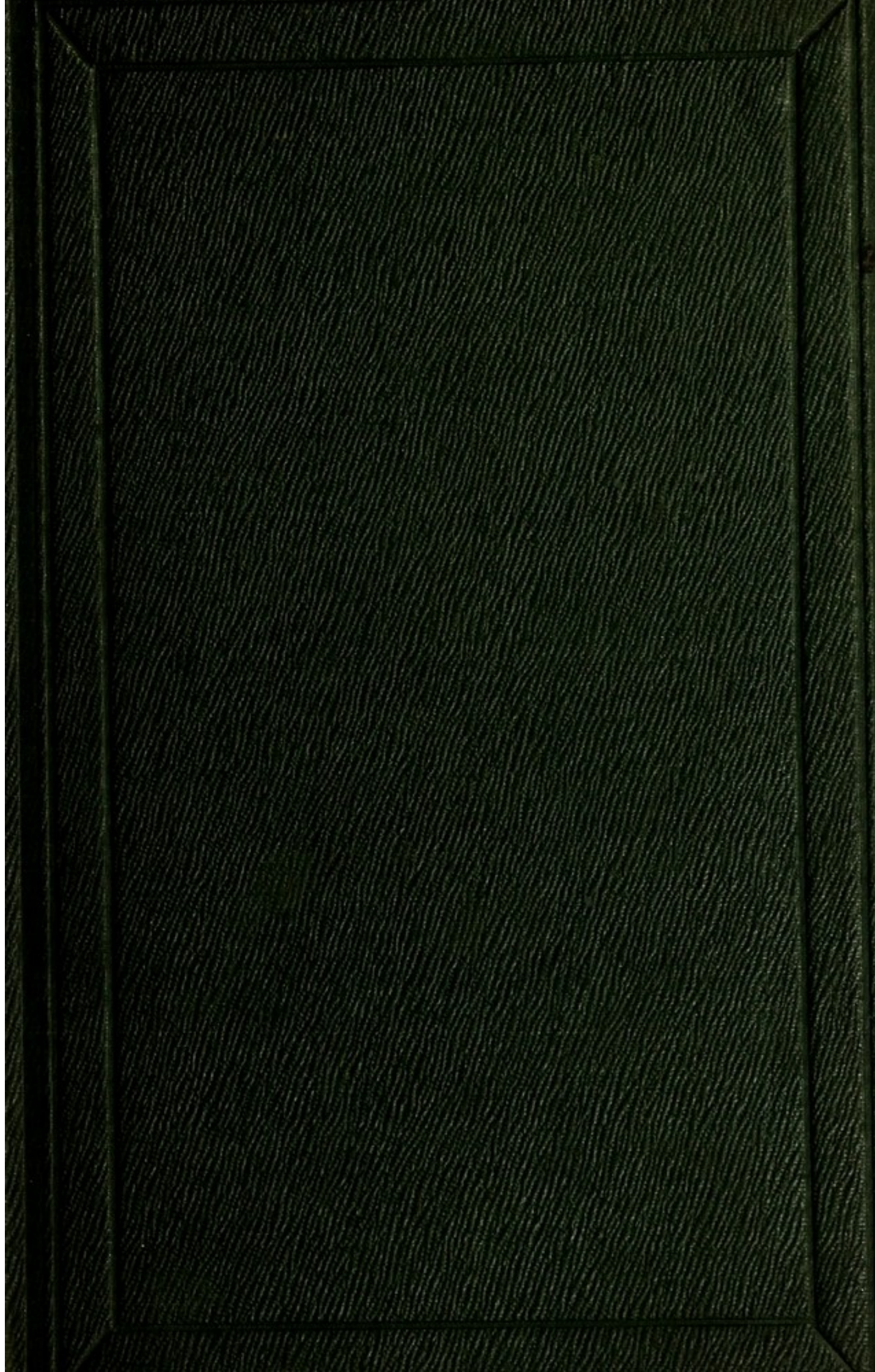
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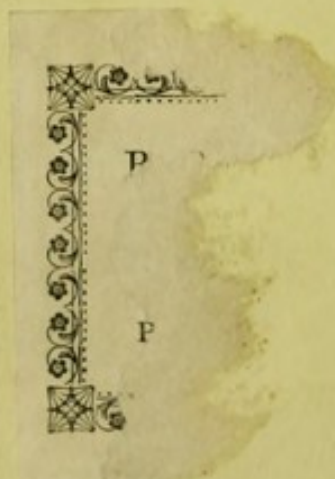






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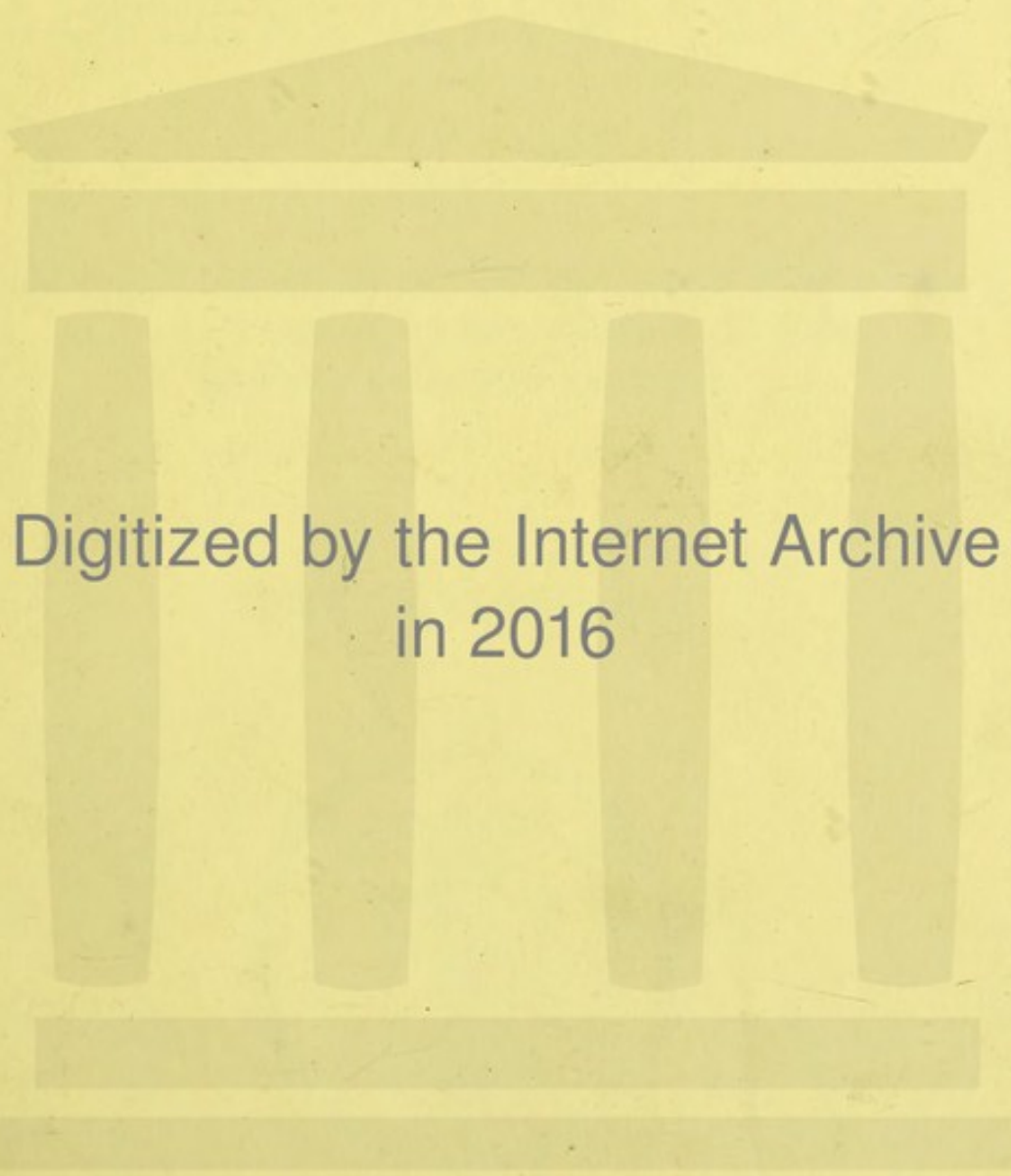
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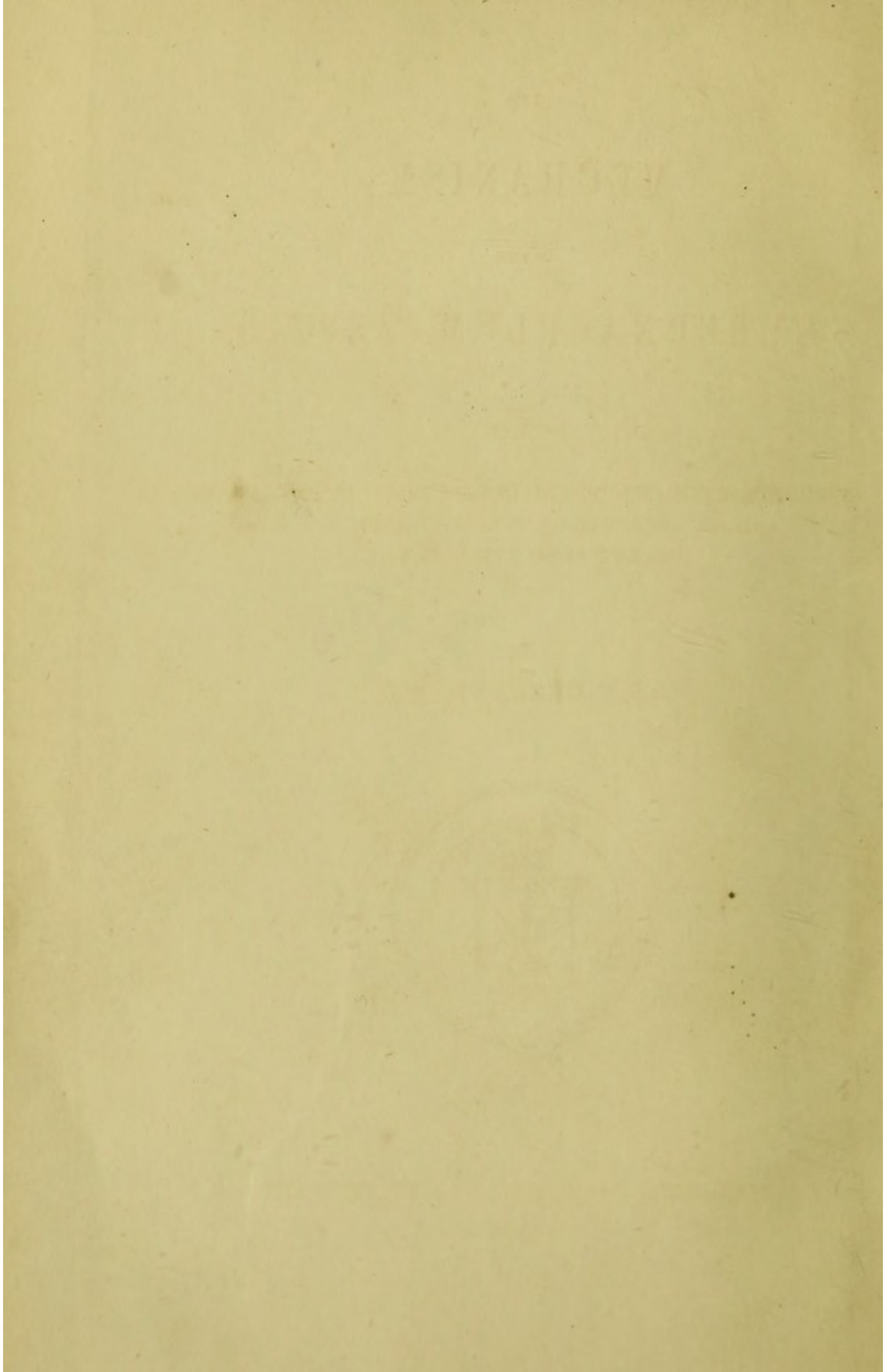
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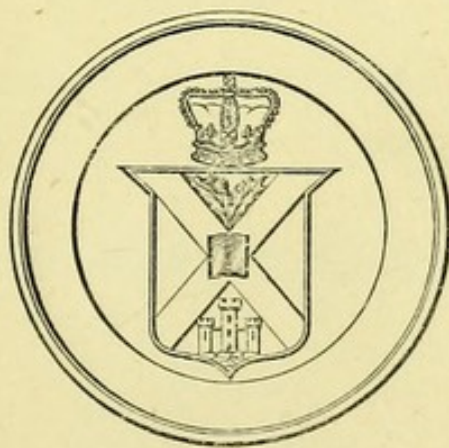


THE  
MECHANISM  
OF THE  
GUBERNACULUM TESTIS,

WITH AN  
INTRODUCTORY SKETCH OF THE DEVELOPMENT OF THE TESTES,  
AND AN APPENDIX ON THE PURPOSE OF THEIR  
DESCENT FROM THE ABDOMEN.

BY  
JOHN CLELAND, M.D.

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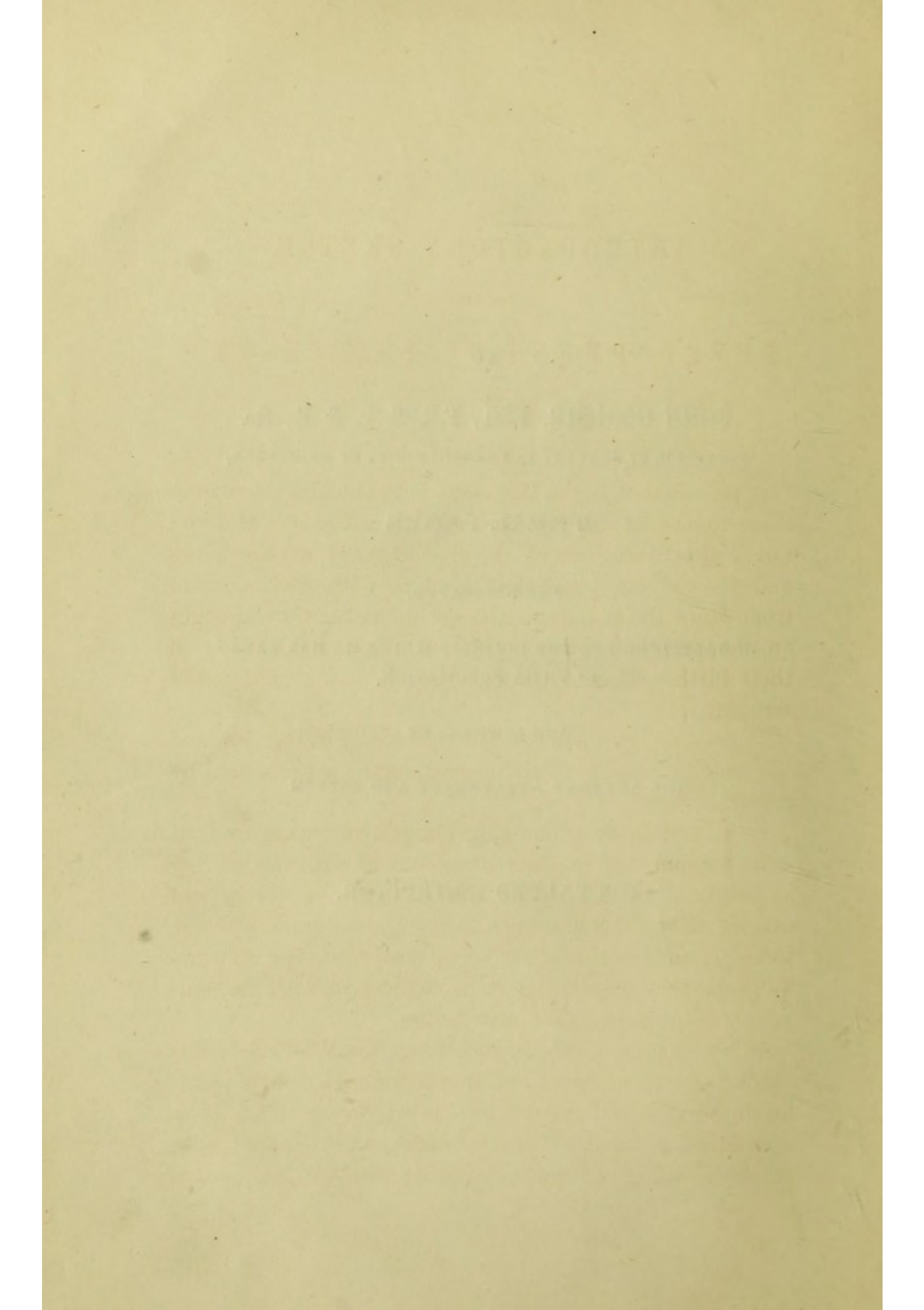
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# INTRODUCTORY SKETCH

## OF THE

### DEVELOPMENT OF THE TESTES.

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THE principal object of this essay is to elucidate the structures connected with the Gubernaculum Testis of Hunter ; but a short account of the development of the testes and their ducts, associated as it is with their descent from below the kidney to the groin, will not be thought an inappropriate introduction to the consideration of their further descent through the abdominal wall to the scrotum.

Introduc-  
tion.

It is moreover a subject little treated of in English, and the true account of which has been somewhat obscured by incorrect views.

In all vertebrate animals the generative organs are intimately connected in their development with the urinary apparatus. In fishes and batrachians the testes and ovaries make their first appearance on the surface of the kidneys, and in the other vertebrata, from the serpents upwards, they are developed in connection with the temporary kidneys—the Wolffian bodies.

Genito-uri-  
nary organs.

In a foetal sheep half an inch long, the Wolffian bodies extend the whole length of the abdominal cavity, parallel to the vertebral column and nearly in contact. They are formed of tubules which commence at the inner border of the gland in dilated extremities like the Malpighian

Wolffian  
bodies.



capsules of the kidneys, and proceed transversely to open into the excretory duct. This duct extends along the whole length of the external border of the gland, and has further a short course from its inferior extremity to the lower part of the allantois.

Reproductive organs;  
their first  
appearance.

The reproductive organs, whether testes or ovaries, make their first appearance along the internal border of the Wolffian bodies in the form of white streaks, and are parallel to one another on each side of the spinal column. It is at this time impossible to say whether they are testicles or ovaries. Rathke<sup>1</sup> and Arnold<sup>2</sup> describe the testes as developed from prolongations of the tubules of the Wolffian bodies which are transformed into the semi-

Independent  
of Wolffian  
bodies.

nal tubules; but they are formed in reality from independent portions of blastema, just as, according to Rathke himself,<sup>3</sup> they are developed in fishes and batrachians independently of the kidneys, although in connection with them. As the kidneys grow, they appear above and internal to the Wolffian bodies, and the latter come to occupy

Their change  
of position.

an oblique position as if they were separated by them. If the animal is a female this declination is continued till they are nearly in the transverse position, and this furnishes one of the earliest sexual distinctions. The repro-

Their form  
in male and  
female.

ductive organs are at first of an elongated form; if they are ovaries they retain that shape, and exhibit a deep groove along their external aspect, where they are connected by the peritoneum to the Wolffian bodies. If, on the other hand, they are testicles, they assume a rounder form and remain solid, and the contained blastema commences to arrange itself in transverse bands. The peri-

<sup>1</sup> Abhandlungen zur Bildungs—und Entwicklungs-Geschichte des Menschen und der Thiere von Dr Heinrich Rathke. 1832.

<sup>2</sup> Arnold's Anatomie des Menschen, vol. ii., p. 1330.

<sup>3</sup> Rathke, Beobachtungen über die Entwicklung der Geschlechts-werkzeuge bei den Wirbelthieren. 1825.



toneum now invests the testicle completely, and in the sheep and calf I found that it formed a ligament or mesorchium of considerable length, between the testicle and the Wolffian body. In this membranous duplicature a process was observable, arising from the posterior and upper aspect of the former organ, and proceeding downwards and somewhat forwards to the latter, on whose anterior surface it was afterwards traced to a junction with its principal vessel. In the meantime, small vessels surrounded it; its centre was ultimately hollowed, and became the spermatic artery, which in the animals above-mentioned, is afterwards remarkably convoluted. (Pl. III., fig. 1.)

Formation  
in male  
of mesor-  
chium;

of spermatic  
artery.

While the above changes were going on, the so-called Müllerian duct, destined to become the excretory duct of the generative gland, was developed along the outer border of the Wolffian body, and from its white colour contrasted with the red of that already diminishing viscus. It ended at the upper part in a small bundle of convoluted tubules. This duct has been described by Rathke<sup>1</sup> and Kobelt<sup>2</sup> as identical with the proper duct of the Wolffian body, but the latter follows a course similar to what Rathke describes as occurring in reptiles and birds;—it becomes concealed among the secreting tubules, and as M. Follin<sup>3</sup> has shown, is distinct from the Müllerian duct; below the level of the Wolffian body, however, it is closely united to, and ultimately blended with it. As to the convoluted tubules at the upper end of the Müllerian duct, they are indeed formed at the expense of the Wolffian body, that is to say, in a position originally occupied by the lat-

Müllerian  
duct in  
male;

its position.

Termination  
in tubules.

Distinct  
from Wolf-  
fian bodies.

<sup>1</sup> In his work of 1832. In that of 1825, he held them to be distinct.

<sup>2</sup> Kobelt. *Du Parovarium chez la femme l'analogue de l'épididyme chez l'homme.* The summary is given in the *Archives Générales de Médecine*, t. xxv., p. 327.

<sup>3</sup> E. Follin. *Thèse sur les corps de Wolf, à Paris. 1850.* The summary is given in the *Archives Générales de Médecine*, t. xxv., p. 330.



ter, so that a part of it must be absorbed before them ; and this is evident, for I found that the upper extremity of the testicle was now on as high a level as the Wolffian body, though originally on a lower ; but they cannot be composed of the canals of that organ transformed, as Kobelt supposes ; for were this the case, we should find them consisting of hollow tubules from the first, whereas they began as solid bands indistinctly separated, and smaller than the Wolffian tubules. This little mass of tubules becomes joined by a short, straight cord to the upper part of the testicle.

Junction  
with testes.

Müllerian  
duct in fe-  
male.

The Müllerian ducts in the female are destined to form the Fallopian tubes, and end in a slight bulbous enlargement, surrounded by a mass in which I have seen striæ analogous to the tubules just mentioned in the male,—the first rudiments of the fimbriæ. At their inferior extremity these ducts are united in the female to form the uterus. The ducts of the Wolffian body remain separate, and are said by Follin to persist as hollow tubes which open into the lower part of the vagina, and form the ducts of Gärtner.

Ducts of  
Gärtner.

Atrophy of  
Wolffian  
bodies.

In the more advanced embryo of the calf, the Wolffian body was found in an atrophied condition, separated completely from the ducts of the testicle at every part, except the upper extremity, which was still in close contact with the convoluted tubular mass. It had the appearance of transverse granular bands. The substance of the testicle was now separated into convolutions, which seemed to be at first without any membrane, but afterwards bounded by a homogeneous membrane, evident on addition of acetic acid. Bischoff<sup>1</sup> maintains that the tubuli seminiferi are formed of blended cells ; but in this opinion he is singular. (Pl. III., fig. 2.)

Tubuli sem-  
niferi.

<sup>1</sup> Bischoff on Development. Translated into French by Jourdan, Encyclopédie Anatomique, vol. viii., article Testicle.



As the development went on, the cord connecting the testicle to the excretory parts became striated longitudinally, and each striation became a distinct vas efferens. The convoluted mass, into which this cord entered, could, with care, be now shown to form the coni vasculosi, and not more of the epididymis than the portion into which they were inserted; for, by very slight unravelling, several of the fine tubules forming its convolutions were seen given off from the main duct. The rest of the epididymis was formed from that part of the duct which ran along the side of the Wolffian body, the remaining part of it becoming the vas deferens. The separation between the vas deferens and epididymis was marked by a few sharp turns, and this point was at first some distance below the level of the testis. In the female, the duct presented a convolution at the corresponding point, and this marked the termination of the cornu of the uterus and commencement of the Fallopian tube.

Vasa efferentia.

Coni vasculosi.

Epididymis.

Vas deferens;

their junction.

Cornu uteri and Fallopian tube.

As the testicle descends, it turns somewhat on its outer side; whereas, originally, it rather lay on its inner side. Thus the vessels come to lie superiorly and internally to the organ; and as it pursues its course onwards, the vas deferens is brought into its ultimate position along its posterior and inner aspect.

Change of position of testes.

In the lamb and calf, the remains of the Wolffian body extend from the lobus major of the epididymis along the vessels, and ultimately its vestiges are seen in front of the vascular tumour. In the human subject, the hydatids of Morgagni are formed by the atrophy of the Wolffian bodies.

Adult remains of Wolffian bodies.

In the female, they form the parovaria, or bodies of Rosenmüller. Follin believes that in the male there is formed an organ homologous with the parovarium of the female. According to him, the lower part of the Wolffian duct forms the vas aberrans Halleri, as Kobelt also describes, and the upper part forms the hydatid of Morgagni; while from the Wolffian body itself are formed

Parovarium.



Homologue  
in male.

certain "diverticular canaliculi" in the caput epididymis, which communicate with the rete testis, but not with the canal of the epididymis, and which have a secretion in which spermatozoa are never found. The hydatid of Morgagni, he thinks, is homologous with the pedunculated vesicle in the female, frequently found at the fimbriated extremity of the Fallopian tube. Some of these particulars, however, require confirmation.

The epididymis gradually becomes convoluted, and, at the same time, its lower end approaches the extremity of the testicle, and thus a pouch of peritoneum is formed,

Digital fossa. which is the digital fossa.



## THE STRUCTURE OF THE GUBERNACULUM.

The descent of the testicles from the abdomen is a subject on which many authors have written with much diversity of opinion for more than a century.

John Hunter was the first to describe the structure extending from the testicle in the abdomen to the scrotum, which bears his name. Unfortunately, the term gubernaculum has been very loosely employed. It has been applied by some to a projection occupying the posterior aspect of the processus vaginalis, and by others to the fibrous structures which reach down to the scrotum. This confusion has arisen from authors having studied the whole apparatus as a single structure, and some insisting particularly on one part, while others have studied a different part and neglected the former. We shall, therefore, use the word gubernaculum only when we speak of the apparatus generally. Some have called the peritoneal projection just mentioned *mesorchium* (Seiler, &c.), a name which is more properly confined to the fold attaching the testicle to the abdominal wall, and which contains the vessels and vas deferens. The projection is better named *Plica gubernatrix* (Arnold).

Use of terms.

Gubernaculum.

Mesorchium.

Plica gubernatrix.

At the time when the atrophy of the Wolffian bodies has begun, there may be seen very distinctly in the calf and the rabbit, and also in the human subject, though the atrophy occurs there at an earlier period, a peritoneal elevation passing from the lower end of the testicle, on the surface of the Wolffian body, to the junction of the epididymis and vas deferens. It shortens and disappears by the approach of these points to one another, and the adhesion of the inferior extremity of the testicle to the end of the epididymis. A more marked elevation continues

The gubernaculum;

first appearance.



the preceding one from the latter point to the groin, and a pit soon begins to form round the inguinal attachment of this. (Pl. III., fig. 3.)

Homologue  
in female.

So far similar changes are observed in the female. The elevation between the ovary and the cornu uteri, corresponding to that between the testicle and commencement of the vas deferens, is the first rudiment of the ligament of the ovary; and a further elevation from the cornu uteri to the groin is the round ligament of the uterus. There is also a pit at the inguinal extremity of the round ligament—the canal of Nuck.

Processus  
vaginalis.

In the male subject, the inguinal pit deepens, and becomes the processus seu bursa vaginalis peritonei, and the elevated fold projects into it from behind in its whole length, constituting the plica gubernatrix. It reaches the bottom of the scrotum in the latter part of utero-gestation, and the testicle follows, so as to be in the scrotum at the time of birth. Bourdon<sup>1</sup> asserts that the process is slower in cold and humid countries, as Holland, and that this becomes in such countries a frequent cause of congenital hernia.

Congenital  
hernia.

Gubernac-  
ular cord.

Surrounding the processus vaginalis, but stronger behind than in front of it, and reaching from the extremity of that process before it has begun to penetrate the muscular walls, is a fibrous structure attached inferiorly to the skin of the scrotum, and which we shall distinguish as the gubernacular cord. This has been described by most authors as a bundle of fibres continued upwards in the plica gubernatrix to the testicle. Such is the general nature of the structures whose disputed minutiae we shall examine in detail.

Review of  
opinions.

Let us first review the opinions held by various writers on the structure of the gubernaculum.

<sup>1</sup> Bourdon, *Principes de Physiologie Comparée*, 1830, p. 290.



Hunter<sup>1</sup> wrote as follows:—" In the fœtus the testis is Hunter connected in a very peculiar manner with the parietes of the abdomen, at that place where in adult bodies the spermatic vessels pass out, and likewise with the scrotum. This connection is by means of a substance which runs down from the lower end of the testis to the scrotum, and which at present I shall call the ligament or gubernaculum testis, because it connects the testis with the scrotum, and directs its course in its descent. It is of a pyramidal form; its large bulbous head is upwards, and fixed to the lower end of the testis and epididymis; and its lower slender extremity is lost in the cellular membrane of the scrotum."

Hunter believed the whole apparatus to consist of the ligament described by him, and the process of peritoneum in front of it, to which, however, he attached little importance. He believed this ligament to be fibrous in structure, but possessed of contractile properties. Moreover, although he failed to trace the fibres of the cremaster on the surface of this ligament, he thought it probable that they passed upwards to the testis, and that they helped its transition. He was led to this opinion by analogies drawn from some of the lower animals; but the principal motor agency he attributed to the ligament.

Girardi of Parma (according to Brugnoni) was the first to describe a number of muscular fibres ascending to the testis. Palletta afterwards observed them, but doubted if at so early a period they were sufficiently developed to cause the descent of the testis. Pancera<sup>2</sup> ascribes to them more importance. He considers that, among the causes draw-

Cremaster  
ascending  
to testis.  
Girardi.  
Palletta.

Pancera.

<sup>1</sup> Hunter on the Position of the Testicle in the Fœtus, and its Descent into the Scrotum.

<sup>2</sup> De Pancera de Testis humanæ ex abdomine in Scrotum Decensu. Vienna, 1778. Extract in Langenbeck de Structura Peritonæi.



ing down the testicle, while it lies high up in the abdomen, the cremaster merits the first consideration. In the second place, he mentions the cellular tissue of the scrotum.

Lobstein. He thought, as also did Lobstein,<sup>1</sup> that since the cellular tissue has power to corrugate the scrotum, it may also be supposed capable of helping to pull down the testicle. He considered that, having arrived at the external abdominal ring, the further descent of the testicle to the bottom of the scrotum was accomplished by the birth of the child, the commencement of respiration, and efforts of abdominal pressure,—an opinion held also by Haller and others. The tunica vaginalis he described as formed by the eversion of what he called the cylinder,—viz., the plica gubernatrix.

Haller. The existence of muscular fibres reflected upwards to the testicle from the internal oblique and transverse abdominal muscles has been confirmed by several writers. Brugnoli.<sup>2</sup> Brugnoli<sup>2</sup> imputed the descent to this agency, and combated the doubt entertained by Palletta of their being sufficiently developed to effect this, by showing that the other muscles are then capable of action, since they produce the movements of the fœtus felt by the mother.

Seiler.<sup>3</sup> Seiler<sup>3</sup> also describes ascending muscular fibres. His description is as follows:—"In the region of the abdominal ring, a fold or sheath of peritoneum (*processus vaginalis peritonæi*) rises up, adhering at the inferior extremity of the testicle with the portion of peritoneum which forms the tunica albuginea. This sheath includes a small conical ligament (*Gubernaculum Hunteri*), formed of dense cellular tissue, which commences at the apex of the fold or

<sup>1</sup> Lobstein, *Recherches et Observ. sur le Position de Test. chez le Fœtus*. Paris, 1801. Extract in *Langenbeck de Structura Peritonæi*.

<sup>2</sup> Brugnoli de *Testium in Foetu Positis*. Mémoires de l'Académie de Scéances de Turin, 1788.

<sup>3</sup> B. G. Seiler, *Observationes nonnullæ de Testium Decensu*. Leipsic, 1817.



sheath, where the inferior extremities of the testicle and epididymis are in contact. It thickens as it descends; it traverses the abdominal ring, and divides into two slender branches, of which one is joined to the cellular tissue that covers the aponeurotic expansion before the abdominal ring, and the other, still slenderer, mixes itself with the dense cellular tissue towards the symphysis pubis. If we cautiously raise the envelope of peritoneum, we display muscular fibres, which curve upwards from the internal oblique and transverse abdominal muscles, and cover the cellular mass and adhere to it, so that the Gubernaculum of Hunter seems to be for the greater part a tendinous production of these muscular fibres, for the passage of cellular tissue into membranous, serous, and tendinous texture, is almost unobservable." He ascribes the descent of the testis in part to the muscular fibres, but chiefly to the development of the parts.

The description of M. Robin<sup>1</sup> is much to the same purpose, but gives more importance to the muscular fibres. Robin. "Arrived at the inguinal canal," he adds, "the organ finishes its descent into the scrotum either by the pressure of the viscera or by its own proper weight, and the muscle is inverted as a muscular pouch."

The description of Mr Curling<sup>2</sup> is nearly identical with Curling. M. Robin's. He describes a central soft, gelatinous part, and an external and internal muscular part. He adds, that these muscular fibres may be traced the whole way from the ring to the testicle.

An account has been given by Professor E. H. Weber<sup>3</sup> of Weber;

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<sup>1</sup> Ch. Robin, *Recherches sur la Nature Musculaire du Gubernaculum Testis, et sur la situation du Testicule dans l'Abdomen*. Extrait de la *Gazette Medicale de Paris*, 1849.

<sup>2</sup> *Cyclopædia of Anatomy and Physiology*—article Testicle.

<sup>3</sup> E. H. Weber, *Ueber den Descensus Testiculorum bei dem Menschen und einigen Säugethieren*. *Müller's Archivs*, 1847.



Weber's  
shut sac.

the descent of the testicle, which coincides with those already mentioned, in as far as he describes the cremaster as originally directed upwards ; but he attributes only a secondary importance to it, and regards as the principal agent of the descent a shut sac, independent of the peritoneum, and which he is the first to describe. "This vesicle," he says, "grows with its upper part into the abdominal cavity, and drags asunder the lamellæ of the peritoneal fold in which the testicle is hung as in a purse, and bears on it muscular fibres, which are given off from the internal oblique muscle upwards to near the inferior extremity of the testis. Hence it is clear that the part called the Gubernaculum by Hunter is not a solid cord, but that it is a bladder overlaid with muscular fibres. The under part of the bladder grows downwards from the inguinal canal into the scrotum, drags asunder the cellular tissue, and prepares a way for the testis, before that organ has left its place. Thus there exists a large bladder, which is narrowest in the middle where it lies in the inguinal canal, whose upper part projects into the abdominal cavity, is broader, and overlaid with muscular fibres, which pass upwards from the internal oblique, and cover the bladder in oblique and transverse directions ; while the under part of the bladder, which is still wider, is not overlaid with muscle, and descends into the scrotum. The descent of the testis is effected thus :—The upper part of the bladder, with the adhering peritoneum, is shoved into the lower part, which passes down into the scrotum, just as you can shove the one-half of a nightcap into the other." It will be observed that the peculiarity of Weber's view is, that he describes a defined sac or bladder ; for that the centre of the gubernaculum is hollow or pulpy is no new idea.

Almost all the authors yet mentioned seem to concur in viewing the elongation of the processus vaginalis as produced by the eversion of the plica gubernatrix ; that is to



say, that the peritoneum originally forming the plica gubernatrix is everted, so as to become part of the tunica vaginalis reflexa.

There are other authors who entirely deny the formation of the cremaster from fibres originally passing upwards to the testicle in the abdomen, and maintain that it is derived from fibres extending from Poupart's ligament to the pubis, which precede the testicle in its descent, in the form of arches on the surface of the processus vaginalis. M. Cloquet<sup>1</sup> has strenuously upheld this doctrine, and Carus<sup>2</sup> and Arnold<sup>3</sup> also maintain it.

Cremaster  
found in  
arches.

Cloquet,  
Carus, and  
Arnold.

To arrive at true conclusions about these structures, as to which so many conflicting opinions have been held, it is necessary that they be studied in the human subject, and that all analogies drawn from the lower animals be kept completely out of view, till we ascertain the answer of the parts themselves to all the questions that can be put to them, else such analogies will but lead us into error, and blind us in the study, with prejudices. In the first place, I shall detail my own dissections of the gubernaculum. I shall then give the results at which I have arrived, and compare them with those of authors; and shall afterwards inquire how far facts bear out the analogies so frequently drawn from comparative anatomy.

Method of  
study.

*Dissection I.*—My first dissection was made upon a foetus in the fifth month, a preparation which had been kept in spirit. The left groin, on which it was made, had been already interfered with, so that it was necessarily imperfect. It served, however, to demonstrate two points, viz., that many of the fibres of the gubernacular cord descending into the scrotum are connected superiorly with

Cord to scro-  
tum from  
abdominal  
walls.

<sup>1</sup> Jules Cloquet, *Recherches Anatomique sur les Hernies de l'Abdomen*. 1817.

<sup>2</sup> Carus, *Comparative Anatomy* by Gore, vol. ii., p. 347.

<sup>3</sup> Arnold, *Anatomie des Menschen*, vol. ii., p. 1331.



Plica independent of it.

the walls of the abdomen, and that the plica gubernatrix is independent of that cord; that is to say, the plica gubernatrix did not contain a fibrous bundle which ran down to the scrotum and formed the gubernaculum, as described by Hunter and others. On the contrary, the plica gubernatrix seemed connected with the cord by mere cellular tissue.

*Dissection II.* (Pl. I., fig. 1.)—This dissection was made on a recent subject about the same age as the former. Well-developed fibres were seen inserted into the skin of the scrotum, both from the fascia and the aponeurosis of the external oblique muscle; and amid these was a more definite bundle inserted superiorly into the deeper parts of the abdominal wall, both toward the external and internal aspect of the inguinal canal, and a few fibres of which passed up between the others, there to be lost on the bulbous projection of the peritoneum containing the processus vaginalis, which in this case reached to about the level of the border of the internal oblique muscle. No fibres of the internal oblique muscle were discovered passing upwards on the bulbous projection. The processus vaginalis did not penetrate the whole length of the projection, but the bulbous extremity of the latter was formed of tissue exterior to it. In this tissue the appearance of a shut sac was detected, which seemed to run up into the plica gubernatrix; but under a powerful lens the appearance was not such as to warrant the supposition that it was a serous cavity. This is, doubtless, what has been described as a shut sac by Weber, and to which he attributes so important a function.

Weber's sac  
not serous;  
runs up into  
plica.

*Dissection III.* (Pl. I., fig. 2.)—This dissection was made on the untouched side of the subject on which the first dissection had been made. As in the previous dissection, the fibrous bundle inserted into the scrotum was derived partly from the fascia, partly from the external



oblique aponeurosis, and partly from a deeper source. The peritoneal projection formed by the processus vaginalis consisted of two layers, an external or cellular, and the serous layer or true membrane. The serous layer descended less than half the distance of the testicle from the internal oblique muscle. The cellular layer, which was quite distinct from the serous layer towards the groin, passed down to the level of the external inguinal ring, and was lost in the gubernacular cord. Within this prolongation were some bundles of fibro-cellular tissue; a mass of cellular tissue also depended from the lower end of the testicle, and occupied the plica gubernatrix. Some fibres of the internal oblique muscle, on the outer side of the gubernaculum, passed down upon it; some were connected with it as they crossed in front of it, and the muscularity of these fibres was tested by the microscope. On the inner side of the gubernaculum a distinct and well-developed layer of fibres passed upwards, inside and behind it, from the internal oblique muscle, and were inserted on the superficial surface of the cellular layer of peritoneum. These proved under the microscope to be striped muscular fibres.

Two layers  
of perito-  
neum.

Ascending  
and descend-  
ing muscular  
fibres.

*Dissection IV.*—This dissection was made on a considerably smaller foetus, which had been long kept, and whose textures were excessively hardened. The gubernacular cord received additions both from the aponeurosis of the external oblique muscle and from the fascia. A bundle of fibres of the internal oblique muscle passed downwards on the outer side of the gubernaculum. The processus vaginalis extended to a little above the level of the border of the internal oblique muscle. A cellular layer of peritoneum, separable from the serous layer, formed a prolongation downwards, and became incorporated with the gubernacular cord. It was strengthened by a dense layer of areolar tissue. The edge of the internal oblique muscle

Corroborations in a  
younger  
subject.



merged into fascia, inclining upwards to join this layer. But no ascending muscular fibres were detected under the microscope.

*Dissection V.* (Pl. I., fig. 3.)—This dissection was made on a recent subject, a foetus of the sixth month. The testicle was still within the abdomen, just at the mouth of the processus vaginalis. A firm bundle, consisting superficially of fibres from the fascia, but inclosing others, was firmly attached to the scrotum. The aponeurosis of the external oblique muscle at the inguinal ring was much connected with the fascia. The deeper fibres of the gubernacular cord pierced it, and joined the fascial bundle. Fibres from the external oblique aponeurosis passed upwards on the gubernacular cord. A marked bundle of fibres from the internal oblique muscle passed downwards externally to the gubernaculum, to be inserted into the pubis, and a number of fibres, whose muscularity was proved by the microscope, arched downwards upon the surface of the gubernaculum. On vertical section of the lower part of the internal oblique muscle, its border was found connected with the transversalis fascia, and sending fibres upwards in it on the surface of the gubernaculum. The gubernacular cord consisted superficially of a layer of fibrous membrane, lost above in the peritoneum, but distinct and dense below, where it inclosed a cavity which reached down to the level of the external inguinal ring. The structure which was projected downwards into this pouch did not reach so far as the border of the internal oblique muscle. It had a bulbous extremity, and was only attached to the walls of the pouch by cellular tissue, more or less dense. The peritoneum composing it was so thick as to admit of being separated into layers, and the mere serous layer could be detached from the others, so as to expose the fibro-cellular matter which had occupied the plica gubernatrix. That it was nothing more

Ascending  
fibres from  
ext. oblique.

Shut sac  
between fi-  
brous layers.



than fibro-cellular matter was proved by the microscope. It was lost below in the intermediate layers of peritoneum.

*Dissection VI.* (Pl. II., fig. 1.)—This dissection was made on the other side of the same foetus as the last. On this side the process was further advanced than on the other—a circumstance interesting, both as a departure from symmetry, and as illustrating the variability of the period at which the descent is accomplished. The testicle had just disappeared from the abdomen into the processus vaginalis. The fascia was much connected with the external oblique aponeurosis, and this connection was so arranged round the external inguinal ring that a sort of pouch was formed, in which lay the bulbous extremity of the gubernaculum, only attached to the walls of the pouch by more or less dense cellular tissue. The border of the internal oblique muscle passed over the gubernaculum, and sent fibres arched downwards on its surface. The processus vaginalis reached to the bottom of the bulb of the gubernaculum. The gubernaculum consisted of thickened peritoneum capable of being divided into layers, and the serous or true layer separable from the other, and from the fibro-cellular substance occupying the plica gubernatrix. Some doubtful fibres of the internal oblique muscle were inclined upwards in the transversalis fascia.

Unsymmetrical descent.

Pouch between ext. oblique and fascia.

Gubernaculum free below.

*Dissection VII.* (Pl. II., fig. 2.)—This dissection was made on a foetus of five months, preserved in spirit. The testicle was just about to quit the abdomen, but in this case there was scarcely any processus vaginalis preceding that organ in its descent. On front of the gubernacular cord were very distinct muscular fibres passing downwards in arches. Above the level of the border of the internal oblique muscle, the greater part of the bulk of the cord was derived from a remarkably developed set of muscular fibres passing up from this muscle to the level of the testicle. On the interior of the cylinder so formed passed

Atrophy of processus vaginalis.

Muscular fibres much developed.



up some fibres from the external oblique aponeurosis, and in the centre was a fascial prolongation of the peritoneum from the inferior extremity of the testicle, and which some appearance of being hollow.

Such are the dissections which I have had the opportunity of making of the descent of the testes in the human subject. I have recounted them thus minutely, to show candidly the authority for the conclusions which I shall draw. Let us sum up briefly the points which they indicate:—

*Summary.*

Testis free  
from gubernacular cord.

Fusion of  
tissues.

Weber's sac  
a varying  
space.

Ascending  
and descend-  
ing muscular  
fibres.

*First,* They show that there is no simple ligament running directly from the testicle to the scrotum, but that the fibrous tissue of the gubernaculum is composed of a superficial fibrous layer of peritoneum, and of the fibro-cellular tissue within the same, which occupies the plica gubernatrix; of ascending and descending fibres from the aponeurosis of the external oblique muscle; and of ascending and descending fibres from the fascia of the groin.

*Secondly,* They show that there is no permanent definite sac, such as is described by Weber, but that there is a sac-like space left, in the first instance, between the serous and fibrous layers of peritoneum, afterwards between the different fibrous layers, and lastly between the fascia, on the one hand, and the gubernaculum, as made up of all the peritoneal structures, on the other.

*Thirdly,* They confirm the existence of cremasteric fibres, arched downward upon the gubernaculum, and also of an ascending set of muscular fibres; but these latter do not occupy the position which authors have assigned them,—namely, within the plica gubernatrix.

On these three subjects we shall make remarks separately.

*Detailed  
argument.*

As regards the first point—the direction of the fibres entering into the structure of the gubernaculum;—our as-



section that there is no simple ligament, such as has been often described, running directly from the testicle to the scrotum, is not a mere denial, meaning only that we have been unable to see it, and which might be translated as indicating no more than that it had been destroyed in making the dissection, or had not been looked for in the proper way; but the structures which we have shown do exist differ from the descriptions which speak of such a ligament, and are incompatible with its existence. The presence of such a ligament is quite incompatible with the anatomy displayed in Dissections V. and VI., in which the extremity of the bulb containing the processus vaginalis was found to lie free in a pouch,—in the fascia in the latter case, and in the outer layer of the gubernacular fibres in the other.

Ligament  
from testis  
to scrotum  
impossible.

With reference to the manner in which fibres of the gubernaculum are derived from the various layers of the abdominal wall, it is worthy of remark that a similar arrangement occurs in the round ligament of the female, as the following dissection of a female foetus of the fifth month illustrates:—

(Pl. II., fig. 3.) The round ligament was dissected from the outside, and traced upwards through the muscles of the abdominal wall. A number of aponeurotic fibres were inserted into the labium, a great number of which were derived from the aponeurosis of the external oblique muscle; but some of them pierced that structure, and, with other fibres which they received from it, proceeded upwards, and pierced the internal oblique and transversalis muscles. A large number of fibres were reflected from these muscles, and passed upwards, sheathing the ligament. The ligament thus increased terminated in part in the transversalis fascia, but for the most part turned inwards, and formed the round ligament, as it may be seen from the peritoneal aspect. On further dissection, it ap-

Round liga-  
ment of fe-  
male has  
descending  
and ascend-  
ing fibres  
from ext.  
oblique;

from int.  
oblique.



Fibres inserted in peritoneum and uterus.

peared that all the fibres from the internal oblique and transversalis muscles terminated in the peritoneum, but the main cord passed on to the uterus, and its fibres became incorporated with those of the uterus.

The plica contains texture.

Series of spaces formed as process. vagin. descends.

In the next place, we have to consider Weber's shut sac. That there are pouches of a certain sort in the gubernaculum, although not serous, we have seen. But we are compelled to differ from Weber's idea that there is only one defined sac, which extends into the plica gubernatrix, and persists and undergoes modification of form in the descent. We find that although the plica gubernatrix is occupied by a pulpy-looking substance, yet this is a fibro-cellular tissue, not a gelatinous fluid; and although it is in close connection with the sac-like excavation in the fifth month, at a more advanced period it is separated from the latter by very strong tissue. Instead of Weber's shut sac being a defined structure, such as he describes, we have only to do with spaces in the tissue, and a series of these is formed as the processus vaginalis descends. Thus the space exhibited in Dissections II. and III. is not the same as that of Dissection V., nor that of Dissection V. the same as that of Dissection VI.

Gubernaculum begins by fibres to scrotum from peritoneum and walls.

Process. vagin. appears;

It is probable (although I have had no opportunity of dissecting a foetus quite so young as absolutely to demonstrate it), that the first condition of the gubernaculum is as a cord formed above from the external surface of the peritoneum, and perhaps some fibres issuing from the plica gubernatrix, and that this gives and receives fibres in the various layers of the abdominal wall until it reaches its inferior attachment at the scrotum. The foetus on which Dissection IV. was performed, was a little more advanced. It displays a processus vaginalis of some depth; and now the fibres from the external layer of peritoneum begin to be developed in two directions, some clinging to the processus vaginalis, and some following the direction of



the gubernacular cord. As the process advances, how-  
 ever, the first set are the principal, and, ultimately, only  
 ones which are developed, and so we have a gradually  
 thickening bulbous extremity, which pushes its way down  
 the centre of the gubernacular cord, whose fibres are se-  
 parated before it, forming a kind of funnel-shaped cavity,  
 and at last, when the processus vaginalis has finished its  
 journey, are quite incorporated with the neighbouring tis-  
 sues. The cases in which, as in Dissection VII., the pro-  
 cessus vaginalis scarcely exists in advance of the testicle,  
 must be considered as exceptional, although probably of  
 not unfrequent occurrence.

fibres grow  
round it;

it scatters  
the first set  
of fibres.

The third subject suggested by our Dissections is the  
 formation of the cremaster muscles. Strangely enough,  
 none of the accounts hitherto given have even suggested  
 the possibility of there being two sets of muscular fibres.  
 Yet it would be hard to say of the observers who espouse  
 either of the two sides, that they have not seen what they  
 so particularly describe. It is therefore satisfactory to  
 find sets of fibres corresponding to both descriptions.

The ascending set are described by Weber as covering  
 the superior part of the shut sac in transverse and oblique  
 directions, and by Seiler, Robin, Curling, &c., as ascending  
 to the testicle, and covered like it with peritoneum. They  
 are not, however, in reality, attached to the testicle, nor  
 do they ascend in the plica gubernatrix. Such an ar-  
 rangement is incompatible with the structure of the gu-  
 bernaculum, which we have described, when there is pre-  
 sent a plica gubernatrix and processus vaginalis in ad-  
 vance of the testis, as is normally the case. The contents  
 of the plica gubernatrix are interior to the whole thick-  
 ness of the superficial layers of peritoneum which we have  
 spoken of; whereas the fibres of the internal oblique  
 muscle are necessarily superficial to these, and pass up-  
 wards on their surface.

Musc. fibres  
ascend, not  
in plica,

but external  
to perito-  
neum.



Descending  
fibres form  
cremaster.

Ascending  
fibres atrophied.

But it is from the fibres descending in front of the gubernaculum, that the cremaster muscle is entirely formed. As for the ascending fibres, I believe them to be atrophied, for they were much more evident in Dissection III. than in Dissection V.; while in Dissection VI. they could scarcely be said to exist. Their great strength in Dissection VII. was probably a compensation for the non-development of the plica gubernatrix. If they underwent the sort of eversion ascribed to them, to bring them into the ultimate position of the cremaster, that process would of necessity have begun long before the processus vaginalis had reached the point which it had in Dissection V.; and it is impossible that fibres occupying at that period the ascending position along the outside of the processus vaginalis could ever extend to the bottom of the scrotum.

The authors who describe the ascending fibres as inverted to form the cremaster, must have only dissected cases where the processus vaginalis was atrophied, as in Dissection VII., or have artificially destroyed it by pulling the testicle upwards in the abdomen before proceeding to dissect. Yet so well developed is this process in other cases, that the processus vaginalis and plica gubernatrix are the only parts at all described or figured in a paper by Vicq D'Azir on the subject.<sup>1</sup>

Comparative  
Anatomy.

It is chiefly with regard to the origin of the cremaster that comparative anatomy has been appealed to in the subject of the descent of the testes. Thus Hunter puts great importance on the upward direction of the cremaster in rams in which the testicles had been retained in the abdomen. M. Robin,<sup>2</sup> also, in 1849, exhibited to the Société Biologique a muscular gubernaculum in a dog in which the same thing had happened. Such observations,

<sup>1</sup> Sur la position des Testicules. Par M. Vicq D'Azir, Mémoires de l'Académie Royal de Sciences de Paris, 1780.

<sup>2</sup> Gazette des Hôpitaux, 1849.



however, have only a limited value in the discussion, and arguments drawn from them, being mere arguments of analogy, can only add probability to views supported upon other grounds. Hunter writes, "In the ram, when the testis is come down into the scrotum, the cremaster is a very strong muscle, and though it is placed more inwards at its beginning, it passes down pretty much as it does in the human body, and is lost on the outside of the tunica vaginalis; but in the ram, whose testis still remains suspended in the abdominal cavity, I find that the cremaster still exists, although it is a weaker muscle, and instead of passing down as in the former case, it turns inwards and upwards, and is lost in the peritoneum that covers the ligament which attaches the testis to the parietes of the abdomen, which, in this state of the animal, is about an inch and a-half in length. In the human foetus, while the testis is retained in the cavity of the abdomen, the cremaster is so slender that I cannot trace it to my own satisfaction, either turning up toward the testis or down toward the scrotum. Yet, from analogy, we may conclude that it passes up to the testicle, since, in the adult, we find it inserted or lost in the lower part of the tunica vaginalis, in the same manner as in the adult quadruped."

Hunter concludes from anatomy of ram that

the human foetal cremaster ascends to the testis.

Now, in the *first* place, the anatomy of the cremaster in the human subject varies considerably in different bodies. In some instances it is composed of very distinct loops; in some, of loops whose lower part is lost in the fascia inferiorly; and in others, of definite bundles, which continue well pronounced in their whole length; usually there is a mixture of these different sorts of fibres. The looped fibres are undoubtedly formed on the surface of the descending bulb of the gubernaculum; but Hunter's description ignores these fibres altogether, and represents the human cremaster as similar to the ram's, which is indeed, as he describes it, a very strong muscle, which

Human cremaster not like the ram's.



passes downwards and is inserted on the outside of the tunica vaginalis.

Anatomy of  
foetal ram  
contradicts  
Hunter.

In the *second* place, the anatomy of the foetal ram in which the testes are about to descend, is at variance with the notion of muscular fibres ascending toward the testis to pull it down. In both the calf and the lamb the plica gubernatrix is a very large structure, much larger than in man, and in the former projects so much from the wall of the processus vaginalis that it is folded in upon itself. It is filled with gelatinous looking substance, and increases in bulk until its extremity has reached the bottom of the scrotum. (Pl. III. fig. 2.) At that time the cremaster may be seen occupying its ultimate position, passing down to the lower part of the tunica vaginalis. The testis has still the whole length of the plica gubernatrix to traverse, and there are no muscular fibres in the plica, nor indeed can there be, for it is formed as in the human subject, in the thickness of the peritoneum, being a fold of the serous layer, and bounded behind and thoroughly separated from the superficial structures by a stout external layer. It is quite evident, therefore, that it is not the cremaster which pulls down the testis in these animals; and if the cremaster ever had in them an upward direction, it must have been before the processus vaginalis had reached the inguinal ring. But in these animals that event happens at a very early period, long before muscular fibre can have any contractile virtues. In foetal lambs, between three and four inches long, in which the muscles of the abdominal wall are but feebly developed, I find that the bulb of the gubernaculum already projects a long way beyond the external abdominal ring. In the case of retention of the testis described by Hunter, what he describes as the ligament attaching the testis to the walls of the abdomen is evidently the plica gubernatrix; the processus vaginalis had failed to be developed, but the fibres of the

No ascend-  
ing muscle  
in normal  
state.

Hunter's  
ascending  
fibres expli-  
cable.



cremaster were directed as usual to the extremity of the plica. The anatomy was thus rendered similar to what we shall shortly have occasion to notice in the foetal rabbit.

I should mention that in the calf and lamb, the only gubernacular structures are those above described; there is no gubernacular cord attached to the scrotum. Rathke has found it absent in swine, dogs, hares, and ruminants, but in cats a prolongation of the fibres of the processus vaginalis is attached to the scrotum.<sup>1</sup>

The anatomy of the hedgehog is also appealed to by Hunter in evidence of the ascending origin of the cremaster, and is still referred to as an illustration by those who follow his opinion, and think that the tunica vaginalis is lengthened by the eversion of the plica gubernatrix as one everts the fingers of a glove. There is however no argument to be drawn from it at all. When the hedgehog is dissected with the testis drawn down beyond the external abdominal ring, its cremaster is seen to be not essentially different from that of the human subject; but it is stronger, and presents a beautiful example of a cremaster formed entirely of loops. Hunter appears to me to have thought, as well as some of the writers after him, that the testes of the hedgehog were always in the abdomen, which, had it been the case, would have made the argument a far more urgent one. But since they are in reality at times extended from the abdomen, the question comes to be, What is the normal position of the testes in animals in which they descend periodically. I have had no opportunity of determining this point upon the hedgehog, but from the foetal condition of another animal in which there is a periodical descent, I find reason to believe that the position external

Gubernacu-  
lar cord  
absent in  
animals.

Cremaster  
of hedgehog  
proves  
nothing.

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<sup>1</sup> Rathke, Abhandlungen zur Bildungs und Entwicklungs-Geschichte des Menschen, und der Thiere, 1832. P. 80.



Testes in  
scrotum in  
foetal leveret.

Scrotum  
proper site  
of testes in  
cases of  
periodical  
descent.

to the abdominal cavity is the true one, and that within the cavity adventitious in the adult ; and I think we shall be justified in considering the same thing true of all animals of this description. In a foetal leveret near birth the processus vaginalis projected downwards from the abdomen, and the testes hung in it beyond the external inguinal ring, just as in animals in whom the descent is permanent. It is quite evident that if the intra-abdominal were the proper position of the testes in these animals, and the external one a departure from the normal state, assumed for mere functional exigency, we should find no inclination to the latter till the commencement of rutting ; but the gradual assumption of this position in the foetus associates these animals with those in whom the descent is permanent. Now, if the normal position of the testes of the adult hedgehog is in the abdomen, it may be considered as affording an example of an ascending cremaster or muscular gubernaculum ; but if this is not the case, there is nothing whatever in the anatomy of its cremaster from which to assume the existence of such a structure in the human embryo. Its cremaster must be considered as essentially similar to that of the human subject, though incidentally kept usually drawn up into the abdomen. As to its function, it probably indeed acts as a gubernaculum to bring down the testes to the internal abdominal ring when above it, but it is equally adapted for compressing that organ or elevating it when it is outside the ring.

Cremaster  
of rabbit  
gives no  
support to  
Weber.

The cremasters of the rodentia are referred to by a number of authors, and, among others, Weber appeals to the anatomy of these animals in support of his peculiar views. "In no class of animals," he says, "is the process of the descent better observed than in the rodentia, *e. g.* the hare and rabbit, but especially the beaver." Of these let us take the rabbit for an example. What has just been said



of the hedgehog as to the impropriety of considering it as presenting an example of an ascending cremaster in the adult condition, applies equally here. Neither can the cylindrical space formed by the inversion of the cremaster be considered as a sac, nor can any analogy be drawn from it to support the idea of such a sac as Weber describes in the human subject. We have here no real sac-like structure, but only the space in the cellular tissue, which must result of mechanical necessity, from pulling the processus vaginalis outside-in, and forming a pit where there had been a projection. In structure and development the cremaster of the rabbit is altogether different from the human cremaster. It is composed of two distinct sets of fibres, besides some fibres of the external oblique, which are lost on the front of the pouch of the testis. One set is continuous with the internal oblique muscle, whose fibres arising from Poupart's ligament and the pubis, pass inwards and downwards on the pouch of the testis. The fibres from the pubis are strongest, and pass downwards on the posterior aspect of the pouch. The other set of fibres diverge from a vertical line on the back of the pouch, and embrace it—some passing upwards and inwards, some upwards and outwards, so as to make a penniform muscle. This set is deficient above. A band of the inner fibres joins a band from the cremaster of the other side in front of the pubis, and, with some fibrous tissue, forms a commissure (Pl. II., fig 4). The action of the longitudinal fibres will draw the processus vaginalis to the inguinal ring, and the circular ones will either push the testis into the bottom of the processus vaginalis or extrude it from it, according to its position, and whether the superior or inferior fibres act. If the testis be beyond the abdominal ring, and the walls of the abdomen and the cremasters all contracted, the testis will be powerfully compressed. Thus the cremaster is as much adapted for

Its anatomy  
peculiar.

Its functions  
cremasteric.



the ordinary function of cremasters as for a gubernacular action.

Anatomy  
peculiar in  
foetal rabbits.

In foetal rabbits between two and three inches long, the external oblique aponeurosis passes down over the inguinal ring, like a ligament to the side of the penis. Beneath this the internal oblique is seen reflected upwards, except at the outer side, in a hollow cylinder, which reaches some little distance and is continued by an impervious plica gubernatrix to the testicle. The fibres on the outer side continue their course downwards with some fibres issuing from the inguinal ring (Pl. III., fig. 4). Thus not only the structure of the cremaster, but the anatomy of the descent of the testis, differs greatly in the rabbit from that of the human subject.

Process. vagin. supposed  
to grow by  
eversion  
of plica.

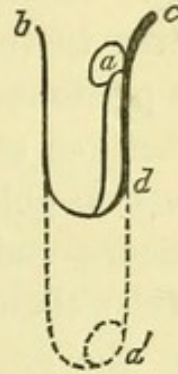
But there is another point in which the descent in the human foetus has been compared with what occurs in the adult rabbit, viz., in the supposed prolongation of the processus vaginalis by eversion; and this brings us to the next topic which we propose taking up—The manner in which the processus vaginalis is prolonged. It has been generally believed by those who have held the opinion of the cremaster ascending to the testis, that the processus vaginalis is lengthened by the eversion of the plica gubernatrix, just as the finger of a glove turned in upon itself is pushed out again. By this eversion they account at the same time for the prolongation of the process, and for the testis reaching the bottom of it. If, however, the plica gubernatrix only involves the innermost layer of peritoneum, such an eversion of the plica and elongation of the processus vaginalis becomes impossible. Independently of this, and supposing the parts to be as these authors describe them, it is by no means so easy to conceive of the eversion in the human foetus as in the rodentia. In the latter the testis is attached by a very broad mesorchium, so that the operation can take place

Eversion of  
plica impos-  
sible.



quite simply as they describe, and the mesorchium alone has to accommodate itself to the change. But in the human subject the mesorchium is quite short, and the testicle adheres to the posterior wall of the processus vaginalis, so that the only sort of eversion which could take place would be as follows. The peritoneum, *a*, covering the testis, would travel to *a'* without any growth of the peritoneum which lies between *a* and *b*; whereas the peritoneum between *a* and *c* would have to lengthen itself to such an extent as to fill the whole space from *c* to *a'*. Thus the proceeding would be very different from what happens periodically in the rodentia.

Consequences of the supposition awkward



If, as we wish to show, the plica disappears, not by eversion, but by contraction, there is still necessity for a growth behind which is not required in front, but to a less extent, namely, from *c* to *d*, and only in the track of the contracting plica. The puckerings in the peritoneum, as observed in the calf when the testicle nears its destination, correspond with what is to be expected from this contraction—that is to say, they are directed from the lower end of the plica, spreading upwards on each side of it. Moreover, as the testicle descends, the plica, formerly plump and full, assumes a shrivelled appearance, as of a body undergoing atrophy.

Plica contracts.

There is little left to say at this stage upon the causes operating to bring down the testes. If muscular action has any influence, it is only at an early stage, and by means of the fibres which we have described ascending on the surface of the gubernaculum. Perhaps these fibres have their existence as much as representatives of the fibres which ascend in like manner in the round ligament of the female, as for aiding in the descent; just as the canal of Nuck seems to exist in the female rather as the represen-

Descent of testes effected,

not by muscular fibres,

which are probably mere homologues of female structures,



but by vital  
process.

tative of the processus vaginalis in the male than for any important function, or as the sinus poculosa appears to be present in the male merely as representative of the uterus. The descent of the testes to the scrotum is independent of mechanical action, and is similar to the previous descent from below the kidneys to the internal abdominal ring. It is marked by the atrophy of the plica gubernatrix in front of the descending organ, and growth of the peritoneum behind it; but that the plica, or other structures of the gubernaculum, exercise a mechanical effect in pulling it down, there is no reason to suppose. Pancera and Lobstein attributed some influence to the cellular tissue of the scrotum, and the former considered that the expulsion through the abdominal ring was only accomplished at birth by the compression then exerted on the child, by commencing respiration, and by abdominal pressure. This, however, was an error, as it is quite certain that the testes usually reach the scrotum before birth.

*Summary.*

Gubernaculum has two parts—

a peritoneal process, and a fusion of parietes.

In conclusion, the sum of the structure of the gubernaculum is this: It consists of two essentially distinct parts; *firstly*, the structure descending in advance of the testis—viz., the processus vaginalis and its plica gubernatrix; and, *secondly*, a fusion of the parts forming the wall of the abdomen,—fibres passing downwards from the peritoneum, upwards and downwards from the internal oblique muscle and the aponeurosis of the external oblique, and upwards from the fascia and integument. The first portion pushes its way down through the second, and disperses it, and afterwards, as the plica gubernatrix contracts, the testicle reaches the bottom of the scrotum.



## APPENDIX.

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### ON THE OBJECT OF THE DESCENT OF THE TESTES.

No one can study the structures which we have been considering, without the question frequently occurring to him, For what purpose is all this? What is the object of the descent of the testes from the abdomen, for which so many complicated provisions have been prepared? And if we turn to pathology, and observe how many maladies are favoured by it; how, on the one hand, it weakens the abdominal wall, forming the most frequent passage for hernia, and, on the other hand, exposes the testis itself and its coverings to injury, and thus multiplies the causes of orchitis, and opens the way for hydrocele and scrotal diseases, we must feel sure that the object gained is an important one; and this, even although experience has shown that the retention of the testes in the abdomen is quite compatible with virility. This latter circumstance only makes the matter look more inexplicable. So unaccountable, indeed, has it appeared to be, that not a shadow of an explanation has been offered, save the general statement, that the pendulous position favours the flow of blood to the part, and that an abundant supply of slowly moving blood is required in an organ whose secretion is so elaborate. In venturing a few remarks on a subject on which so little is written, we only seek to assemble the facts at our disposal, and see what can be arrived at by their aid.

The normal position of the testes in the vertebrata is within the abdomen. In fishes, reptiles, and birds, they are so placed, and in some mammals. Man is the only animal in which the tunica vaginalis is closed so as completely to separate them from the abdominal cavity; and in him this peculiarity, after the taking place of the descent, is sufficiently accounted for by his erect posture. In all mammals they are originally developed in the abdomen; and in the females of those species in which they descend, the corresponding organ—the ovary—remains in the abdomen through life. It is plain, therefore, that the explanation of the descent is not to be sought in morphological but in functional considerations.



The principal functional peculiarities of the testicle are these :— That it prepares a secretion the most complicated of the body, in respect of structure, function, development, and the length of tube it has to travel ; and that its secretion is rapidly discharged at uncertain periods.

Let us now look at the anatomical peculiarities. Besides its pendent position, for which we seek an explanation, we have to notice that it is the most complicated gland in the body ; that notwithstanding the manner in which its secretion is expelled, there is no reservoir for its accumulation ; that it is contained in a space limited by an unusually dense capsule—the tunica albuginea ; and that it is surrounded by contractile structures,—viz., the cremaster and dartos—capable of elevating and also of compressing it, especially when the abdominal muscles are contracted so as to offer a firm resistance to it when pressed against them ; and, *thirdly*, the organic muscular coat described by Kölliker, which is calculated particularly to compress the vessels.

It is also supplied with very remarkable bloodvessels. The artery has a very long course before it reaches the organ it is destined to supply ; and an extraordinary circumstance is that it increases in diameter as it proceeds. In addition to this, it is usually much convoluted, if not in the trunk at least in the ramifications. In the bull and ram the convolution of the trunk of the artery is carried to such an extent that it forms a large tumor, like a coiled rope, on the superior extremity of the testis ; and in these animals we may notice that the testes are likewise very large, very minutely tubulated, and very pendulous. In the hare the spermatic artery splits up into several branches before reaching the testis, all larger than the parent trunk. The spermatic veins are large, flexuous, and numerous. They are so much so in the human subject that they are called *vasæ pampiniformæ*, and are also particularly inclined to varix.

The abundance and tortuosity of the veins, and the increasing diameter of the artery, give, as Sir Astley Cooper<sup>1</sup> has indicated, a slow and plentiful supply of blood, and protect the organ from sudden violence of the circulation. Now, were it not for the pendent position, the enlarged artery would be always half empty ; but with that position it follows that it is always full. The circulation is made slower by the varicose inclination and imperfect valves of the veins, which must tend to produce accumulation in their lower part, so that the testis will be kept in a slowly-moving bath of blood.

In addition, let us take into consideration the dense nature of the tunica albuginea, with difficulty admitting of any distension. It is evident that its cavity will only admit a certain amount of fluid in it

<sup>1</sup> Sir A. Cooper on the Anatomy and Diseases of the Testicle—Bloodvessels.



at a time, so that if, when the tubules are empty, it is filled with blood by its pendent position, the bloodvessels must in turn be comparatively empty when the seminal tubules are full. This circumstance seems to furnish the key both to the functional and anatomical peculiarities which have been enumerated.

In the first place, it influences the secretion. When the tubules are empty the bloodvessels will be distended, and, consequently, the gland will be in the most favourable circumstances for generating secretion. But as the tubules fill, the blood will be forced out of the cavity of the tunica albuginea, till when they are full the vessels will be empty, and thus, instead of the secretion still going on so as to overflow the gland, matters will be disposed in the manner best fitted to promote absorption. By this means in the healthy state an equilibrium is effected, and the testicle is kept filled with fresh secretion, but not overflowing.

In the second place, the same circumstance of the cavity of the tunica albuginea affording only a limited accommodation for fluid, aids the process of expulsion. When the dartos, cremaster, abdominal walls, and unstriped muscular tunic are all contracted, not only must the general bulk of the testis sustain considerable pressure, but the veins in particular must be compressed. In consequence of this, as the blood is propelled into the capsule of the organ and finds no exit, it distends per force the vessels and expels the contents of the tubules from the cavity of the capsule. By this means, immediately on being evacuated, the gland is left in the condition most favourable for its repletion.

If these views are correct, there is afforded an explanation of the pendent position and peculiar bloodvessels of the testis, and of how the secretion is kept in readiness without overflowing, and is expeditiously expelled without the intervention of a reservoir.

There are some animals which present exception to the general mammalian rule of the descent of the testis, and it is difficult to say why they do so. It may be remarked, that they are generally large animals, and are only in heat at long intervals. Such are the elephant, rhinoceros, cetacea, morse, &c. In the monotremata, likewise, the testes remain in the abdomen, but in their case this is only one of the many points in which these animals differ from the generality of mammalia. A circumstance which struck Cuvier is worthy of notice. "The vasa deferentia,"<sup>1</sup> he writes, "have usually walls, firm and thick, generally of an equal diameter throughout their whole extent, and a direct route without inflections except those necessary for arriving at their destination. But in all these respects there are found remarkable exceptions; their walls have seemed to us much less thick and less consistent in the animals whose testicles never leave the abdomen, such as the

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<sup>1</sup> Cuvier, *Leçons d'Anatomie Comparée*, t. v., p. 20. *Génération, Org. Prep. Males.*



ant-eaters, the echidna, the elephant, the porpoise, and the dolphin, &c., than in those which have these organs constantly or momentarily outside the same cavity. In the first case, they have besides a course extremely flexuous in part of their extent. Those of the elephant, for example, form a very great number of sinuosities and inflections in the part which passes along the superior aspect of the bladder to its neck. Those of the echidna continue very flexuous till near the place where they commence and the epididymis ends. They are indeed less flexuous in the dolphins,—this disposition is still found however very remarkably in them. They are found equally flexuous in the daman and ant-eaters.” The comparative thinness of the walls of the vasa deferentia in these animals is explicable by taking into consideration that the circumstance here no longer exists which calls for a tube of the firm cartilaginous consistence found in animals with the testes pendent. The induration of the tube in these latter is to support in its ascent a perpendicular column of fluid; but in the former the column is not perpendicular. The convolution of the vas deferens would seem to show that the greater part of the secretion expelled has previously gathered in it, from which we may gather that in these animals of great size, or of the lower types, the secretion is less delicate than in other mammals, since it does not require to be kept in such immediate contact with the secreting membrane. The presence of a reservoir, and the less delicacy of the secretion are probably reasons why the descent does not take place in these animals.

The animals in which the descent is only temporary are of a very different description,—the rodentia, bats, hedgehogs, &c. They are mostly animals prolific, and with testicles comparatively large. Perhaps the object is to secure more perfect repose for these organs between the ruts. Their functional activity is intermittent, to compensate perhaps for its being, when they are in action, so great as is indicated by their large volume.



## EXPLANATION OF ILLUSTRATIONS.

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I. Fig. 1, Dissection II. of the description. *a*, Testis; *b*, Vas deferens; *c*, Processus vaginalis slit open; *d*, Plica gubernatrix; *e*, The cavity described by Weber as a shut sac; *f*, Fibres inserted inferiorly in a bundle into the scrotum, and superiorly into the abdominal wall; *g*, Fibres from the same bundle which ascend to the bulbous process, which contains the processus vaginalis; *h*, Internal oblique muscle; *i*, Aponeurosis of the external oblique muscle; *k*, Integument reflected down.

Fig. 2, Dissection III. of the description. *a*, Testis; *b*, The serous or true layer of peritoneum reflected over the testis; *c*, Superficial layer of peritoneum; *d*, Fibres ascending in the process formed by this superficial layer; *e*, Plica gubernatrix; *f*, Junction of the epididymis and vas deferens; *g*, Bladder; *hh*, Internal oblique and transversalis muscles cut across and turned aside; *i*, Muscular fibres ascending to be inserted in the superficial layer of peritoneum; *k*, External oblique aponeurosis.

Fig. 3, Dissection V. of the description. *a*, Testis; *b*, Serous layer of peritoneum forming the processus vaginalis separated from the adjoining tissues; *c*, *d*, Superficial fibrous layers of peritoneum; *e*, Tissue which had occupied the plica gubernatrix; *f*, Pouch-like cavity between the layers of peritoneum; *g*, Fascia transversalis; *h*, Transversalis muscle; *i*, Internal oblique muscle; *k*, Aponeurosis of the external oblique muscle; *l*, Integument; *mm*, Conjoined portion of the internal oblique and transversalis muscles cut across and reflected; *nn*, Muscular fibres ascending on the gubernaculum; *o*, Looped muscular fibres on the front of the gubernaculum.

II. Fig 1, Superficial stage of Dissection VI. *a*, Aponeurosis of the external oblique muscle; *b*, Bulbous process which contains the processus vaginalis; *c*, Sort of pouch formed by the intermixture of fibres from the fascia, and aponeurosis of the external oblique muscle; *d*, Fascia reflected.

Fig. 2, Dissection VII. *a*, Processus vaginalis; *b*, Muscular fibres ascending toward the testis; *c*, Fibrous prolongation of the peritoneum; *d*, Internal oblique muscle; *e*, Trace of a hollow space; *f*, Aponeurosis of the external oblique muscle sending fibres up into the gubernaculum.

Fig. 3, Round ligament of the uterus in a human fœtus during the fifth month. *a*, Aponeurosis of the external oblique muscle; *b*, Fibres passing from the labium to the aponeurosis of the external oblique; *c*, Fibres passing from the labium toward the uterus; *d*, Internal oblique muscle cut across; *e*, Muscular fibres from the internal oblique muscle given off to the round



ligament; *f*, Fibres of the round ligament lost in the peritoneum; *g*, Fibres passing on to the uterus.

Fig. 4, Cremaster muscles of the rabbit. *a*, External oblique muscle sending down some fibres on front of the cremasteric pouch; *b*, Cremasteric fibres from the internal oblique muscle; *c*, Penniform fibres of the cremaster; *d*, commissural fibres.

IV. Fig. 1, *a*, Kidneys; *b*, Suprarenal capsules; *c*, Testes; *d*, Wolffian body; *e*, Duct of Wolffian body; *f*, Müllerian duct ending in *g*, a tubular mass, the future coni vasculosi; *h*, Commencing spermatic artery; *i*, Ureters; *k*, Urachus.

Fig. 2, *aa*, Testes; *bb*, Masses composing the coni vasculosi; the left side shows some of the individual tubes joining the epididymis; *cc*, Remains of the Wolffian bodies; *dd*, Spermatic arteries; *ee*, Junction point of epididymis and vas deferens; *f*, Abrupt cord joining the testis and coni vasculosi, and becoming split into the vasa efferentia; *gg*, Upper part of the plica gubernatrix between the testis and epididymis; *h*, Main part of the plica gubernatrix, occupying the processus vaginalis, which is slit open to show it—the fibres of the cremaster shine through the processus vaginalis; *i*, Entrance of the processus vaginalis; *k*, Urachus.

Fig. 3, Dissection of a foetal rabbit one inch long. *a*, Kidneys; *b*, Urachus; *cc*, Wolffian bodies; *dd*, Müllerian ducts; *e*, Generative glands, testes or ovaries; *ff*, Elevation of the peritoneum between the generative glands and the point of the Müllerian duct where, in the male, the epididymis ends and the vas deferens begins; *gg*, Continuation of the preceding elevation to the groin.

Fig. 4, Dissection of a foetal rabbit between two and three inches long. *a*, Testis; *b*, Remains of the Wolffian body; *c*, Vas deferens; *d*, Plica gubernatrix; *e*, External oblique muscle; *f*, Internal oblique muscle; *gg*, Fibres from the internal oblique muscle passing down with fibres issuing from the abdominal ring to the pubis; *h*, Fibres from the internal oblique muscle ascending to the impervious part of the plica gubernatrix.



Fig. 2.

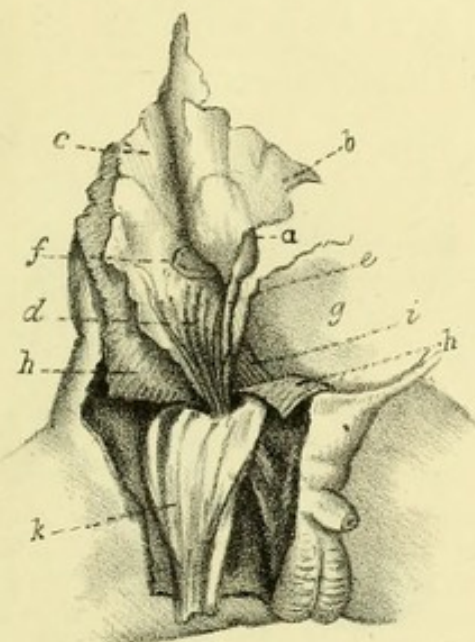


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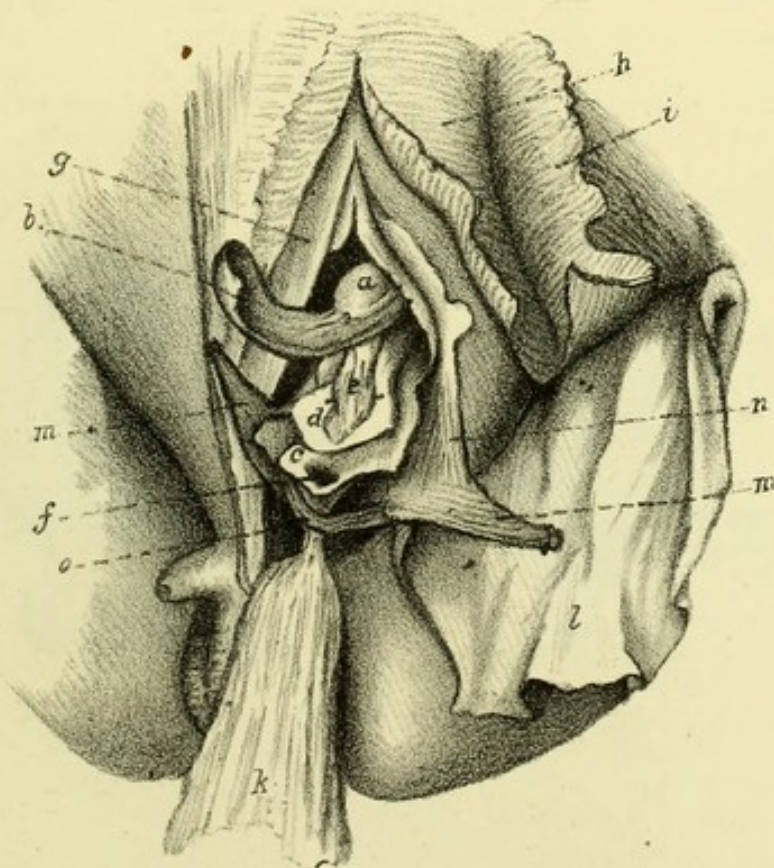
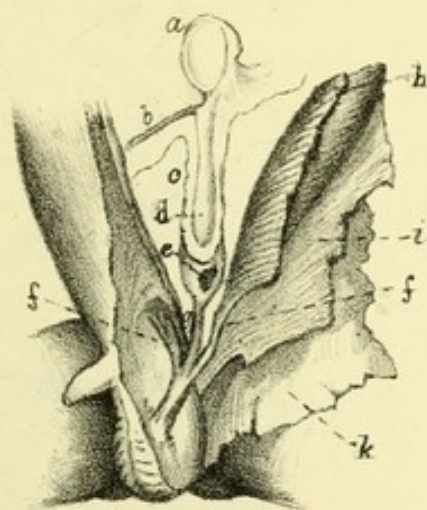


Fig. 3.







Fig. 1.

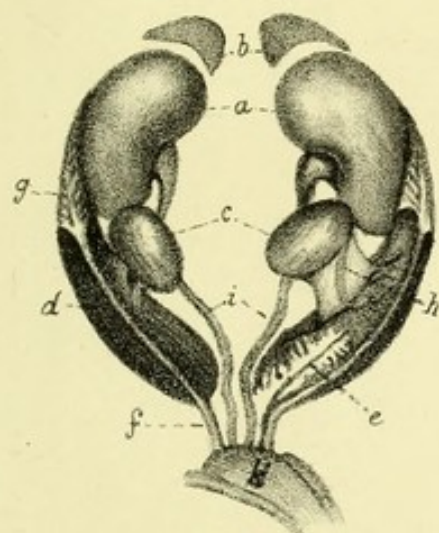


Fig. 2.

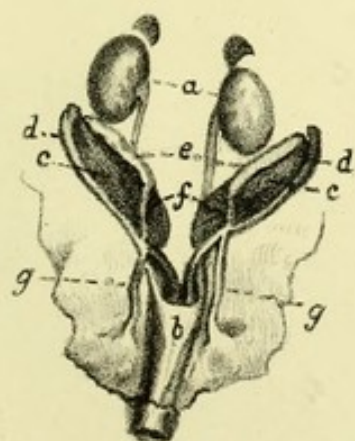
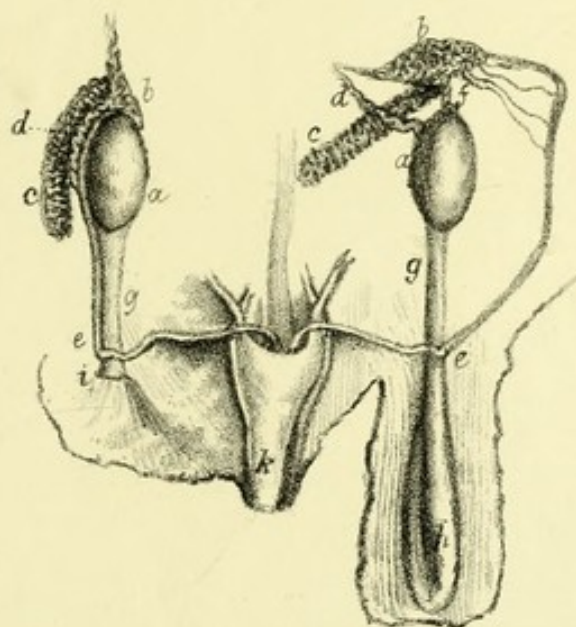


Fig. 3.

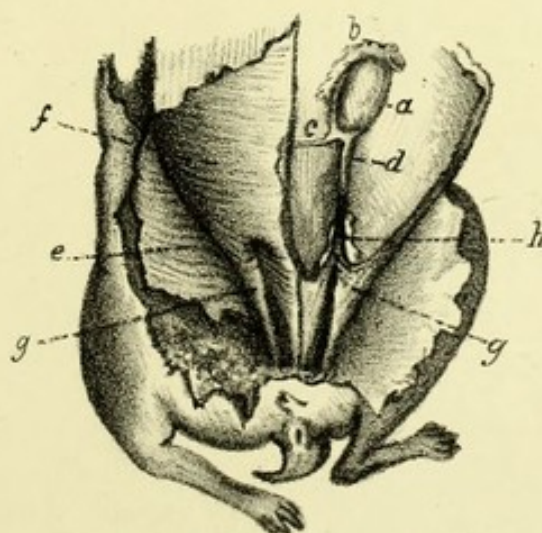


Fig. 4.



