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THE SEMINAL VESICLES

ANATOMY, COMPARATIVE ANATOMY AND DEVELOPMENT.

BY

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INTRODUCTION.

There are many reasons which induced me to choose this subject for a thesis. I would like to mention only the most important one.

Between 1942 and 1945, while in the South African Medical Corps, I was posted to the Wynberg Military Hospital. During this time I was closely associated with the urological service of the hospital.

It struck me very forcibly how many soldiers were off duty on account of a genito-urinary complaint. In the majority of these the diagnosis was prostatovesiculitis; and it must be stressed, as it has been done by many others, that an infection with the gonococcus was the exciting cause in no more than one half the number of cases. I formed the opinion that more soldiers were off duty on account of prostatovesiculitis than for any other single disease. Quite a number of them remained the best part of a year in hospital.

I had the good fortune to become well-acquainted with this clinical entity. The diagnosis, management and treatment of these cases requires patience and expert training. Except in the mildest cases the treatment is very protracted. In some of them the condition remains baffling and the results are disappointing. Signs and symptoms may be referred to nearly all parts of the body, and severe neurasthenia is the inevitable result, unless the focus of disease is

adequately dealt with.

It has been suggested by numerous authorities that most of the trouble in prostato-vesiculitis, emanates from the infection in the seminal vesicle; that in fact the vesiculitis forms the basis of what has for many years been called "prostatic rheumatism".

To this purpose then, I determined to find out what I could about the seminal vesicles. It seemed essential to me that a good knowledge of the structure and function of these glands must precede any serious attempt to understand its pathology.

The material available for this study came from various sources. I used twelve cadavers whose ages ranged between 8 years and 70 years. When the students in ^{the} anatomy dissection room had completed that part, I removed the seminal vesicles from their 16 cadavers. I collected 12 fetuses of various ages. I recovered the bladder, rectum and accessory glands from 15 autopsy cases. I attended 6 official judicial hangings and these six cases offered an exceptionally good opportunity to study the structure and function of these glands. In all there were then 61 specimens. Only six of these were from Europeans, the rest being mainly natives.

The subject will be discussed under the following chapters :-

- (1) BRIEF HISTORICAL REVIEW.
- (2) ANATOMY.
- (3) EMBRYOLOGICAL DEVELOPMENT.
- (4) COMPARATIVE ANATOMY.

HISTORICAL REVIEW OF THE ACCESSORY
GENITAL GLANDS.

There is but scant reference made to the accessory genital glands in medical history. Only one pair is associated with a personal name, viz: Cowper's glands. The fact that these are small and hidden in the muscular meshes of the urogenital diaphragm, accounts for this. Anatomical structures are as a rule associated with the names of their discoverers only when their description and recognition is relatively recent. The ancient anatomists often overlooked structures which in later days were recognised because of their functional importance and by superior methods of investigation. This in no way implies ^{any} discredit to those early pioneers, but for whom there would have been no basis on which to work. On the contrary one is amazed at the accuracy and the detail which they provided, when one bears in mind the difficulties they had. These men were often taken to the stake for expressing views based on direct observation when such views were at variance with the accepted teachings, and especially those of the Church.

We must take it though that the earliest anatomists described the genital system and the accessory glands. There is no proof to the contrary; certain it is that from earliest days there was sufficient interest taken in the genital system. Hippocrates, who lived three centuries before Christ, makes reference to such matters. He was a very keen observer and a student of nature. His "Aphorisms" are classic; and to this day physicians speak of the "Facies Hippocratica", so typically seen in certain acute febrile diseases.

I would like to quote his 28th and 30th paragraphs in Section IV of his Aphorisms :-

"Eunuchs do not take gout, nor become bald"

"A young man does not take gout, until he takes coition".

These quotations have a large measure of truth in the light of our present day knowledge. "Prostatic rheumatism" is a well known clinical entity, and many authorities maintain that the majority of prostatic infections follow venereal infection. Certain it is that infections in either the prostate or the seminal vesicles are often associated with very marked and painful joint lesions. In the time of Hippocrates all such afflictions were probably called gout.

Hippocrates never had the privilege of doing human dissection. He, and another profound thinker of a century later, the celebrated Aristotle, inferred their human anatomy from animal anatomy. Aristotle also wrote the first book on Embryology, and based his work on observations of the developing chick embryo. His work was not improved upon for 2000 years !

It was for the school at Alexandria to lay the foundation stones of human anatomy. Here in the third century B.C. Erasistratus and Herophilus did human dissections. Their original writings are lost, and we only have references of their work from later scientists, notably Galen (130-201 A.D.) This voluminous writer influenced the scientific and medical mind for many centuries. During the bleak period of the Dark Ages, medicine was kept alive by the Arabians, and with the Renaissance in Europe came daring men who challenged Galen's fictitious postulates and placed anatomy and all scientific investigations on a sound basis once more. It now became necessary to see before one believed.

Outstanding amongst these earliest anatomists are the names of Mondino de Lucci; (1275 - 1326), Leonardo da Vinci; (1452 - 1519), and Andreas Vesalius; (1514 - 1564) They drew up the first anatomy text books; and basing their work on direct observation at dissections of the human body,

it is quite certain that the accessory genital glands were described. Names for anatomic structure were in Latin and given to describe the position or supposed function.

In this way the prostate (prostata) was so called probably because it lay partly in front of the urethra - a typically human state of affairs, and found in no other primates and very seldom in other animals. It is also claimed that the name arises from the fact that the prostate lies in front of the seminal vesicles. The "vesica seminalis" designated that the function of these paired organs was as a reservoir for semen. A flood of controversy has descended on this concept and will be fully discussed later. The bulbo-urethral glands were described by William Cowper in 1699. Actually these were independently described in France by Méry in 1685. These glands are called Cowper's glands in common international usage. Such mistakes in priority of nomenclature are a very common occurrence in medicine.

There are other glands which can be classed as accessory to the genital tract. They are para-urethral glands, and associated with the names of Littré and Albarran. These will be considered in more detail in a later chapter.

Finally it will be fitting to mention a few historical facts about the spermatozoa, which are the ultimate essential elements in the male share of reproduction. The general function of the prostate, seminal vesicles and other sex glands is directed in the well-being of the spermatozoa.

In 1677, Ham, a student of the celebrated Van Leeuwenhoek, for the first time saw and described human spermatozoa. They were regarded as tiny animals because of their active movement. Their name indicates this idea and was coined by Von Baer, who also laid the foundations of modern Embryology. It was only in 1841 that Kölliker demonstrated that these "animals" were nothing of the sort and arose by a

process of spermatogenesis in the testes. Meanwhile the mammalian ovum had been recognised (1827), but it was not until 1875 that Oskar Hertwig proved that reproduction followed a process of fertilization of the ovum by one spermatozoon.

A N A T O M Y .

The seminal vesicles are essentially male glands, which, together with the prostate and bulbo-urethral glands, constitute the accessory sex glands in the male. These glands together produce a secretion which is vital to the proper function of the spermatozoa.

The seminal vesicles are a pair of lobulated sacs which lie on the dorsal aspect of the base of the bladder. The ampullae of the vasa deferentia lie between them. Behind them lies the second part of the rectum. They are separated from the side wall of the pelvis by a sheath of veins embedded in dense fascia. Above, they reach beyond the point of entrance of the ureters into the bladder, lying lateral to this point on each side. Below, they converge on to the median lobe of the prostate. The seminal vesicles, together with the ampullae, are enclosed in a fascial compartment, which holds these organs closely applied to the bladder.

The seminal vesicles drain their secretion, together with that of the ampullae of the vasa deferentia, into the prostatic urethra. This is effected by means of a common duct (ejaculatory) for the ampulla and vesicle of each side.

The seminal vesicles are no where attached to a fixed point. They are firmly adherent to the prostate, but this gland is capable of a small amount of up and down movement. The position of the vesicles then is dependent on the state of distension or otherwise, of the bladder and rectum, which also affects (but to a less extent) the position of the prostate.

In this and the following description of the anatomy of the seminal vesicles, it is assumed that the body is in the erect posture. This is the usual anatomic position. The bladder will thus be anterior, and the rectum, posterior to these organs. The base of the prostate will be below or inferior, and the recto-vesical peritoneal fossa will be above, or superior. It is also essential to know that the pelvis is tilted forward when the person stands in the erect position. A horizontal line through the tip of the coccyx will pass through the centre of the symphysis pubis. A vertical line dropped from the promontory of the sacrum will just miss the posterior margin of the symphysis pubis. The symphysis pubis and the urogenital diaphragm lie almost horizontally. It is important to bear these basic relations in mind.

A description of the anatomy of these glands, necessarily includes some reference to the surrounding structures. These will form the relations. The seminal vesicles belong to a group of accessory reproductive glands. The prostate and Cowper's glands will thus have to be described. The function of the seminal vesicles, too, will have to be considered, and this will evolve a description of the sphincter mechanism of the bladder.

The Anatomy thus covers a group of aspects which will best be discussed under separate headings :-

- (A) The Seminal Vesicles.
- (B) The Relations.
- (C) The Function.

Under (A) will be considered :-

- (1) Shape.
- (2) Size.
- (3) Structure.
- (4) Capsule.
- (5) Ejaculatory Ducts.
- (6) Blood and Lymph Supply.
- (7) Nerve Supply.

Under (B) will be considered :-

- (8) Ampulla of Vas Deferens.
- (9) Prostate.
- (10) The Bladder.
- (11) Pelvic Wall and Fascia.
- (12) Peritoneum.
- (13) Rectum.
- (14) Surgical Approaches.

Under (C) will be considered :-

- (15) Seminal Fluid.
- (16) Spermatozoa.
- (17) Ejaculation.
- (18) The Mechanism of Micturition and Ejaculation.
- (19) Summary.
- (20) Radiological Examination of Seminal Vesicles.

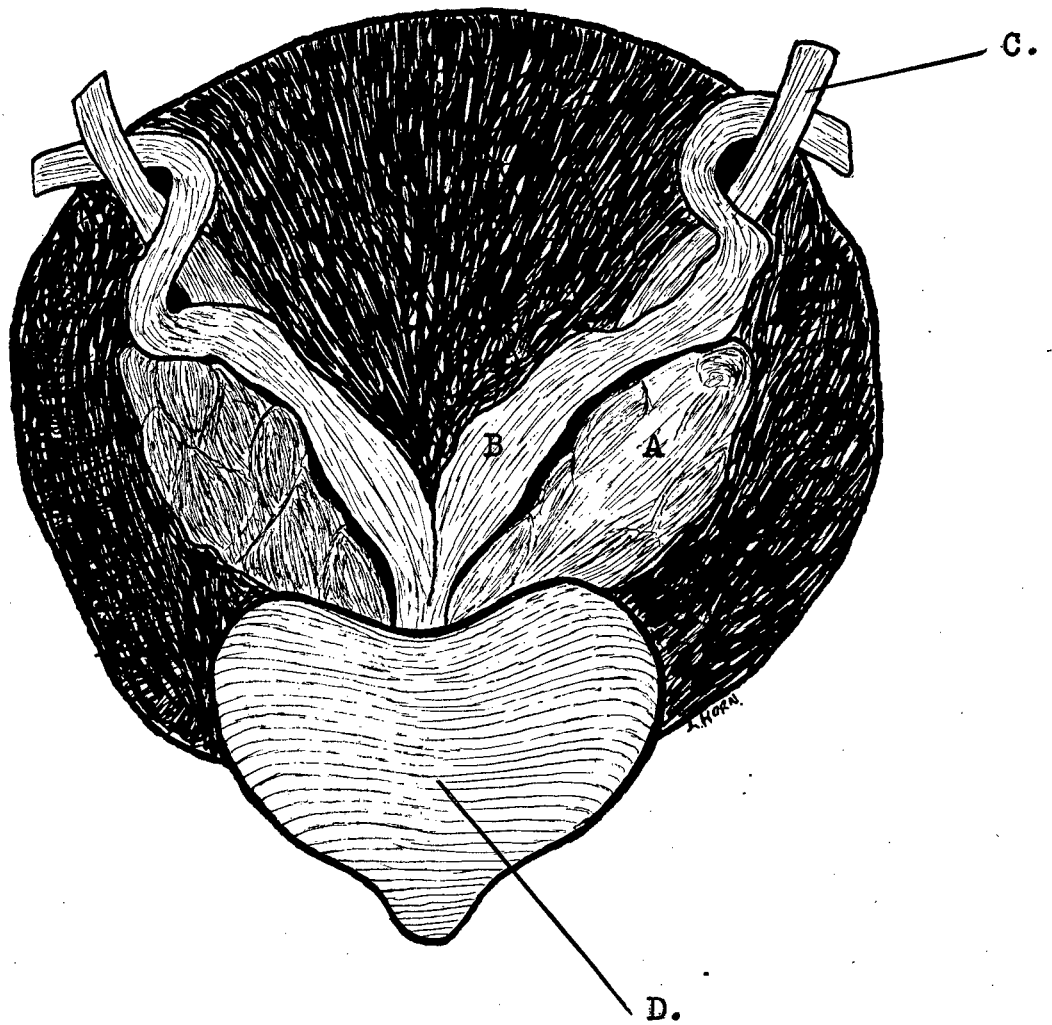


FIG. 1. DORSAL ASPECT OF BLADDER.

The arrangement of the seminal vesicles, ampullae and terminal ends of the ureters is shown.

- A. Seminal Vesicle,
- B. Ampulla of Vas Deferens,
- C. Ureter,
- D. Rectal Aspect of the Prostate.

(From Gray's Anatomy).

S H A P E .

The seminal vesicles are bilaterally symmetrical organs. If a peculiarity of shape or size exists on one side, it will usually be reduplicated on the other side. Very rarely is a seminal vesicle congenitally absent on one side. In these few cases there is also an absence of the kidney on the same side and the congenital fault is a failure of the development of one mesonephric duct. Very occasionally there are small differences in either size or configuration on the two sides. McMahon (27) 1938 reported one case of complete reduplication of a seminal vesicle on one side.

The shape of each seminal vesicle is roughly ovoid. The widest part is most commonly in the middle. Sometimes the widest part may be at the apex or even in some few cases, near the base. Many anatomy books describe the vesicles as being typically pyramidal in shape; in other words, the apex shows the widest girth. From the specimens which I examined, I cannot agree with this observation. Of the specimens which I examined, most of them were widest in the middle part of the gland.

The seminal vesicles have a lobulated external appearance. Each organ consists of a coiled and convoluted tube. The lumen shows irregular constrictions and areas of dilatation. There are numerous diverticuli and ramifications from the main lumen which add to the complexity of the internal structure. If the organ is cut across lengthwise, it is impossible to follow the lumen from base to apex. When the gland is cut through transversely, it looks as if there are 3 or 4 lumina. In such a section it is also seen that the seminal vesicle is almost completely round.

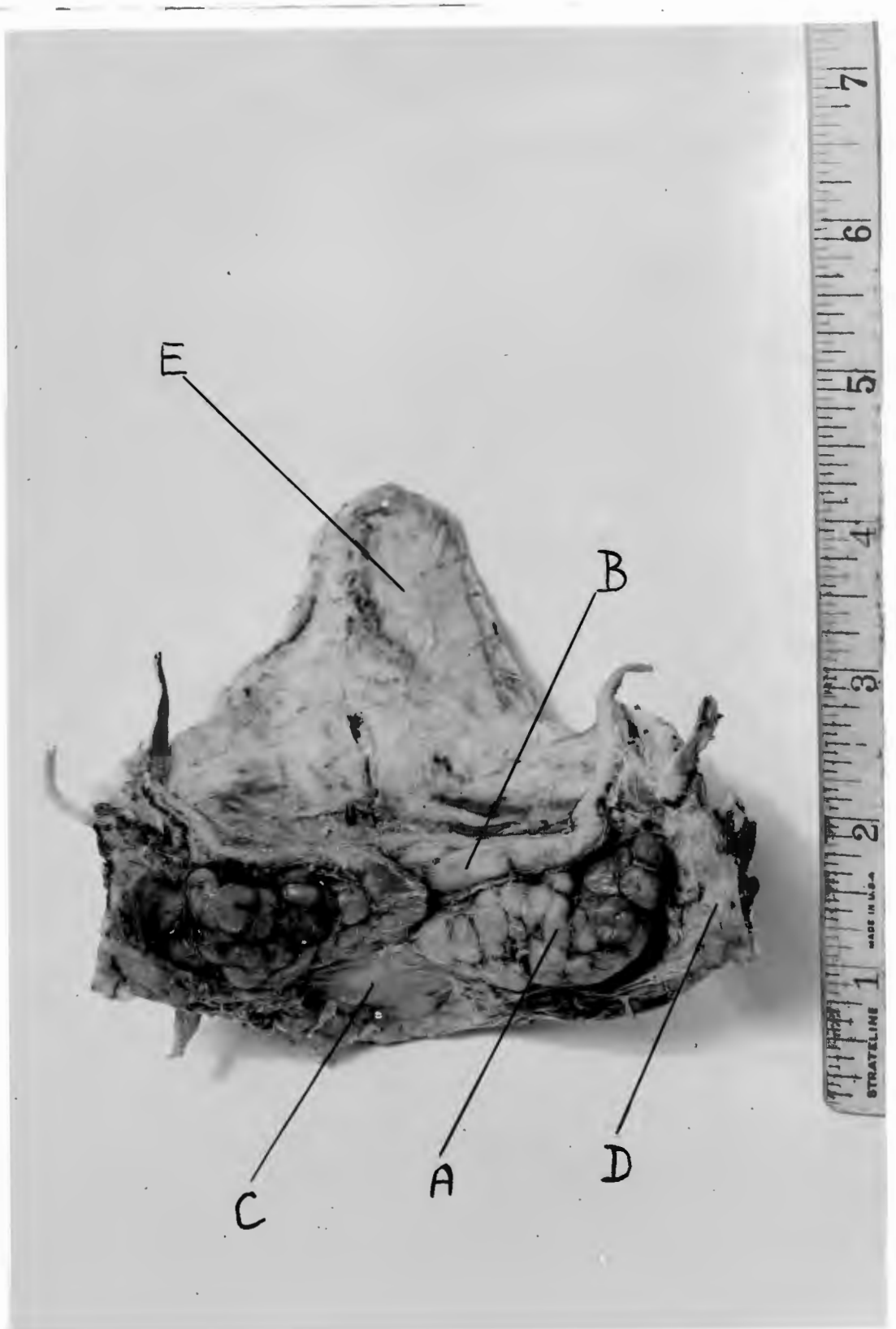


FIG. 2 SEMINAL VESICLES IN NORMAL POSITION
9/10ths NATURAL SIZE.

The bladder and prostate are viewed from behind. The dorsal layer of the fascial sheath has been stripped off the ampullae and vesicles.

- A. Right Seminal Vesicle.
- B. Ampulla of Vas Deferens.
- C. Rectal Aspect of Prostate.
- D. The Vesical Venous Plexus and its associated Fascia (post. ligt. of the bladder).
- E. Apex of Bladder.

The tip or apex of the seminal vesicle does not always represent the extreme end of the lumen. In about half the specimens I examined, the terminal portion of the gland was bent on itself. The part which doubled back always lay on the inferior aspect of the gland. Some authorities have described specimens where the gland is so much bent on itself that the tip lies at the base. In none of the specimens I examined was this found.

The base of the seminal vesicle rapidly narrows down to form a short neck. This part leads into a short excretory duct which is joined by the lower end of the vas deferens to form the ejaculatory duct. The ejaculatory duct leads into the posterior urethra and lies between the middle and lateral lobes of the prostate. (See Fig. 16)

S I Z E .

In all the specimens I examined I took measurements of the length and widest girth. In adult males between 20 and 50 years I found the average size to be $1\frac{3}{4}$ inches long by $\frac{6}{10}$ ths of an inch broad. In this age group the largest measured $2\frac{1}{2}$ inches by $\frac{3}{4}$ of an inch. The smallest seminal vesicle I found in a man of 70 years old. It was 1 inch by $\frac{4}{10}$ ths of an inch. These measurements were made on specimens which had been fixed in formalin. They agree with those given in the anatomy text-books.

When the fibrous tissue between the lobules is dissected out and the seminal vesicle is unravelled, the

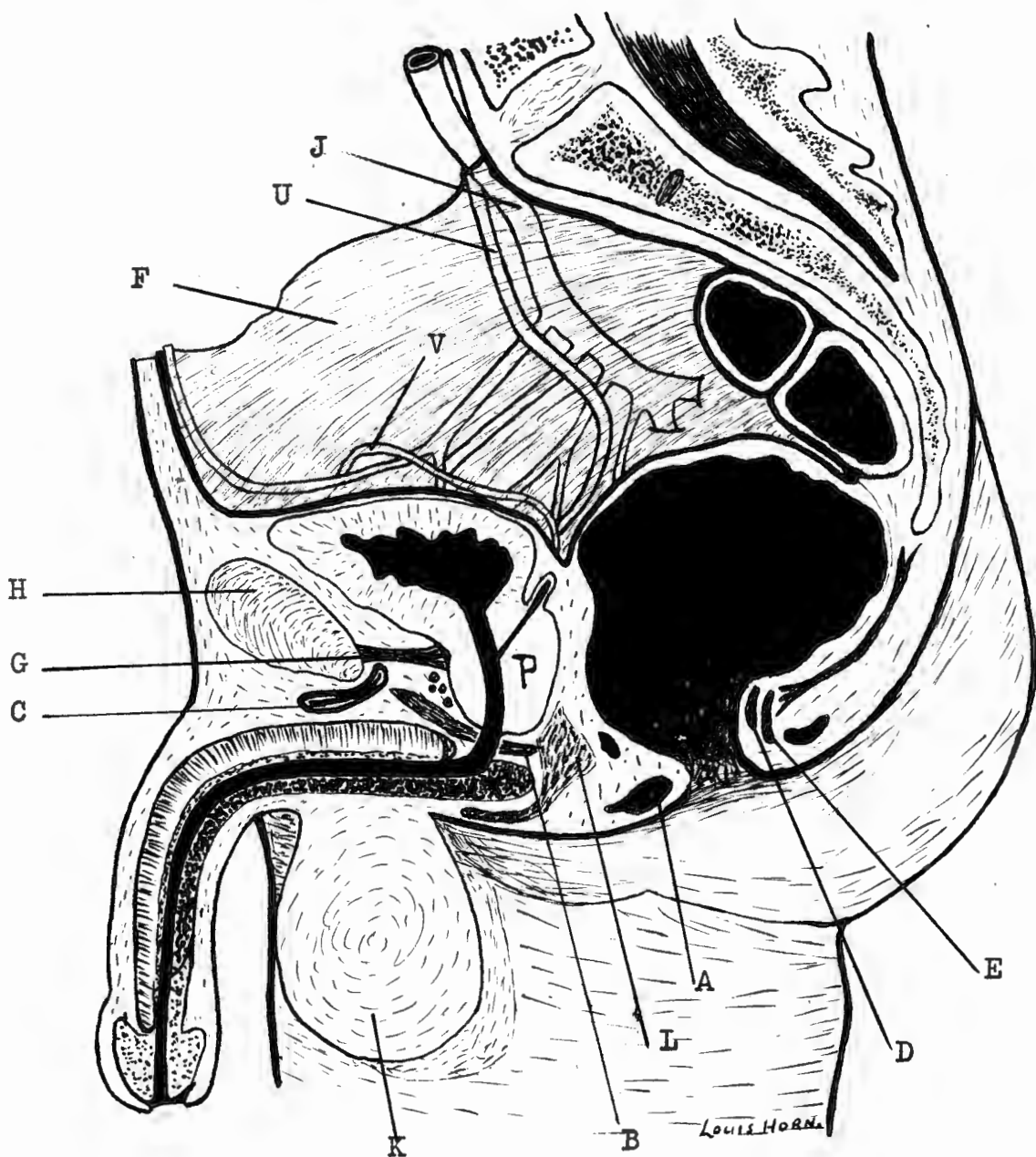


FIG 3 SAGITTAL SECTION THRO THE MALE PELVIS (DIAGRAMMATIC)

It shows the anatomic relation of the prostate gland. The ejaculatory duct passes backwards from the prostatic urethra to the ampulla of the vas. The seminal vesicles and bulbo-urethral glands are not shown in this midline section.

- A. Sphincter ani externus, B. Urogenital diaphragm,
- C. Dorsal vein of the penis, D. Sphincter ani internus.
- E. Insertion of M. levator ani, F. Pelvic Peritoneum,
- G. Pubo-prostatic Ligament and Muscle, H. Symphysis Pubis.
- J. Hypogastric Artery, K. Scrotal Septum,
- L. Central point of Perineum, P. Prostate, U. Ureter,
- V. Vas Deferens.

extent of the ramifications and irregular diverticuli becomes much clearer. The length of the duct system is then increased by 2 or 3 times.

The size of the seminal vesicles varies with the age of the individual. During youth they are relatively small. At puberty they rapidly enlarge, to attain the mature adult size. After the 5th decade they gradually diminish in size and become considerably more fibrous. I believe that there is thus a special growth curve for the seminal vesicles. Unfortunately I did not have sufficient material to demonstrate this growth curve as it should be done. Nevertheless, I have corroborative evidence which very strongly supports such a contention.

The evidence is :-

- (i) Some experimental facts,
- (ii) Analogy with the prostate,
- (iii) Observations on a specimen from a child and an immature baboon.
- (iv) Small size of the vesicles in old men.

(i) Some Experimental Facts.

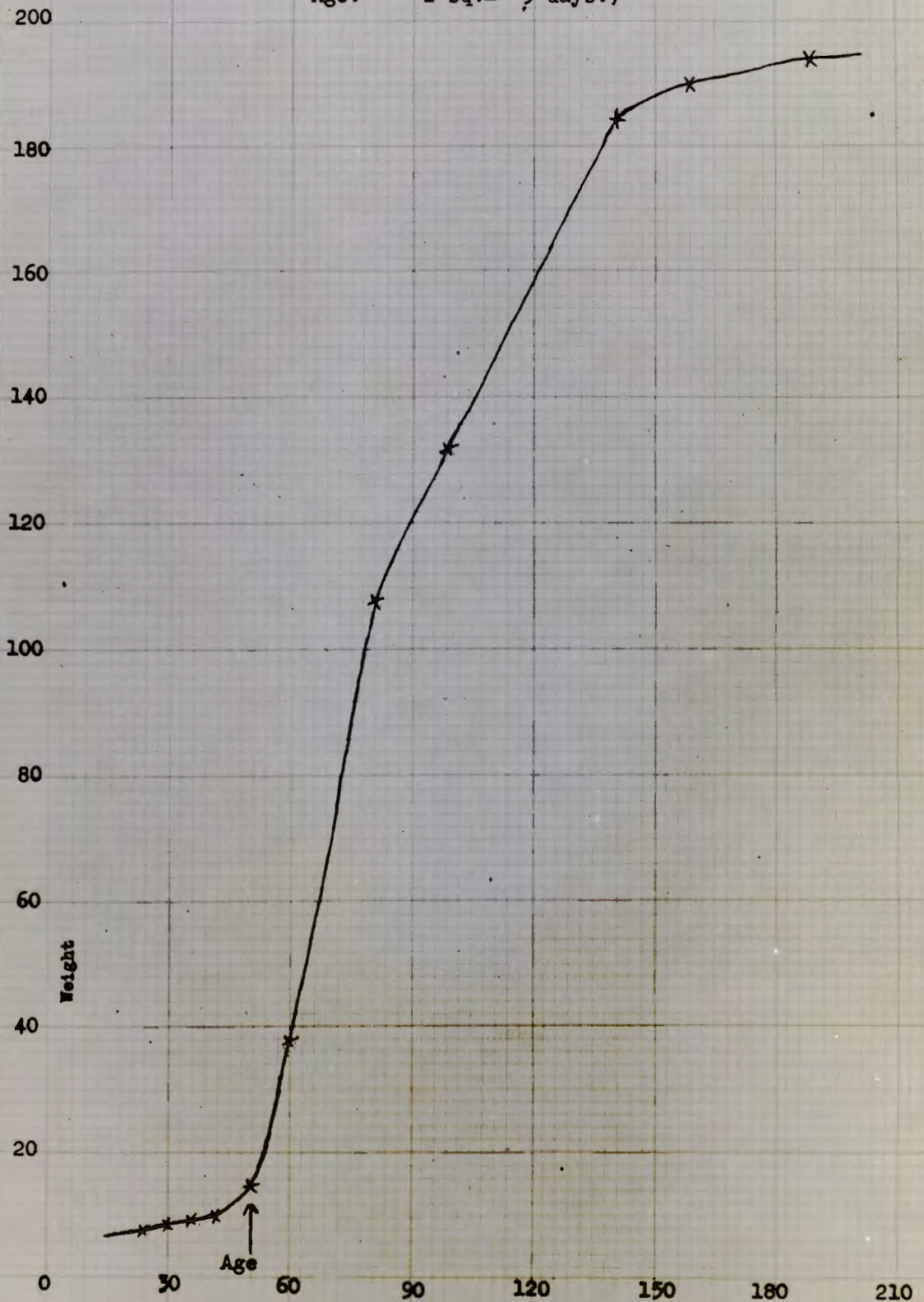
B. J. Meyer, M.Sc., of the Physiology department of the University, Pretoria, happened to be working on spermiogenesis in white rats. In the course of his study he removed and recorded the weights of the seminal vesicles. In his control groups, he was able to show convincingly that the seminal vesicles increase rapidly in size when the animals become sexually mature. A graph is appended to show the growth curve of the seminal vesicles in white rats. (Fig. 4.).

FIG 4

GROWTH CURVE OF THE SEMINAL VESICLES IN
WHITE RAT.

The arrow indicates at which period spermatozoa are found. There is thus a steep rise in the growth curve when the rats become sexually mature (i.e. at 50 days).

(Scale Weight: 1 sq. = 2 mg. (from B.J. Meyer).
Age: 1 sq. = 3 days.)



(ii) Analogy with the Prostate.

G. I. M. Swyer in 1944 published an excellent treatise on the prostate gland. His conclusions were drawn from a large number of specimens examined. He produced a graph to show the normal growth curve in the human prostate. (See Fig. 5.).

(iii) Observations on a specimen from a child and an immature baboon.

Besides a few newly born babies, I was able to get only one specimen in the prepuberal period. This was a native boy of eight. The photograph in Fig. 6 shows the appearance and size of his seminal vesicles. It will be seen that the vesicles are relatively tiny when compared with those of an adult in Fig. 2.

I also obtained a Chacma baboon to dissect. This animal was 3 - 4 years old and must have been close to puberty because his testicles had descended into the scrotum. (This aspect will be fully discussed in a later chapter). Histological sections of his entire genital tract showed that he had not yet formed spermatozoa. For this reason he was thus sexually immature. Fig. 7 shows the appearance of his accessory genitalia. If this appearance is compared with that of a mature baboon in Fig. 54, the marked difference in size and appearance will be noted.

(iv) Small Size of Vesicles in Old Men.

I examined several cadavers whose ages had been between 55 and 70 years. In them the seminal vesicles were small, tough and indurated. Precisely similar changes are known to occur in the prostate, and in Cowper's glands with advanced age.

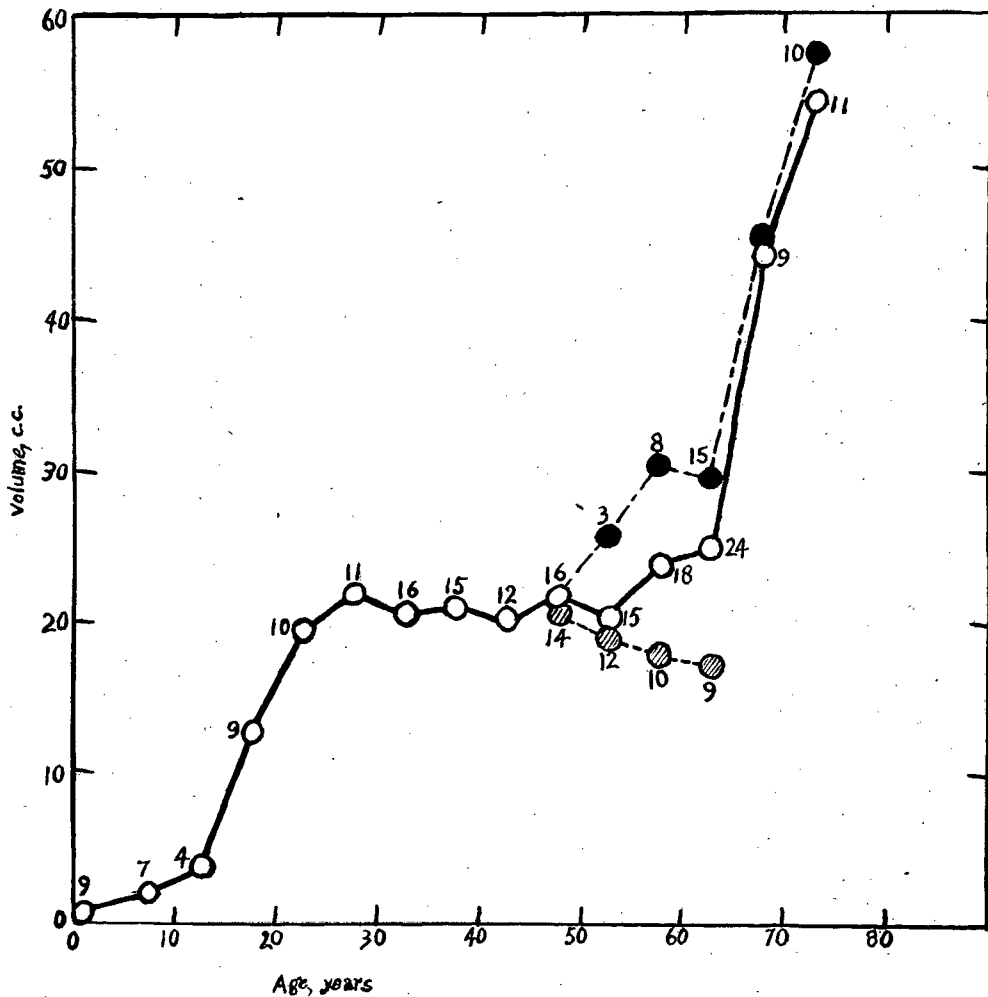


FIG 5 GRAPHIC ILLUSTRATION OF THE GROWTH CHANGES IN THE PROSTATE GLAND WITH AGE.

Between 12.- 15 years there is a sudden increase in volume corresponding with puberty. Between 20 - 50 years the volume (size) remains more or less the same. Thereafter the normal prostates gradually atrophy (shaded dots), whereas the prostates with benign adenomatous change, rapidly increase in volume (black dots). The white dots after 50 years represent a mean value between the shaded and black dots. The numericals opposite the dots indicate the number of specimens in that group.

(From Swyer)

To sum up - It has been shown that the seminal vesicles of white rats have a very definite growth curve. These organs do not develop as does the rest of the animal, but at a certain period there occurs rapid and excessive growth. Swyer has conclusively proved that a similar growth curve exists for the human prostate. By analogy it is not unreasonable to suggest that a similar process affects the human seminal vesicles. Finally I have shown that in actual fact there is a marked difference between the size and appearance of these organs in a person before and after puberty. That a similar condition exists in baboons is added evidence to support the contention.

It is reasonable to conclude that the human seminal vesicles show a definite growth curve which corresponds with the age and sexual development of the individual. The maximum period of growth occurs at puberty.

McCarthy, Ritter and Klemperer in 1927 gave figures for the capacity of the seminal vesicles. The average volume of each vesicle in an adult male was estimated at 3.6 cc's. In different persons they found a range in capacity between 2 and 7 cc's.

S T R U C T U R E .

The seminal vesicles are essentially hollow muscular organs, which are lined by secretory epithelium. There is a fibrous adventitious coat which is derived from the surrounding fascia.

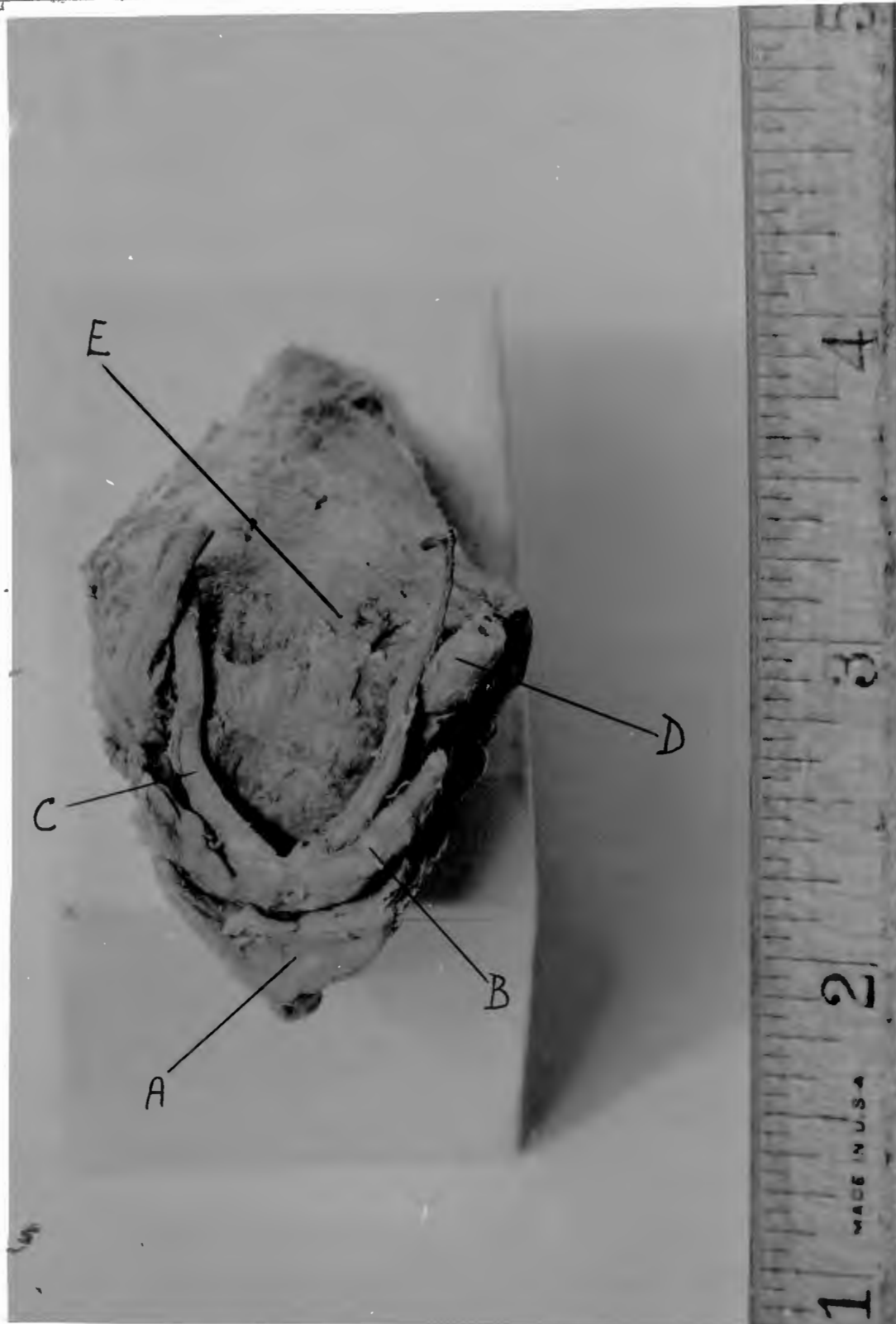


FIG. 6 BLADDER AND SEX GLANDS IN A CHILD OF 8 YEARS.
TWICE NATURAL SIZE.

The lower ends of the vasa and the vesicles lying on the base of the bladder. Note the immature appearance and small size of the seminal vesicles.

- A. Prostate.
 - B. Seminal Vesicle.
 - C. Vas Deferens.
 - D. Ureter.
 - E. Dorsal Aspect of Bladder.
-

The muscular coat has the usual two layers; an outer longitudinal and inner circular. Both are composed of plain muscle which is innervated solely by the autonomic nerves. The outer adventitious layer forms the true capsule of the gland. It carries the blood vessels and nerves to all parts of the vesicle. This layer also sends fibrous septa in between the lobules, which in turn binds the lobules together.

When a seminal vesicle is dissected free from the surrounding parts, it is found that the largest blood vessels approach and leave the gland on that aspect which lies adjacent to the ampulla of the vas deferens of the same side. The main lymphatic trunks presumably also lie here. This area of the gland can therefore be compared to the hilum of an organ like the kidney.

The lining of the seminal vesicle is epithelium derived from the mesonephric duct. It is essentially secretory in nature. Macroscopically it presents a fine, reticulated, honeycomb appearance. In mature persons when the specimen is fresh there is a definite brown pigmentation of the lining epithelium.

The lumen seldom exceeds 1/8 inch in diameter, and as has been said, it is extremely tortuous. It could well be termed the vesicular labyrinth. Of all organs in the body, it would appear to be the one which par excellence would favour stasis of the content. This fact probably explains why inflammatory conditions of the seminal vesicle so readily tend to become chronic. The drainage under the best circumstances must be

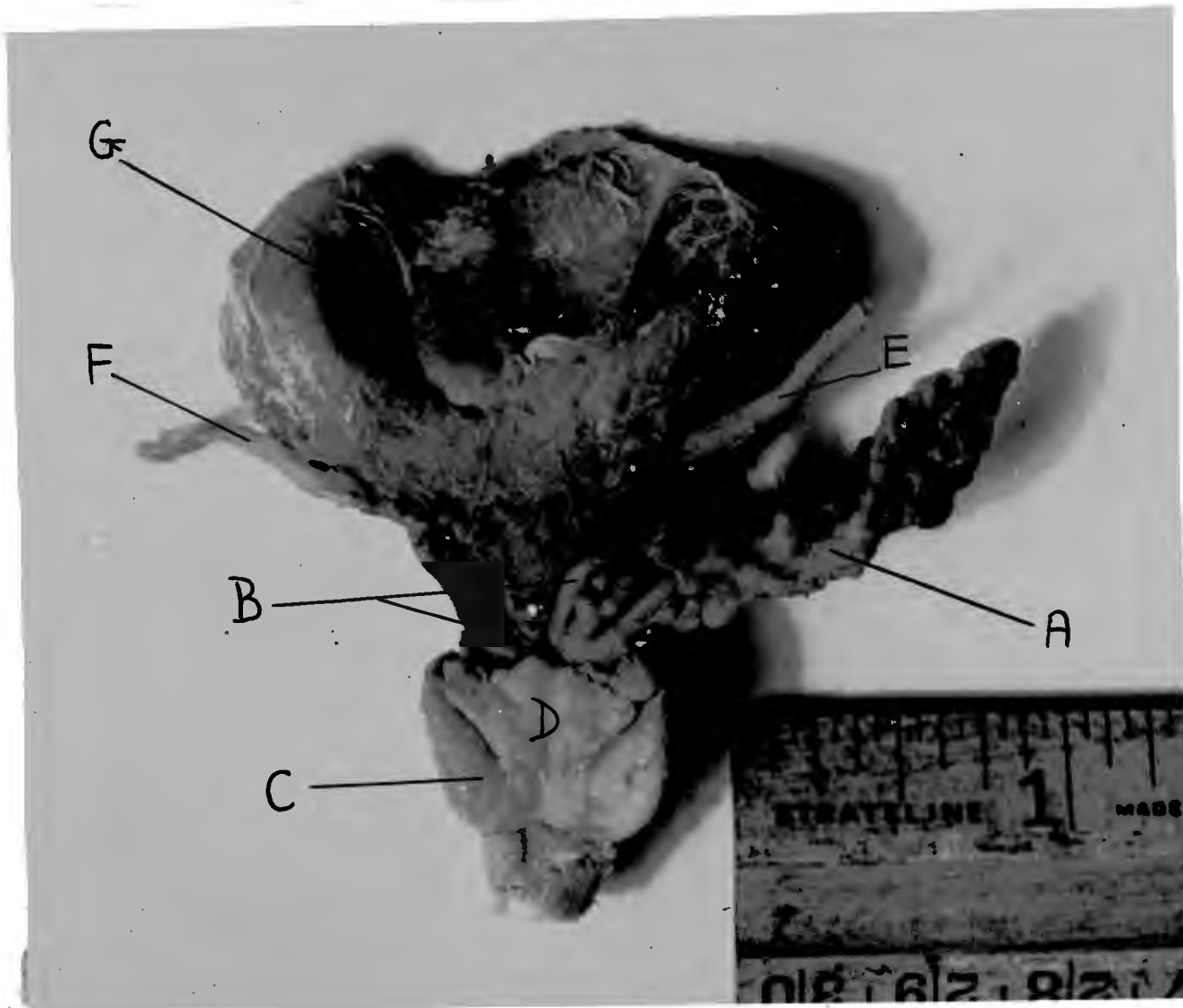


FIG 7 . DORSAL ASPECT OF BLADDER AND SEX GLANDS OF AN IMMATURE CHACMA BABOON. TWICE NATURAL SIZE.

Left seminal vesicle has been removed. Note the relative smallness of the seminal vesicle as compared with mature adult. (See Fig. 54).

- A. Right Seminal Vesicle.
- B. Vasa Deferentia.
- C. Lateral Lobe Prostate.
- D. Cranial Lobe Prostate.
- E. Right Ureter.
- F. Left Ureter.
- G. Bladder.

incomplete, and even more so, when the lumen is decreased by inflammatory oedema.

Microscopically it is seen that the epithelium is thrown into numerous minute folds; so much so, that the appearance at once suggests a glandular structure. But there are no glands opening into the lumen of the seminal vesicle. It is the epithelium itself which is secretory. The marginal cells are tall columnar cells with basal nuclei, and beneath this single layer there is a thin basement membrane. (See Fig. 8 "A".).

Very interesting work has been done in regard to the secretory nature of this single layer of tall columnar cells. Armitstead (1) has shown histological differences in these cells which depend on the sexual activity of the animal. This evidence, and much other, has gone to prove that the content of the vesicles is derived solely as a secretion from the epithelial cells.

The content of the seminal vesicles is a viscid, sticky fluid. Each vesicle, when distended, holds between 3 and 4 cc's. The fluid from the seminal vesicle coagulates when it comes into contact with the prostatic secretion. The vesicular secretion is specific in many ways. The reaction is definitely alkaline (p H 7.4); glucose content is high (306 mgs %); acid soluble phosphates are present in higher concentration than in the blood; the protein substances present are largely proteoses. The content of chloride is materially less than that of the blood.

C A P S U L E.

The true capsule of the seminal vesicle has been discussed. Both vesicles, together with the ampullae are also enclosed in a fascial compartment which forms a sheath for these glands. The fascia forming this sheath is part of the visceral pelvic fascia. The features of the pelvic fascia will be sketched a little later on; but the fascial capsule of the seminal vesicles must be discussed now.

The urinary bladder has a complete fascial coat. It lies external to the muscle and just beneath the serous lining, in that area where the bladder is covered by peritoneum. This is called the vesical fascia. It is easily recognisable over the peritoneal aspect of the bladder and, as it passes anteriorly and laterally towards the bladder neck, it becomes somewhat thinner and fat tends to accumulate on its external surface. The fascia which passes from the peritoneal surface posteriorly towards the base of the bladder forms a well-marked, dense sheet. It is this part of the vesical fascia which forms the fascial compartment for the seminal vesicles. As it approaches the ampullae and seminal vesicles from above, it splits into two layers. One passes between these organs and the bladder wall and the other passes dorsally over these organs. Below, each layer fuses with the base of the prostate. The dorsal layer binds the base of each seminal vesicle firmly to the base of the prostate.

In such a way a fascial compartment is formed

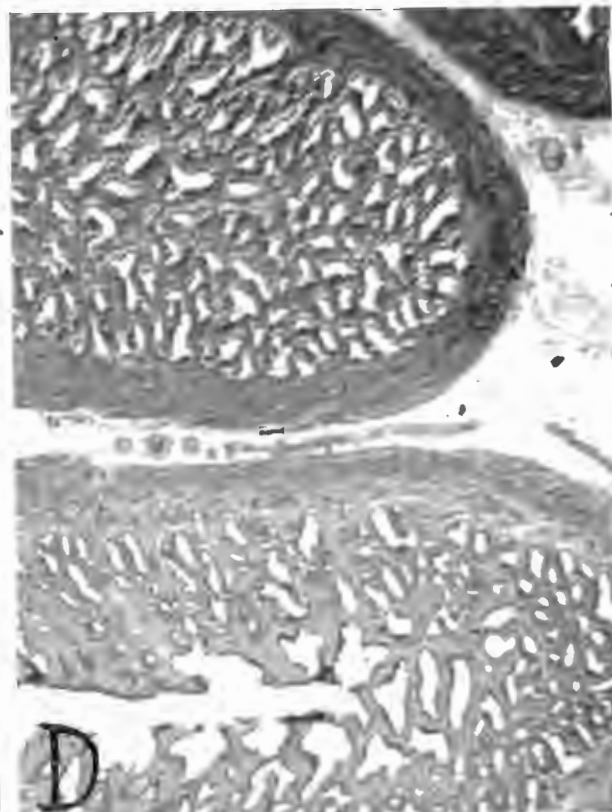
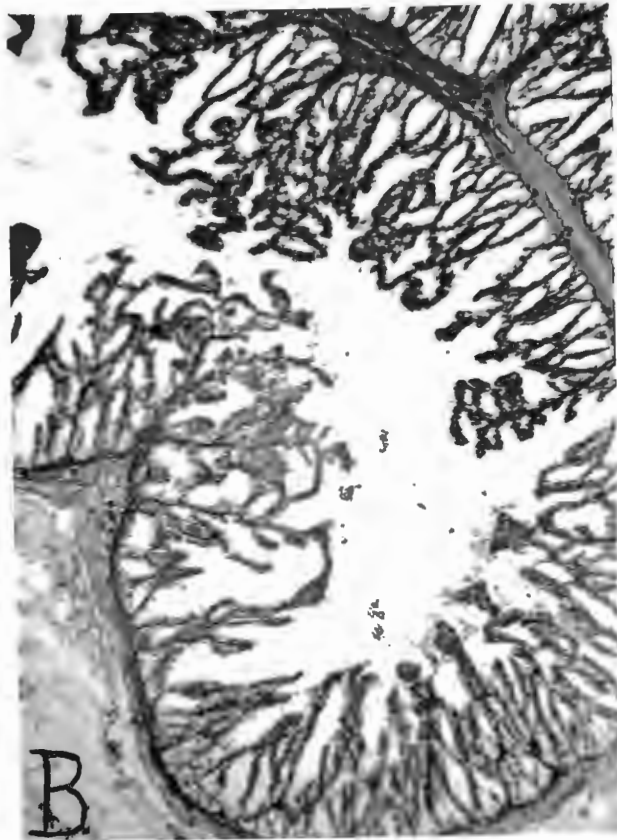
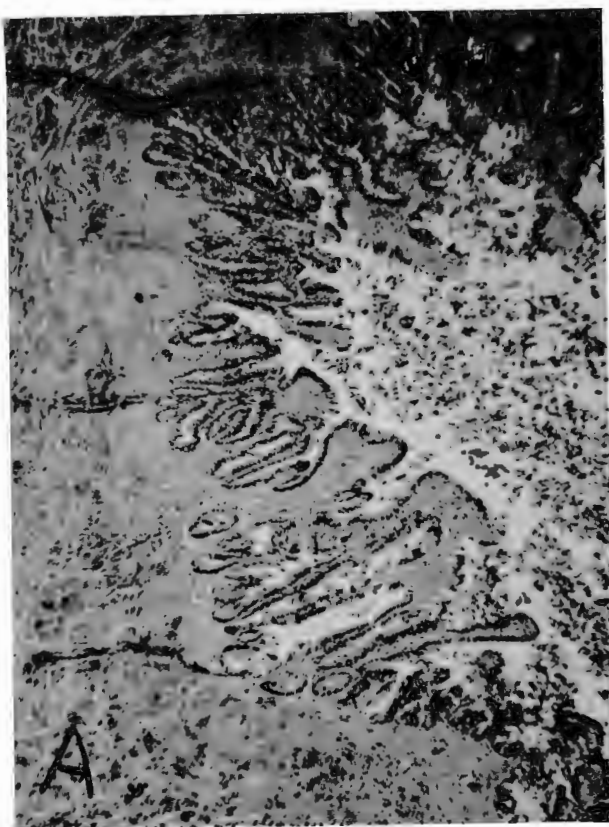


FIG. 8 MICROPHOTOGRAPHS OF SEMINAL VESICLES.

To compare the histological structure of the human seminal vesicles with that of a monkey and a baboon.

A. Human Seminal Vesicles x 60.

Note thick muscular wall and lumen filled with loose debris.

B. Mature Chacma Baboon x 50.

Folds of secretory epithelium more complicated than in human.

C. Mature Vervet Monkey. x 60.

D. Immature Chacma Baboon. x 75.

Small lumen, thick muscular wall.

for the ampullae and the seminal vesicles. In the mid line the two layers of fascia are blended so that the ampulla and seminal vesicle of each side have a separate compartment. Moreover the fascia around the ampulla is fairly firmly adherent to that structure, whereas the fascia about the vesicle is loosely attached to the vesicle. When dissecting the seminal vesicle, one finds that a plane of separation exists between the true capsule of the vesicle and its fascial sheath. In other words, the seminal vesicle can be almost completely shelled out of its surrounding fascia. It is most firmly attached at the base to the prostate, and less firmly at the apex where the blood, lymph vessels, and nerves approach it.

This fascia which encloses the ampullae and the seminal vesicles is normally thick and dense. In it are embedded blood vessels, lymph channels and nerves. Of these, the veins are the most prominent. In chronic inflammatory conditions of the seminal vesicles, it is this fascial sheath which becomes even more dense and thickened. This pathological change constitutes the perivesiculitis, so frequently described by clinicians.

Plain muscle fibres are found histologically in the fascia which stretches between the seminal vesicles. The fascial capsule therefore is partly muscular. By contraction of these fibres the seminal vesicles and ampullae are more effectively emptied.

THE EJACULATORY DUCTS.

The neck of the seminal vesicle narrows down rapidly to form a short excretory duct not more than 1/8th of an inch in length. The distal end of this short duct is joined at an angle of about 30° by the lower end of the ampulla of the vas deferens. The common duct thus formed constitutes the ejaculatory duct, which terminates in the urethra on the lateral aspect of the veru montanum. The ejaculatory duct commences at the base of the prostate, and the length of the duct lies imbedded in prostatic tissue. Anterior to it lies the median lobe of the prostate, and posterior to it lies the lateral lobe of the respective side. (See Fig. 16).

The length of each ejaculatory duct is given at just under 2 ccm's. McMahon (27) in 1938 recorded his findings from an examination of these ducts in 100 cases. He found the average length to be 1.46 ccm's. There was no appreciable difference in length between the two sides. The diameter at the origin averaged 1.35 mm, and at the distal end .45 mm. Some writers have recorded that a sinus is formed at the point of origin of each duct, with a sphincter beyond it. McMahon found a slight dilation present in this area in 11 of his cases, and was not able to demonstrate a sphincter in any of them.

Each ejaculatory duct is a tube lined by flat cuboidal epithelial cells. There is also a thin surrounding coat of plain muscle tissue. Both ducts lie embedded in a flat sheath of fibrous tissue which separates the middle lobe from the lateral lobes of

- the prostate -

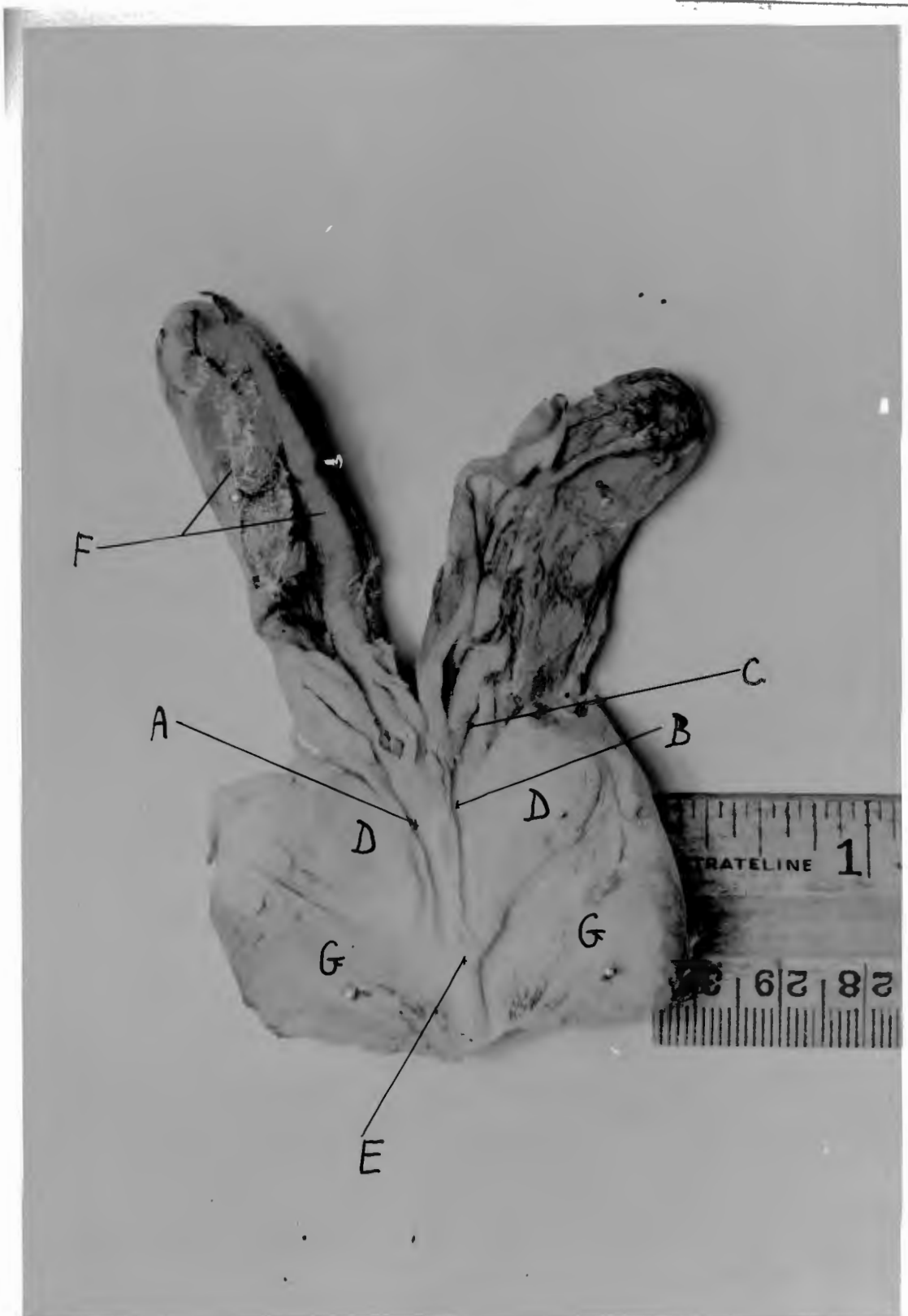


FIG. 9. EJACULATORY DUCTS. ENLARGED $1\frac{1}{2}$ TIMES.

The posterior urethra has been split on the ventral aspect. The median lobe of the Prostate has also been cut through to expose the ejaculatory ducts.

- A. Right Ejaculatory Duct.
- B. Left Ejaculatory Duct.
- C. Excretory Duct Left Vesicle.
- D. Cut Surface Median Lobe Prostate.
- E. Veru Montanum.
- F. Right Seminal Vesicle and Ampulla.
- G. Cut Surface Ant. Lobe of Prostate.

the prostate. Between the ducts and on the same level is situated the utriculus masculinus. This latter is an epithelial-lined cul-de-sac which opens into the urethra on the veru montanum. It averages 9.8 mm in length and 2.5mm in width.

If the ventral wall of the prostatic urethra is split longitudinally, the epithelial surface of the dorsal wall will be exposed. The veru montanum will be seen lying in the midline. It is an elongated crest 15 mm long, 3 mm wide, and 3 mm high. It tapers to a point at both the proximal and distal extremities. It is also known as the urethral crest, caput gallinaginis or colliculus seminalis. The proximal end of the veru montanum fades imperceptibly into the uvula vesicae. The utriculus masculinus opens in the midline on the summit of the veru montanum. A thread of medium silkworm gut will readily pass into the lumen of the duct.

On the lateral wall of the veru montanum the ejaculatory ducts open, one on each side. Most commonly these openings are situated exactly opposite or just proximal to the opening of the utriculus masculinus. In only 14% of cases are the openings distal to that of the utriculus. (McMahon). The apertures of the ejaculatory ducts are just under 2 mm apart. In some few cases one or both of the ejaculatory ducts may open into the utriculus masculinus.

The course of the ducts is of importance because they frequently are catheterised. At their origin the medial walls of the ducts are 2 mm apart. From there the ducts converge as they approach the summit

of the veru montanum. In the distal thirds they are practically adjacent with the utriculus between them and lying slightly posterior. In the last 2 mm of their course they diverge so that each opens on the side of the veru montanum. The opening of each duct will admit a thread of No. 1 silkworm gut.

It has been said that the ampulla of the vas joins the excretory duct of the seminal vesicle at an angle of 30° . An examination of cases shows that this angle may vary from 20° to 90° . Most commonly it is an acute angle ranging between 20° and 30° . When one examines these small ducts, it is very definite that the duct from the ampulla is a tributary, and that the continuation of the lumen of the vesicle is the main channel. This point is of practical importance because it facilitates the passage of a fine catheter from the urethra into the seminal vesicle.

BLOOD AND LYMPH SUPPLY.

The arterial blood reaches the seminal vesicles mainly via branches of the inferior vesical artery. This vessel is one of the visceral branches of the hypogastric artery. It runs from its point of origin on the side wall of the pelvis towards the base of the bladder. It is surrounded by branches of the vesical plexus of veins in the terminal part of its course. (See Fig. 10).

In the region of the base of the bladder there occurs a rich anastomosis between the terminal branches of the middle vesical, inferior vesical and middle

- haemorrhoidal arteries -

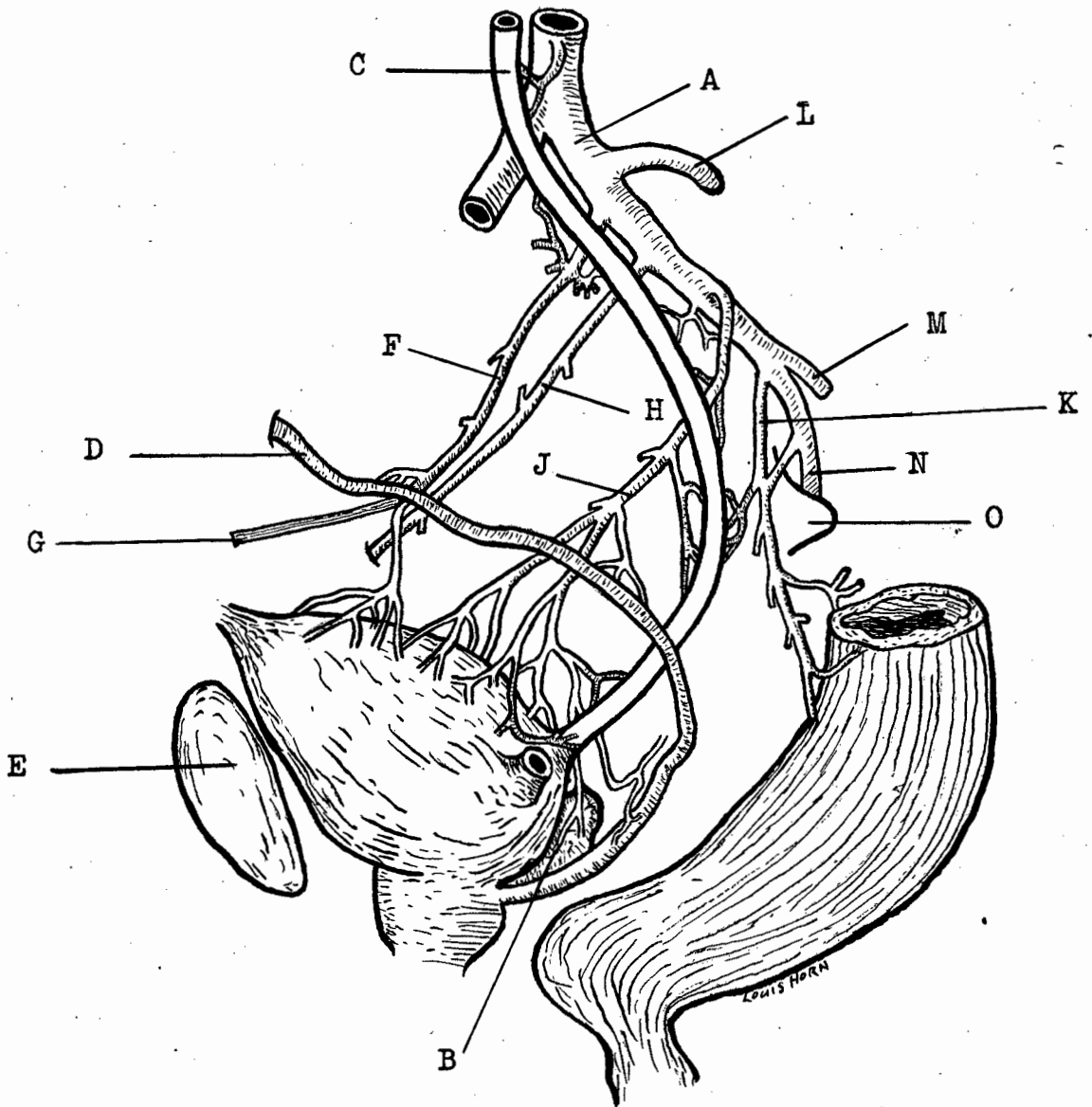


FIG 10 BLOOD VESSELS OF THE PELVIS.

To show that the blood supply of the seminal vesicle is derived chiefly from the inferior vesical artery. The blood supply of the vas and ureter is also illustrated.

A. Hypogastric Artery, B. Seminal Vesicle, C. Ureter
 D. Vas Deferens, E. Symphysis Pubis, F. Superior Vesical Artery, G. Obliterated Umbilical Artery, J. Inferior Vesical Artery, K. Middle Haemorrhoidal Artery.
 L. Superior Gluteal Artery, M. Inferior Gluteal Artery, N. Pudendal Artery, O. Spine of the Ischium.

(From Harper)

haemorrhoidal arteries of both sides. The seminal vesicles undoubtedly derive arterial blood from this anastomosis.

In a dissection of this part, the veins are much more prominent than the arterial stems. Since the vesical plexus of veins forms such an important relation to the seminal vesicles, it deserves some description.

The dorsal vein of the penis dips under the lower border of the symphysis pubis to join the pudendal plexus. This plexus lies in the tissues between the front of the prostate and the superior layer of the urogenital diaphragm. Besides the dorsal vein of the penis, the pudendal plexus also is joined by veins from the perineum and form the anterior aspect of the bladder and prostate. The pudendal plexus continues backwards on each side of the prostate and towards the bladder-neck. In this position it constitutes the prostatic plexus which lies in the fascial sheath of the prostate.

The prostatic plexus sweeps round the prostate and the main venous trunks congregate in the angle between the prostate and the bladder. Here the plexus is joined by large veins from the bladder to form the vesical plexus. This continues round the lateral sides of the seminal vesicles and the blood collects into about half-a-dozen large venous trunks which empty into the hypogastric vein.

As the vesical plexus sweeps round the vesicles, it is embedded in dense fascia; the whole forming a broad, flat mass about 1/2 inch thick which separates the vesicles from the side wall of the pelvis. The lower

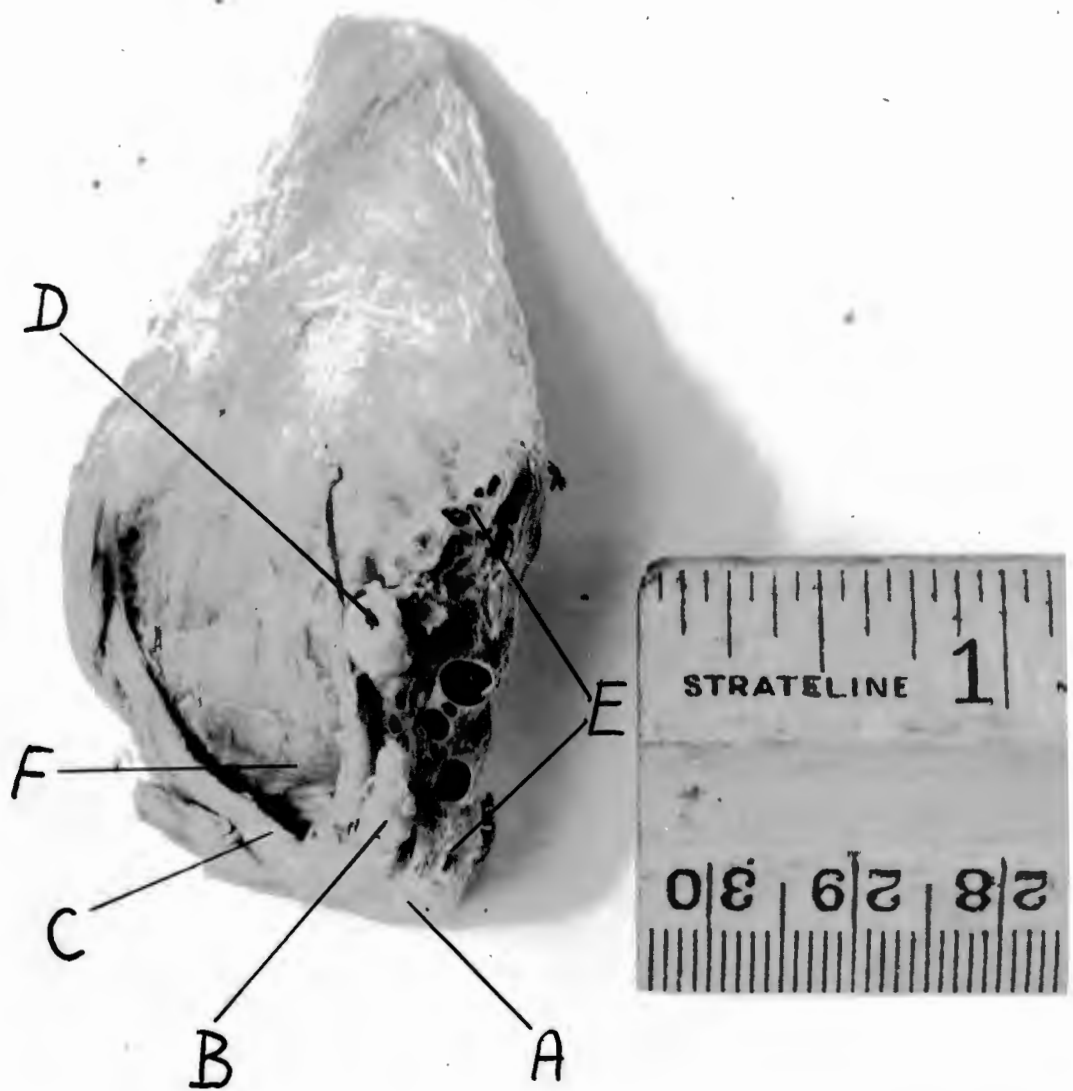


FIG. 11 SIDE VIEW OF BLADDER AND GENITALIA IN CHILD
OF 8 YEARS x 2.

This photograph shows clearly the relation of the Vesical Venous Plexus to the seminal vesicles and the ureter.

- A. Prostate.
- B. Seminal Vesicle.
- C. Vas Deferens.
- D. Right Ureter.
- E. Vesical Venous Plexus.
- F. Base of Bladder.

end of each ureter is surrounded by branches of the vesical plexus. The extent of the prostatic and vesical plexuses is shown in Figs. 11 & 12. The vesical venous plexus and the surrounding fascia is often called the posterior ligament of the bladder.

The lymph channels from the seminal vesicles run with those of the prostate and bladder to the hypogastric lymph glands. From there they drain into the iliac lymph glands, which in turn communicate with the aortic group of glands. The lymph vessels from the vesicles are embedded in the fascia which surrounds the vesical venous plexus. The lymph from the seminal vesicle may also drain via a few channels which lie in the hollow of the sacrum. These will ultimately terminate in the aortic glands.

Some urologists believe that the lymph drainage of the seminal vesicles is exceptionally rich. Anatomically this has not to my knowledge been shown to be so. I think the contention must be based on a clinical hypothesis. In the chapter on Comparative Anatomy there is described a brief experiment on a baboon and a monkey, to try and demonstrate the lymphatics of the seminal vesicles. The lymphatic network of these organs does not appear to be richer than that of many other viscera.

NERVE SUPPLY.

The nerve supply of the seminal vesicles, as also that of the prostate and Cowper's glands, is derived from the autonomic nervous system. The sympathetic

- supply comes -

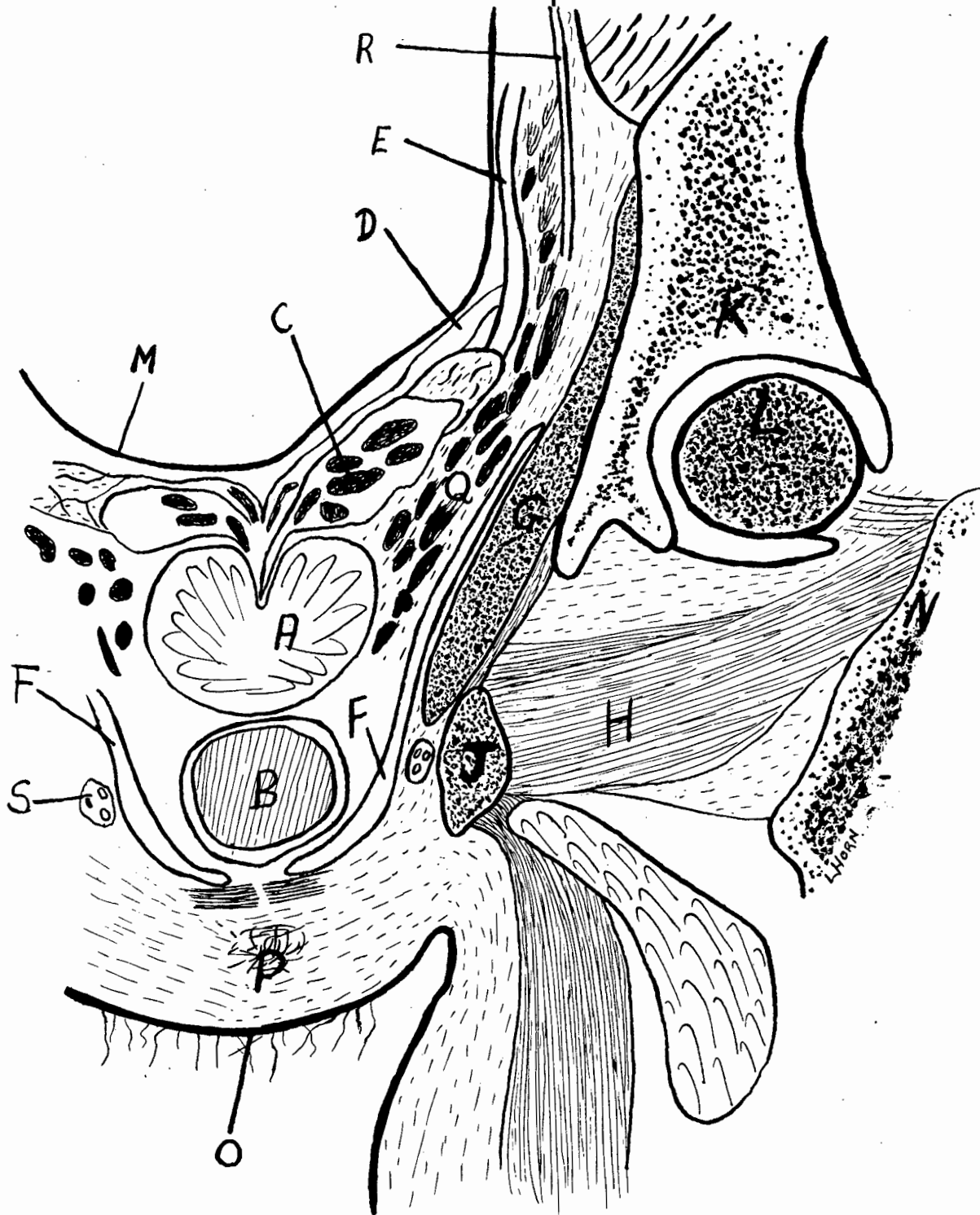


FIG 12 CORONAL SECTION THROUGH MALE PELVIS.

The section was cut along a vertical line dropped from the promontory of the sacrum. It passed $\frac{1}{2}$ in behind the post-border of the symphysis pubis. The section passed thro' each seminal vesicle.

- A. Prostate, B. Portion of Ant. Rectal Wall,
 C. Seminal Vesicle, D. Vas Deferens, E. Ureter,
 F. Levator ani, G. Obturator Internus, H. Obturator
 externus
 J. Pubic Ramus, K. Os Pelvis, L. Head of Femur,
 M. Pelvic Peritoneum, N. Femur, O. Perineal Skin,
 P. Perineal Body, Q. Sheath of Fascia in which are
 embedded the Venous Plexus. R. Obturator Nerve,
 S. Alcock's Canal.

supply comes via the hypogastric plexus, and the parasympathetic supply from the nervi erigentes.

The anatomy of these nerves will be briefly sketched now, and will then need no further description when the mechanism of micturition and ejaculation is discussed later.

The nervi erigentes or pelvic splanchnics are derived from the anterior roots of the second and third sacral nerves. From the hollow of the sacrum this sheath of nerves runs across the side wall of the pelvis, but separated from it by the numerous venous and arterial branches of the hypogastric vessels. The separate small nerves which together form the pelvic splanchnics, are readily found in a dissection of the pelvis. These nerves supply the bladder, rectum, and erectile tissue of the penis in the male. They are pre-ganglionic fibres which synapse with ganglia situated in the wall of the viscus supplied.

The function of the nervi erigentes is mainly to cause emptying of the bladder and rectum. In the female it has the same motor effect on the uterine muscle. At the same time it probably has an inhibitory action on the sphincters of the bladder and anus. As elsewhere in the body the parasympathetic nerves here have an action directly opposite to that of the sympathetic.

The fibres of the parasympathetic which supply the penis play the largest share in erection of this organ. They are vasodilator fibres to the blood spaces of the erectile tissue. Erection of the penis

- (or clitoris)

(or clitoris) is also partly effected by contraction of the ischiocavernosus muscles. These act by compressing the venous drainage from the erectile tissue, and so help to maintain erection.

The sympathetic nerves to the pelvic viscera are derived from the abdominal sympathetic trunk and the aortic plexus. It is known that the whole sympathetic nervous system flows out from the spinal cord only between the 1st thoracic and the second lumbar segments. So we find that white rami communicantes leave the anterior divisions of the spinal nerves T 1 - L 2 inclusive, to join the respective sympathetic ganglia. On the other hand grey rami carry fibres from the sympathetic ganglia to all the spinal nerves. The white rami are pre-ganglionic fibres. Each of these will make contact with a ganglion which may be in the sympathetic trunk or outside it. The nerve fibre leading from this latter ganglion will be a post-ganglionic fibre. All the grey rami contain post-ganglionic fibres, whereas the white rami have preganglionic and afferent sympathetic fibres.

A diagram in Fig. 13, shows the arrangement of the sympathetic nerves which form the hypogastric plexus and nerves. The hypogastric plexus lies on the body of the fifth lumbar vertebra being covered by peritoneum. It is formed by a right and left lateral root from the 1st and 2nd lumbar ganglia, and a middle root from the aortic plexus, which descends on the abdominal aorta. The lateral roots cross the commencement of the right and left common iliac arteries. Apart from these three main roots, there are smaller twigs which run from the

ABDOMINAL AORTA.

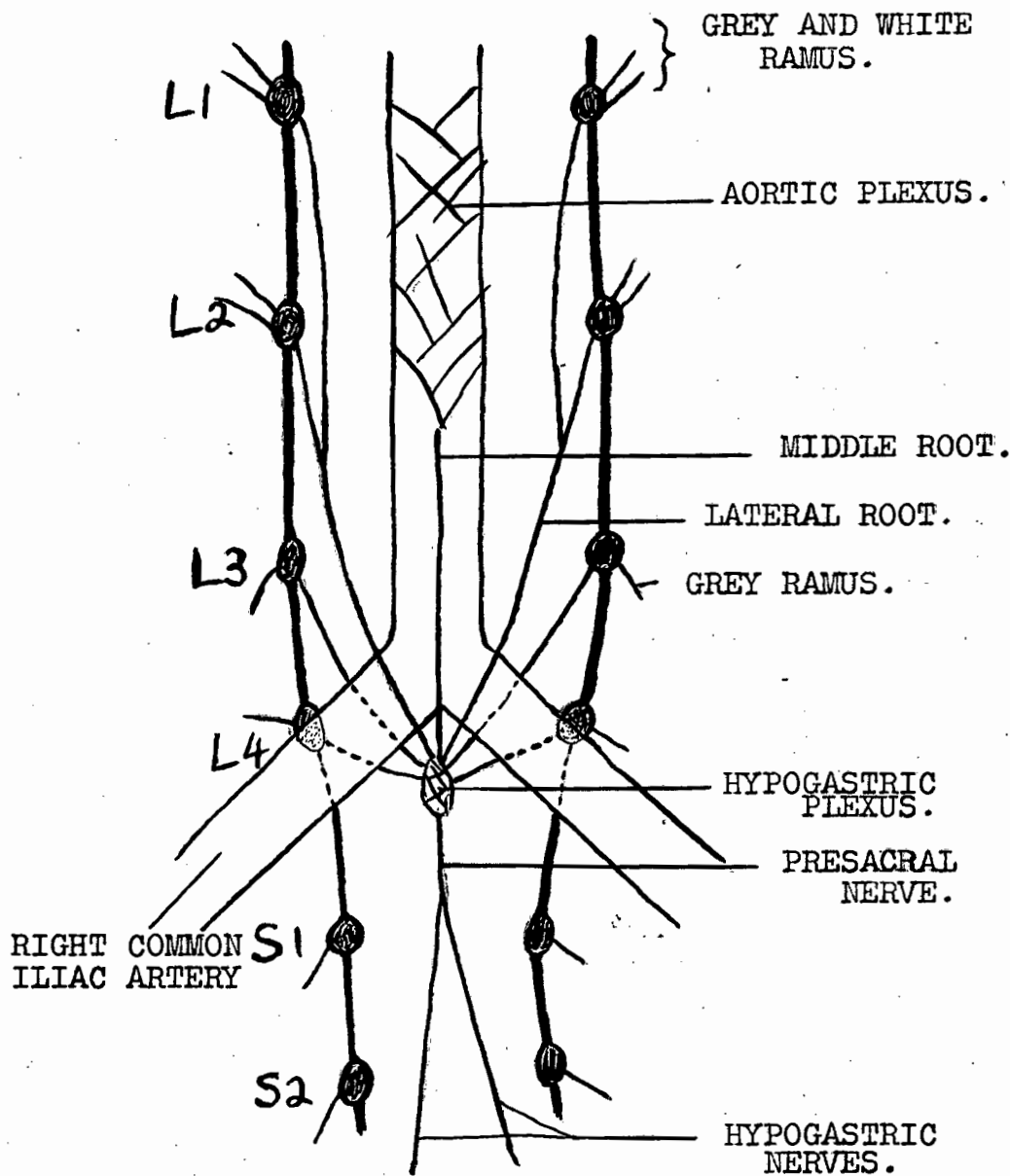


FIG 13 SYMPATHETIC SUPPLY OF THE PELVIC VISCERA.

Four lumbar and two sacral ganglia are shown with the sympathetic trunk which connects them. It is shown that the hypogastric plexus is formed mainly from a middle and two lateral roots. Note that no white rami communicantes are given off below L2.

(Modification from a drawing by Dr. A. Lee Mc Gregor).

3rd and 4th ganglia to join the hypogastric plexus.

From the plexus there arises in the majority of cases a single nerve trunk, the presacral nerve, which follows the hollow of the sacrum. This nerve divides into right and left hypogastric nerves, which pass on either side of the rectum and terminate in the hypogastric ganglia, which lie between the lower end of the rectum and the base of the bladder. From these ganglia post-ganglionic fibres are given off to the bladder, rectum and accessory genital glands.

The general function of the pelvic sympathetic nerves is to oppose the action of the nervi erigentes. These latter have also been called the "emptying nerves". This certainly applies to the bladder, rectum and uterus, but not to the male genital glands. The muscular coats of the vas deferens, seminal vesicles, prostate and bulbo-urethral glands are innervated by sympathetic nerves. Stimulation of the presacral nerve leads to ejaculation of seminal fluid.

The knowledge that the hypogastric nerves are motor to the accessory sex glands, is made use of in several operations. Presacral neurectomy is not the operation of choice in male children who suffer from Hirshsprung's disease. A ganglionectomy of the 2nd, 3rd, and 4th lumbar ganglia is preferable. In the operation of lumbar sympathectomy, the 2nd, 3rd and 4th ganglia with the intervening sympathetic trunk are removed. Both these operations leave the 1st lumbar ganglion intact, and so do not render the patient impotent.

In the operation of Smithwick and White for essential hypertension the thoracic splanchnic nerves and the sympathetic trunk between T 5 and L 2 are removed.

Since the operation is performed on both sides, these patients will necessarily be impotent. The cause of the impotence will be due to the inability of the accessory sex glands and the vasa deferentia to empty themselves of their content. There is thus no ejaculation. Whether or not there is an orgasm I do not know. I should think probably not.

From this description it follows that the motor fibres to the accessory glands must leave the sympathetic trunk through the 1st lumbar ganglion. As far as I am aware this has not been proved experimentally. From the evidence available, however, it seems a fair enough supposition to make.

From experimental work done on the cat it has been shown that the centres for ejaculation and erection of penis are situated in the lumbar and sacral regions of the spinal cord respectively. Coitus is a spinal reflex, which can be successfully performed by an animal with a transverse lesion of the cord above the lower lumbar segments. Nevertheless the higher cortical areas of the central nervous system have an important influence on the reflex of erection and ejaculation. This is especially so in human beings.

Besides carrying motor fibres to the reproductive glands, the hypogastric nerves also influence the bladder and rectum. In regard to the bladder, experimental work indicates that the sympathetic nerves maintain a steady tonus of the internal sphincter. At the same time these nerves have an inhibitory effect on the detrusor of the bladder. When the animal allows itself to urinate, the parasympathetic nerves cause the detrusor

to contract, and the sympathetic nerves cause an inhibitory relaxation of the internal sphincter.

Normally the pelvic splanchnics carry the afferent fibres which record the sensation that the bladder is filling. But there is good reason to believe that painful stimuli are carried by afferent fibres in the hypogastric nerves. For this reason a presacral neurectomy is sometimes advised in cases where a growth or ulcerative condition is causing excessive pain in the bladder.

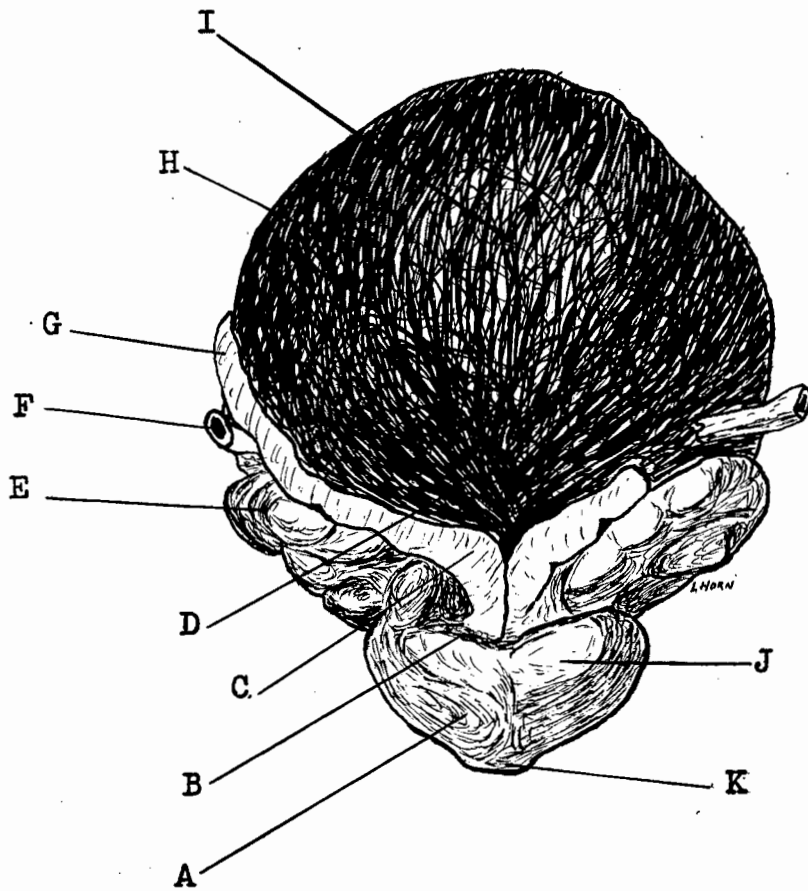
AMPULLA OF VAS DEFERENS.

This is a bilateral structure and represents a dilatation of the lower end of each vas deferens. Not only are the walls of the vas thickened, but also the lumen is increased. This structure does not develop in many animals including the lower primates. (Figs. 14 & 15).

Each ampulla lies adjacent to the seminal vesicle of the same side and just above it. It presents an external lobulated surface which resembles that of the seminal vesicle. There are irregular areas of dilatation and the proximal part of the ampulla is sometimes markedly tortuous. It lies in a fascial compartment which it shares with the corresponding vesicle. This fascial covering is rather firmly adherent to its external coat, and branches of the vesical venous plexus course over its surface.

When the ampulla is cut open in its length, the lumen is found to be irregularly dilated. The lining epithelium is almost indistinguishable from that of the seminal vesicle. It has the same fine reticulated

FIG 14 DORSAL ASPECT OF BLADDER AND SEX GLANDS.



A. Lateral Lobe Prostate, B. Prostates-vesicular Groove, C. Ampulla, D. Base of Bladder, E. Seminal Vesicle, F. Ureter, G. Vas Deferens, H. Lateral Aspect of Bladder, I. Vertex of Bladder, J. Base of Prostate, K. Apex of Prostate.

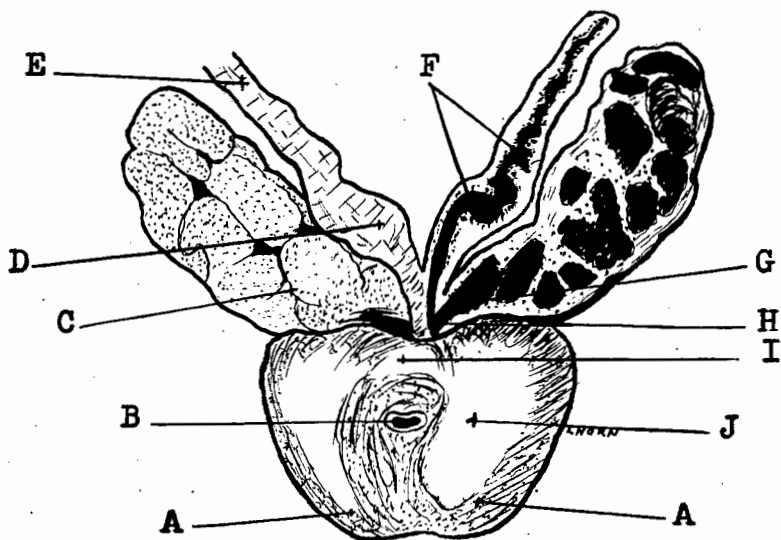


FIG 15 PROSTATE, SEMINAL VESICLES AND AMPULLAE.

Viewed from above, the bladder being removed.

The Ampulla and seminal vesicle of one side have been cut open length-wise.

A. Rt. & Lt. Lobes of Prostate, B. Urethra emerging at base of Prostate, C. Seminal Vesicle, D. Ampulla, E. Vas Deferens, F. Lumen of Ampulla, G. Lumen of Seminal Vesicle, H. Ejaculatory Duct, I. Mid. Lobe Prostate, J. Basal Aspect of Prostate.

(From Spalteholtz).

appearance, but there is no brown pigmentation apparent.

The histological appearance also is remarkably like that of the vesicle. There is a thick muscular coat of plain muscle fibres. The lining epithelium has characteristics which make it plain that its function is secretory. The folds are not as complex as those of the seminal vesicle, but a single row of tall columnar cells forms the lining layer.

The distal end of the ampulla narrows down to form a short duct, which joins that of the seminal vesicle to form the ejaculatory duct. The duct from the ampulla is much narrower than that of the vesicle.

No more than a few drops of secretion are normally present in the ampulla. It is not as gelatinous as that of the seminal vesicle. Numerous spermatozoa are frequently present in this secretion. There are also present a fair number of epithelial cells. In humans it would seem that the ampullae have a dual function :-

(a) As a reservoir for spermatozoa,

(b) As a secretory gland.

In this respect humans differ from nearly all other animals, where the ampullae, when present, are essentially secretory glands. The lower primates, like baboons and monkeys, have no ampullae which can be recognised by the naked eye. But even in these animals the epithelium of the lower end of the vas is secretory. (See Fig.58.D.). These features will be more fully discussed under the comparative anatomy.

PROSTATE.

This gland is intimately related to the seminal vesicles, and thus warrants some description.

The prostate gland surrounds the first part of the urethra in the male. Its base is applied to the urinary bladder, and its apex rests upon the superior layer of the urogenital diaphragm. The posterior aspect is applied to the anterior wall of the rectum, with the recto-vesical fascia intervening. The anterior aspect is separated from the symphysis pubis by fatty areolar tissue and attached to it by the fibro-muscular pubo-prostatic ligament. The levator ani muscles sweep round the lateral aspects of the gland.

For purposes of description the prostate gland is divided into five lobes. There is no line of demarcation between any of these lobes. The largest mass of the gland is formed by ^{the} two lateral lobes. The tissue which connects these lobes in front of the urethra is called the anterior lobe. Some text-books refer to this portion as the anterior commissure. It contains very little glandular tissue, and is largely made up of fibrous tissue. The posterior lobe is that area between the lateral lobes behind the urethra. This part of the prostate and a portion of each lateral lobe is what can be palpated by rectal examination. The middle lobe of the prostate lies between the urethra and the ejaculatory ducts. It is also called the median, third or presper-matic lobe. It normally projects a little into the urethra and bladder to form the uvula vesicae.

The ducts from the prostate are multiple and empty into the prostatic sinus on the dorsal wall of the urethra.

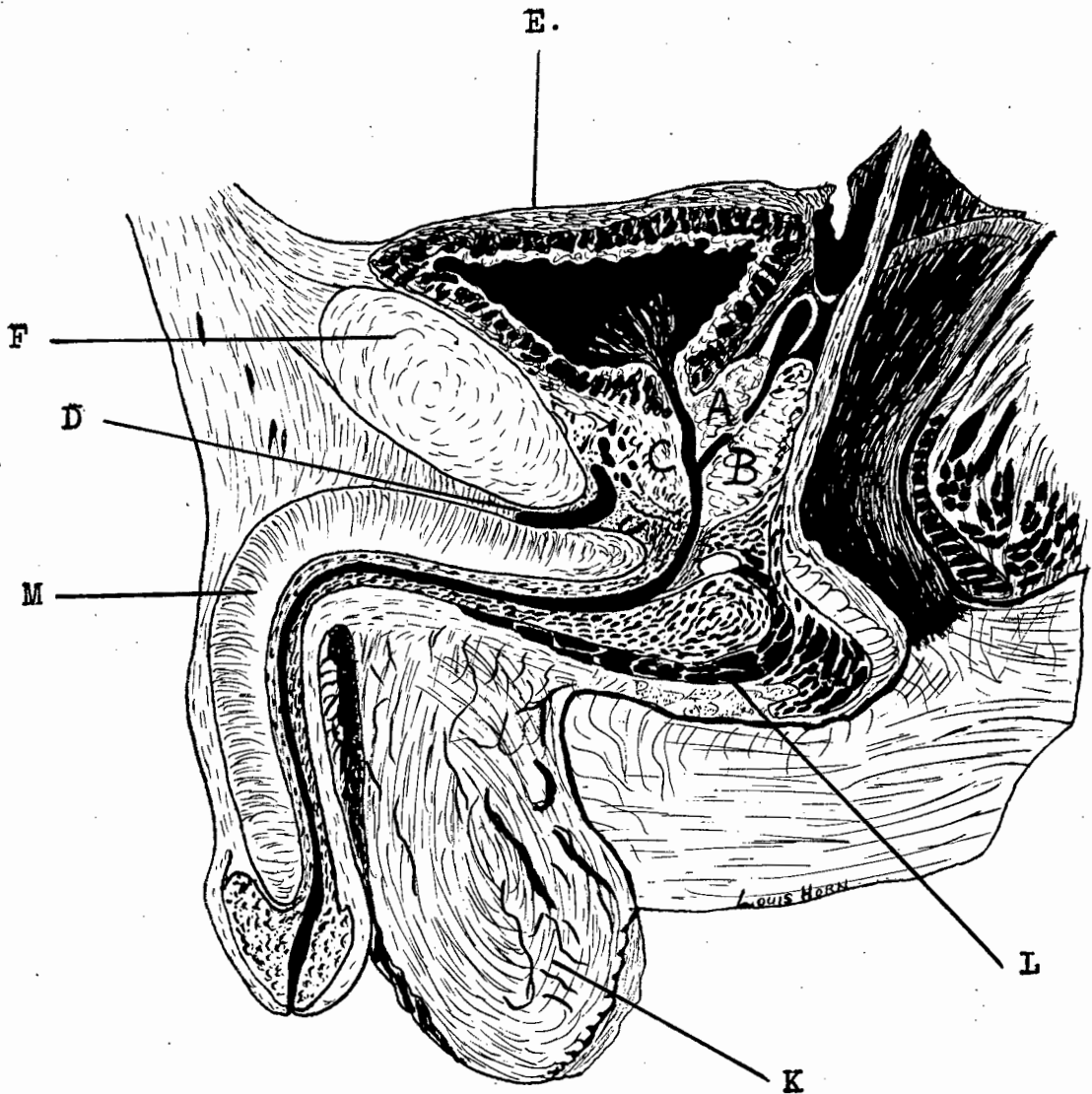


FIG 16 SEMI-DIAGRAMMATIC SKETCH OF MALE PELVIS. MIDLINE SAGITTAL SECTION.

To show the different lobes of the prostate. Note the intimate relation that the base of the bladder bears to the prostate gland. The position of Cowper's gland is indicated.

A. Prespermatic (middle) Lobe of Prostate; B. Posterior Lobe; C. Anterior Commissure (or Lobe). D. Dorsal vein of the Penis. E. Peritoneal Surface of the Bladder. F. Symphysis Pubis, K. Scrotal Septum, L. Musculus Bulbo Cavernosus covering the Corpus Spongiosum, M. Septum Corpus Cavernosus Penis.

The openings can be seen with low magnification in the hollow on each side of the veru montanum. The ducts from the median lobe open in a triangular area between the bladder-neck and the proximal point of the veru montanum.

The secretion of the prostate is added to the ejaculate. It is not copious. When a fresh specimen is massaged firmly it is not possible to collect more than an egg-spoonful of secretion. The secretion has a characteristic musky odour, and has an acid reaction. It contains a high concentration of cholesterol (330 mgs.%), and also of the enzyme, acid phosphatase. Microscopically there are numerous lecithin granules, and occasionally corpora amylacea.

Associated with the prostate, and having a similar embryological origin, are certain submucosal glands. They occur in three regions. Those surrounding the prostatic urethra are the para-urethral glands. A group situated opposite the internal vesical sphincter are the subcervical glands (of Albarran). There are also a few in the trigonal area, which constitute the subtrigonal glands.

The interest in these submucosal glands lies in the fact that many authorities consider that a benign adenoma of the prostate arises from one or other of this group of glands.

THE BLADDER.

The seminal vesicles lie on the dorsal aspect of the base of the bladder. At their base these glands are separated from the bladder wall only by a layer of fibrous tissue. At their apices they are $\frac{1}{4}$ of an inch from the bladder with a portion of the vesical venous plexus intervening. The relative position of the seminal vesicles, ampullae and terminal ends of the ureters is well seen in

the accompanying diagrams. It will be seen that the apex of the seminal vesicle projects a short distance beyond the point where the ureter enters the bladder wall.

The relation of the seminal vesicles to the inside of the bladder is also worthy of notice. It is sometimes necessary to remove the vesicle via the bladder. This relationship is shown in Fig. 17. The relative position of the ampulla of the vas and the line of the ureter is illustrated in Fig. 19.

The bladder-neck is so intimately connected to the prostate, that some urologists describe the prostate as a glandular portion of the bladder-neck. The external muscle fibres of the bladder are continuous with those which envelop the prostate and form the muscular stroma of the gland.

PELVIC WALL AND FASCIA.

Certain muscles and the pelvic fascia need description. The side wall of the pelvis is formed by the bony pelvis together with the obturator internus muscle which covers up the gap of the obturator foramen. The fascia which covers the obturator internus is the obturator fascia and it is attached to the bone around the margins of the muscle. This is the parietal layer of pelvic fascia and comparable to the fascia transversalis of the abdomen.

The pair of levator ani muscles arise from the side wall of the pelvis and slope downwards and inwards to meet around the viscera in the midline. Together they constitute the pelvic diaphragm. The pair of coccygeus



FIG. 17 . INSIDE OF TRIGONE AREA OF THE BLADDER.

The ureteric orifices are marked by black stilettes. The dotted outline corresponds to the position of the seminal vesicle. The solid black line indicates the upper border of the vas deferens.

A. Urethral Orifice of Bladder.

B. Outline of the Right Seminal Vesicle.

muscles complete the diaphragm behind. The origin of each levator ani stretches from the posterior aspect of the symphysis pubis in front, to the spine of the ischium behind. Between these bony points the muscle arises from a thickened line of the obturator fascia. In the male the levator ani muscles sweep round the lateral sides of the prostate to be inserted into the central point of the perineum. The succeeding fibres are inserted into the anal wall between the internal and external sphincters, and behind the rectum into a midline raphe extending to the coccyx. The seminal vesicles lie adjacent to the levator ani muscle on each side separated from it by fascia and the vesical venous plexus. (Fig. 12).

The upper and lower surfaces of the levator ani are clothed with fascia. That on the lower aspect is called the anal fascia. The fascia on the superior aspect of the levator ani arises from the obturator fascia along the same line of origin as the muscle. This layer of fascia is part of the visceral fascia of the pelvis. By some anatomists it is called the recto-vesical fascia. The latter term seems undesirable because it causes confusion with the recto-vesical septum of Denonvilliers. It is better to call this layer the superior fascia of the levator ani. Below, both the superior and inferior fasciae of the levator ani fuse with the superior fascia of the urogenital diaphragm, the central point of the perineum, and the fascia covering the rectum, from the front towards the back. The fascial sheath of the prostate also meets these two layers on the urogenital diaphragm. The pubo-prostatic ligament is formed in the interval between the two levator ani muscles. It stretches between the prostate and the symphysis pubis and is formed by

a fusion of the superior and inferior layers of the levator ani fascia.

The vesical fascia is that layer of fibrous tissue which encloses the bladder. It covers the entire bladder, and as it reaches the bladder-neck, it becomes continuous with the fascial sheath of the prostate. The posterior portion of the vesical fascia has been described as forming a fascial compartment for the seminal vesicles. Just like the urinary bladder, the rectum also has a fascial covering, which is called the rectal fascia. It will become continuous with the fascia of the levator ani around the anal canal. Between the base of the bladder and the posterior aspect of the prostate in front and the rectum behind, there is a dense layer of fascia. This is the recto-vesical septum or fascia of Denonvilliers. Above, it is adherent to the recto-vesical pouch of peritoneum. Below, it fuses with the central point of the perineum behind the apex of the prostate. Laterally this fascia extends to the outer extremities of the seminal vesicles above, and the sides of the prostate below. It is thus a triangular sheet of fibrous tissue with a broad part above attached to the peritoneum, and a narrower part below attached to the central point of the perineum. The sides of this fascial sheath fuse with the tissue which forms the posterior ligaments of the bladder on each side. This ligament is the dense fibrous tissue in which is embedded the vesical plexus of veins. (See Fig. 18).

The recto-vesical septum is an embryological remnant. In the male foetus of 4 months the recto-vesical peritoneal pouch extends deeply towards the pelvic floor and separates the prostate and rectum. This pouch becomes obliterated to a great extent to form a dense fibrous septum. It is relatively avascular and an important

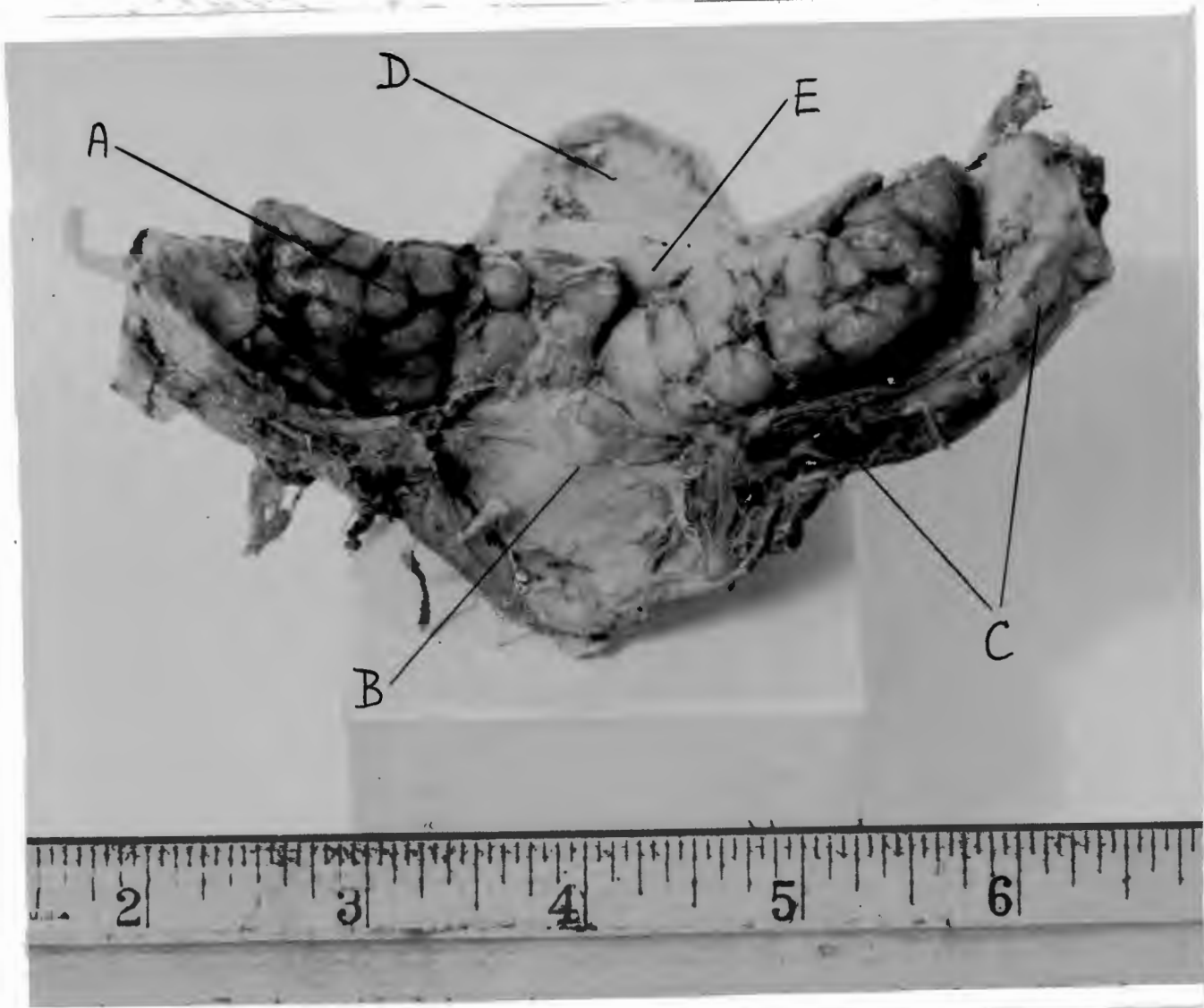


FIG. 18 THE SEMINAL VESICLES FROM BEHIND x 1½.

The rectal aspect of the prostate is at right angles to the camera. This is a visual representation of the prostate and seminal vesicles as felt by rectal examination.

- A. Left Seminal Vesicle.
- B. Posterior aspect of Prostate, covered by recto-vesical fascia.
- C. Vesical Venous Plexus (posterior ligt. of Bladder)
- D. Apex of Bladder in far distance.
- E. Right Ampulla.

The Fascia covering the seminal vesicles has been removed, and the vesicles have been eased out of their fascial beds.

land-mark in all operations around the region of the prostate.

This recto-vesical septum or fascia is loosely attached to the anterior wall of the rectum behind. In front it is more firmly united, but with dissection, a plane of separation can be made between it and the prostate and seminal vesicles. It helps to form the sheath of the prostate on the posterior aspect of the gland. Above, it is attached to the layer of the vesical fascia which covers the posterior aspect of the vesicles and ampullae. On the sides, the recto-vesical fascia is firmly adherent to the visceral fascia in this area.

The urogenital diaphragm fills the gap between the inferior rami of the os pubis. Two muscles form the bulk of the diaphragm viz: the sphincter urethrae membranaceae and the transversus perinaei profundus.

On both the upper and lower aspects of these muscles there is a layer of fascia. These have been referred to as the superior and inferior fascia of the urogenital diaphragm.

THE PERITONEUM.

The pelvic peritoneum also forms a relation of the seminal vesicles. That part of the peritoneum which dips in between the bladder and rectum partially clothes these glands. When the recto-vesical fossa is inspected, the seminal vesicles can be seen protruding slightly into the peritoneal cavity.

The peritoneum descends in the recto-vesical fossa to within $\frac{1}{2}$ an inch of the base of the prostate. This area can be palpated by the examining finger, and forms the anatomic basis of a very important clinical examination.

The vas deferens can also be palpated as it courses up the side wall of the pelvis under the peritoneum. The ampullae of the vasa are partially hidden between the base of the bladder and the seminal vesicles.

In some animals, like the horse, the seminal vesicles and ampullae are large and almost completely covered by peritoneum. In these animals a fold of peritoneum exists in which these structures lie.

R E C T U M .

The second part of the rectum is intimately related to the seminal vesicles. This anatomical relation has been discussed sufficiently well and needs no further description. Figs. 3 and 16 show clearly how the anterior rectal wall lies adjacent to the prostate below, and the seminal vesicles above.

A rectal examination affords an efficient way of palpating all the accessory sex glands in the male. If the index finger is inserted through the anal sphincter into the ampulla of the rectum, the bulbo-urethral glands can be grasped between the index finger and the thumb, as they lie on each side of the midline in the urogenital diaphragm. The whole of the posterior aspect of the prostate can also be felt. The base of the prostate lies about $2\frac{1}{2}$ inches from the anal orifice.

In the majority of persons the seminal vesicles and ampullae can also readily be felt by doing a rectal examination. The obesity of the patients' buttocks are more often the cause of failure than a relative shortness of the examiner's index finger. The seminal vesicles lie about 3 inches from the anal orifice. To the examining finger each vesicle feels like a soft sausage-shaped mass, which diverges gently from the midline upwards and laterally. In the normal healthy state they flatten under gentle pressure and the content is expressed into the posterior urethra. When the vesicles are emptied in this way, the patient experiences no orgasm. In a normal person even gentle pressure over these glands produces an unpleasant rather sickening feeling. Firm pressure is painful.

The ampulla on each side can very rarely be felt as a separate structure. It lies very close to the seminal vesicle, and in expressing the contents of the vesicle, it is quite impossible to avoid emptying the ampulla as well. Quite often one is able to palpate the lower end of the vas deferens when doing a rectal examination. This does not mean that such a vas is pathological. The lower ends of the ureters can not be felt per rectum in the male. See Fig. 18.

SURGICAL APPROACHES TO THE SEMINAL VESICLES.

It is not often necessary to expose a seminal vesicle by surgical operation. The commonest pathological change is an inflammatory process, and the treatment seldom includes surgical removal. Neoplastic changes in the seminal vesicles are rare. Concretions do form in

the lumen of the vesicles, but seldom give rise to colic or need removal. Nevertheless the indication sometimes arises for one or both of the vesicles to be removed or drained. There are four main surgical approaches :-

1. Perineal,
2. Abdominal - extraperitoneal,
3. Suprapubic - cystostomy,
4. Transperitoneal.

(1) Perineal Approach.

This is the one which is used most commonly.

To those surgeons who are accustomed to do prostatectomies by the perineal route, it will be natural to expose the vesicles by the same route.

An incision is made transversely across the perineum. It runs just in front of the anus and between the ischial tuberosities. Some surgeons prefer a curved incision with the convexity of the curve forwards. The centre of the incision passes through the perineal body. The object is to find a plane of separation in front of the recto-vesical septum.

Certain superficial muscles of the perineum are fixed to the central point of the perineum, which is a mass of felt-like fibrous tissue. They are the bulbo-cavernosus in front and the sphincter ani externus behind. On each side is fixed the superficial transverse perineal muscle. Dissection is made through the central point of the perineum and behind the superficial transverse perineal muscles. A sound in the urethra will facilitate exposure of the membranous portion of the urethra, as it

lies in the muscles of the urogenital diaphragm. The apex of the prostate is located and a plane of separation is found between the prostate and the rectum, by separating the recto-vesical septum from the prostate. By continuing in this fascial plane the seminal vesicles and ampullae are exposed as they lie above the prostate.

Only two arteries need be watched for. The transverse perineal artery, a branch of the perineal artery, runs superficially upon the superficial transverse perineal muscle. This vessel is usually retracted forwards with the muscle. On a deeper plane the artery to the bulb of the urethra runs transversely in the posterior border of the urogenital diaphragm.

The terminal portion of the perineal nerve runs parallel with the transverse perineal artery and just behind it. Since the incision is in line with the direction of this nerve it is unlikely to be damaged. Frequently it is recognised and can be preserved. This nerve supplies the superficial and deep perineal muscles and also, sensation to the posterior urethra. If it is damaged on both sides, the external vesical sphincter will be paralysed.

(2) Abdominal - Extraperitoneal approach.

This surgical exposure of the seminal vesicles has certain indications. In tuberculosis of the male genital tract, some urologists advise removal of the testis, epididymis, vas deferens and seminal vesicle in one mass. The incision is an inguinal one, prolonged if needed onto the scrotum. After cutting through the

abdominal muscles above the inguinal ligament, dissection is made between the bladder and the side wall of the pelvis.

The bladder is mobilised by cutting its medial umbilical ligament, and by tying off the superior vesical artery. The difficulty comes in exposing the seminal vesicle as it lies on the base of the bladder. The posterior ligament of the bladder, which is really the vesical venous plexus and inferior vesical artery embedded in dense fascia, lies between the base of the bladder and the side wall of the pelvis. This structure must be dissected free and partially tied off. Bleeding can be very troublesome from this area, and the dissection is deep down in the pelvis.

The same approach to the seminal vesicles can also be made through a midline suprapubic incision.

(3) Suprapubic - Cystostomy Approach.

In this operation the bladder is opened by the usual extraperitoneal suprapubic incision and dissection. The position of the seminal vesicles relative to the trigone of the bladder is shown in Fig. 19.

The removal of one or both seminal vesicles by this route has been called by Young a "destructive vesiculotomy". The indication for this operation is usually an abscess of the vesicle. Frequently the inflammatory mass bulges into the bladder, and the operation then consists of incision into the abscess followed by curettage of the cavity.

It seems to me that this approach should be

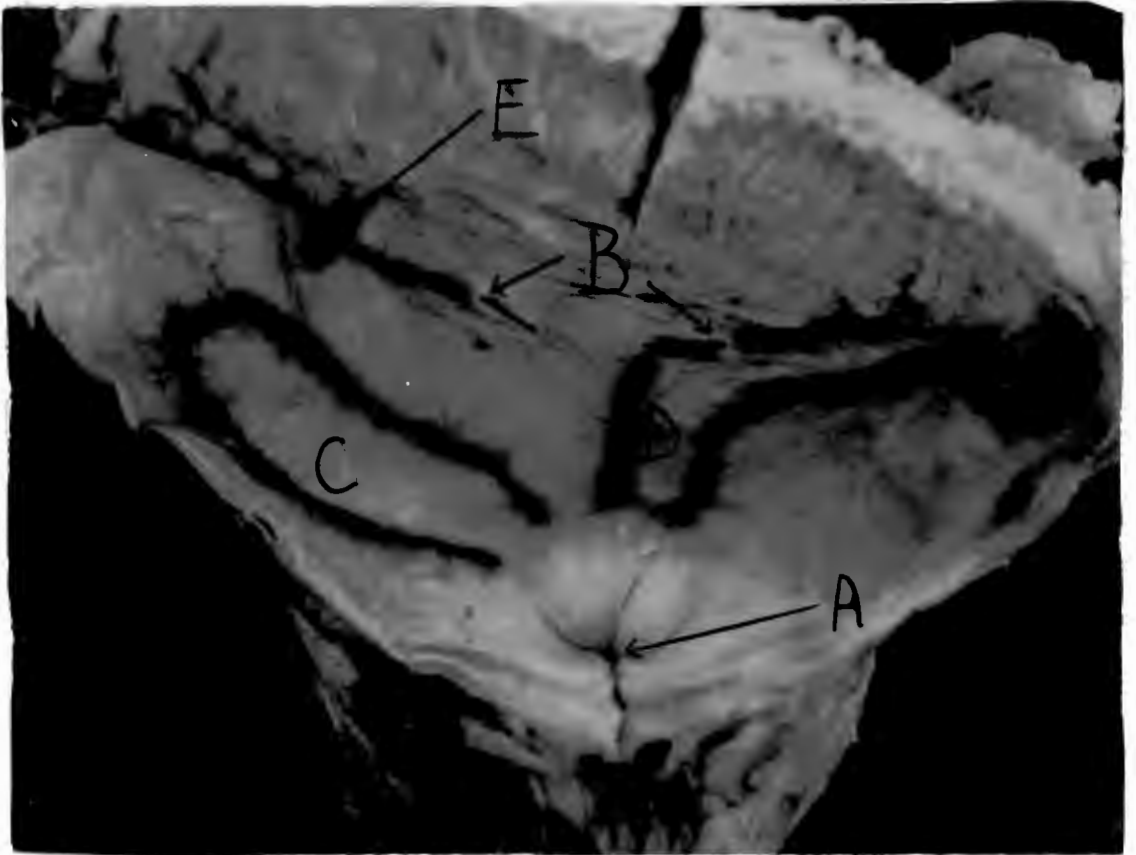


FIG. 19 TRIGONE AND BASE OF BLADDER VIEWED FROM
THE INSIDE x 1½.

The relative position of the seminal vesicle and ureter is shown on the right side. The outline on the left side indicates the position of the ampulla of the vas deferens.

- A. Urethral Orifice.
 - B. Ureters, marked by stilettes.
 - C. Right Seminal Vesicle.
 - D. Left Ampulla.
 - E. Position where Right Ureter pierces the
outer wall of the bladder.
-

used more frequently than it is done. The seminal vesicles lie closely applied to the bladder wall. The vesical venous plexus lies mainly on the outer aspect of the vesicle. The main arterial supply enters the vesicle on the side adjacent to the ampulla of the vas deferens. The incision through the bladder mucous membrane and muscle is made with a diathermy knife. The seminal vesicle can be dissected out of its fascial sheath. The cavity which results will drain into the bladder and is treated like the cavity which remains after the prostate has been removed.

In those cases where the seminal vesicle is densely adherent to its fascial sheath, most of the gland can be scraped away by curettage. Such a procedure is aptly described by Young's term "destructive vesiculotomy".

(4) Transperitoneal Approach.

In 1932 Wilhelm (53) described a case where he removed both seminal vesicles by an abdominal intraperitoneal operation. In his case both the vesicles were involved in an abscess due to Bacillus coli infection. He states that the operation is without difficulty and could be performed under direct vision.

It has been shown how the seminal vesicles do project slightly into the peritoneum. The dissection necessary for their removal by this route should thus be easy. The objection to this method has always been the danger of septic infection of the peritoneal cavity. However, other septic foci are frequently removed from the abdominal cavity, and moreover the pelvic peritoneum is

very resistant to infection. This route therefore has much that can be said for it; it remains for surgeons to record their experience when using it.

Both the perineal and abdominal extraperitoneal approaches, necessitate a very deep dissection. Vision in the depths of these wounds is always poor, and is obscured by venous bleeding. Frequently it amounts to a blind digital removal of the glands, or removal by curettage. The transperitoneal approach offers the best chance to see what one is doing. If a curettage of the vesicles is aimed at, it seems to me that the best route is via the inside of the bladder.

SEMINAL FLUID.

The total volume of seminal fluid which is ejected with one orgasm is called an ejaculate. The average volume in healthy adult males is about 4 cc's. Each cubic centimetre of the ejaculate contains approximately 120 million spermatozoa, but this number varies with many factors. In males who have been abstinent for a long while, the spermatozoa count of the first ejaculate is low. The count also falls gradually when coitus is frequently repeated. Local disease of the genitalia and general systemic disease adversely affects the number of spermatozoa present.

The volume of the ejaculate is made up by the combined secretions from the bulbo-urethral glands, the prostate and the seminal vesicles. The largest bulk comes from the seminal vesicles. The prostate probably produces less than 1 cc, and the Cowper's glands only a few drops.

The secretion from Cowper's glands flows most freely in the pre-orgasm stage. Its function is to remove traces of urine from the urethra, and as a lubricant fluid during coitus. Cowper's fluid does not contain spermatozoa. This knowledge is of practical value in the technique of contraception.

Much work has been done on the seminal fluid in the last few years. Many interesting facts are coming to light which have a practical bearing on animal breeding and on artificial insemination in humans. But there are still many facts concerning the physiology of the seminal fluid which remain obscure.

Seminal fluid has an alkaline reaction, due largely to the portion which comes from the vesicles. The pH varies between 7.05 and 7.41. (Huggins, Scott, Heinen. (15)).

Semen contains large amounts of chemically reducing substances. The percentage values for calcium, potassium, glucose and organic phosphorus are higher than in blood serum. The amount of chloride is relatively low. The protein compounds are mostly proteoses. The secretion from the vesicles has a high glucose content. Prostatic secretion is rich in cholesterol and acid phosphatase.

The semen from most animals, including man, coagulates soon after it is shed. This aspect will be fully discussed under the comparative anatomy. In humans the semen commences to coagulate in a few seconds after ejaculation and remains in a semi-solid jelly-like mass for several minutes. Thereafter it begins to liquify, and is completely fluid at the end of 15 minutes.

It is the secretion from the seminal vesicle which is coagulated by probably a secretion from the prostate. I attended several judicial hangings, and was able to recover vesicular secretion within 20 minutes after the victim had died. This secretion did not gel, even when exposed to air. From a comparative study it is clear that the secretion from a certain portion of the prostate sets in motion the coagulation of the secretion from the seminal vesicles.

The exact mechanism of the coagulation and subsequent liquifaction of the seminal fluid is not clearly understood; nor is the function of this phenomenon. Nevertheless it appears to be a very necessary process. There are certain cases of male infertility, where the pathology seems to be a breakdown of the process of coagulation and liquifaction.

In lower mammals the coagulation of semen is a much more prominent feature than in humans. It serves to form a firm mass of semen which is lodged in the vagina for many hours. In some few animals this vaginal plug remains there for months. The semen of dogs does not coagulate. This is understandable since they have no seminal vesicles. Perhaps this fact explains why dogs remain locked for about 20 minutes after copulation. The penis of the dog acts as a vaginal plug in the passage of the bitch.

When semen is stored the sperms gradually die off. Some substance is produced in old semen which is spermaticidal. Fresh ejaculates may be mixed with no ill effect on the combined spermatozoa. If fresh sperms are added to old ejaculate they promptly die. Brown (7.) showed that the spermaticidal effect of semen develops

more slowly at low temperatures. Thus it is not evident in semen stored at 5°C. until after 145 hours, whereas it appears after 30 hours at 37°C. More recently it has been shown that spermatozoa survive for long periods in the seminal fluid when frozen to -196°C. (Parkes, B.M.J. 1945, Aug. 18, p.212).

Much experimental work has been done to try and establish the effect of the secretions of the various sex glands on the spermatozoa. The results are somewhat conflicting. So Brown^(7.) showed that the separate secretions of the Cowper's glands, prostate and seminal vesicles have no effect on the longevity of spermatozoa. Armitstead^(1.) working with guinea-pigs reported that the secretion of the seminal vesicle activates spermatozoa in the first instance, and later inhibits their movements when coagulation occurs. Some authorities are of the opinion that the vesicular secretion stimulates spermatozoa to movement, and because this expends their energy, they soon become immobile and die. Most experts are agreed that spermatozoa are immotile while in the epididymis and vas deferens. It is the contact with the secretions of the prostate and vesicles which makes them actively motile. Whether the actual exciting factor is a chemical constituent of these secretions, or a relative increase or lack of either oxygen or carbon dioxide is not as yet known.

The seminal fluid may or may not affect the activity and longevity of spermatozoa. But one thing is sure, the spermatozoa do not execute their function in the absence of the secretions from the accessory glands. It may be that the main function of the secretions is to neutralize the acid reaction of the vaginal secretions.

This was very well shown by Armitstead (1) in guinea-pigs. The seminal fluid of these animals has a pH of 7.6. The vagina of the female in heat is pH 6.4. The reaction of the vaginal plug is approximately 7.4. In human beings certain cases of barrenness is purely a question of chemical reaction. Either the semen of the husband is not alkaline enough, or the vaginal secretions of the wife are too acid. A simple vaginal douche with weak bicarbonate solution before co-habitation, will result in pregnancy. On the other hand a douch with acetic acid solution soon after coitus is an effective contraceptive measure.

The secretion of the seminal vesicles normally harbours a fair number of cells. They resemble epithelial cells, and are about the size of pus cells. They have a large nucleus and clear cytoplasm. These cells can be mistaken for lymphocytes, and when degenerate, may resemble pus cells. They probably originate from the lining epithelium of the seminal vesicle. Exactly similar cells are found in the secretion of the ampulla of the vas deferens.

I had an opportunity of examining the bodies of six criminals who were hanged. Permission was given to perform an autopsy as soon as the victim was dead. I am told that the body frequently writhes for several minutes after the fatal fall. The heart in some cases continues to beat for 15 minutes. Quite often these persons pass urine and faeces in their spasmodic twitchings, but it has not been observed that they get an erection of the penis. I have perforce to mention these gruesome details, because it affects certain inferences I wish to make later on. The point being that certain hollow muscular organs

share in the convulsive spasmodic contractions which these victims undergo after the cervical spine has been snapped.

In these six autopsy cases I removed fluid from the ampullae, the seminal vesicles and the tail of the epididymes. The secretions of the ampullae and the seminal vesicles constantly showed the presence of epithelial cells, as described before. The presence of the cells can thus be taken as a normal finding. This is stressed because some urologists believe the presence of these cells, in a specimen expressed by digital massage of the vesicles is the result of trauma to the gland, or of a local inflammatory condition. I find myself in agreement with those who believe that the presence of these cells in the expressed secretion speaks for the normality of the gland.

SPERMATOOA.

An important aspect of the function of the seminal vesicles remains to be ventilated. Are these paired sacs reservoirs for spermatozoa or not? If not, where are spermatozoa normally stored?

In attempting to answer these questions it is necessary to review some history, but chiefly to collect evidence from comparative anatomy, from physiologists, from clinicians and from a personal study of a few cases. The personal evidence is based on the autopsy material I collected from the six persons who were executed.

It may be argued that the correct answer to these questions is purely of academic interest. My answer is, that if this is so, it still does not mean that the questions should not be answered if possible.

But it happens to be of practical consequence too. The seminal vesicles are often involved in an inflammatory process; in fact it is the chief type of pathology which affects these glands. In order to assay the extent of pathology present, there are certain means of examination at our disposal. The seminal vesicles can be palpated per rectum; the findings may be inconclusive. An endoscopic examination of the bladder and the posterior urethra often does yield indirect evidence, but not always. These organs can be examined radiologically; this is a sure and accurate method but obviously should only be done as a last resort. A very practical and simple means of examination, consists in looking at the secretion which has either been expressed or ejaculated. For this reason it is important to know what normal constituents we will expect to find in the secretion. If spermatozoa are normally present in the seminal vesicles, in what numbers are they to be found, and are they healthy or dead. An accurate diagnosis of vesiculitis can not be made in many of the cases, unless we have this knowledge.

To consider briefly the historical background, it can immediately be said that the question whether the seminal vesicles contain spermatozoa or not has interested the medical mind for many years. The early anatomists of the Renaissance called these sacs "vesiculae seminalis" because they believed that semen collected here. In this they were largely correct. Then spermatozoa were discovered, and the fact that they were the most important part of the semen. It was taken for granted that the vesicles were reservoirs for the whole semen, including spermatozoa.

But soon, many men began to doubt this belief. Since then there have been two schools of thought about the subject. So for instance in England during the 18th century Fallopius and de Sraof maintained that the vesicles were seminal reservoirs, (i.e. they stored spermatozoa). Opposed to this view were amongst others Swamerdam and Hunter. The Royal Society of London asked de Sraof to try and settle the question. He was not able to arrive at any definite decision. The controversy continued, and still exists today. It would be tiresome to mention the names of all the men who have expressed their opinions on this subject. There is no unanimity of opinion.

Some hold that the chief function of the vesicles is as a reservoir for spermatozoa, and that the spermatozoa in these organs are mature and healthy.

Others believe that the seminal vesicles are essentially glands with an external secretion. This secretion is vital to the proper function of the spermatozoa. If spermatozoa are found in the vesicles their presence there is adventitious, and probably they do not survive for long in this site.

Still others maintain that in man the seminal vesicles have a dual function. They serve as a reservoir for spermatozoa and are glands with an external secretion. The spermatozoa profit by their presence in the vesicles, and are finally matured in the favourable medium of the vesicular secretion.

A study of comparative anatomy is very illuminating in regard to this problem. The true homologue of human seminal vesicles is only to be found in some mammals.

In these animals the seminal vesicles never act as a reservoir for spermatozoa. Only very rarely are they present in these organs. In most animals, too, the seminal vesicles join the urethra by a separate duct, and do not communicate directly with the lower end of the vas deferens. Also the glandular element of the seminal vesicles in most animals is much more evident than in the human vesicles. For these pertinent reasons comparative anatomists prefer the term "vesicular glands" to "seminal vesicles" in respect of animals.

The lower primates are somewhat different to other mammals and resemble man more closely. In many of them an ejaculatory duct is formed, and there is thus an easy path for spermatozoa into the seminal vesicles. In their sexual habits too, apes and monkeys differ from animals and resemble man. As I shall show later on, spermatozoa are sometimes found in the seminal vesicles of monkeys. It seems that the reservoir function of the seminal vesicles may be a feature of primates only.

In birds and some fishes it is the rule for the lower end of the vas deferens to dilate, and this area very definitely serves as a site where spermatozoa collect. In such animals this site very correctly may be called "vesicula seminalis". The homologue in mammals would be the ampulla of the vas deferens. With the exception of man, there are very few mammals which develop an ampulla of the vas deferens, which is worthy of the term. When present it is rarely a sacciform dilatation, and is largely formed by glandular tissues in the wall of the vas deferens. The human being thus resembles birds, rather than mammals in having an ampulla of the vas deferens.

Most authorities are agreed that in man the ampullae very definitely serve as a reservoir for spermatozoa, in addition to having a small secretory function. It may be that birds have well-developed "vesiculae seminalis", because of their build and habits; coitus in birds occurs in most species by brief cloacal contact, and the sperms must of necessity be close at hand to be effectively ejected. One cannot in fairness apply this argument to human beings.

If the opinion from comparative anatomists is definite then that from physiologists is no less so. Most text books on human physiology stress the point that the seminal vesicles are excretory glands and not seminal reservoirs. These authorities hold that spermatozoa are stored and undergo full maturation in the tail of the epididymis. From there they migrate down the vas deferens continuously as their numbers are added to from the testis above. It is not definitely stated, but one can assume that in this conception, the spermatozoa which reach the ampullae or the seminal vesicles are spent and useless. One can also assume that incest spermatozoa are continuously voided in the urine. That this latter fact is so, has been affirmed by many workers. Laboratory technicians show no surprise when they report the presence of spermatozoa in routine urine examinations.

Physiologists, and many others, maintain that when ^{an} orgasm occurs, the spermatozoa travel down the vas deferens to be mingled with the secretions of the vesicles and prostate gland in the posterior urethra. Part of the ejaculation reflex therefore is strong peristalsis of the vas deferens. It seems a long way for spermatozoa to

travel in a very short period of time. On the other hand it must be granted that the muscular coat of the vas deferens is outstandingly thick.

The effect of temperature on spermiogenesis is a factor which is stressed by physiologists. Body temperature is thought to be inimical to spermatozoa and for this reason the testes descend into the scrotum where it is cooler. It is believed by many of these authorities that spermatozoa probably do not survive longer than 48 hours after reaching the vagina, because of the temperature.

I will discuss the pros. and cons. of this conception fully under comparative anatomy. Certain it is that spermiogenesis proceeds normally in some few animals at their body temperature because the testes in these animals are permanently intra-abdominal. But such animals are an exception to the usual rule, and descensus of the testis is a feature of most mammals. Perhaps the low temperature is only required for the development of the spermatozoa in the testis. Nevertheless it is claimed that spermatozoa soon die when exposed to body temperature. How then can the seminal vesicles which are situated deep in the pelvis ever serve as reservoirs for spermatozoa ?

Clinicians, most of them urologists, have contributed much in the solution of this problem. It is part of their daily routine to examine and observe all parts of the male genital tract. It is also of interest to these workers, to form an idea of the physiology of spermatozoa. The secretion of the prostate and vesicles is frequently obtained for purposes of careful scrutiny, both macro- and microscopically. The opinion therefore of these men is of value. They are the only ones who can really

claim to have performed physiological experiments on human beings. Unfortunately there exists the greatest divergence of opinion among these very clinicians, who should know best. The various opinions are those which I have already enumerated.

There are but few things which are fairly generally accepted. It is believed that in human beings, healthy and mature spermatozoa collect in great numbers in the ampullae of the vasa deferentia. These will form the mass of spermatozoa in the ejaculate.

Other clinicians accept the opinion of physiologists and believe that with each orgasm masses of spermatozoa come from the epididymes. Many urologists accept the seminal vesicles as being reservoirs for spermatozoa. Nearly all are agreed that spermatozoa are constantly shed in the urine apart from sexual activity.

When the prostate gland and the seminal vesicles are massaged, a secretion is expressed which flows from the penis or can be recovered in the urine. In normal healthy males this secretion invariably contains spermatozoa. Some are motile, others are dead. Some authorities believe that the incest spermatozoa come from the seminal vesicles, and that the live ones come from the ampullae. This view is modified, in that some investigators believe that incest spermatozoa mean that the seminal vesicle is diseased. It has not been shown (and would be very difficult so to do) that the motile spermatozoa recovered by this means, are indeed alive and healthy enough to effect fertilisation.

A lot of work has recently been done on the finer structure of spermatozoa. There are histological

differences between immature, mature and post-mature forms. The motility of spermatozoa has also received much attention and it has been suggested that active motility is a sign of full maturity. A lot of space would be needed to describe even the essentials of all this work and in large part it falls outside the scope of the present discussion. Only a few succinct facts will be quoted from the literature.

It is maintained by many authorities that spermatozoa have no motility prior to ejaculation. They are dependent for their movement on the muscular action of the organ they inhabit, or the action of the ciliated lining epithelium. (McLeod (23) Cowdry (60)). Also in their travel from the tail of the epididymis towards the urethra, they gradually decrease in vitality. Lasley (19) showed that the spermatozoa in ejaculated semen of the boar were more susceptible to cold than were those recovered from the epididymis. Collery (9) records that the middle piece bead of the mammalian spermatozoon passes gradually from the neck towards the tail, as the spermatozoon moves from the testes downwards. When this bead reaches the junction of the middle piece and the tail, it is thought that the sperm is able to move actively. This histological change is part of the maturation process. Walker (47) believes that in man the maturation process is brought about in the tail of the epididymis. Close (8) records that spermatozoa expressed from the seminal vesicles by digital massage are often incest, and does not regard this as abnormal.

The autopsy findings in the six criminals can now be examined. These were native males between the

ages of 25 and 40. In all of them the external genitalia were normal by inspection and palpation. In one of them there existed a chronic perivesiculitis of the left seminal vesicle. The bodies were seen about 10 minutes after death had occurred. In all of them I recovered secretions from the epididymis, seminal vesicle and ampulla, usually on both sides. Smears were made of the secretions, and were examined after staining with methylene blue. Before taking the smears, the vasa deferentia were severed in the scrotum, to exclude as soon as possible any post-mortem movement of the spermatozoa down the vas deferens.

Most of the previously recorded findings of spermatozoa in the seminal vesicles, have been based on an examination of cadavers in anatomy departments. Physiologists have rightly objected that in these cases the spermatozoa may have been squeezed into unnatural sites by the contraction of plain muscle which occurs soon after death. Some contraction of the muscular coat of the vas deferens may also have occurred in the case of these criminals who were hanged. I have mentioned that sometimes there are violent muscular spasms and the bladder and rectum may be emptied reflexly. The ideal chance of examining the normal physiological content of various parts of the male genital tract would occur when operations are performed on these various sites.

I have recorded the findings in these six autopsies in tabulated form. The presence or absence of spermatozoa in the cauda epididymis, ampulla of the vas, and seminal vesicle are recorded. It will be seen that spermatozoa were always present in great numbers in the tail of the epididymis. Spermatozoa were present in both the ampullae and the seminal vesicles in four of the cases examined. In three of these four cases there were

TABULATED RESULTS FROM JUDICIAL HANGINGS.

ORGAN EXAMINED	AUTOPSY 11/6/45		AUTOPSY 11/6/45		AUTOPSY 4/7/45		AUTOPSY 23/7/45		AUTOPSY 7/8/45		AUTOPSY 7/8/45	
	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left
Cauda Epididymis	4+	4+	4+	Not done	4+	4+	Not done	4+	4+	Not done	4+	4+
Seminal Vesicle	-	-	2+	2+	2+	2+	Not done	3+	4+	-	2+	2+
Ampulla of Vas Deferens	-	-	2+	2+	3+	3+	4+	4+	2+	-	4+	3+
Vasa Deferentia severed or not	Severed		Not severed		Severed		Severed		Severed		Severed	
Genitalia (Ext. & Int.)	Normal		Normal		Normal		Normal		Left Vesiculitis		Normal	

SPERMATOZOA
 (- = Absent
 (4+ = Abundant
 (3+ = Moderate numbers
 (2+ = Few
 (1+ = Very few.

All these cases were Adult Natives between 20 and 40 years old.

more spermatozoa in the ampullae than in the seminal vesicles.

Two autopsies were done on the 11th June, 1945. In the first the vasa were cut, in the second not. In the first I found no spermatozoa in either the vesicles or ampulla, whereas they were present in these sites in the second case, where the vasa had not been tied off. In both these instances the slides were only made some hours after the organs had been recovered, and I thought I had established the fact that spermatozoa are indeed pushed down the vas after death. This was upset by finding spermatozoa in the vesicles, in several other cases where the vas had also been severed.

In Autopsy IV there was very definite peri-vesiculitis on the left side. This vesicle and ampulla contained no spermatozoa. Unfortunately the epididymal secretion was not collected from this side.

From all this evidence I have drawn certain conclusions regarding the physiology of spermatozoa in the human :-

1. Spermatozoa are present in greatest numbers in the tail of the epididymis. In this site they are immobile, but fully matured. During a sexual orgasm they are rapidly expelled from this site by means of muscular contractions of the vas deferens. They join the seminal secretions in the posterior urethra.
2. There also occurs a continuous migration of spermatozoa down the vas deferens apart from ejaculation. These spermatozoa are temporarily held up in the ampulla of the vas, and often

penetrate into the seminal vesicles. From both these sites they are continuously or intermittently discharged into the bladder to be voided with the urine.

3. The spermatozoa in the ampulla and particularly in the seminal vesicles are probably post-mature forms, and do not possess the fertilizing capacity of those which emanate from the epididymis. Spermatozoa in the seminal vesicles are frequently incest. Their presence here is adventitious.
4. The main function of the seminal vesicles is to provide an abundant volume of medium favourable to the spermatozoa when they are deposited in the vagina.
5. The ampulla of the vas deferens also has a glandular secretion, the nature of which is essentially similar to the vesicular fluid. Spermatozoa do tend to collect in fair numbers at this site, and under certain conditions they may be physiologically active. If their sojourn in the ampulla is protracted, they become progressively less viable.

E J A C U L A T I O N .

The seminal fluid and its constituents have been dealt with in some detail. With this knowledge it is possible to deduce the sequence of events as occurring in the genital tract with a sexual orgasm.

McLeod (23) has recorded the results of an interesting experiment. He collected the seminal fluid

as it was ejaculated in separate successive portions, in much the same way as urine is collected for the 2 or 3 glass test. An analysis of the various portions revealed interesting results.

The first 40% of the ejaculate contained 75% of the total number of spermatozoa. The first 25% was very rich in acid phosphatase. The last portion contained the highest percentage of glucose. In other words the vesicular secretion is ejected last, whereas the prostate empties in the first phase of the reflex. Since the prostate definitely does not harbour spermatozoa, and the vesicles empty last, it can be deduced that the greatest mass of spermatozoa which appear in the first 40% of the ejaculate, cannot have come from the vesicles. It is evident then that the majority of the spermatozoa come from the ampulla and the vas deferens.

With ejaculation the accessory glands therefore contract and empty themselves in the following order. In the earliest phase the prostate contracts and pours its secretion into the posterior urethra. In the next phase, which partly overlaps the first, the vas deferens, from the tail of the epididymis down to the ampulla, empties itself. In the last phase the seminal vesicles contract and add some of their secretion to the ejaculate.

The seminal vesicles are probably very seldom completely emptied with one orgasm. This seems obvious when one bears in mind their structure, and from the knowledge that coitus can be repeatedly performed in quite a short space of time. The secretion from Cowper's glands flows freely in the pre-orgasm phase, and adds but little to the volume of the ejaculate.

This conception of ejaculation fits in with what has been deduced about the physiology of the various parts of the male genital tract. Clinical experience also supports such an idea. Some men are in the habit of having an incomplete orgasm. Only the first phase occurs, and the ejaculate consists merely of prostatic secretion. For one of many possible reasons (often psychological) the reflex does not spread sufficiently to involve also the vas deferens, and seminal vesicles.

MECHANISM OF MICTURITION AND EJACULATION.

It is particularly the trigone area and the sphincters of the bladder I wish to discuss. The ejaculatory ducts emerge into the posterior urethra between the internal and external sphincters of the bladder. It is only when both these sphincters are competent that the posterior urethra is able to function effectively in either its genital or urinary capacity.

The muscular coat of the urinary bladder is composed of two layers, more or less distinct from each other. The outer layer of longitudinally directed fibres is incomplete, in that a gap exists in the area where the ureter pierces the bladder wall. The inner layer of circularly placed fibres is thick and it forms a complete coat.

As the outer layer of muscle descends from the vertex of the bladder towards the bladder-neck, it forms an anterior and a posterior band. It becomes deficient on the lateral side below the entrance of each ureter. The fibres of the anterior band lose themselves in the pubo-prostatic muscle, around the prostate and in the urethral wall.

The posterior band collects over the base of the bladder and passes between the two ureters. The fibres are inserted into the prostate and its true capsule, and also are continued into the posterior urethra.

The fibres of the internal muscle coat sweep around the entire bladder from the vertex to the neck. At the bladder-neck there is formed a thickened circular band which constitutes the main mass of the internal sphincter. Some fibres of this sphincter muscle are also derived from the outer longitudinal layer.

Both the internal and external muscle layers, together, form the detrusor muscle of the bladder. The internal sphincter lies upon the base of the prostate. These muscle fibres are plain and involuntary. They are supplied by the pelvic sympathetic and parasympathetic nerves. The external sphincter of the bladder is the sphincter urethrae membranaceae, which lies in the urogenital diaphragm. It is composed of striated muscle fibres, and is a voluntary muscle, supplied by the pudendal nerve. The pudendal nerve also gives the sensory supply to the posterior urethra. Sensation from the bladder wall and bladder mucous membrane travels by afferent fibres in the sympathetic and parasympathetic nerves.

McCrea (25) reported in 1926 that he found striated muscle fibres forming part of the internal vesical sphincter. Similar fibres were found also in the wall of the prostatic urethra and in the trigone area of the bladder. These fibres form a complete coat of the urethra in the foetus. In lower mammals such a layer of striated muscle around the urethra is a

prominent feature and is called Wilson's muscle. Remains of this muscle in the adult human is of considerable interest both developmentally and practically.

Micturition, according to physiology text books, occurs by contraction of the detrusor muscle and relaxation of the internal and external sphincters. In the cat, Barrington has shown that there are six reflexes which are brought into play. The centre for micturition lies in the sacral segments of the spinal cord, and the cerebral cortex has an important control over this centre. The wall of the bladder shows rhythmic waves of contraction, which increase in intensity as distention proceeds. These waves can be damped down by the cerebral cortex. When the animal allows itself to micturate, the sphincters are relaxed and the detrusor contracts. It is believed that the pelvic splanchnic nerves cause contraction of the detrusor and reflex inhibition of the internal sphincter. The pelvic sympathetic nerves are believed to cause tonic closure of the internal sphincter and inhibitory relaxation of the detrusor. The external sphincter can be closed at will, not actively opened. It opens widely as a reflex action which results from the passage of urine through the posterior urethra.

This very briefly is the conception of the physiology of micturition which one gathers from physiologists. The opening of the internal vesical sphincter is a negative type of inhibitory relaxation. A more reasonable view was put forward by Young and Wesson (55) in 1921. They described a trigonal muscle of the bladder. Actually part of this muscle was originally described by Bell.

It is quite simple to demonstrate the trigonal muscle by dissection in a fresh autopsy specimen. A transverse incision is made across the trigone of the bladder half-way between the urethral and the ureteric orifices. Only the mucous membrane is incised, and it is then gently peeled off the underlying trigonal muscle to which it is attached. A thin layer of plain muscle will be found to extend from the region of the ureteric orifices to the proximal limit of the veru montanum. It is formed by a continuation of the longitudinal fibres of the ureters, and it crosses over the external vesical sphincter as it proceeds into the urethra. The diagram in Fig. 20 shows the essential features of the trigonal muscle.

The action of this muscle is to actively dilate the urethral orifice of the bladder. It is thus the opponent of the internal vesical sphincter. Presumably it is supplied by the nervi erigentes. Support has been given to the importance of the trigonal muscle by Macalpine (21) McCrea (25) and Walker.

Evidence of its function is given by the fact that this muscle becomes visibly enlarged where an obstruction develops in the posterior urethra. Trigonal hypertrophy is a sign always looked for in suspected prostatic enlargement.

It has been mentioned that erection of the penis is due to parasympathetic influence, whereas ejaculation follows stimulation of the pelvic sympathetic nerves. It is also believed that with sexual excitement the internal bladder sphincter closes tightly, whereas the external sphincter relaxes. This would be the effect of sympathetic stimulation.

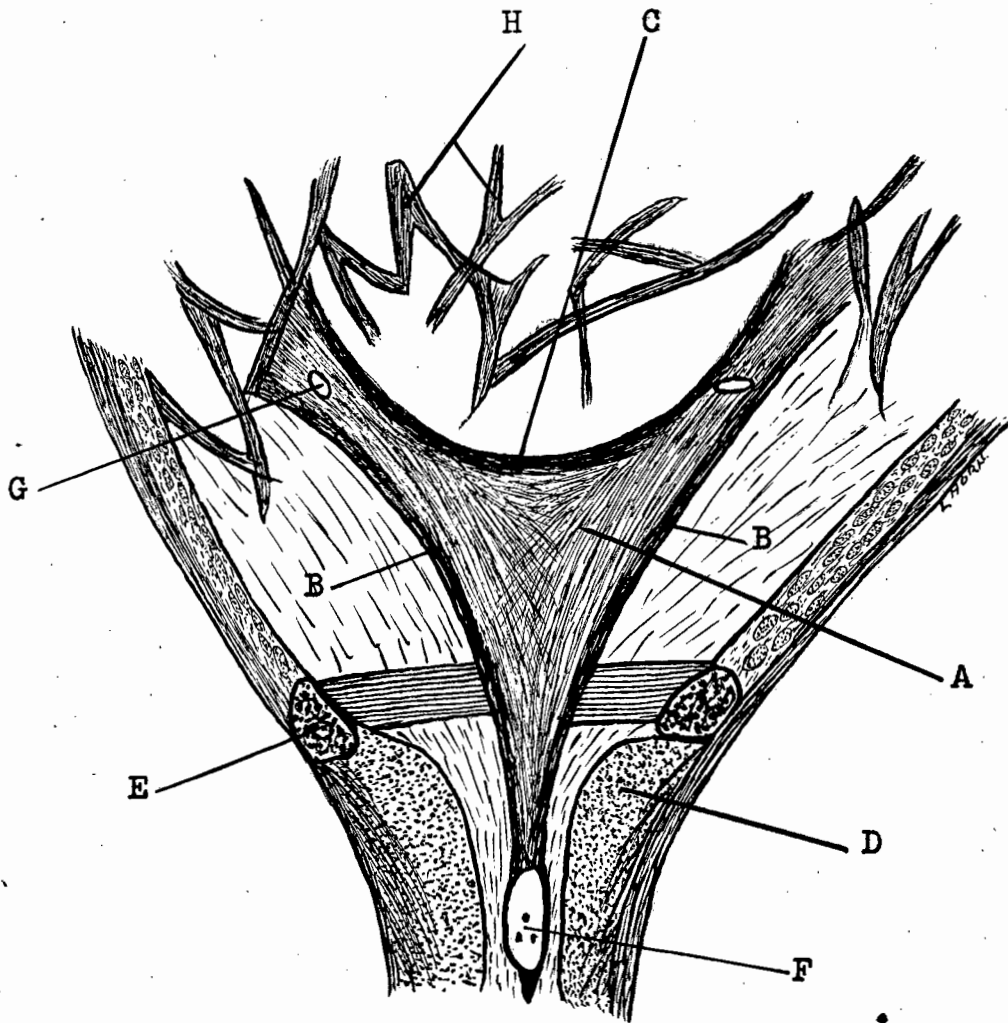


FIG 20 THE TRIGONAL MUSCLE.

The bladder and the prostatic urethra have been opened in the midline ventrally. The mucous membrane of the urethra and trigone area has been stripped off, to expose the trigonal muscle. Note that this muscle crosses the fibres of the internal sphincter.

- A. Trigonal muscle, bounded on each side by the Bands of Bell(B), and above by Mercier's Bar(C).
- D. Prostate (cut across).
- E. Internal Sphincter (cut across).
- F. Veru Montanum.
- G. Ureteric Aperture.
- H. Bladder Trabeculae.

The same effect of this latter reflex is demonstrated in cases of vesical calculus who develop priapism.

When ejaculation occurs the internal sphincter remains tightly shut and the external sphincter relaxes completely. Where the internal sphincter is paralysed or traumatised the semen will flow back into the bladder. This is seen in cases of tabes, disseminated sclerosis, and following suprapubic prostatectomy. A case is recorded by Macalpine (21) of a man with a "cord bladder" due to a transverse myelitis. His internal sphincter was completely paralysed. The external sphincter kept him continent. With an erection of the penis he dribbled urine, and leaked urine rapidly when he ejaculated. This occurred because the external sphincter relaxes with coitus, and in his case the detrusor muscle of the bladder was hypertonic.

There are many causes of what is called a "funnel-necked" bladder. This term indicates that the posterior urethra is widely open and communicates with the bladder. The obvious cause is a complete paralysis of the internal sphincter. The condition is recognised either cystoscopically or on a cystogram. One of the many causes is a physiological one, and happens when the bladder is very fully distended.

This physiological continuation of the bladder cavity into the posterior urethra is of some practical importance. Some urologists are convinced that by this means urine can regurgitate up the ejaculatory duct. If the urine is infected it may result in vesiculitis or epididymitis. This phenomenon may account for the curious cases of spontaneous epididymitis, which settle just as quickly as they develop. It may also be the reason for those cases of epididymitis which follow a "strain".

I have seen several patients with prostatitis and purulent urine, who have developed epididymitis after slipping on a step, or after picking up a heavy weight. The explanation seems to be that a sudden unexpected increase in abdominal pressure, forces urine from a full bladder into the posterior urethra and from there up the ejaculatory ducts. Such a view was supported by Belfield^(3,4) as long ago as 1913. He was doing the operation of vasotomy at the time, and records the fact that dye, which he had instilled into the bladder, was regurgitated through his vasotomy wound.

S U M M A R Y .

The anatomy and function of the seminal vesicles has thus been discussed. I would suggest that these glands are ^{not} to be regarded as seminal reservoirs. The term, seminal vesicle, is thus a misnomer if one concedes that the spermatozoa are the essential constituent of semen.

RADIOLOGICAL EXAMINATION OF THE SEMINAL VESICLES.

A short survey of this procedure follows naturally on a discussion of the anatomy and physiology. Many facts about the structure and function of these glands have been gleaned from their radiological study.

There are two methods of obtaining a vesiculogram. In the first, the radio-opaque material is injected down the vas deferens from a scrotal incision. It is usually called vaso-vesiculography.

The second method is described as retro-grade vesiculography, and is comparable to retrograde pyelography of the renal tract. It is accomplished by passing a fine catheter up the ejaculatory duct, and then instilling a sufficient quantity of radio-opaque fluid. A special endoscope is needed which gives a clear view of the veru montanum. The operation is technically difficult, but with practice and a good knowledge of the local anatomy, it has been successfully mastered.

The idea of vaso-vesiculography was conceived in America by Belfield (3,4) in 1913. Since 1905 already he had performed the operation of vasotomy, in order to irrigate the ampulla of the vas deferens and the seminal vesicles. He found that fluid injected into the scrotal portion of the vas deferens filled the vesicle before it leaked into the urethra. Belfield's first vesiculograms were made with argyrol solution, and the shadow cast on the X-ray plate was vague and indefinite.

Since 1913 great strides have been made in this direction. Various radio-opaque fluids have been employed, such as collargol, sodium iodide, iodized oils, the uroselectan group of drugs and now lately diodrast. Most advance occurred in America. Kidd in 1931 reported the first vesiculogram done in England. (Wilhelm (51)).

Vase-vesiculography is possible because of the anatomical arrangement of the ampulla, the seminal vesicle and the ejaculatory duct. It can easily be shown on a fresh autopsy specimen that fluid injected down the vas will successively fill and distend the vas, the ampulla and then the seminal vesicle; thereafter it will escape into the urethra.

The amount of fluid necessary to fill this tract before it leaks into the urethra, varies between 3 and 5 cc's. It depends in large measure on the normality of the parts, and whether the seminal vesicle is empty or full. Thick oily solutions will not displace the vesicular content but thin fluids apparently do so, or diffuse throughout the content. Better filling of the vesicles will result if the gland is first emptied either physiologically, or by digital massage, or by preliminary irrigation with a bland fluid. I have not seen it mentioned in the literature, but it has struck me that a dilute solution of acetic acid would be an excellent irrigating fluid, since the vesicular content so readily dissolves in it.

Very good vesiculograms can be obtained by this method of injection down the vas. There are a few disadvantages. The vas deferens must of necessity be traumatised and stenosis may result. Many urologists have expressed the opinion that this rarely if ever occurs. If the fluid regurgitates through the vasotomy wound, a painful nodule develops in the spermatic cord. It is not of any real consequence. The fluid may regurgitate even further back and lead to a sudden acute epididymitis. This does not often happen. When it does it probably is due to regurgitation of urine from the posterior urethra when the bladder is overfull. In any case it invariably resolves completely.

The advantage of vaso-vesiculography is chiefly that it is a simple operation, and can be performed under local anaesthesia. With this anaesthetic the patient is fully co-operative while the X-ray exposures are being made. The results are good. Sargent (36) in 1929 gave a favourable report on this method over a series of

200 cases.

Retrograde vesiculography on the other hand requires expert training and no mean measure of skill. This method has been developed almost exclusively in America. Gonzales-Iman (10) in 1943, gave a clear dissertation on the technique, indications and value of this procedure. He mentions that men like Young, Lowsley, McCarthy, Ritter, Santa Maria and Valverde are to be regarded as pioneers in this work. Actually Klotz apparently catheterised the ejaculatory ducts as early as 1895. From 1930 onwards, the literature abounds with information about all the various aspects of retrograde vesiculography.

The impression I have gathered is that with careful preparation and after some practice, the technique is readily mastered. Once this happens one can expect success in some 98% of cases attempted. The anatomy of the veru montanum and the ejaculatory ducts is fairly constant, and has been discussed. The pertinent point in the anatomical arrangement is that a catheter passed up the ejaculatory duct invariably slips into the seminal vesicle.

With a catheter in the seminal vesicle or even well in the ejaculatory duct, the vesicular content can be aspirated or washed out. Thereafter 1 - 3 cc's. of radio-opaque fluid is gently instilled. Gonzales-Iman (10) recommends diodrast solution, as giving the best results. The urinary bladder may be filled with air to give very clear definition to the vesiculogram. This filling of the bladder with air is a procedure not without danger and it is probably advisable to omit it.

As a result of seminal vesiculography much has been learnt about the function of these glands. By taking X-ray photographs daily after the instillation of the dye, it can be seen that the vesicles gradually empty. In normal cases no opaque material remains after 5 days. (Sargent (36)). Where argyrol has been used, the urine remains stained for several days.

In some cases the vas deferens and ampulla are outlined by either vaso- or retrograde vesiculography. This material is also gradually expelled and none remains after a week. This observation firmly establishes the view that the vasa deferentia, the ampullae, and the seminal vesicles continuously expel their secretions, and that this does not occur only with ejaculation.

Quite often patients experience a nocturnal emission within 48 hours of having their vesicles filled. I have found no record of what is found on a subsequent X-ray, but presumably the male genital tract will be free of radio-opaque material. I would not be surprised though to find a residue in the seminal vesicle, even when the gland was normal.

In cases where the vesicles are pathological there is often found stasis of the content. This is easily recognisable radiologically. One can infer from this finding that the muscular wall of the vesicle is either atonic or fibrosed, and the diagnosis in such cases is comparable to a similar finding of stasis of barium in the lumen of an appendix, which is the seat of chronic inflammation.

As would be expected it is the pathological ejaculatory duct which is difficult or impossible to negotiate with a catheter. The veru montanum may be oedematous or covered in granulation tissue. Topical applications of phenol-glycerine solution on several successive occasions, help a great deal to facilitate a clear view of the ejaculatory ducts.

With experience it is possible to deduce a lot from a vesiculogram. Stasis has been mentioned. Filling defects, atonicity, abscess cavities and more can be recognised, and the method is a valuable aid to diagnosis.

At present there is no way of outlining the seminal vesicles by a procedure like uroselectan for the kidneys or shadocol for the gall-bladder. It has been mentioned that vesicular secretion is specific in that certain chemical constituents derived from the blood are highly concentrated. It seems possible that a substance may yet be found which would be selectively secreted in the vesicles and be radio-opaque.

D E V E L O P M E N T .

The seminal vesicles develop in the foetus as outgrowths from the lower end of the Wolffian ducts on each side, close to the cloaca. In offering a description of their development, it is necessary to enter more or less fully into the embryological evolution of the entire urogenital tract, and in particular to consider what happens to the cloaca and what structures arise therefrom. Much that will be mentioned will be recapitulated in the chapter on comparative anatomy. This cannot be otherwise, because embryological and phylogenetic development are closely linked. The knowledge of each is complementary to the other.

When the human embryo is still less than 2 weeks old, it consists of a flattened disc between the adjacent sides of the ectodermal and entodermal vesicles. This disc is composed of the three primary layers, viz: ectoderm, secondary mesoderm and entoderm; See Fig 21. Thereafter a process of differentiation of the three primary layers commences. The neural tube and the notochord come to occupy the central longitudinal axis of the embryonal disc. This divides the mesodermal mass into two halves, one for each side.

During the 3rd week the mesoderm becomes progressively segmented, from the head-end towards the tail-end, so that each side consists of blocks of mesoderm or somites. Thirty-eight somites are formed in all, but the process is not completed until the embryo is 4 weeks old, and measures five mm. in length.

At this stage there has occurred also definite folding of the embryo. It results from more rapid growth in the centre of the embryonal disc than at the periphery,

- and leads -

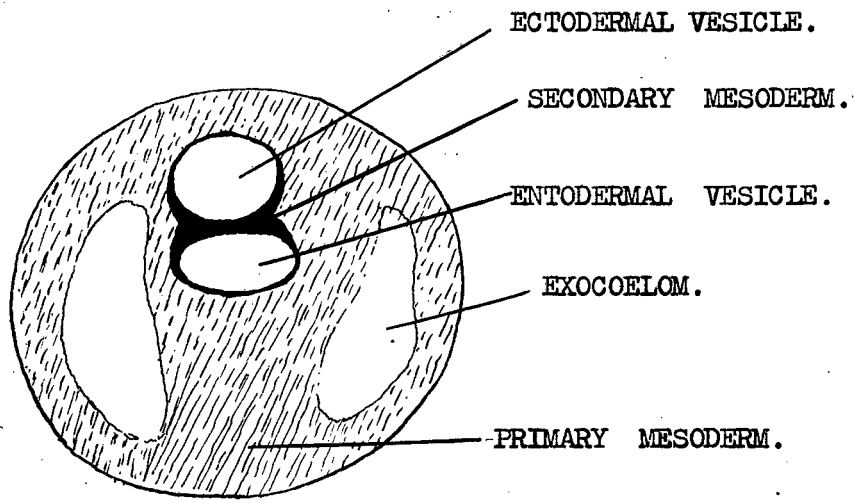


FIG 21 THE EMBRYONAL DISC COMPOSED OF A LAYER OF ECTODERM, MESODERM AND ENTODERM.

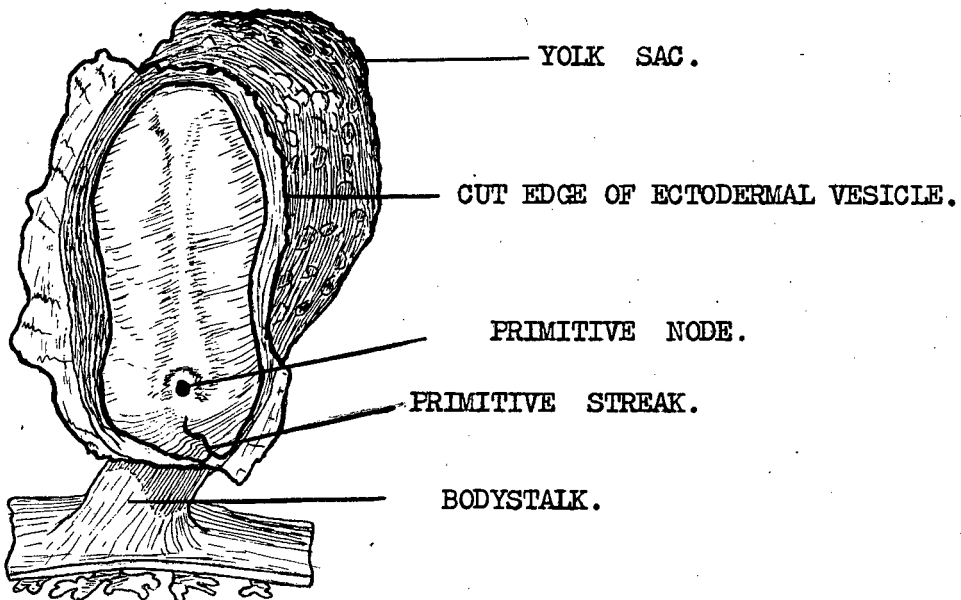


FIG 22 THE EMBRYONAL DISC VIEWED FROM THE ECTODERMAL ASPECT.

The ectodermal vesicle (Amniotic cavity) has been opened.
 (From Gray's Anatomy. After GRAF SPEE).

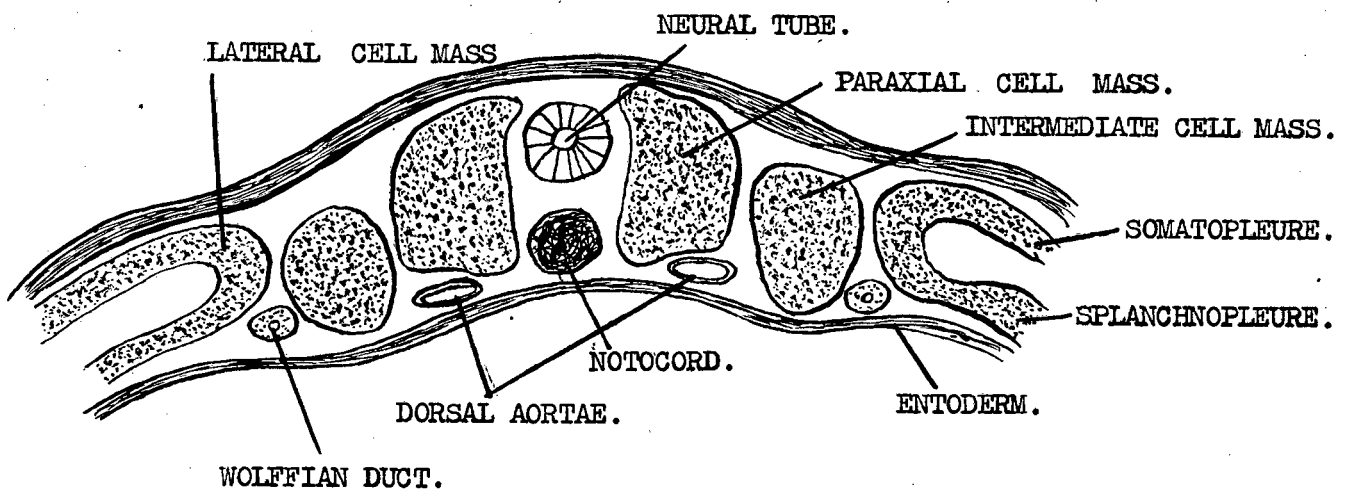


FIG 23 TRANSVERSE SECTION OF AN EMBRYO \pm 3 WEEKS OLD.

It shows the differentiation of the mesoderm into paraxial, intermediate, and lateral cell masses.

and leads to the head-end approaching the tail-end on the ventral aspect of the foetus. Since the folding process occurs all around the periphery, the entodermal vesicle becomes constricted at the site of the future umbilicus, and gives rise to an extra-embryonic yolk-sac and an intra-embryonic archenteron. The archenteron in its turn is naturally divisible into fore - mid - and hindgut. Near the caudal end of the hindgut there is a short diverticulum, the allantois, which is rudimentary in man. In all embryos developed in an egg, however, it is a functional organ of respiration. This stage is depicted in Fig 25., and is reached by an embryo 4 weeks old.

The folding of the embryo continues and the ectodermal vesicle (amniotic cavity) rapidly expands. This leads to the entire embryo being covered by ectoderm and the organisation of the umbilical cord, with the remains of the yolk-sac and the allantois in it. The allantois is progressively drawn ventrally and towards the umbilicus as the tail-fold curls in and the amniotic cavity expands. The umbilical cord has formed at 5 weeks. This is the critical stage for organogenesis, and it will now be more convenient to follow the succeeding steps in development in selected regions. These will be discussed under the following headings :-

1. THE INTERMEDIATE MESODERMAL CELL MASS.
2. THE WOLFFIAN AND MULLERIAN DUCTS.
3. THE CLOACA.
4. THE ACCESSORY SEX GLANDS.
5. THE SEMINAL VESICLES.
6. S U M M A R Y .

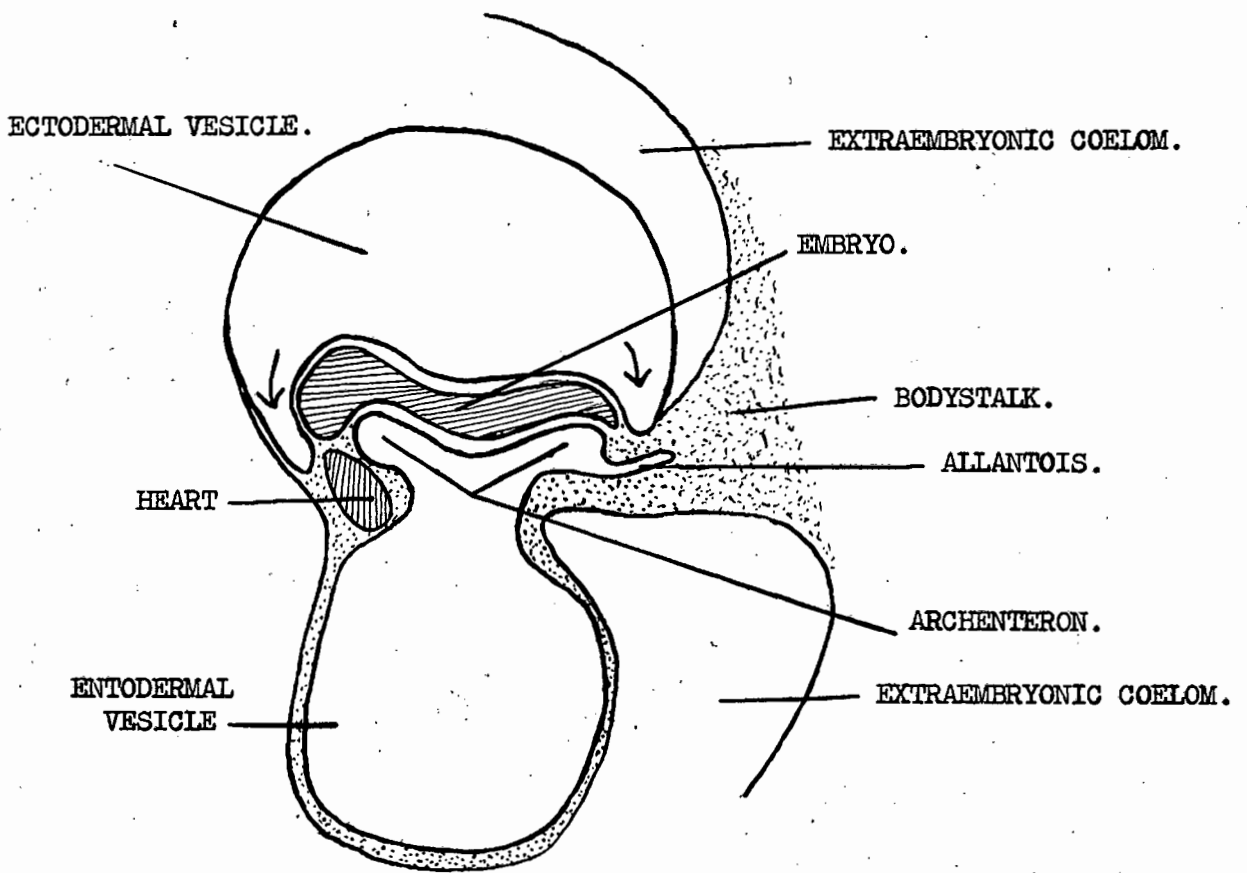


FIG 24 SCHEMATIC REPRESENTATION OF AN EMBRYO \pm 3 WEEKS OLD.

The ectodermal vesicle is rapidly expanding. Archenteron being constricted off from the vesicle. Folding of the embryo is commencing.

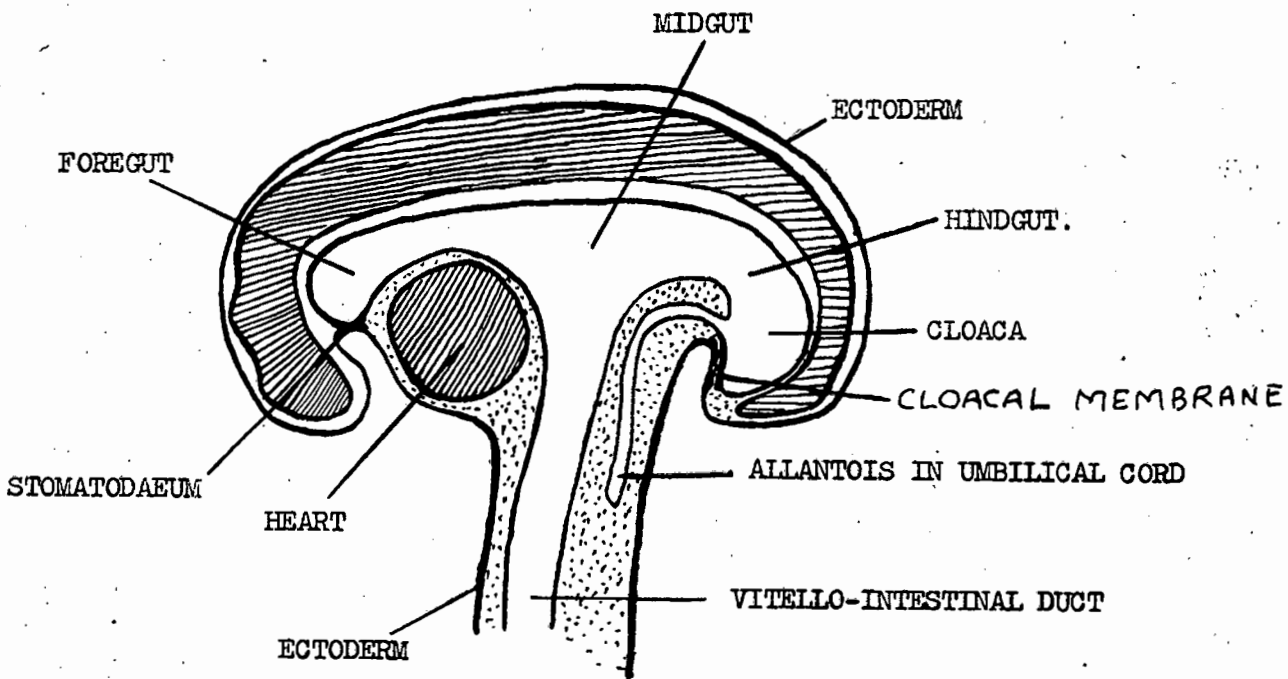


FIG 25 THE EMBRYO AT \pm 5 WEEKS.

Fore - Mid - and Hindgut are indicated. The cloaca is the caudal part of the hindgut. Folding of the embryo is well advanced.

THE INTERMEDIATE MESODERMAL CELL MASS.

We have seen how the mesodermal somites come to exist. The next stage consists of differentiation of the mesoderm and is bilateral. It affects all the somites as they are formed. That part of the mesoderm adjacent to the midline becomes separated off as the paraxial mass. That part which lies most peripherally is the lateral mass. Between the two there is the intermediate cell mass of mesoderm, and from it will develop a kidney, gonad and adrenal on each side. See Fig. 23.

The kidney arises from the lateral part of the lateral mass, and shows the successive stages of the pro - meso - and metanephros. The pronephros develops from the 7th to the 14th somites, and is very transitory and difficult to recognise. It has disappeared by the 4th week. Its excretory duct, however, is prolonged caudalwards and is appropriated by the mesonephros. The mesonephros or Wolffian body develops from the 9th to the 26th somites during the 5th week, and reaches its height when the embryo is 7 weeks old. Thereafter it atrophies, to be replaced by the metanephros, which arises from probably all the somites below the 26th. The metanephros is the adult and permanent kidney of all animals above fishes and amphibians. Metanephric development commences in the 7th week and steadily progresses to attain its adult shape and position at the 16th week.

Each gonad is meanwhile evolving from the medial aspect to the intermediate cell mass. A bulge towards the coelomic cavity, earns for it the name of the genital ridge, which is obvious during the 5th week. The testis or ovary is only just recognisable as such by the 8th week. Each is abdominal in position, and lies at a higher level than the metanephros. By the 16th week the kidney lies, as

in the adult, in the loin, and the testis has descended to an inguinal position. It is only much later between the 7th and 9th months of intrauterine existence, that the testes negotiate the inguinal canals to reach the scrotum.

THE WOLFFIAN AND MULLERIAN DUCTS.

The mesonephric or Wolffian duct, which is a prolongation of the pronephric duct, is a structure of prime importance. In the adult male it will become the channel for the conveyance of the spermatozoa. The mesonephros and its duct are functionless in the human embryo, but in fishes and amphibians the mesonephros is the functioning adult kidney.

The mesonephric duct joins the cloaca at the end of the 4th week. From the lower end of the duct where it enters the cloaca, there arises in the 5th week a bud-like diverticulum, which rapidly elongates towards the metanephros, and becomes its channel of excretion, called the ureter. The later development of the Wolffian duct will be followed when the cloaca is discussed.

The paramesonephric or Mullerian ducts develop adjacent and lateral to the Wolffian ducts, and also proceed downwards towards the cloaca. Near the cloaca the ducts approach each other and later fuse, and in this position they lie between the lower ends of the Wolffian ducts. The Mullerian duct is vestigial in the grown male, but goes to form the main part of the female reproductive tract. The utriculus masculinus, a small little cul-de-sac, imbedded in the median lobe of the prostate, is all that remains patent of the Mullerian ducts in the male.

THE CLOACA.

The somewhat dilated caudal end of the hindgut seen in the embryo at 4 weeks, constitutes the cloaca, or common receptacle for the genital, urinary, and rectal excrements. It is turned inwards towards the site where the umbilicus is about to be formed. The cloaca, sometimes in modified form, is functional in lower mammals and in fishes, reptiles, and birds.

On the ventral aspect of the cloaca there is an area where the covering ectoderm and the lining entoderm are in contact. This area is the cloacal membrane. The allantois opens into the upper part of the cloaca on its ventral aspect. It has been mentioned that the lower ends of the mesonephric ducts reach the cloaca at this early stage. This, and the succeeding stages, are illustrated in Fig.26.

The cloaca now becomes divided into a ventral urinary, and a dorsal rectal part. This commences when the foetus is 5 to 6 weeks old. A mass of mesoderm lying between the base of the allantois and the hindgut proliferates and extends towards the cloacal membrane. This partition also arises somewhat from the side walls of the cloaca. The division is so effected that the mesonephric ducts open into the ventral portion of the cloaca, which is destined to become the bladder, and a portion of the urethra in the male. The process of sub-division is completed by the 7th week. Behind, there is the rectal canal. In front and ventral there is formed the bladder and the urogenital sinus. The cloacal membrane meanwhile has been divided on its ectodermal aspect into a urethral and a rectal plate by the perineum. The rectum and urogenital sinus break through to the exterior by the end of the 7th week. The bladder and urogenital sinus need further elucidation.

A. Cloaca; B. Cloacal Membrane, C. Hindgut; D. Allantois; E. Mesonephric Ducts; F. Ureteric outgrowth; G. Mesodermal mass dividing cloaca into ventral and dorsal parts. H. Bladder; J. Urogenital sinus K. Rectum; T. Tailgut, which soon disappears. M. Metanephric anlage.

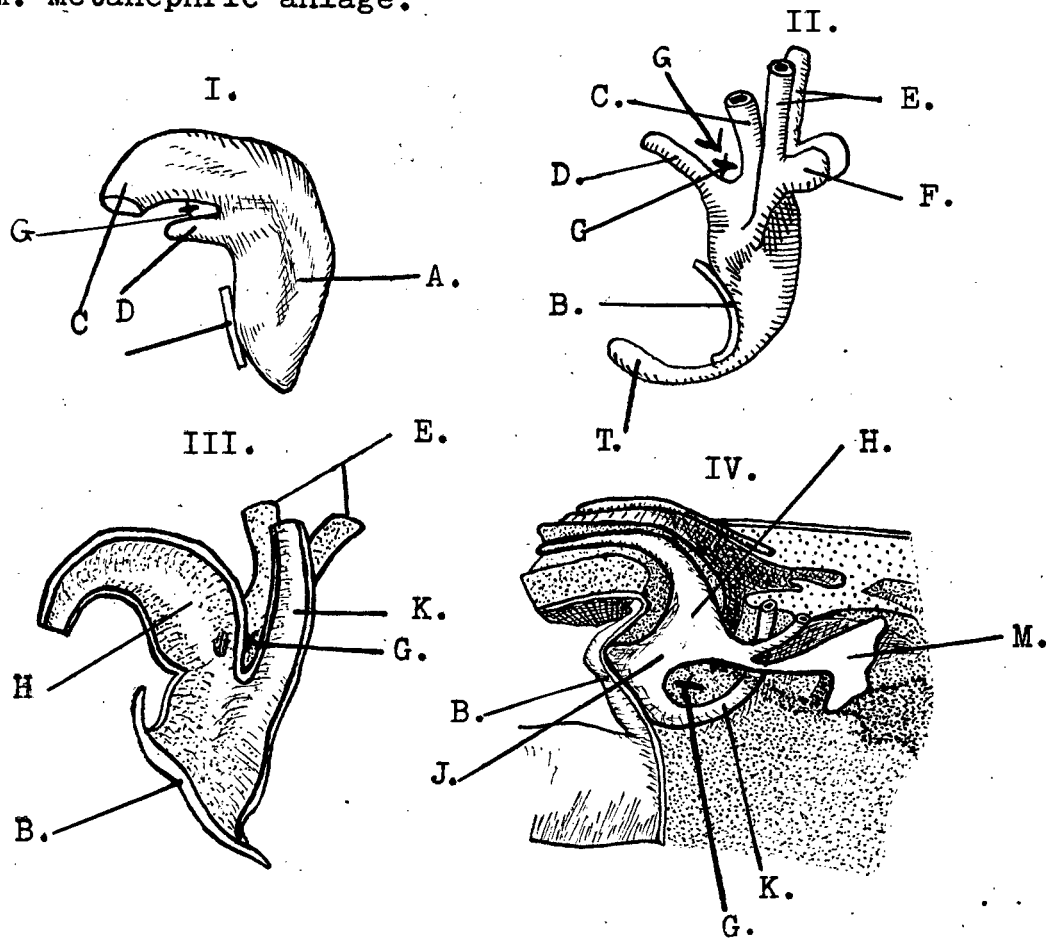


FIG 26 FOUR STAGES IN THE DEVELOPMENT OF THE HUMAN CLOACAL REGION.

I, 3½ Weeks; II, 4 Weeks; III, 4½ Weeks; IV, 5½ Weeks. - The inside of the lumen is shown in III.

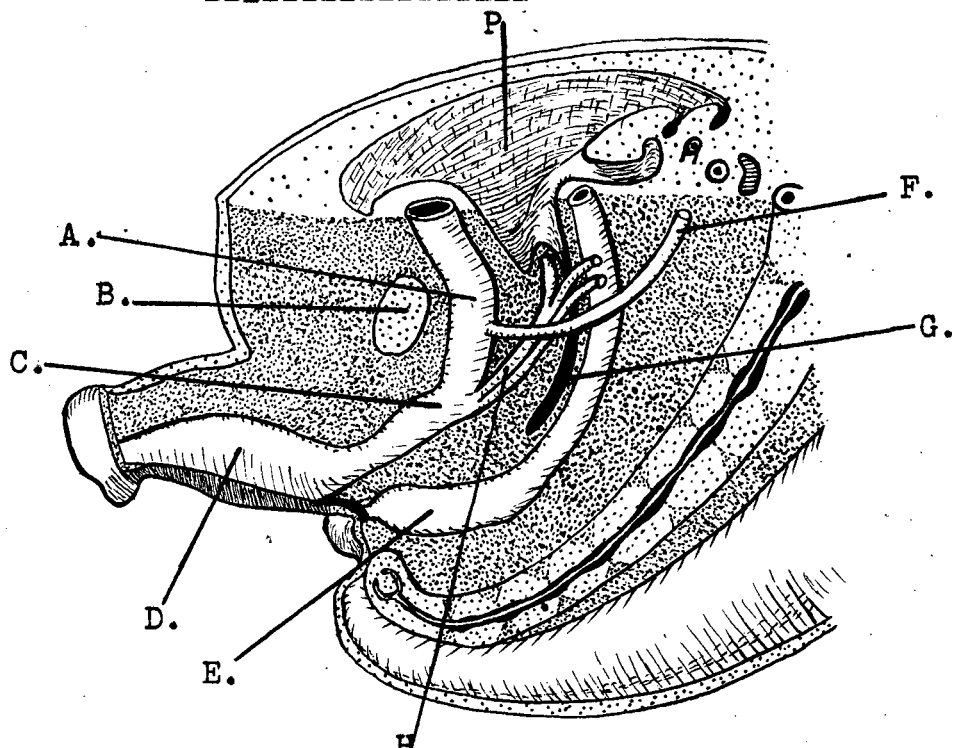


FIG 27 PELVIC REGION OF HUMAN EMBRYO OF 9 WEEKS.

A. Bladder; B. Symphysis pubis; C. Urogenital sinus; D. Urogenital sinus (Phallic) E. Rectum; F. Ureter G. Peritoneum (future pouch of Douglas); H. Genital cord; P. Peritoneum.

(From Arey after Keibel)

The ventral portion of the cloaca has been completely separated off from the dorsal rectal portion by the 7th week. The upper part of this ventral cloaca, continuous above with the allantoic stalk, is now called the bladder. The lower part, which abuts on the cloacal membrane, constitutes the urogenital sinus. The bladder and urogenital sinus are a continuous cavity, separated from each other by a slight neck or constriction. The mesonephric ducts, with the Mullerian ducts between them, open into the junction between the bladder and the urogenital sinus. The urogenital sinus itself is divided into a pelvic and phallic part. The latter is the portion which lies upon the urethral plate (cloacal membrane). This is clearly shown in Fig. 27.

The adult bladder is formed from the ventral cloaca as we have mentioned. At first it is a tube, which gradually becomes more sacciform. Its apex, pointing towards the umbilicus, narrows still more and forms a blind-ending tube, called the urachus. In the adult this tube is patent and may or may not communicate with the bladder cavity. It is agreed by most authorities that the allantois takes no part in the formation of the urachus or the bladder. This was clearly pointed out by Begg in 1927 and 1930. (2)

The insertion of the mesonephric ducts into the bladder is interesting. At this stage the ureter has already been given off as a diverticulum from the lower end of the mesonephric duct. By a process, which is not clearly understood, the openings of the ureters and the mesonephric ducts (vasa deferentia) become separated. The ureters come to open at the base of the trigone in the bladder, whereas the vasa deferentia retain their exit at

the
the junction of/bladder and urogenital sinus, which in the adult is in the prostatic urethra. By some, this process is interpreted as meaning that a portion of the Wolffian duct is taken up to assist in forming a part of the bladder. In other words that the trigone of the bladder and the proximal part of the prostatic urethra are derived from the lower ends of the Wolffian ducts. .

We have already noted the functional importance of the bladder trigone and its anatomic structure, distinct from the rest of the bladder. It does not seem a far cry to correlate this with its probable extraneous embryological origin.

The ventral cloaca furthermore gives origin to the entire female urethra, where the pelvic part of the urogenital sinus goes to line the vestibule, ^{and} the phallic part disappears. In the male, which is our present concern the part of the urethra proximal to the openings of the ejaculatory ducts, is derived from the foetal bladder. The prostatic urethra distal to the ejaculatory duct openings, (i.e. distal to the veru montanum) and the bulb of the anterior urethra, take origin from the pelvic part of the urogenital sinus.

The urethra, anterior to the bulb of the urethra, is considered by many observers to arise from the phallic portion of the urogenital sinus. Thus the lining is entodermal. Others, however, contend that the anterior urethra forms by closure of the genital folds, which are ectodermal. These genital folds in the female go to form the labiae minores. There appears to be some disagreement among embryologists as to whether the anterior urethra arises from ectoderm or entoderm. Richardson ⁽³³⁾ favoured the view that it was an ectodermal derivative. He went on to

mention that the accessory sex glands were essentially threefold, viz: seminal vesicles, prostate and Cowper's glands and that each was associated with a different developmental portion of the genital tract. Thus the vesicles with the Wolffian ducts, the prostate with the urogenital sinus, and Cowper's glands associated with the ectodermal anterior urethra. In other words, each embryological part which had a share in the development of the genital tract, also contributed a gland, the secretion of which would aid the spermatozoa. There is evidence that supports such a view apart from the inconclusive embryological observations. In certain animals, as will be shown later, there develops an ectodermal cloaca, with which Cowperian-like glands are associated.

The most recent observation in regard to this problem comes from Siddiqi in 1938. His conclusions completely support the suggestions made by Richardson in 1904. He made a thorough investigation of the cloacal region of human embryos, and showed that the condition closely resembles that found in a spermophile. From his findings he deduces that the anterior or penile urethra in man arises partly from entodermal and ectodermal elements. Cowper's glands arise from the ectodermal part. An illustration (Fig 28) and notes, show clearly what he found. In view of this work the problem is largely solved. Such a solution certainly has support from a study of comparative anatomy.

One point merits attention before we pass on to consider the development of the prostate and seminal vesicles. In a young foetus before the prostate becomes prominent, there is plainly seen in the region of the urethra, a very definite layer of striated muscle fibres.

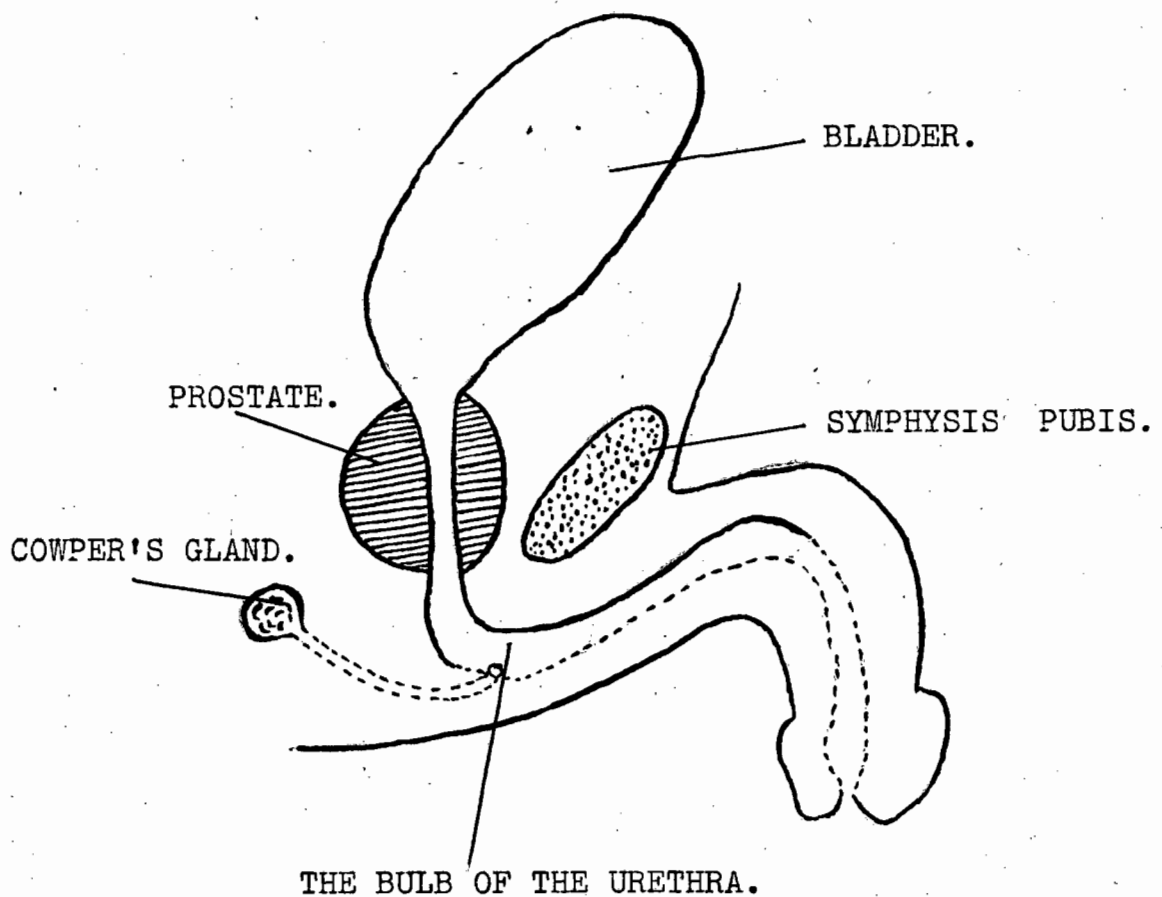


FIG 28 CROSS-SECTION OF HUMAN BLADDER AND URETHRA.

It shows the entodermal and ectodermal portions of the urethra. The dotted line indicates that portion derived from the ectoderm viz, the bulb of the urethra and Cowper's glands, the floor of the proximal $\frac{2}{3}$ rds. and the whole of the distal $\frac{1}{3}$ rd. of the urethra. The rest of the prostatic and anterior urethra arises from entoderm.

(After Siddiqi) 1938.

The fibres surround the urethra and are longitudinally directed, lying exterior to the inner involuntary muscular coat of the urethra. This striated muscle layer almost completely disappears as the foetus develops, but remains of it persist, and have been mentioned as taking part in the formation of the internal vesical sphincter. When later the anatomy of animals is considered, it will be seen that this muscle persists as a prominent feature and constitutes the musculus urethralis. It is a voluntary muscle and aids in urination.

THE ACCESSORY SEX GLANDS.

The problematical derivation of the anterior urethra and bulbo-urethral glands has been mentioned. Little remains to be said except to stress their possible ectodermal origin, and that the Cowperian glands are homologous with the Bartholinian glands in the female. In both sexes these glands make their first appearance as solid epithelial out-growths in the foetus of 9 weeks. Soon after, the epithelial cords become canalised. The extreme ends of these epithelial cords undergo proliferation to form a glandular nodule. Thus in the foetus of 4 months, the bilateral bulbo-urethral glands, each with their single excretory duct, is fully developed. After this they grow in keeping with the individual, to reach their ultimate adult state. Whereas the duct of Cowper's gland opens into the male urethra, the duct of the Bartholian gland opens into the vestibule of the vagina, which is derived from the urogenital sinus. In both sexes the muscular coat of the gland and the duct is derived from the mesoderm into which the epithelial out-growths occur.

The prostate arises from epithelial and mesodermal elements. The glandular portion of the prostate develops from multiple outgrowths of the epithelium of the bladder-neck and urogenital sinus. These outgrowths are commonly referred to as prostatic buds. There are formed about 60 of these prostatic buds, and they make their first appearance in the foetus of 11 weeks old. The stroma of the gland is contributed by the surrounding mesoderm.

Some authorities hold that these buds appear in two groups below the entrance of the mesonephric ducts into the urethra. This makes the prostate an essentially bi-lobed structure as seen in many animals. Lowsley in 1912 maintained that the prostatic buds appear in 5 groups around the urethra, to correspond with the described 5 lobes of the adult prostate. His view has been widely accepted. Some recent workers, however, doubt the separate origin of the anterior and posterior lobes. They claim that there is no distinct grouping of prostatic buds to be seen in a foetus of an appropriate age.

The concensus of present-day opinion favours the view that the prostate arises from the urethral buds above and below the mesonephric ducts. Also that the greater majority of these buds arise from the dorsal aspect of the urethra. This completely fits in with the grown state, where the prostatic ducts open largely alongside the verumontanum.

All are agreed that the epithelial elements of the prostate come from the lining of the urethra, and the fibro-muscular stroma from the surrounding mesoderm. Also that in man the prostate is very intimately connected with the bladder. What we know of its development only goes to strengthen the concept that the prostate is merely a glandular portion -

glandular portion of the bladder-neck. In this respect it differs from many animals, where the prostate is a bi-lobed organ, separate and distinct from the urethra.

The female foetus also shows at a similar period evidence of prostate formation. But nothing remarkable comes of it, and the glands remain rudimentary. In the adult female the para-urethral ducts of Skene are probably homologous with the male prostate.

In the male foetus all the prostatic buds have formed by the 4th month. The buds are solid epithelial cords at first, later to become canalised. The epithelial cords and the condensed surrounding fibro-muscular tissue constitute the prostate gland at this stage. The utriculus masculinus, formed by the fusion of the lower ends of the Mullerian ducts, is a small cul-de-sac opening into the urethra, and lying just in front (ventral) of the lower ends of the mesonephric ducts. The utriculus masculinus lies imbedded in that group of prostatic buds, which will form the median or prespermatocystic lobe of the grown prostate.

From the 4th month till birth the prostate grows as the foetus grows. At birth the form and shape are as in the adult, except that the prostate is relatively tiny. As has been seen, the prostate gland rapidly enlarges with the advent of puberty. The prostate of the full-term foetus has certain characteristics. The epithelial cords (or ducts) arise from the urethra and extend to the periphery of the gland. The cords or ducts have no branches. When puberty arrives these main ducts will develop end buds and give rise to numerous secondary diverticuli. In this way the complex glandular structure of the adult prostate will be formed.

The prostate of the new born babe shows a remarkable series of histological changes in the epithelial cords or ducts. This lasts for one to two weeks after birth. The changes very strongly suggest activity and closely resemble the hyperplastic changes seen at puberty. Moore (29) in 1936 drew attention to this phenomenon and suggested that it represented stimulation by maternal hormones. Comparable changes occur in the breasts of infants to produce the so-called Witch's Milk.

The para-urethral glands found all along the urethra and at the bladder-neck, may also be classed as accessory sex glands. They all develop as short diverticuli from the urethra. Those in the anterior urethra are called Littre's glands. Special groups were noted at the bladder-neck when the anatomy was discussed. They are the subtrigonal, subcervical and urethral glands. There is nothing special about their embryological development.

The seminal vesicles have only briefly been mentioned thus far, and all the attention has been given to the structures in the vicinity of these glands. But since a study of the vesicles is the ultimate object of this paper, their development will now be fully gone into. What has gone before will serve as a necessary background.

THE SEMINAL VESICLES.

Their first appearance is noted in the male foetus at 13 weeks. They are lateral outpocketings of the Wolffian ducts close to the bladder. They arise in a manner very similar to the earlier ureteric diverticuli, which have by this time migrated bladderwards.

FIG. 29.

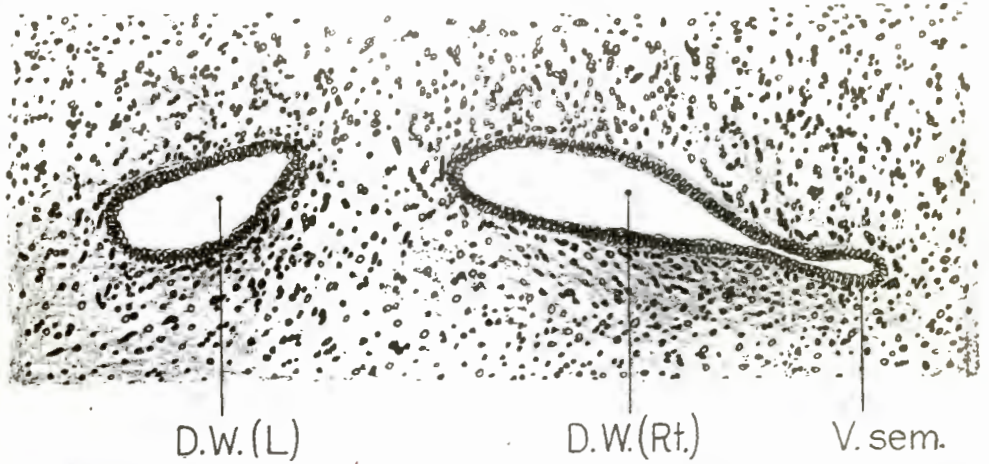


Fig. 2 Sketch showing a transverse section from the same specimen represented in figure 1, taken at a different level. It shows the primordium of the right seminal vesicle as a flattened evagination from the Wolffian duct of that side, the two being separated by a rather marked sulcus.

FIG. 30.



Fig. 3 Graphic reconstruction of the lower end of the Wolffian ducts, showing the lateral evaginations which form the seminal vesicles. Human fetus 80.3 mm. crown-rump length, estimated age 13 weeks (Carnegie Collection, no. 768c). Enlarged 25 diameters.

FIG. 31.

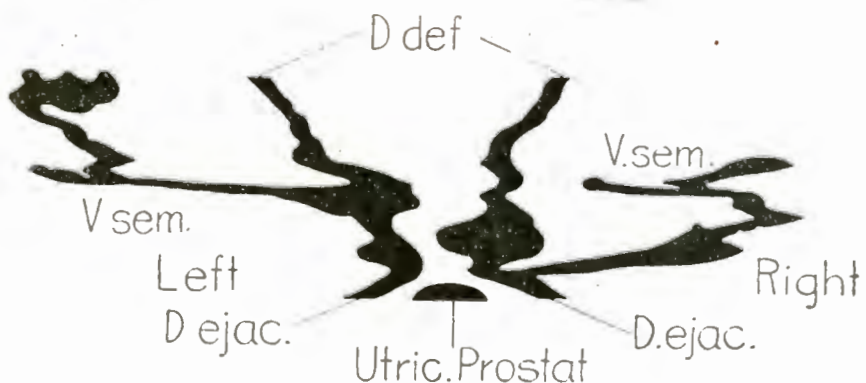


Fig. 4 Graphic reconstruction showing the seminal vesicles and their relation to the deferent ducts in a human fetus 105 mm. crown-rump length, estimated age 14 weeks (Carnegie Collection, no. 1358e). Enlarged 25 diameters.

No similar homologous structures are observed in the female foetus. At the 12th week the gonads of each sex assume characteristic and more or less adult propensities. The seminal vesicles begin to show one week later in the males. Can it be that the male gonadic hormone is the cause ?

It is necessary to take one small step backwards before we proceed. At the early 7th week stage, when the cloaca has been subdivided into bladder and rectum, the Wolffian and Mullerian ducts lie in the intervening mesodermal septum. Even at this stage the Wolffian and Mullerian ducts show a tendency to lie nearer the bladder. Together with their surrounding mesoderm in this region, they constitute the genital cord. A prolongation of the coelomic cavity (or peritoneum) grows down between the bladder and rectum to form the future pouch of Douglas. But the genital cord continues to hug the bladder wall, and so we find that the developing seminal vesicles, and the lower ends of the Wolffian ducts (ampullae of the vas deferens), remain closely adherent to the posterior wall of the bladder. In the adult too, the seminal vesicles are flattened against the bladder, and separated from the rectum by the dense recto-vesical fascia.

As has been said the seminal vesicles appear at the 13th week. Their epithelial lining is continuous with that of the Wolffian duct, from which they arise. The muscular coat is contributed by the mesoderm into which they grow. At first the diverticulum is a straight tube, but by the 14th week it has become bifurcated at the tip. The lumen in the distal $\frac{2}{3}$ rds, of the gland even at this early stage shows irregular outpocketings. This is the commencement of the sacculi which are so characteristic of the adult seminal vesicles.

FIG. 32.



Fig. 5 Graphic reconstruction of the seminal vesicles showing their relation to the deferent ducts in a human fetus 130 mm. crown-rump length, estimated age 16 weeks (Carnegie Collection, no. 1018). Enlarged 25 diameters.

FIG. 33.

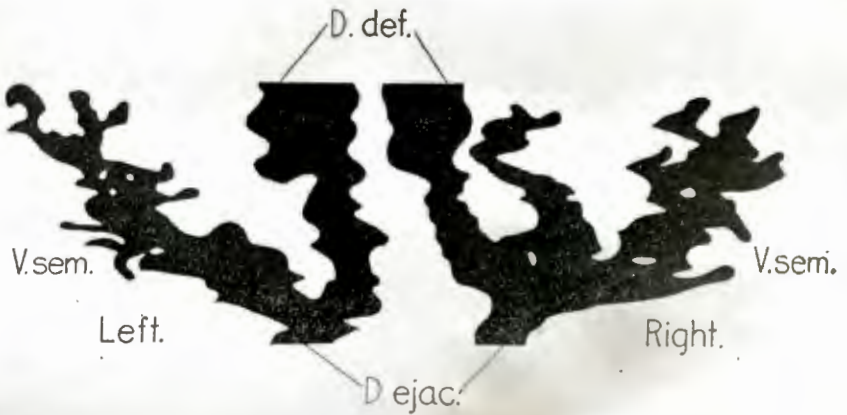


Fig. 6 Graphic reconstruction of the seminal vesicles showing their relation to the deferent ducts in a human fetus 171.4 mm. crown-rump length, estimated age 19 weeks (Carnegie collection, no. 1049). Enlarged 25 diameters.

FIG. 34.



Fig. 7 Graphic reconstruction of the seminal vesicles showing their relation to the deferent ducts in a human fetus 178 mm. crown-rump length, estimated age 21 weeks (Carnegie Collection, no. 1171). Enlarged 25 diameters.

Between the 25th and 31st week the seminal vesicles show faster growth than at any other period. They also attain a definite and recognisable muscular coat. The epithelial lining consists of two or three rows of cells.

Between the 31st week and birth, the seminal vesicles grow in keeping with the whole organism. The main feature of this period is the increasing complexity of the diverticuli, so that at birth there are found as an average about ten definite sacculations in the glands. Also during this period the reticulated, honeycomb appearance of the lining epithelium appears. There is some variance of opinion as to whether at this stage any villi-like projections of the epithelium are present or not. These villi are associated with the secretory activity of the epithelium, and it seems more likely that they will become prominent at puberty.

E. M. Watson (48) in 1918 conducted a thorough examination of the development of the seminal vesicles. He made serial sections of foetuses at all ages in this region. By superimposing the serial sections he was able to give a graphic reconstruction of the appearances of these glands. The photographs in Figs: 29, 30, 31, 32, 33, 34, 35, and 36, are taken from his article which was published in the Annals of Surgery, Vol. 68, 1918. These pictures give a very realistic impression of the development.

The appearance of the seminal vesicles and the ampullae of the vasa at birth is shown in Fig 37. It will be noted in this specimen that the vesicles are well developed, whereas the ampullae are relatively insignificant.

FIG. 35.

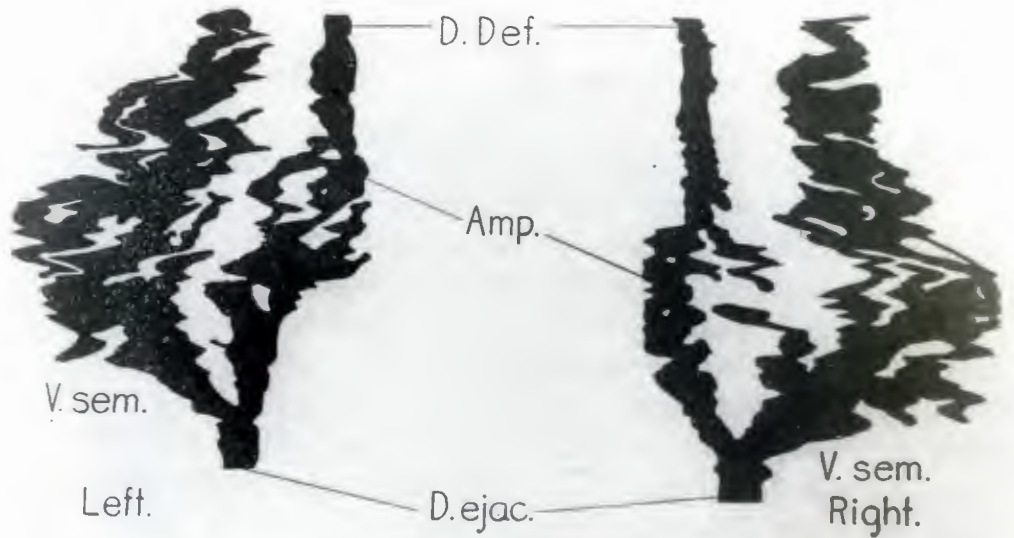


Fig. 8 Graphic reconstruction of the seminal vesicles showing their relation to the deferent ducts in a human fetus 276 mm. crown-rump length. estimated age 31 weeks. Enlarged 8 diameters.

FIG. 36.

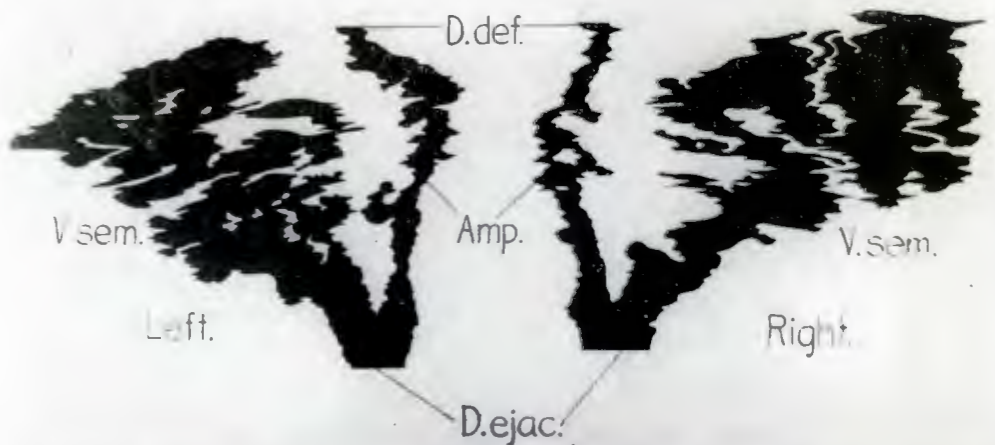


Fig. 9 Graphic reconstruction of the seminal vesicles showing their relation to the deferent ducts in a new-born babe 338 mm. crown-rump length. Enlarged 8 diameters.

The ampulla of the vas deferens begins to show in an embryo of 19 weeks old. There occurs a thickening of the wall and a widening of the lumen of the lower end of the vas deferens. By the 25th week there have developed irregular sacculi very similar to, but smaller than those of the seminal vesicle. The ampullae probably do not reach their adult size and appearance until after puberty.

The seminal vesicles are outgrowths from the mesonephric ducts, in the same way that the gall-bladder is a diverticulum from the bile duct. We would thus expect that the duct draining the seminal vesicles would be a tributary of the vas deferens. The anatomy of the common ejaculatory duct has been discussed in an earlier chapter. If a suitably small catheter be passed up the ejaculatory duct, one would expect it to pass most easily into the ampulla of the vas. In practice the reverse appears to be the case. The catheter more often passes into the seminal vesicle which, as has been mentioned, must be regarded as a tributary channel. At any rate this state of affairs is a happy one, because it facilitates the retrograde catheterisation of the seminal vesicles. It also lends itself to seminal vesiculography.

S U M M A R Y .

1. The mesonephric duct is the excretory duct of the mesonephros or Wolffian body. In the male this duct persists as the vas deferens of the testes.

2. The mesonephric duct gives off the ureter, or duct of the metanephros, as a diverticulum from its lower end. The metanephros is the adult kidney of most vertebrates and man.

3. The prostate is derived from the urogenital sinus (entoderm) and remains an integral part of the bladder-neck.

4. Cowper's glands and the anterior urethra may be of ectodermal origin.

5. The seminal vesicles are outpocketings from the mesonephric ducts. They commence to show their characteristic shape and appearance at an early embryonal stage.

6. The close relation of the seminal vesicles to the bladder is determined by the embryological development.

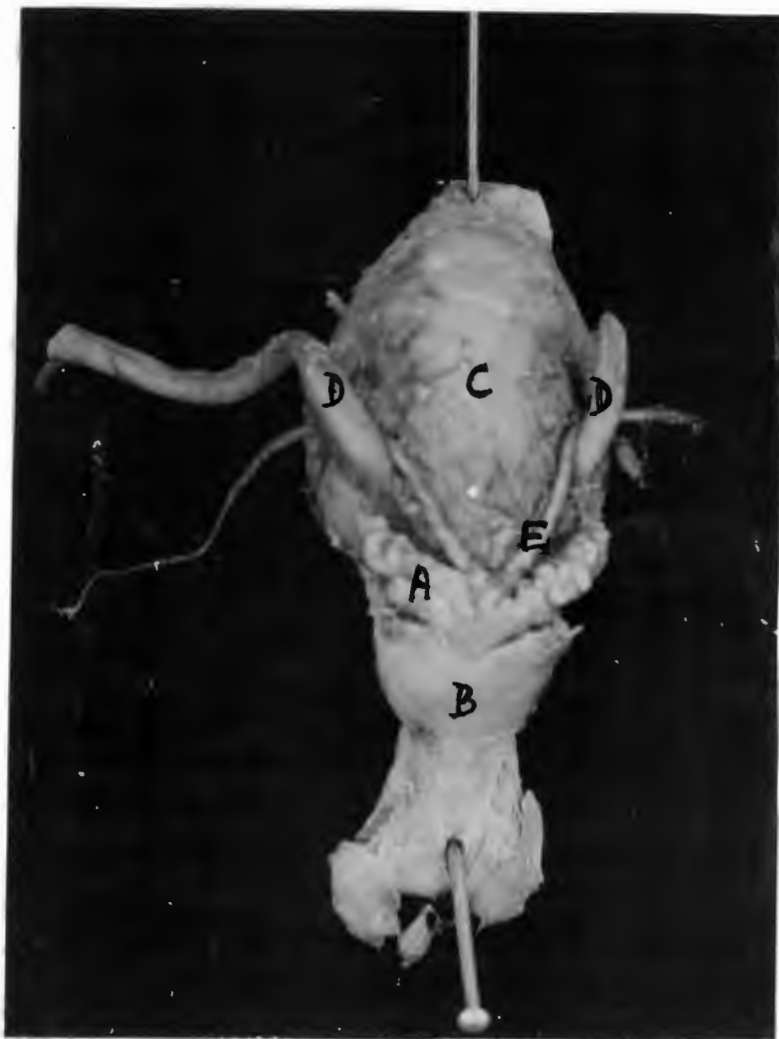


FIG 37 PHOTOGRAPH OF DORSAL ASPECT OF BLADDER AND PROSTATE OF FULL-TERM HUMAN FOETUS.

Note that the apices of the seminal vesicles do not reach the ureters. The ampullae show slight widening and tortuosity.

- A. Seminal Vesicle,
 - B. Prostate,
 - C. Bladder,
 - D. Ureters,
 - E. Ampulla of Vas Deferens ($4\frac{1}{2}$ times natural size)
-

C O M P A R A T I V E A N A T O M Y .

INTRODUCTION.

The aim of this study of the comparative anatomy of the seminal vesicles is to get a broad view of their structure and function in animals. It will also clarify the embryological development as seen in the human. The effect of different environments on the essential function will become clear. In this way the anatomy and physiology of these glands can be more completely understood.

We know that the embryological development of an animal fleetingly repeats its phylogenetic history. This is referred to as the Law of Recapitulation. Thus the developing human embryo passes through stages which resemble the form of animals belonging to lower groups than the primates. We see remnants of our piscian, amphibian, reptilian, avian, lower mammalian and even invertebrate ancestry.

In the early beginnings animals were of simple structure and lived in water. Gradually their form became more complex and whereas some began to inhabit the land and fly in the air, others remained in the water. The environment thus became very varied.

Under the effect of this widely differing environment, the form and structure of animals was accordingly modified. There were certain trends of development; and so we now recognise the subdivision of all animals into groups or phyla, ranging from the simplest to the more complex forms. We thus speak of lower and higher forms depending on their position in our scheme of classification. The terms early and late forms also refer to simple and more complex forms respectively. Examples of most groups are still with us today. Some forms were specialised along lines which clashed with their environment and they went under. We only know them from their fossilized remains.

In correlating all this knowledge, Darwin was able to infer that the higher forms developed by a process of evolution from the lower forms.

This process of evolution can be traced in many different organs of an animal. The reproductive system is always one of prime importance, since the striving to reproduce its kind, is one of the cardinal driving forces of all Nature. A study of comparative anatomy shows the numerous and interesting devices that exist in different animals to ensure the well-being and safe transport of the genital products to their destination.

It is my intention to confine the discussion as far as possible to the male reproductive tract. It may occasionally be necessary to refer to the female tract in order to elucidate a certain point. The object in particular is a study of the seminal vesicles. At the commencement I must stress, however, that these glands cannot be viewed apart from the entire male genital tract.

The seminal vesicles belong to a group of accessory sex glands. In different animals one or more components of the group may be absent. This feature constitutes the main basis of the comparative anatomy of the accessory sex glands. It is only the presence of the testis which never varies. In all animals where the sexes are separate, the testis is always present.

There is also in all animals a close anatomical relation between genital and excretory functions; particularly the excretion of urine.

The discussion will thus embrace a consideration of the anatomy and development of the male genital and urinary systems as found in animals. Particular attention will be paid to the seminal vesicles, prostate and Cowperian glands.

GENERAL PRINCIPLES.

Before proceeding to a description of the anatomy as found in different animals, it will be useful to enumerate certain general principles. In this way much that at first appears to be aberrant, is found to fall into line.

The first is the ubiquitous presence of the testis in all animals where the sexes are separate. It is the essential male gland. Its size, shape, position, colour and structure does vary within wide limits, but it is never absent in fertile males.

The secretion of the accessory sex glands is essential to the proper function of the spermatozoa. In its absence, the spermatozoa of the animals will probably be unable to effect fertilisation of the ovum. This has been shown experimentally in rats. After these animals have been vesiculectomised, they are still sexually active, but are infertile.

These glands are chiefly the seminal vesicles, Cowper's glands and the prostate (or prostates). At least one of these will inevitably be present. They vary enormously in different animals, both as regards size and shape, and in as much as one or more of the group may be absent. Cowper's glands are rarely absent among mammals.

The function of these sex glands is essentially similar. Each appears to be complementary to the other. When their development was sketched, it was shown that each arises from a different embryonal region of the genital tract. In other words, the wellbeing of the sex cells was being ensured at all levels. That their function is similar is even more emphatically indicated by a comparative study. Some animals have prostates only, others have only seminal vesicles and Cowper's glands. The reproductive capacity of

such animals is normal. What is more, when one group of glands is absent, the remaining glands show compensatory enlargement.

The prostate and bulbo-urethral glands are essentially derived from the urethra. They will thus be absent in those animals which have no urethra. This applies in the main to those animals where the intestinal, urinary and genital products are poured into a common cloaca. These glands thus are found only in mammals.

The seminal vesicles are derived from the sperm ducts. Such ducts exist in nearly all groups of vertebrates, and possibly also in specialised invertebrate animals. It will be no surprise therefore when we learn that seminal vesicles, particularly in the strict sense of seminal reservoirs, occur in most vertebrate animals.

The seminal vesicles are essentially male glands. They have no counterpart in the female. The interesting seminal receptacles of the female marsupials, will be mentioned later. Cowper's glands and Bartholin's glands are homologous. Many female mammals have rudimentary prostates. This gland is obvious in certain white rats, and even in the human female, the rudimentary prostate may lead to urethral obstruction at the prostatic age. But there is no gland or structure in the female of the species which is homologous with the vesicula seminalis.

At certain periods, the seminal vesicles together with the other sex glands, undergo temporary enlargement in most animals. This occurs in the breeding season. This enlargement is probably of hormonal origin. It is comparable to the growth of antlers in deer, which, as John Hunter showed, does not occur in castrated males.

There is some evidence that the fecundity of an animal bears a direct relation to the size of its accessory
- sex glands.

sex glands. Veterinary experts, however, are not agreed on this point.

We can now consider the development and comparative anatomy in more particular. This subject may conveniently be discussed under the following headings :-

A. THE PHYLOGENETIC DEVELOPMENT OF THE UROGENITAL SYSTEM.

B. THE MALE UROGENITAL SYSTEM IN :-

- (1) Fishes and Amphibians.
- (2) Reptiles and Birds.
- (3) Lower Mammals (Monotremes and Marsupials).
- (4) Mammals (Monodelphia)
- (5) Primates.
- (6) Two common South African primates :
Chacma baboon and Vervet monkey.

What the above classification lacks in zoological correctness, will be made up for by the clear stages of development it illustrates in the male urogenital system.

PHYLOGENETIC DEVELOPMENT OF THE UROGENITAL SYSTEM.

The Protozoa, which are unicellular animals like the amoebae, perform all the vital functions within their one limiting membrane. Reproduction is asexual; the animal simply divides into two parts.

The multi-cellular animals, or metazoa, are advanced in this respect, that the cells become modified in structure and function to form the various systems and organs. There is thus division of labour, and each system contributes its share to the health of the animal as a whole. Certain remarkable creatures, which live in water, show an intermediate critical stage. It is as if the experiment of multicellularity is being tried out. These creatures may be disintegrated, when each cell is capable of a free-living existence. When the cells are collected into one mass, they all subscribe to the well-being of the animal as a whole. A certain group of cells forms a digestive system, while another forms an excretory system, and so on. It is not understood what power holds these cells together. But nor does anyone know what makes certain cells in an early embryo develop in such a way as to form a liver, a stomach or a brain.

As the metazoic animals progress, they begin to show certain trends which later become constant features. Two such trends are segmentation and bilateral symmetry. By segmentation is meant a process of reduplication. In this way an animal results, which is composed of a series of segments, each of which is functionally complete. This is strict segmentation, and tapeworms offer a good example of this class. Each segment of a tapeworm for instance has its own complete reproductive system. Bilateral symmetry needs

no elucidation; it is obvious in large groups of invertebrates, like insects, and in all vertebrate animals.

The general drift of evolution, however, is against strict segmentation. Thus in vertebrate animals segmentation is only obvious in the embryonal stages. In the grown animal the segments overlap, and can only be inferred from a knowledge of embryological development. We have discussed the mesodermal somites of the human embryo. These somites represent division of the mesoderm into segmental masses. Each segment will have its own blood supply, and pair of nerves derived from a corresponding segment of the neural tube. Moreover, since the kidneys and gonads develop from these mesodermal somites, their origin must of necessity be segmental in character.

It is a striking feature too, that these systems, the urinary and the reproductive, are closely associated with each other. The association dates back very far, and commenced before animals developed a spinal column. Vertebrate animals show it as a constant feature and the systems are naturally grouped in the term urogenital system. A knowledge of the anatomy of lower vertebrate animals, and of the embryology of vertebrates, has made it possible to trace the evolution of the urogenital system very clearly. Although no adult form of the primitive ancestral vertebrate exists to-day, we have a clear hint of the make-up of such an animal. This is possible because of what we know of the embryological development of vertebrates, and of the structure of certain primitive vertebrates. In particular the larval stage of a certain low-grade vertebrate, which lives in water, throws much light on the original form of the urinary system.

This animal is the larva of a myxinoid cyclostome.

The larva is strikingly segmented, and its kidney is formed by a series of uriniferous tubules, one tubule derived from each segment. This primitive kidney has been called an archinephros, to distinguish it from the pro - meso - and metanephros, which will develop in later animals.

Although the archinephros exists as an entity in no full grown animal, the concept of its existence forms a convenient basis on which to explain subsequent kidney development. It is believed that ancestral vertebrates possessed an archinephros, which extended the entire length of the coelomic cavity. The organ was paired. It developed, like kidney tissue in all vertebrates, from the intermediate mesodermal cell mass, also called the nephrotome.

Within the nephrotome there is formed a cavity, the nephrocoele. This cavity communicates by peritoneal funnels with the coelomic cavity. On the lateral side of the nephrotomes, there is formed a longitudinal duct, extending the full length of the archinephros, and opening below into the cloaca. Each segmental nephrocoele communicates by a single tubule with this archinephric duct. It is probable that the archinephric duct drained coelomic fluid via the nephrocoele and the peritoneal funnels.

This contention is supported by the fact that some animals still excrete not only fluid waste products, but also sex cells into the coelomic cavity. This is seen in coelomate invertebrates, like earthworms, and in cyclostomes, which are primitive eel-like fishes. The sex cells may reach the exterior via the equivalent of the archinephric duct, or by separate coelomostomes, which are openings between the coelomic cavity and the exterior.

The pro - meso - and metanephros of vertebrate animals, develops on the same plan as the archinephros.

When the embryology of the human was discussed, it was shown that the pro - meso - and metanephros arose from successive groups of mesodermal somites. The same holds in the development of all vertebrates where each of these kidneys is formed.

The pronephros is a transitory structure in most animals, but does exist as a functional organ in some few fishes, and in the larval stages of amphibians. A tadpole has a perfect pronephros. The kidney of adult fishes in general, is a mesonephros, but the anterior end of such kidneys is infiltrated with lymphoid tissue. This may represent an adenoid pronephros.

The excretory duct of the pronephros bears a striking resemblance to the archinephric duct previously mentioned. The pronephric duct being prolonged caudalwards, constitutes the excretory duct of the mesonephros.

The mesonephros or Wolffian body forms below the pronephros. It will be the permanent functioning kidney of adult fishes and amphibians. It differs from the pronephros in that the tubules are more complex and in that malphigian corpuscles are formed. There are also no longer peritoneal funnels which link the nephrocoele with the coelomic cavity. The mesonephric duct or Wolffian duct is the excretory channel for this kidney, and has been shown to be developed from the pronephric duct.

The mesonephric duct is a structure of great importance. It serves as the excretory duct for the mesonephric kidney, but in many animals the duct also conveys the male sex cells from the testis to the exterior. In such cases the duct has a dual function. In the most

- highly developed -

highly developed vertebrates, the duct will come to be used exclusively by the male genital system. This will happen only in those species which develop a metanephric kidney.

The metanephros develops below the mesonephros and it is the permanent adult kidney of reptiles, birds and mammals. Its excretory duct, or ureter, is derived as an outgrowth from the lower end of the mesonephric duct. This now leaves the latter duct free to function only in the genital system of males. In females of the same species it completely atrophies.

The genital system is so closely bound up with the urinary system in most animals, that what has been said, largely covers both fields. A few points regarding the genital system remain to be mentioned.

A primitive method of shedding the sex cells, consists of their release into the coelomic cavity and thereafter their exit via the genital pores or coelomostomes. This method has been mentioned as occurring in the Cyclostomes. These are very primitive fish, with a round mouth and no jaws. They closely resemble eels. The sex cells of both sexes are extruded from the coelomic cavity, by the mutual pressure of their sexual embrace.

In many fishes there are present sperm-ducts, which connect the lower pole of each testis with the cloaca. But fishes as a class are quite exceptional in this respect, and even among fishes, there are many species where the male genital products escape via the mesonephric ducts. This latter state of affairs becomes the rule in all the higher vertebrate classes.

- Although there -

Although there is in general a close association between the urinary and genital systems, yet some authorities have pointed out, that there exists among vertebrates, a strong urge, which aims at the complete separation of these systems. In lower vertebrates there frequently occurs mingling of urine and spermatozoa. The effect on the sex cells cannot be beneficial, especially in those animals where the urine becomes concentrated. A developmental trend which aims at separating these systems is thus natural, and falls into line with the preservation of the species. This separation is accomplished functionally in all the higher vertebrates, including the mammals. It is only in the female primate though, that this separation is anatomically effected.

It has been shown that the mesonephric duct may have a urinary or genital function, or sometimes a combined function. Considerable controversy exists as to which system, urinary or genital, has prior claim to this duct. Some hold that it is essentially a urine duct which the genital system has appropriated. Others maintain that the duct is formed by, and for the genital system, and that its urinary function is secondary.

Let us accept as an hypothesis that the duct formed in the first instance to convey waste products from the primitive kidney, and that the genital system used this duct already formed. There is quite a lot which supports such a view. What is known of its embryological development suggests that this concept is correct. In the light of such an hypothesis, the formation of successive kidneys begins to look reasonable. We can suggest that as the genital system used

more and more of this duct, the urinary system moved out of the way, i.e. caudalwards. Eventually the metanephric kidney had to be content with a mere diverticulum of the duct, which is essentially a kidney duct. This idea is suggested by Miss Hyman in her Text-book of Comparative Anatomy. (16)

THE MALE UROGENITAL SYSTEM IN FISHES AND AMPHIBIANS.

The fishes and Amphibians are grouped as the Anamniota, because in their embryological development no amniotic cavity is formed.

The extremely antiquated method of shedding the genital products into the coelomic cavity, has been described as occurring in the cyclostomes. These eel-like fish belong to the lowest group of vertebrates.

The urogenital system in fishes varies enormously. Certain features are constant. The single or paired testis is always abdominal in position, and frequently has its own sperm duct. The sperm duct may open separately to the exterior, or with the mesonephric duct into a urogenital cloaca. (Fig. 38). The functioning adult kidney is a mesonephros, with a mesonephric duct. Prostates and bulbo-urethral glands are not present.

Then there are variable features. In many species there is a common urinary and genital duct. The occurrence of a urinary bladder is inconstant. When present it is formed as a dilatation of the lower end of each mesonephric duct. In several species which have a sperm duct, there is present a well-marked dilatation of the lower end, which serves as a reservoir for spermatozoa. This dilatation, or "seminal vesicle"

- is greatly -

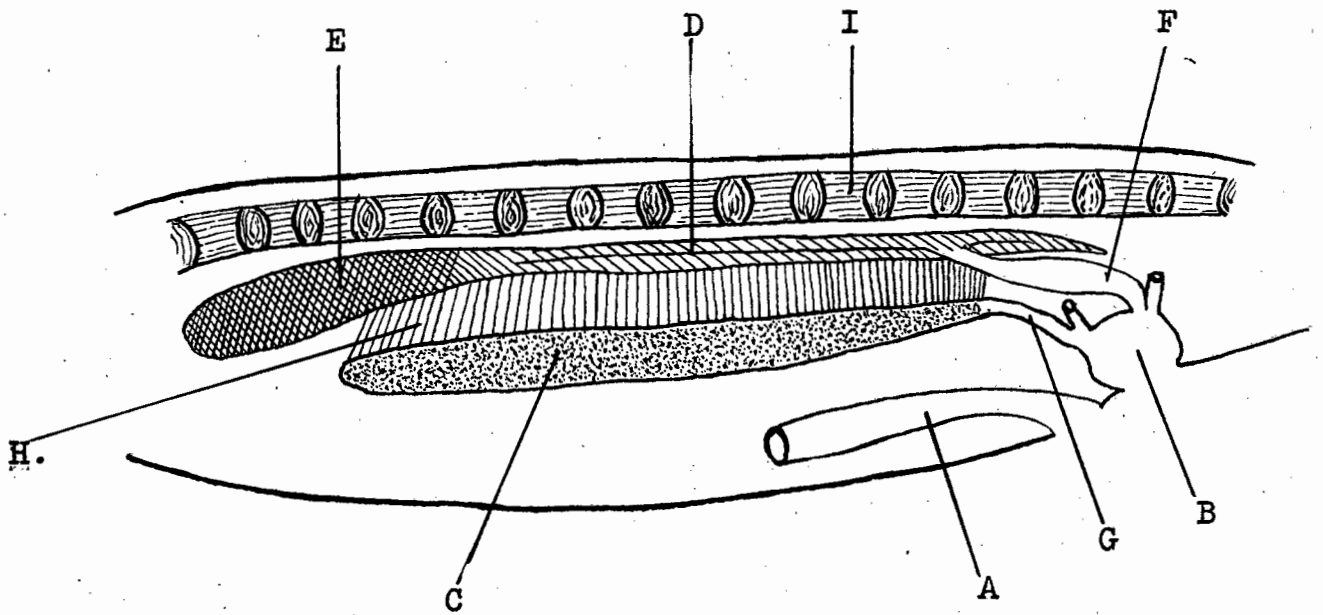


FIG 38 MALE UROGENITAL SYSTEM IN A TYPICAL BONY FISH
(Trout)

Only one testis and kidney are shown.

- A. Lower end Alimentary Canal.
- B. Urogenital Cloaca.
- C. Testis.
- D. Mesonephros.
- E. Adenoid Anterior end of Kidney.
- F. Mesonephric Duct.
- G. Sperm Duct.
- H. Mesorchium.
- I. Spinal Column.

is greatly enlarged and engorged with spermatozoa in the breeding season, and can be typically observed in the sole.

A similar seminal reservoir is found in members of the shark family. These Elasmobranch Fishes are also provided with claspers, which are appendages to the anal fins and are situated on each side of the cloaca. They are presumably for grasping the female in coitu. Associated with each clasper there is a blind sac with a mucous secretion. Since the claspers are of ectodermal origin, is it not feasible that these mucous glands are homologous with the Cowper's glands of higher animals? Perhaps the only just inference to make about these mucous glands, is that their presence adds some fuel to the fire of suspicion that Cowper's glands are ectodermal derivations.

A diagram is appended which illustrates the main features of the urogenital system of the common bony fishes, or Teleosti. (Fig. 38). It depicts these organs as found in the Trout. The urinary and sperm ducts are completely separate structures.

There is also a diagram of the same system in the shark (Fig. 39). In these cartilaginous fishes it is the rule for the male genital products to use the mesonephric duct. This differs from the condition found in bony fishes, as the Trout. In the shark family the testis communicates with the anterior end of the mesonephros, which assists in the formation of the efferent ductuli of the testis. The fluid waste matter from the mesonephric kidney, is collected by several urinary ducts, which normally open separately into the cloaca, but may join the lower end of the mesonephric duct. This state of affairs is very reminiscent of the future

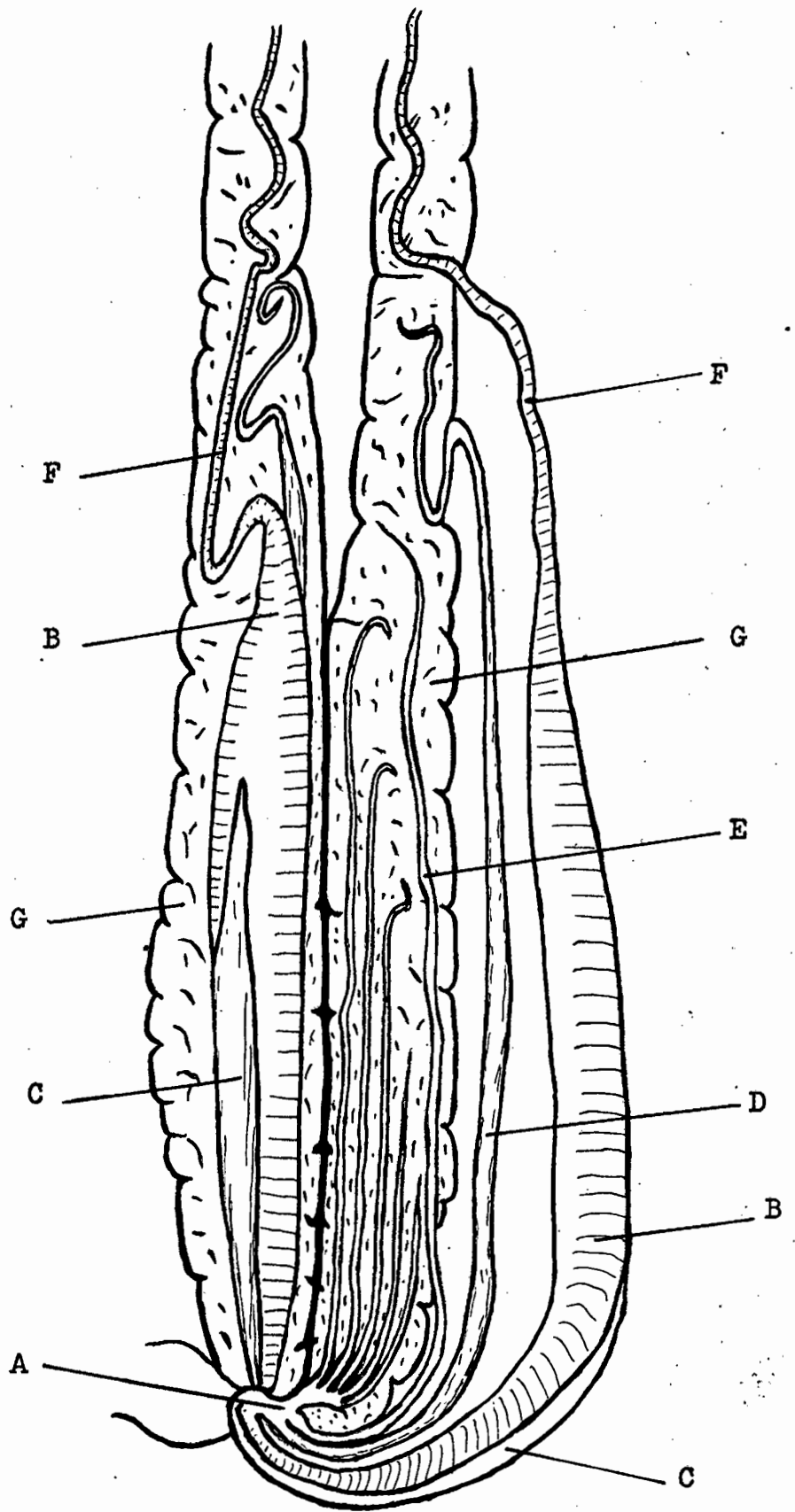


FIG 39 UROGENITAL SYSTEM OF MALE SHARK.

The left mesonephric duct has been pulled aside to show the "kidney" and "ureters" of the same side. The lower end of the mesonephric duct is dilated to form a seminal vesicle.

- A. Cloaca, B. "Seminal Vesicle" (right and left)
 C. Vestigial Oviduct, D. Main Urinary Duct,
 E. Accessory Urinary Ducts, F. Mesonephric Duct,
 G. Mesonephros (Kidney).

(From Hyman)

metanephric kidney, and to designate their special character, the kidneys of sharks are known as opisthonephroi.

The condition found in amphibians is fairly constant, and is shown typically in the frog. (Fig. 40). There is nothing special to note about the testis, and there are no accessory genital glands. The kidney of the grown animal is a mesonephros. The mesonephric duct subserves in most members of this class a combined urinary and genital function. Some salamanders, however, are advanced in this respect that they have separate "ureters", and kidneys which can be classed as opisthonephroi, like the shark family. (Fig. 41).

MALE UROGENITAL SYSTEM IN REPTILES AND BIRDS.

Reptiles are the lowest group of vertebrates, which during embryonal growth, have an amniotic cavity. Thus together with Birds, and Mammals they constitute the Amniota. Among reptiles are included snakes, lizards, tortoises, turtles and crocodiles. They are all cold-blooded creatures, and similar to fishes and amphibians in this respect.

Reptiles show many evidences of advance. The adult functioning kidney is a metanephros with a ureter, the urinary bladder develops from the ventral wall of the cloaca, and there is a rudimentary penis. Reptiles also have a well-formed allantois, which is present in birds and rudimentary in mammals, and which functions chiefly as a respiratory organ in those embryos which develop in an egg. The bladder of adult reptiles is a diverticulum of the cloaca, into which cavity also opens the intestinal tract, the urinary papillae

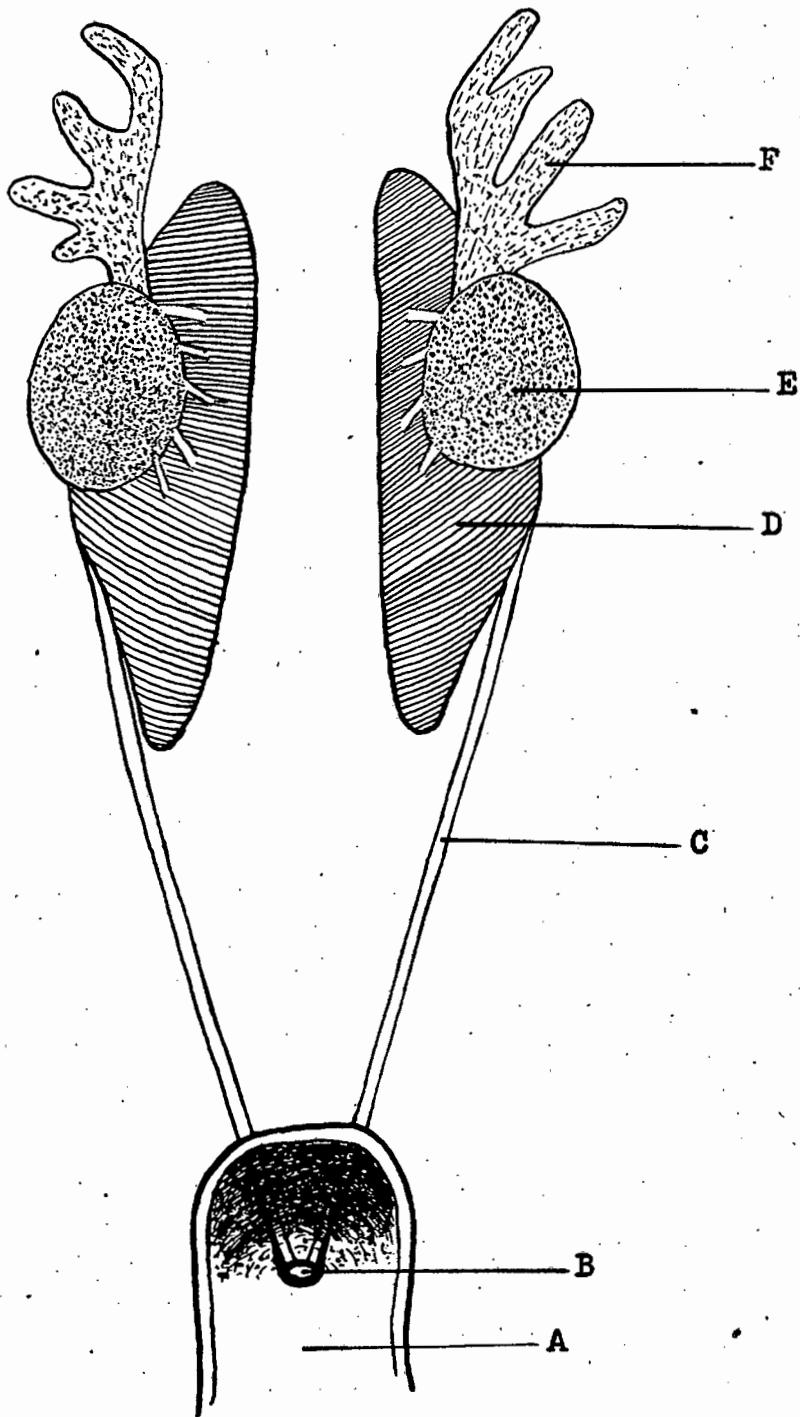


FIG 40 DIAGRAM OF UROGENITAL SYSTEM OF MALE FROG.

The mesonephric ducts drain urine and sperm.

- A. Cloaca,
- B. Urogenital Papilla,
- C. Mesonephric Duct,
- D. Mesonephros (Kidney),
- E. Testis, with fatty Appendage "F"

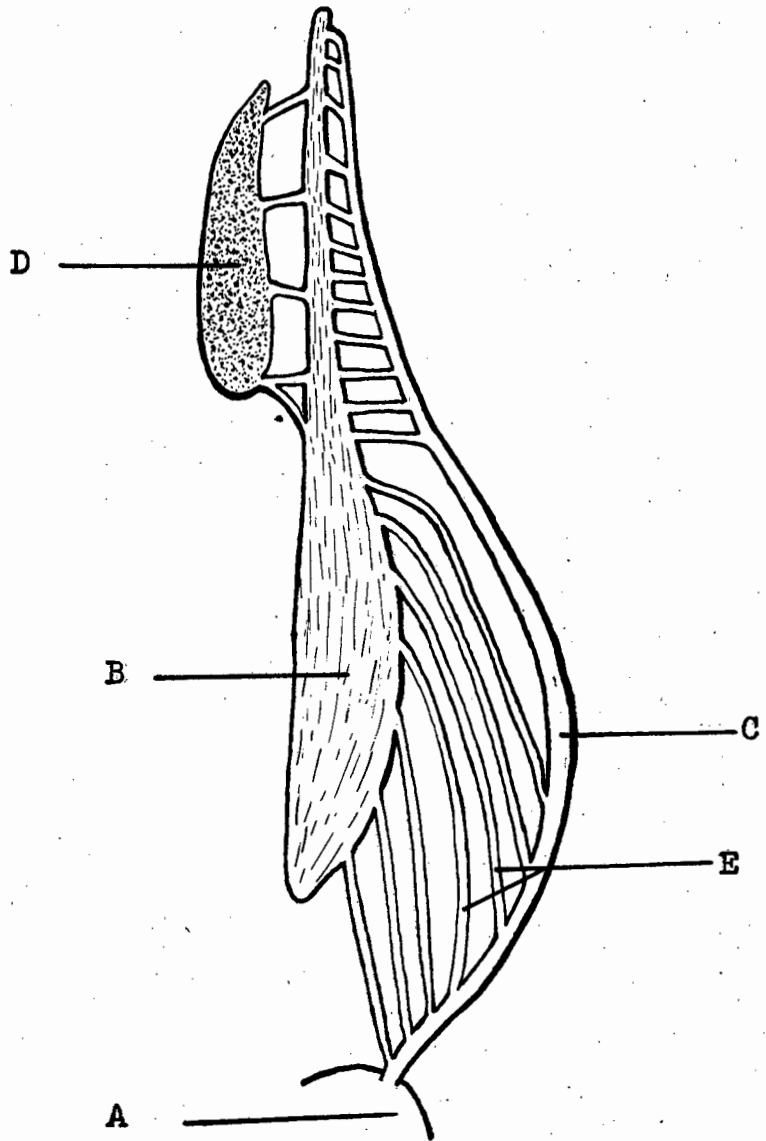


FIG 41 SIMPLIFIED SKETCH OF THE MALE UROGENITAL SYSTEM
IN A NEWT (AMPHIBIAN).

To show an intermediate arrangement between that of
the frog and that of reptiles.

A. Cloaca, B. Mesonephros, C. Mesonephric Duct,
D. Testis, E. Urinary Tubules.

(Modified from Owen).

and the vasa deferentia. A fold of mucous membrane divides the common cloaca into^{an} anterior urogenital part, or urodaeum, and a posterior rectal part, or coprodaeum. In some reptiles, the bladder may be a bi-lobed structure, as in the turtle.

The metanephric kidneys each have a ureter, which drains into the cloaca, by an opening distinct from the corresponding mesonephric duct. The mesonephric duct has become a part of the male genital system and forms the vas deferens, and epididymis of the testis. The epididymis resembles the mammalian type, in that it is a greatly coiled and convoluted tubule. The vas deferens and ureter lie side by side as they approach the cloaca, but open into the urodaeum separately.

In reptiles there is no vesicula seminalis, nor any dilatation of the lower end of the vas deferens to act as a seminal reservoir. It seems that the convoluted coils of the epididymis makes up for this lack. Since there is no true urethra, i.e. a tube draining the bladder and the bladder only, there are no prostates or bulbo-urethral glands.

The penis is a very rudimentary organ. But it is noteworthy, that reptiles are the lowest class of animals to develop a penis. It is composed of two masses of erectile tissue, situated in the ventral aspect of the cloaca and covered by mucous membrane. When the occasion arises these corpora cavernosi become turgid, are extruded from the cloaca, and form between them a groove, along which the spermatozoa are guided.

Birds are in some respects recessive when compared

- with reptiles -

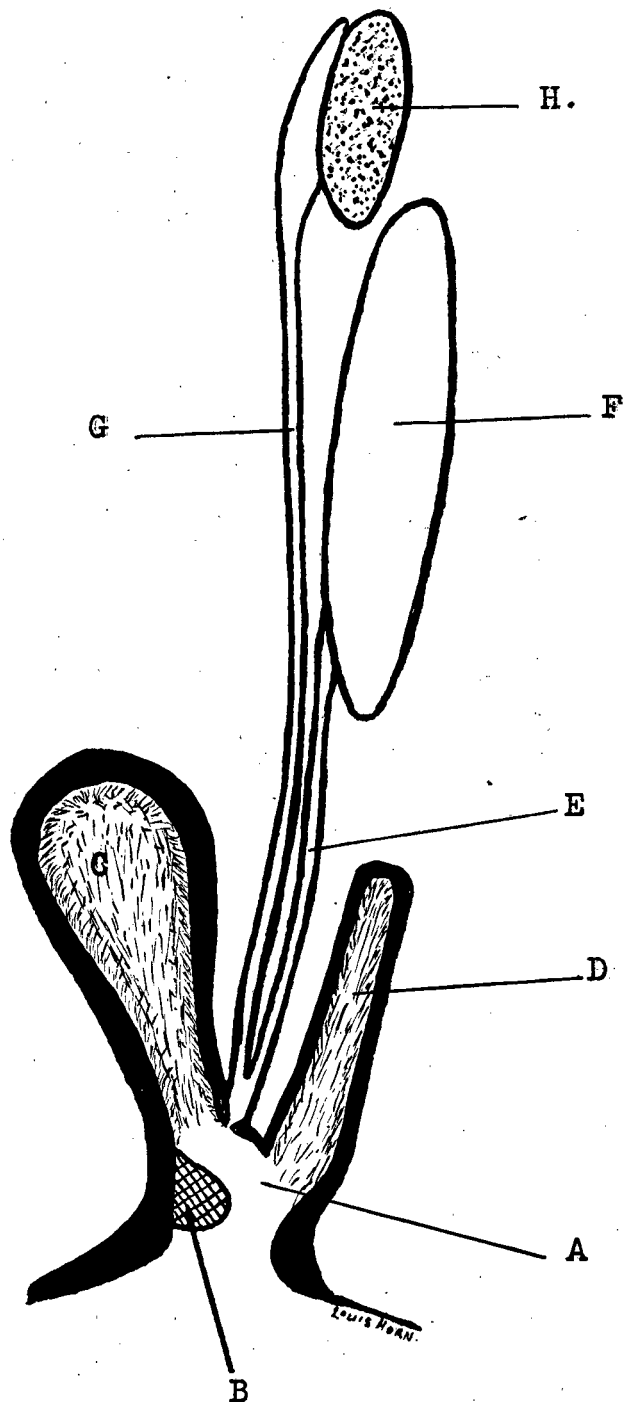


FIG 42 THE MALE UROGENITAL SYSTEM OF REPTILES.

There is a separate ureter; The penis arises from the ventral wall of the cloaca. The sketch shows the inside of the bladder, cloaca and rectum.

A. Cloaca, B. Penis, C. Bladder, D. Rectum,
 E. Ureter, F. Metanephric Kidney,
 G. Mesonephric Duct (convoluted), H. Testis.

The testis and kidney of only one side are shown.

with reptiles, and yet birds are warmblooded animals.

The testes in birds are always abdominal in position. The adult kidney is a metanephros. Urine passes from the kidney to the cloaca by the ureter. The mesonephric duct is atrophic in females and exclusively a genital duct in the males.

Birds have no urinary bladder. The cloaca is a receptacle where the genital, urinary and intestinal excreta accumulate. The cloaca is incompletely divided, as in reptiles, into a urodaeum and coprodaeum. There is a blind diverticulum opening dorsally into the coprodaeum of most birds. It is called the bursa of Fabricius, and is most pronounced in young birds, becoming atrophic with age. Its exact function is not known. It has been compared with the thymus of other animals.

Most species of birds have no penis, and copulate by cloacal contact. The ostrich and duck families are exceptions, and have a cloacal penis similar to reptiles. The absence of the penis in most birds appears to be a secondary loss.

The ureters and vasa deferentia run side by side as they approach the cloaca. They open into the genito-urinary portion of the cloaca by separate apertures. The lower end of each vas deferens is dilated to form an ampulla, which serves as a reservoir for seminal fluid. In the breeding season there occurs a remarkable enlargement of these seminal reservoirs, at which time these sacs are filled with a milky fluid, which teems with spermatozoa. These seminal reservoirs in birds are called seminal vesicles, although it is obvious

- that they -

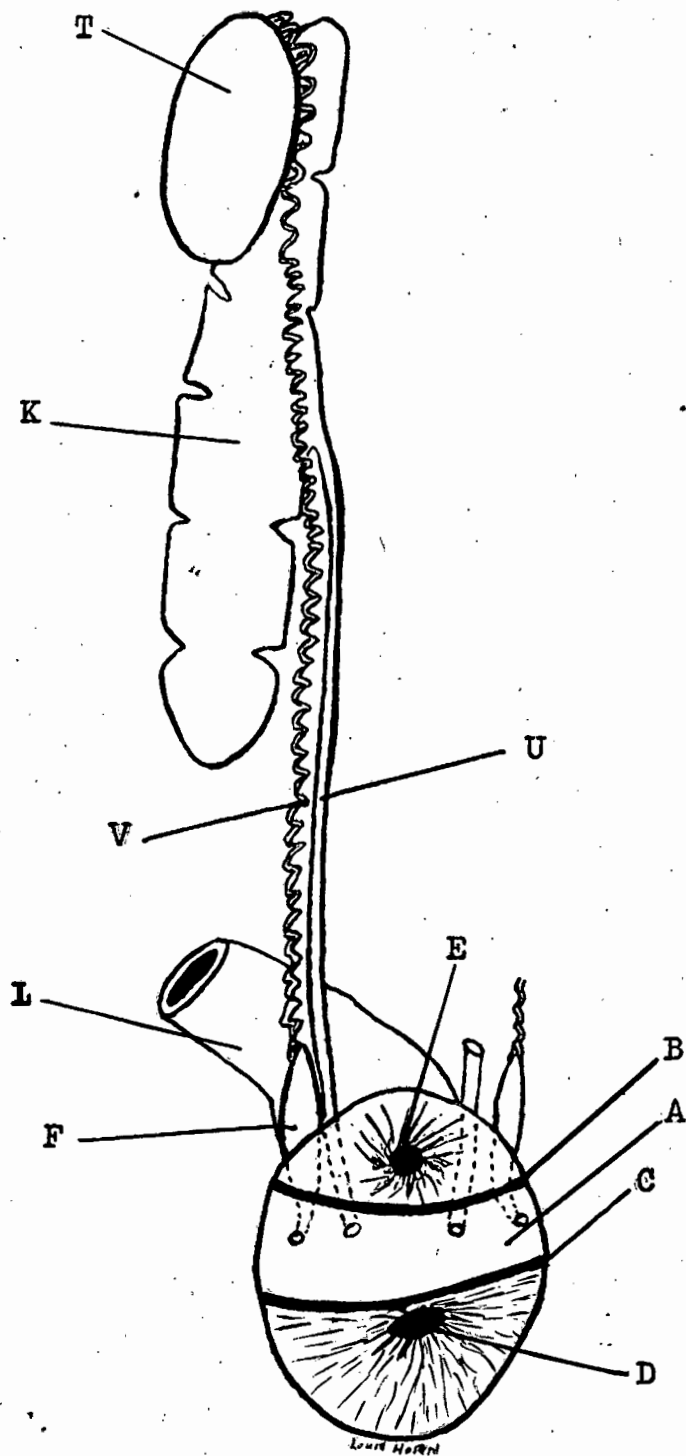


FIG 43 SCHEMATIC REPRESENTATION OF THE UROGENITAL SYSTEM IN A COCK TURKEY.

The vas deferens and the ureter open into the urogenital portion of the cloaca.

- A. Urodaeum, B. Fold of Mucous Membrane separating the urodaeum and coprodaeum. C. Fold separating urodaeum from bursa of Fabricius.
- D. Bursa of Fabricius, E. Coprodaeum,
- F. Vesicula Seminalis, T. Testis, K. Kidney,
- V. Vas Deferens, U. Ureter, L. Lower end Alimentary Canal.

that they are not strictly homologous with the seminal vesicles of other animals.

The periodic enlargement of the seminal vesicles of birds is quite remarkable. There is at the same time increase in size and activity of the testes. It was supposed that the increase in size of the seminal vesicles might be due to passive engorgement by seminal fluid. That this is not the case has been pointed out by Riddle (34). He describes cases where, because of some obstructive lesion, there was no continuity between the testes and the seminal vesicles. In spite of this, both the testes and the seminal vesicles enlarged during the period of heat. The seminal vesicles contained fluid but no spermatozoa. For this reason Riddle deduced that the cyclical growth of the vesicula seminalis in birds was controlled by hormones.

Birds have no prostates or Cowper's glands. In this respect they closely resemble the reptiles. The cloacal penis of reptiles and some birds must be lubricated by a mucous secretion from the cloacal lining. No special glands have been described. It is possible that the bursa of Fabricius may have a sexual function.

THE MALE UROGENITAL SYSTEM IN LOWER MAMMALS

This group includes the Monotremes and Marsupials. They are primitive mammals and show in many respects a transitional stage between reptiles and higher mammals. The kidneys are metanephric, with a ureter separate from the mesonephric duct. The latter functions as a deferent duct from each testis, and is atrophic in the females. There is a well-developed bladder, and in each class there is a cloaca, which especially in the Monotremes has decided reptilian characteristics.

The Monotremes derive their name from the fact that they have one common opening, or cloaca, for the exit of faeces, urine and genital products. The Ornithorhynchus (Australian duck-bill platypus) and the Echidna are the only existent members of this class. These curious animals lay large eggs, and suckle their young. The testes lie within the abdomen, anterior to the kidneys. The penis closely resembles that of reptiles, and differs only in that the sperm groove has become closed over to form a canal. The appearance of the male urogenital system of the Echidna is illustrated in Fig 44.

It will be seen that the cloaca is somewhat complicated. The lower portion is said to be derived from ectoderm, and normally functions in either an excretory (faeces and urine), or genital capacity. The ureters have not migrated to open into the bladder, but open with the mesonephric ducts into the urogenital canal. A sperm canal leads from the urogenital canal to open at the tip of the cloacal penis. With erection of the penis, the sperm canal becomes continuous with the upper part of the urogenital canal, which for the time being has no exit into the true cloaca. This animal is thus unique in that urine does not pass through

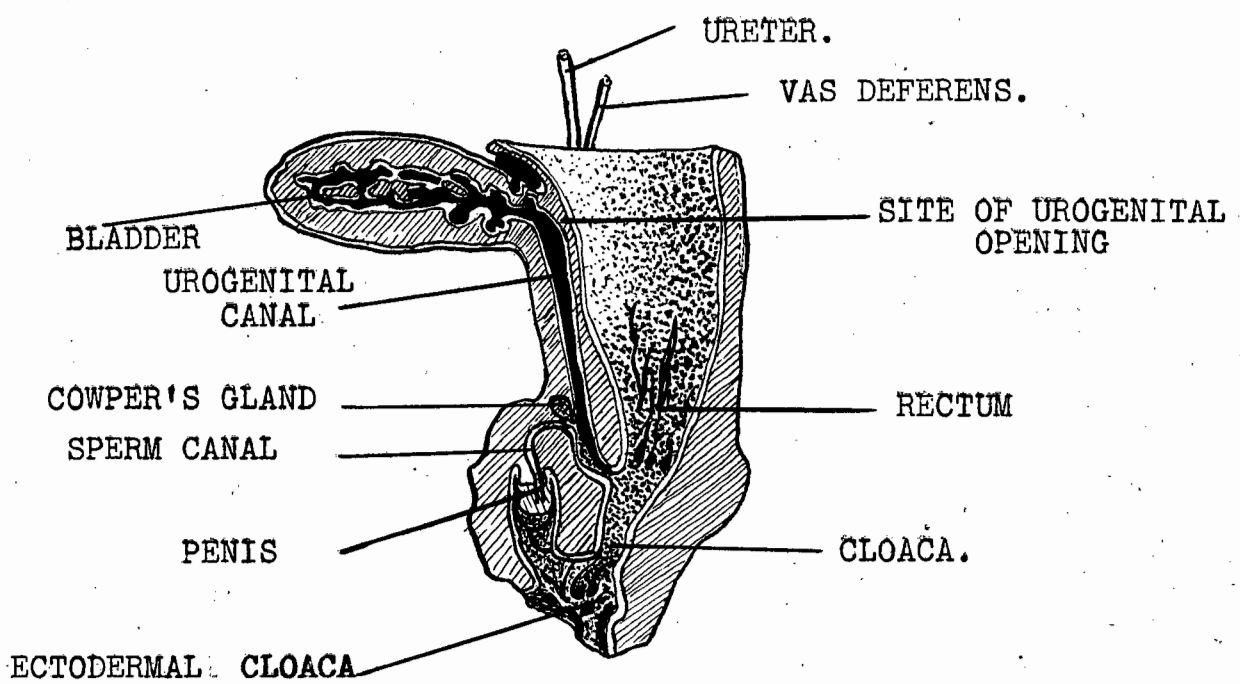


FIG 44 LOWER UROGENITAL SYSTEM OF THE ECHIDNA (Spiny Ant-Eater)

(From M. Weber after Keibel)

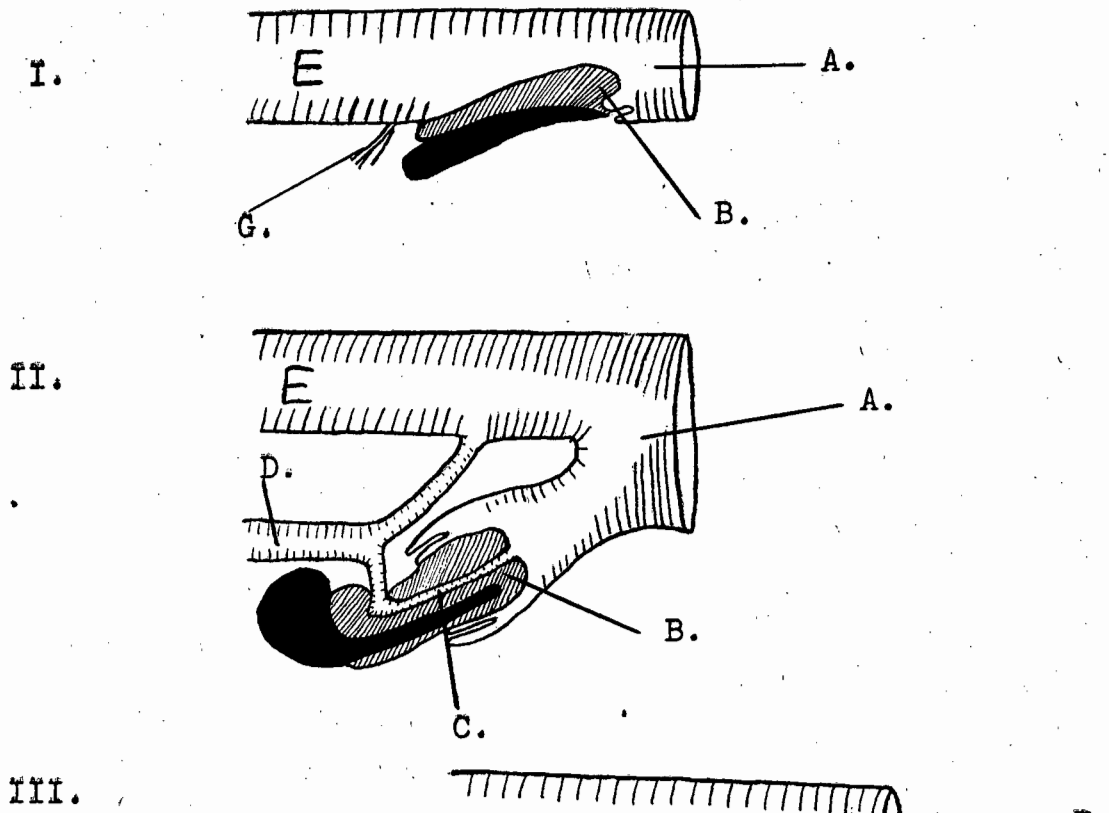
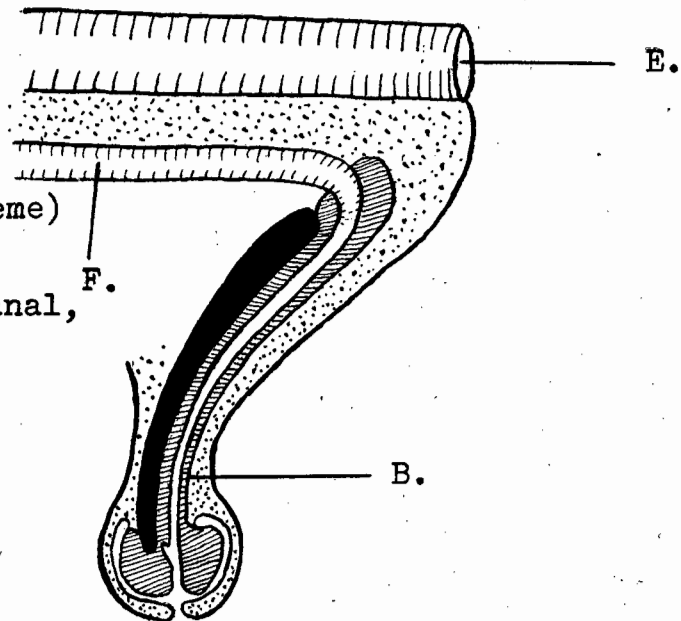


FIG 45 THREE STAGES IN THE DEVELOPMENT OF THE PENIS.

- I. Reptile, II, Echidna. (monotreme)
 III. Higher Mammal,
 A. Cloaca, B. Penis, C. Sperm Canal,
 D. Urogenital Canal, E. Rectum,
 F. Urethra, G. Urogenital Ducts.

(From Hyman)



the penis.

Male Monotremes have a pair of well-developed glands associated with the sperm canal. These glands have a sexual function, and from their position and function, it has been inferred that they are completely homologous with Cowper's glands. Apart from these there are no other accessory glands.

The Marsupials are those mammals, which carry their prematurely-born young in a pouch. Apart from the Opossums, which are found in the Americas, all the Marsupials are found in Australasia. The Kangaroo is the largest and perhaps the best-known member of this class.

The testes in these animals may be either abdominal or may descend into an inguinal scrotum. The latter event occurs in some species during the breeding season. The ureters open into the base of the bladder, and the vasa deferentia lead into the urethra. (Fig 46)

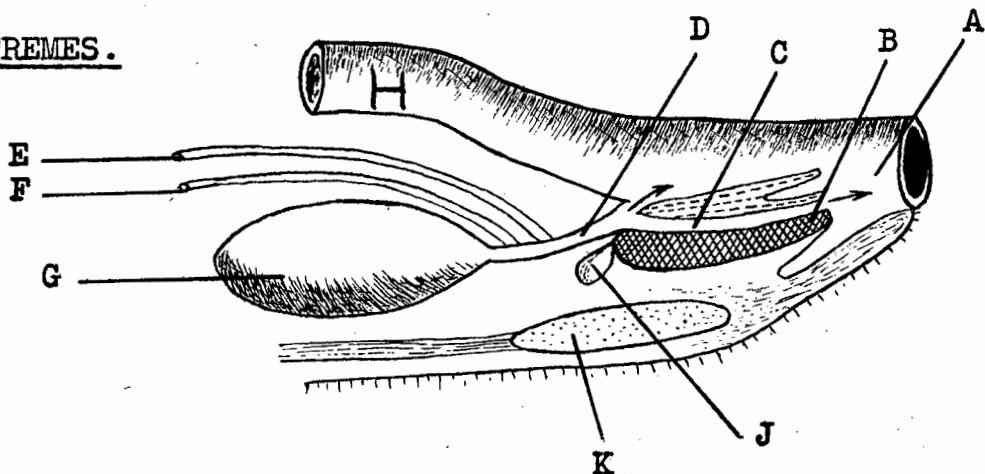
The cloaca of Marsupials is only a shallow vestibule, and the rectal and urogenital systems are almost completely separated. The penis in the erect state, is extruded from the cloacal opening. The tip is forked like a serpent's tongue. The bulbo-urethral glands are prominent and there are usually two or three pairs. These animals are the first to have a prostate gland. It is composed of a mass of tubular glands arranged around the urethra, so as to give the whole mass a spindle-shaped appearance. There are no seminal vesicles.

Female Marsupials exhibit as regards the genital system, such a marked departure from the general rule, that

FIG 46 TO SHOW THE PHYLOGENETIC DEVELOPMENT OF THE GENITAL SYSTEM IN MAMMALS.

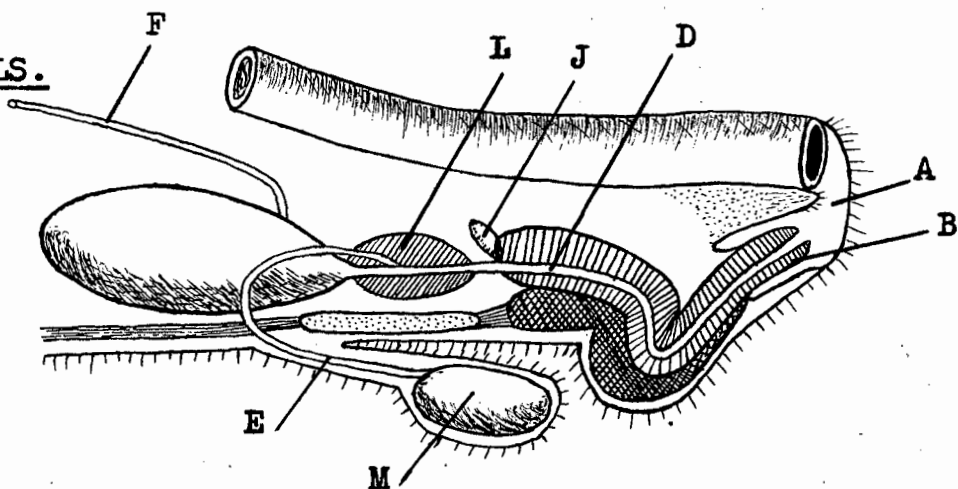
(From Max Weber)

I. MONOTREMES.



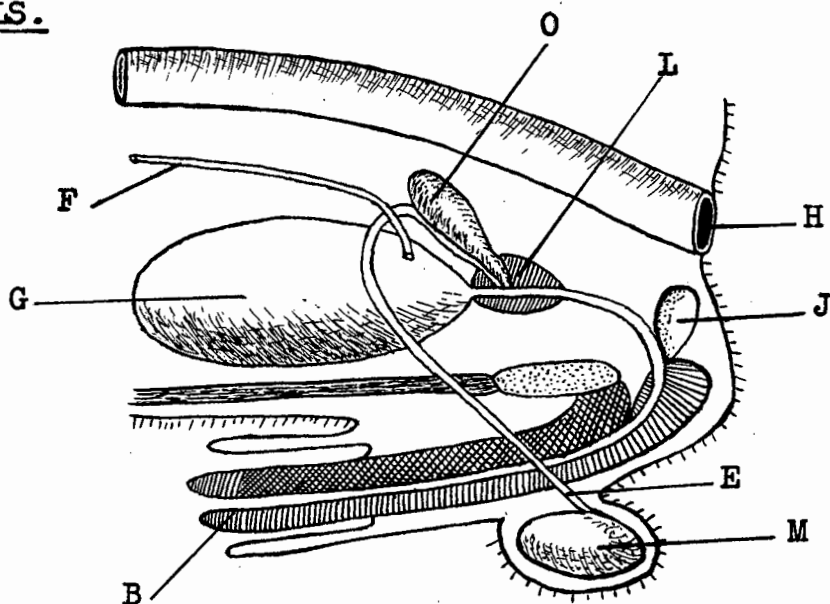
A. Cloaca, B. Penis, C. Sperm Canal, D. Urogenital Canal, E. Vas Deferens, F. Ureter, G. Bladder, H. Alimentary canal, J. Cowper's Gland, K. Symphysis Pubis.

II. MARSUPIALS.



A. Shallow Cloaca, B. Penis, D. Urogenital Canal (Urethra), E. Vas Deferens, F. Ureter, J. Cowper's Gland, L. Prostate, M. Testis, N. Musculature of ant. abd. wall.

III. HIGHER MAMMALS.



B. Penis, E. Vas Deferens, F. Ureter, G. Bladder, H. Anus, J. Cowper's Gland, L. Prostate, M. Testis, O. Seminal Vesicle.

it may be of interest to sketch their structure very briefly. The peculiarity exists in that the Mullerian ducts do not fuse in the midline, and moreover remain on the outside of the metanephric ducts, instead of crossing to the inside, as in all other animals. In other words, the female genital system is reduplicated on each side, and this earns for the class the name of Didelphia. There is thus a fallopian tube, uterus and vagina on each side. The lateral vaginae usually open separately into the urogenital canal. The bifid penis of the Marsupial male is probably a modification to suit the female form. Such a bilateral system would be so impracticable when the foetuses are due to be born, that there is developed as a secondary modification, a vaginal sinus. (Fig 48). This third vagina is a blind cul-de-sac, but it breaks open temporarily into the urogenital canal to allow the foetuses (or foetus) to be born.

It will also be seen from the diagram (Fig 48), that the upper end of each lateral vagina has a large diverticulum. This is a true "receptaculum seminis", in which the female Marsupial is able to store seminal fluid for a long period. The reason for this singular state of affairs, is probably the harsh climate in which these animals live. The Kangaroo for instance, inhabits the desert-like plains of central Australia. Rain falls seldom and at irregular times. After a downpour, there follows a short period of luxuriant growth of vegetation. Food and water is plentiful, and it would be an excellent time for the young to be born. The female Kangaroo does not avail herself of her stored spermatozoa until such a time comes to pass. The period of gestation in Kangaroos is exceptionally short, and within two weeks a baby Kangaroo is born into the pouch. By the time conditions become trying again, the young are able to fend for themselves, and in this way the species is preserved.

I gleaned this information from two excellent articles by Jones in the Journal of Obst. and Gynaec. of the British Empire (17). Jones also recounts some most interesting facts about spermatozoa, which have a more direct bearing on this discussion. He points out that many physiologists are of the opinion that spermatozoa live only a short while after exposure to normal body temperature. This applies to mammals. He goes on to show that this is certainly not a rule which is generally applicable.

The concept is supported by the fact that if the testes of an animal with a scrotum, be transplanted from the scrotum into the abdomen, the testes will soon cease to produce healthy spermatozoa. That the change of temperature is the causal factor, was deduced from the observation that the temperature within the scrotum is lower than that of the general body temperature. But this does not appear to be the whole truth.

There are many animals, amongst these are mammals, whose testes remain permanently within the abdominal cavity. The elephant is an example. Such animals are normal and fertile. So that at least in some animals spermatogenesis proceeds normally even at body temperature. It might perhaps be as well to check up on the internal temperature of such animals.

On the other hand, as will be seen later, there are many animals where the testes descend into the scrotum only during the rutting season. Unless the reason for this temporary descent is to reach a cooler temperature, then, in the light of our present day knowledge, the reason remains obscure

Spermatozoa may be short-lived, once they are deposited in the female passages. It is believed that in most animals, including man, they survive only a few days after normal coitus. The body temperature of the female may, or may not be, the cause. But spermatozoa are not always short-lived under precisely the same conditions. This is clear from a study of certain animals. A queen bee is fertilised only once, and this occurs during her nuptial flight when she is overtaken by the foremost of the pursuing drones. Thereafter she settles down for several years and produces thousands of eggs. Such occurrences are not rare among invertebrates, but, what is more important to us, is that similar oddities occur among mammals. We have seen how spermatozoa may be stored by the female kangaroo. Several observations have gone to prove, that in this animal the sperms may remain unused within the female, for many months.

Bats, which are flying mammals, show similar curious habits. The following observations were made in a Northern Hemisphere country. The male bats are sexually active in October. At this time their genitalia are enlarged and hyperaemic. Female bats exhibit a like change only in March of the following year, and they produce their young 1 - 2 months later. But a female bat killed in October, has her vagina completely filled by a firm plug. This plug consists of coagulated semen, and constitutes the "bouchon vaginale" of Lataste. (Fig. 47). It is obvious that the females do not use the spermatozoa in their vaginae until March. If they were to have been impregnated at the time of coitus, their young would have been born in winter (December). In other words, at a time when insects are scarce, and the cold extreme, and they would surely have perished.

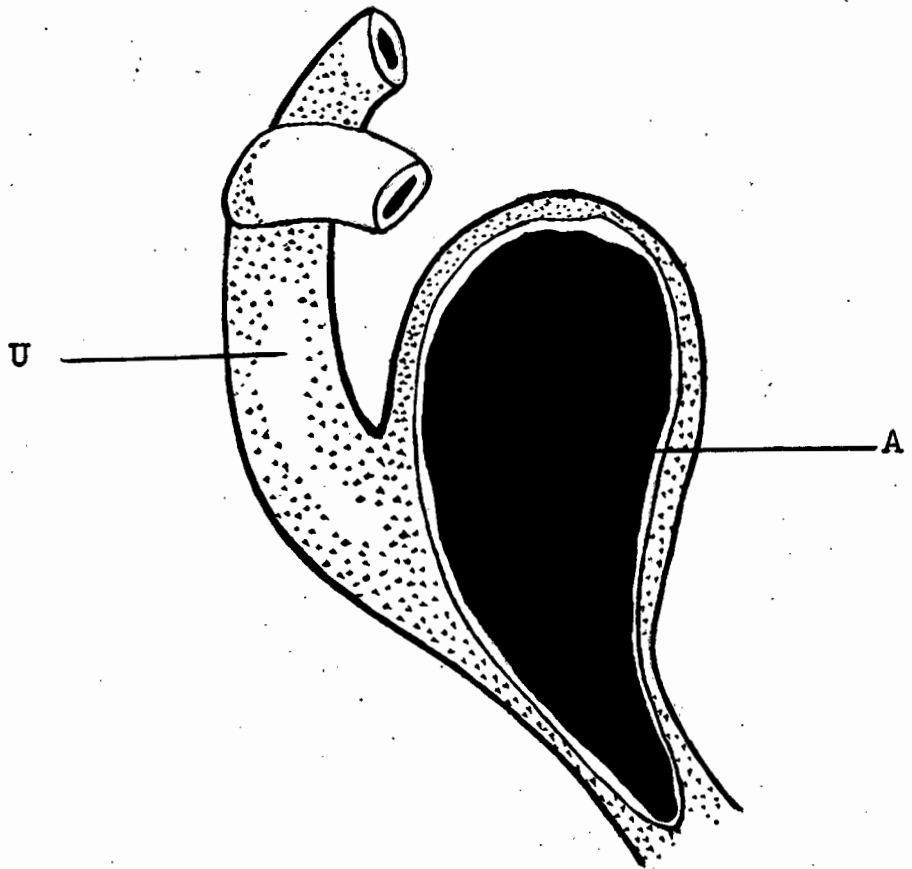


FIG 47 "BOUCHON VAGINALE" IN FEMALE BAT.

- A. Vagina filled with firm coagulated mass of semen.
- B. Uterus. (From Jones)

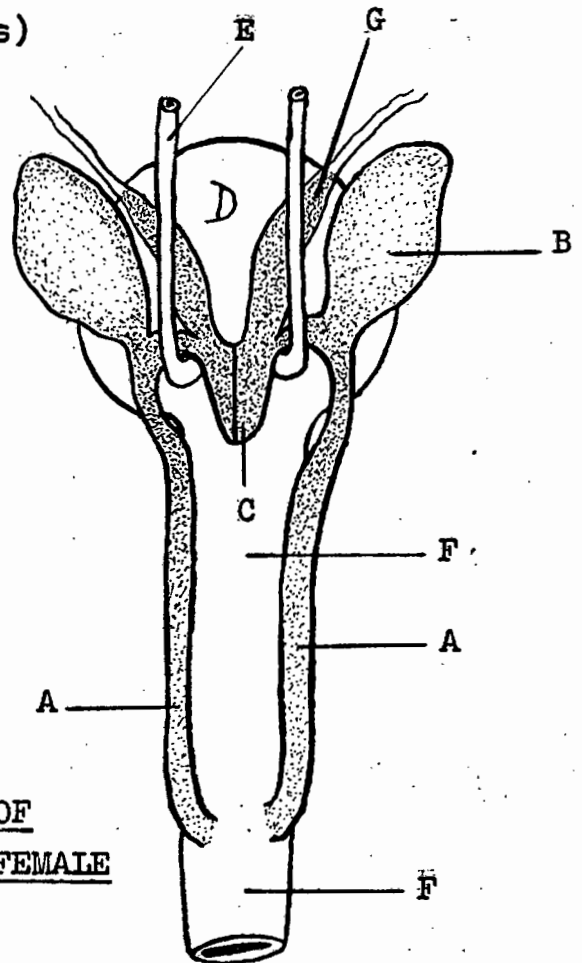


FIG 48 ARRANGEMENT OF
GENITAL ORGANS IN A FEMALE
KANGAROO

- A. Lateral Vagina, B. Receptaculum Seminis,
- C. Vaginal Sinus, D. Bladder, E. Ureter,
- F. Urogenital Canal, G. Uterus.

(From Jones)

These examples show that spermatozoa may live a surprisingly long time, and that at the body temperature of the female. It is possible that the coagulated mass of semen in some way acts as a protection. It has already been shown that coagulation of semen occurs in most animals, and appears to be a vital feature. Exactly how and why is not as yet well understood.

THE MALE UROGENITAL SYSTEM IN MAMMALS.

The Primates, in which class man belongs, will be discussed under a later heading. The lower mammals have already been dealt with. All mammals above Marsupials are often grouped as Monodelphia, which term designates that the lower ends of the Mullerian ducts have fused to form a single vagina. These mammals are also called Placentalia, and it is characteristic of the whole group that the young are born alive.

The Monodelphia include all the common animals, both wild and domestic. In this immense group the testicles as a rule descend into an inguinal scrotum, either permanently, or temporarily, during the season of heat. The testes remain inside the abdomen in elephants, walruses, sloths and armadillos. They descend temporarily in bats, moles and many rodents. The structure of the testis in all these animals is remarkably similar, and the anatomy differs but little from that of the human testis. To the posterior aspect of the testis is attached the epididymis. It is a greatly convoluted tubule between ten and twenty feet long. At the lower end, or tail of the epididymis, the tube becomes straight to form the vas deferens or ductus deferens of the testis. It is characterised by its thick muscular wall and narrow lumen. It pursues a straight course to open into the urethra. The epididymis and the vas deferens are derived from the mesonephric duct.

The kidneys in mammals are metanephroi. The ureters open dorsally into the bladder at the base of the

trigone. The bladder is derived from the ventral wall of the cloaca. The trigone of most animals is not as distinct a structure as seen in the human bladder, since the bladder-neck opening is markedly funnel-shaped. On the dorsal wall of the urethra there is a crest, the colliculus seminalis or veru montanum. On it open the utriculus masculinus and the vas deferens. The duct from the seminal vesicle also opens on the veru montanum, either together with the vas deferens, or by a separate aperture. The veru montanum in most mammals is not as distinct a structure as that found in the primates.

The bladder empties itself through the urethra which in the male passes through the penis. The urethra distal to the veru montanum is thus a urogenital canal. The urethral canal of the female is homologous with that part of the male urethra proximal to the veru montanum. None of these animals have a cloaca as was seen in the lower animal classes.

Due to the fact that the bladder in quadruped animals is placed relatively high in the abdomen, the pelvic portion of the urethra is much longer than that of the human. A more striking difference, however, is the prominent urethral muscle, which surrounds this part of the urethra in animals other than man. It is commonly known as Wilson's muscle and its function is to empty the urethra of urine or semen. It forms an external muscular coat of striated muscle fibres, which interlace and may have a longitudinal or transverse direction. We have already mentioned that this muscle is seen quite distinctly in the human embryo. We have also seen how remains of this muscle persist in the human urethra and play an important

role in the muscular mechanism of the bladder and urethra.

The accessory sex glands are well differentiated in mammals. They comprise a group of glands which, although derived from different embryological parts of the genital tract, yet have a common function. The combined secretion of all these glands will ensure the vitality of the spermatozoa.

That their function is purely sexual is proved by two indisputable facts. Firstly, these glands become atrophic and degenerate in a castrated animal. Secondly, these glands will completely regenerate if such an animal is given injections of male hormone. After a boar has been castrated, the shrinkage in the size of the seminal vesicles is very remarkable. Zuckerman and Parks (56) in 1937 record how a castrated monkey was restored to full functional sexual activity by injections of male hormone. Many other workers have testified to the verity of this statement.

The comparative anatomy of these glands in mammals, is made up chiefly by the fact that frequently one or more members of the group may be absent. The accessory sex glands comprise the following:-

- (1) Ampullae of the Vasa Deferentia.
- (2) Seminal Vesicles
- (3) Prostate(s)
- (4) Urethral Glands
- (5) Bulbo-Urethral Glands of Cowper

AMPULLAE OF THE VASA DEFERENTIA.

The ampulla of each vas deferens is the enlarged lower end which lies adjacent to the seminal vesicles. In animals it does not deserve the name "ampulla" as it does in the human. A more constant feature is the presence of glands in the thickened wall. For this reason the name "glandula vasis deferentis" is more appropriate. In only a few species of animals is there dilatation of the lumen, and even in these the lining epithelium is essentially secretory. The secretion of the "ampullary glands" is similar to that of the seminal vesicles, and probably subserves the same function. In those animals where the ampulla is a widened area of the vas deferens, it probably performs the function of a reservoir for spermatozoa. There is enough evidence to show that this is so in the human being. The ampullae of the vas deferens then would seem to be homologous with the "vesicula seminalis" of birds, and certain fishes.

THE SEMINAL VESICLES.

In the sense that the term designates that these vesicles contain seminal fluid, it is correct. But if the term implies that the vesicles contain spermatozoa, its correctness is open to grave doubt. The word was coined before the advent of the microscope, and so spermatozoa could not be recognised. The human seminal vesicles under certain conditions certainly do contain spermatozoa. The seminal vesicles in other animals never harbour them. This latter fact has been recorded by so many observers that

reference to all their names would fill too much space. Authorities on comparative anatomy are adamant, that the term "vesicula seminalis" is a misnomer when applied to animals, other than man. The consensus of opinion in regard to such animals, is that spermatozoa normally accumulate in the tail of the epididymis, and travel down the vas deferens with each spasm of ejaculation.

If one wishes to recover mature healthy spermatozoa from animals, one collects them from the cauda epididymis. They are present in that situation in untold numbers. They may also be found from time to time in the vas, or in the ampulla of the vas (in those animals which have an ampulla), and just as frequently in the urine. They never penetrate further into the vesicle than to the region of the neck of the vesicle, and their presence here is as adventitious, as their presence in the urine. There is a constant migration of spermatozoa from the cauda epididymis into the urethra, which occurs apart from ejaculation. This must of necessity be so because fresh spermatozoa are constantly being formed in the testis.

The seminal vesicles, when present, drain into the pelvic urethra each by a single aperture. The aperture is situated on the veru montanum. In the majority of animals the duct from the seminal vesicle does not unite with the vas deferens. Each opens separately into the urethra. There is thus no ejaculatory duct as is found in the human. In some animals the vas deferens and seminal vesicle may open by a common aperture, but in no case do they form an ejaculatory duct of any appreciable

length.

The wall of the seminal vesicle is always a glandular structure. In human beings and in those animals where the vesicle has a relatively wide lumen, the epithelial lining is secretory and is always thrown into folds. This sacciform type of vesicle is not common, and found only in Cheiroptera (e.g. bats), Insectivora (e.g. hedgehog) and certain Rodentia (e.g. rats, guinea-pigs) among wild animals. Among domestic animals the horse and pig show a similar dilated seminal vesicle. A much more general finding is that the vesicle is thick walled, with a relatively narrow lumen. The thickness of the wall is largely due to the presence of numerous tubular glands derived from the epithelium. The primary function of the seminal vesicle is thus secretory. The term "vesicular gland" is thus more appropriate than "seminal vesicle".

To complete the picture of the structure of the vesicular glands, it must be stressed that they are essentially hollow muscular organs. There is always a well-developed muscular coat, composed of plain muscle fibres. This is to enable the gland to rapidly empty itself of its accumulated secretion. This function applies in equal measure to the prostate and Cowper's glands. It is of some interest to note that at least one of the glands in any given animal will show dilatation of the lumen. Most frequently it is the seminal vesicle. Quite often the Cowper glands are widely dilated. Very rarely the prostate gland is similarly affected. The reason is naturally to increase the volume of the ejaculate.

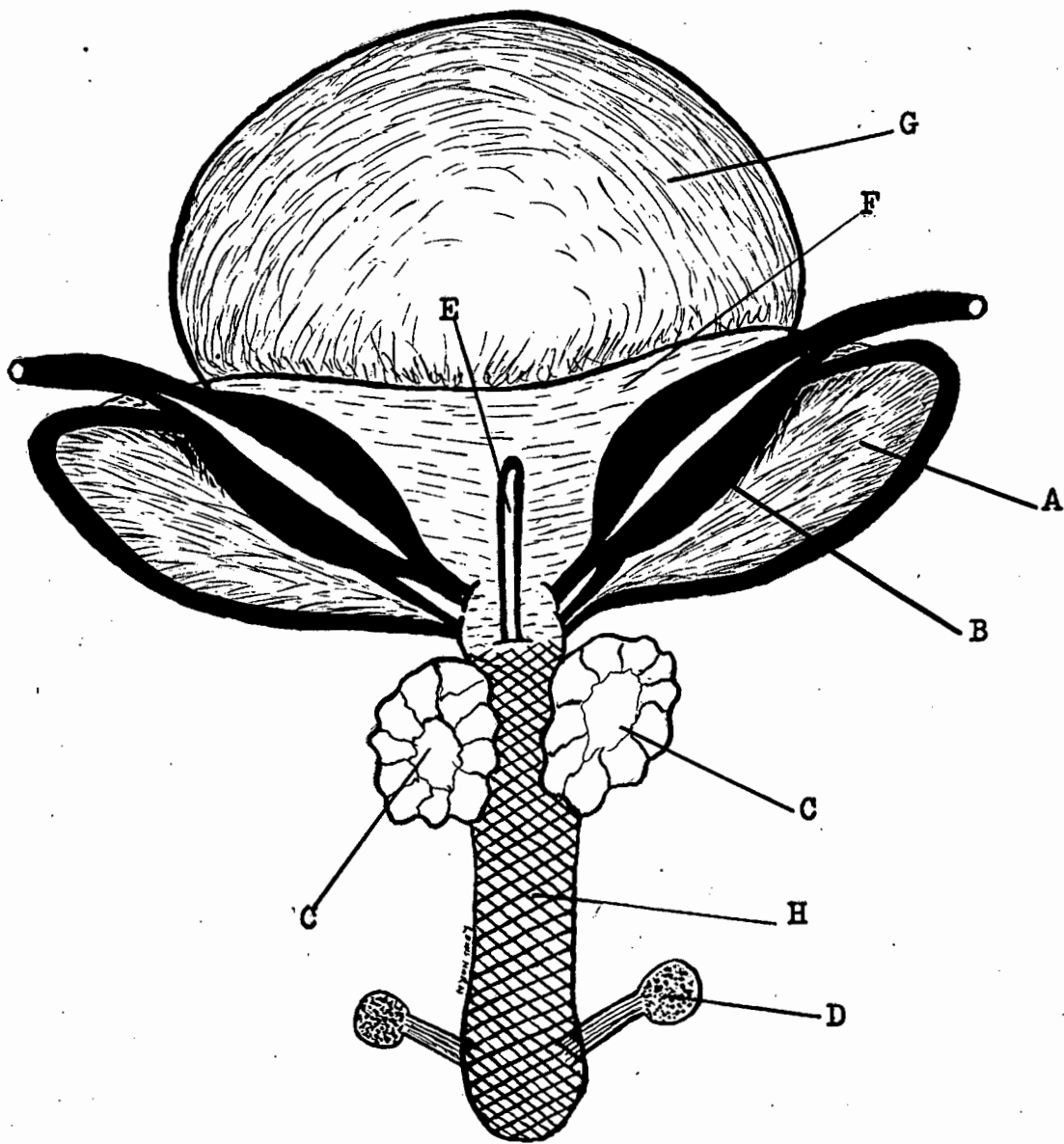


FIG 49 SCHEMATIC REPRESENTATION OF THE ACCESSORY GENITALIA IN A STALLION.

The ampullae and seminal vesicles have been cut lengthwise to show the extent of their lumina.

- A. Seminal Vesicle with wide sac-like lumen.
- B. Ampulla of Vas Deferens. Thick glandular wall and narrow lumen.
- C. Prostate.
- D. Bulbo-urethral Gland, E. Patent Utricleus Masculinus.
- F. Fold of Peritoneum in which A, B, and E. lie.
- G. Urinary Bladder, H. Musculus Urethralis.

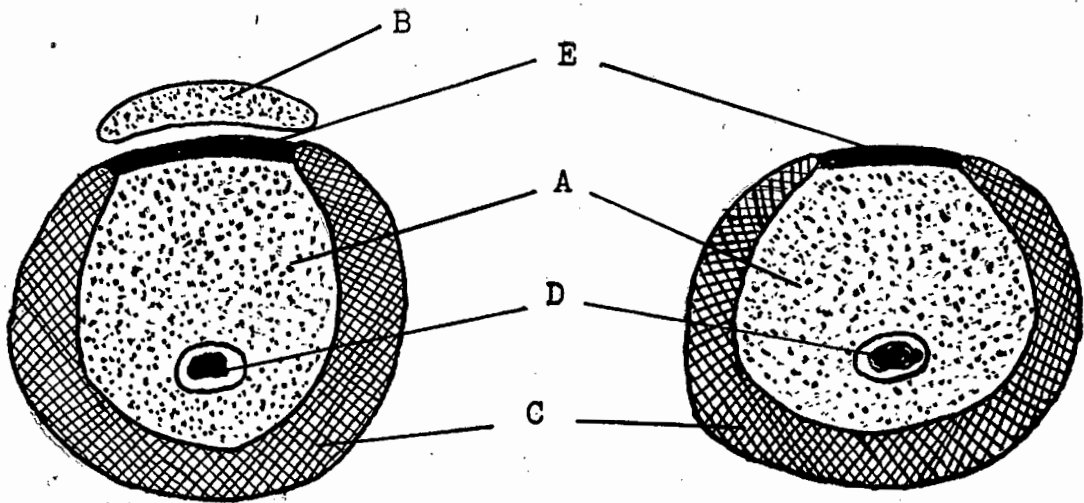
THE PROSTATE AND URETHRAL GLANDS.

These are grouped together because their derivation is so similar. These glands arise as diverticuli from the epithelium of the urogenital sinus. The prostate is merely a solid bunch of such glands. This point is illustrated very clearly by a comparative study. It is also noted that the prostate always drains into the urethra by multiple openings.

There are various modifications of these urethral glands. In marsupials the glands surround the pelvic urethra, but do not penetrate its muscular coat. This has been aptly called a disseminated type of prostate. An exactly similar condition is found in sheep and goats. (Fig. 50.).

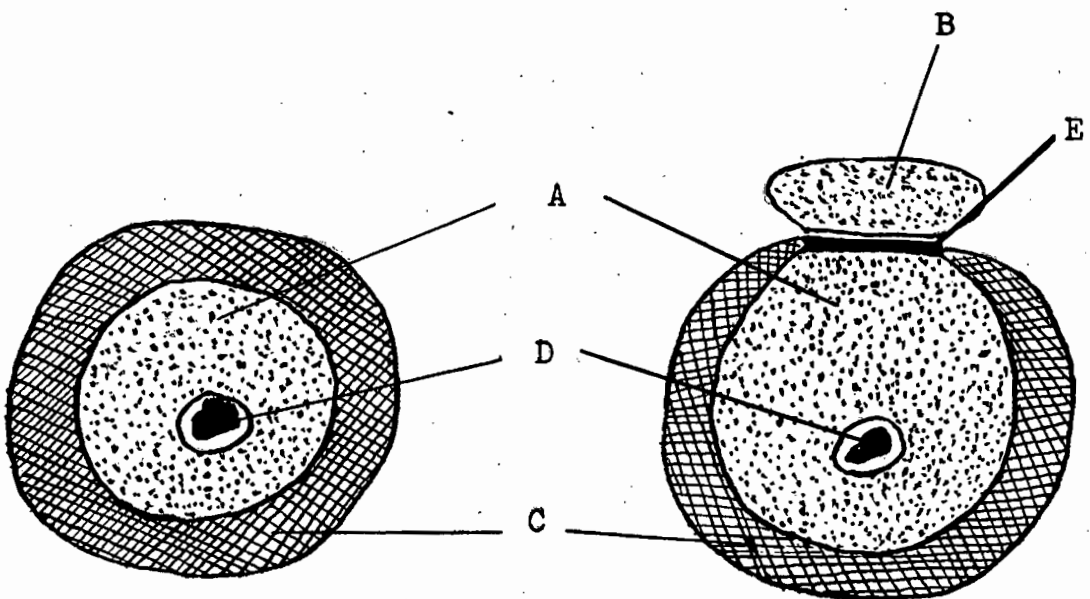
The urethral glands, however, show a strong tendency to collect in one or two masses on the dorsal aspect of the urethra and close to the bladder. When this happens a body of prostatic tissue is formed which lies outside the urethral muscle. This is seen in the bull and the boar. (Fig. 50.). It will be noted that these animals have both a "corpus prostatae" and a "pars disseminata prostatae".

The pars disseminata, which surrounds the pelvic urethra tends to become rudimentary with evolution. The body of the prostate on the other hand has come to stay. Most animal groups have this lobular type of prostate, which is a prominent gland lying in the dorsal aspect of the urethra. It is frequently bilobed, and it would be



1. BULL

2. RAM (Sheep)



3. GOAT

4. BOAR (Pig)

FIG 50

A transverse section through the urethra of each of four common domestic animals, to show the different arrangement of prostatic tissue.

- A. Pars disseminata (prostate tissue surrounding the urethra)
- B. Body of the prostate.
- C. Urethral muscle (Wilson)
- D. Urethra.
- E. Band of fibrous tissue.

more correct to speak of the prostates of animals. In dogs, and primates the two lobes have fused into one mass. In man it seems reasonable to deduce that the urethral glands still present are vestigial remains of the *pars disseminata* of other animals.

In the human prostate the median lobe is a clear entity. But in the great majority of animals no such lobe is clearly recognisable. At any rate it has not thus far been described. The embryological development also does not show that the middle lobe arises as a distinct part. For these reasons, many people are of the opinion that the median lobe of the human prostate is not a separate lobe. It is a term purely descriptive of its position.

But the median lobe of the prostate is particularly liable to adenomatous enlargement. It is frequently the only part of the prostate to be affected. This certainly suggests its separateness from the rest of the prostate. It is thus with some interest that we hear of a cranial lobe of the prostate in some animals, and what is more, that this lobe has a very specific and important function. This lobe in a baboon is depicted in Fig. 51.

In 1910, Walker (46) described in rats and guinea-pigs a portion of prostatic tissue lying in the same sheath as the seminal vesicles. He showed that the secretion of this portion of prostate, caused coagulation of the secretion of the seminal vesicles. This work was referred to and confirmed by Dorothy Price in 1936 (31) She refers to this part of the prostate as the cranial lobe.

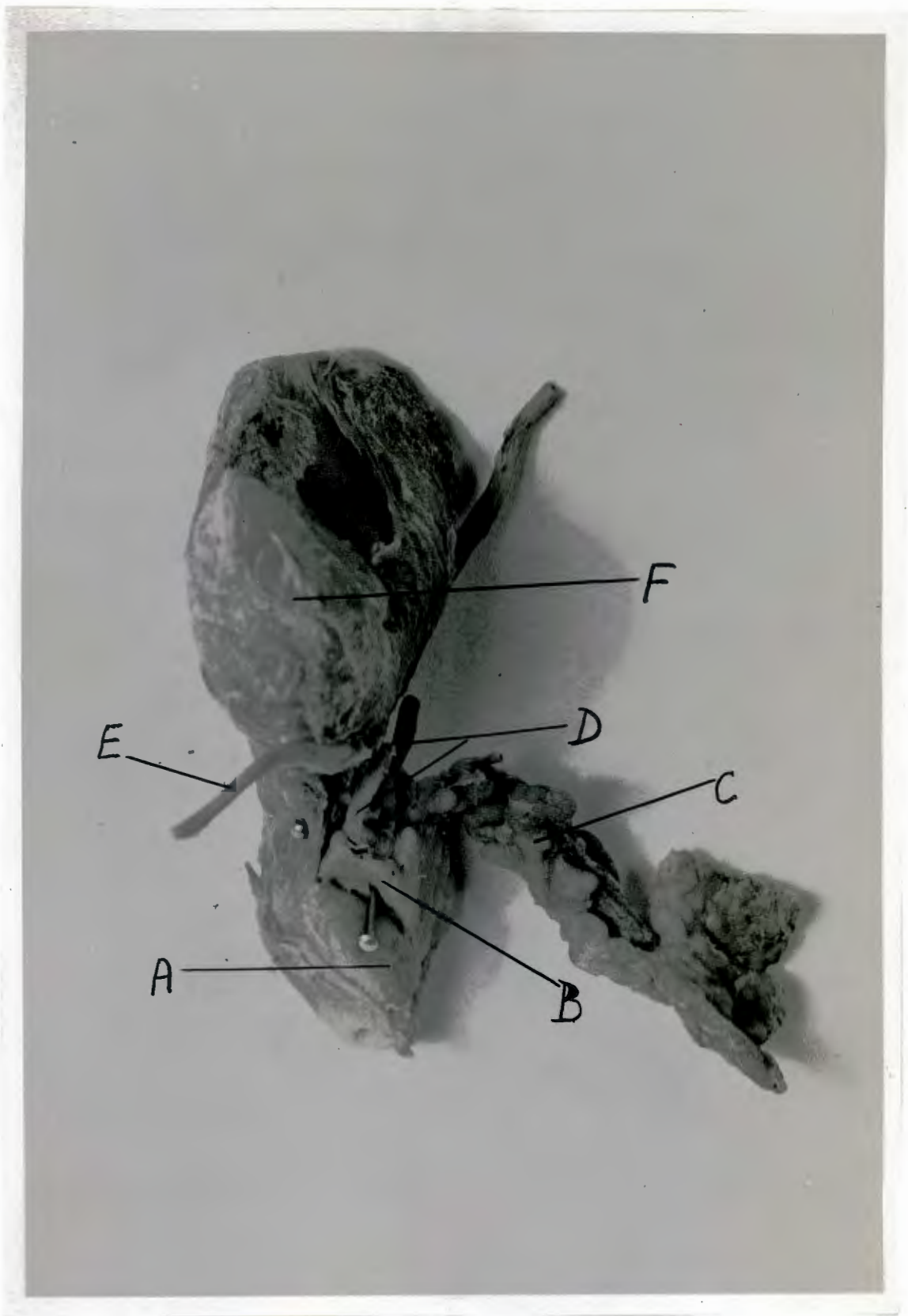


FIG. 51 . LATERAL ASPECT OF BLADDER AND GENITALIA OF THE SPECIMEN SHOWN IN FIG. . (IMMATURE CHACMA BABOON)

This view demonstrates how the cranial lobe of the prostate surrounds the lower ends of the vasa deferentia. Left seminal vesicle removed.

- A. Prostate.
- B. Cranial lobe of Prostate.
- C. Right Seminal Vesicle.
- D. Vasa Deferentia.
- E. Left Ureter.
- F. Bladder.

In rats and guinea-pigs the main body of the prostate is bi-lobed, and there is a third lobe lying closer to the bladder and between the seminal vesicles. Such a cranial lobe is also to be seen in monkeys, as will be shown later. Van Wageningen in 1936 proved that the secretion of the cranial lobe in monkeys, has precisely the same coagulating function on the secretion of the seminal vesicles. What is more the secretion of the cranial lobe in monkeys, coagulates the vesicular secretion of rats and guinea-pigs. The reverse was also shown to be true.

There is thus present in certain animals a lobe of prostatic tissue with a very specific function. Its position in these animals nearly corresponds with the median lobe of the human prostate. The relation has not been proved, but it seems to me very likely that the median lobe of the human prostate is homologous with the cranial (or coagulating) lobe of certain animals.

Prostatic gland tissue is present in all mammalian animals except the monotremes. For this reason it has been called the "sexual heart" of the accessory sex glands. The dog family have only a prostate and no vesicular or bulbo-urethral glands. In this family the prostate is large, and shows dilatation of the ducts. The domestic dog, furthermore, is an exception to all other animals in that the prostate completely surrounds the pelvic urethra. In this respect it resembles man. The prostate of a dog lies exterior to Wilson's urethral muscle and must not be confused with the pars disseminata type of prostate, which occurs in many ruminants. (See Fig. 52).

THE BULBO-URETHRAL GLANDS.

These glands are rarely absent in animals. Normally they have a single excretory duct which opens into the penile urethra. The horse is an exception with 6 - 8 excretory ducts. In some animals the glands are covered by the urethral muscle, and for this reason it is thought that they arise in a fashion, similar to that of the urethral glands. It has been mentioned that they are probably of ectodermal origin.

In some animals these glands are much enlarged and contain a copious secretion. They never harbour spermatozoa. The dilated and saccular type of Cowper glands are typically seen in squirrels and many members of the cat family. In these animals the great bulk of the ejaculate comes from the bulbo-urethral glands. In very few animals are the Cowper glands entirely absent. This is only seen in whales, walruses, dogs, bears and seals.

SOME CONSIDERATIONS OF THE SEX GLANDS AS A GROUP

When the physiology of these glands in the human was described, it was suggested that each had a specific function. So the secretion from Cowper's gland was essentially for lubrication in the pre-orgasm phase. Also the seminal vesicles might function as seminal reservoirs, as well as secretory glands. Nevertheless, the general function of the group of glands was to ensure the vitality of the spermatozoa. In all other animals the general function is very apparent, whereas a specific function for

any one of the glands is decidedly doubtful. This is clearly illustrated by the fact that often one or more of the glands is absent. In such an event, the remaining gland (or glands) shows a compensatory enlargement. A few examples will be given to show that this is really so.

In the Cetacea, which includes whales, dolphins and porpoises, there is present only a prostate gland. The same arrangement is found in the dog-like carnivorous animals. In none of these animals do we find any trace of bulbo-urethral or vesicular glands. In all of them the prostate gland is prominent and large.

Two small prostate lobes are found in Proboscidae, to which class elephants belong. But elephants have large, glandular seminal vesicles, and moderately developed bulbo-urethral and ampullary glands.

The walrus, which belongs to the Sirenia, has no Cowper's glands. Both vesicular glands and prostate are present. The scaly ant-eater has large seminal vesicles, and a prostate which surrounds the urethra and lies entirely under cover of the urethral muscle. It also has no Cowper's glands.

Most of the Ruminantia have all the accessory glands. The camel is an exception. This animal has no seminal vesicles, but a large prostate and moderately-sized Cowper's glands. Although not a ruminant, the pig is grouped with these animals in the order, Artiodactylia. It has been generously endowed with accessory sex glands. Not only has the boar both a fairly large prostate, but it also has enormous seminal vesicles and fairly large bulbo-urethral glands. (Fig. 53).

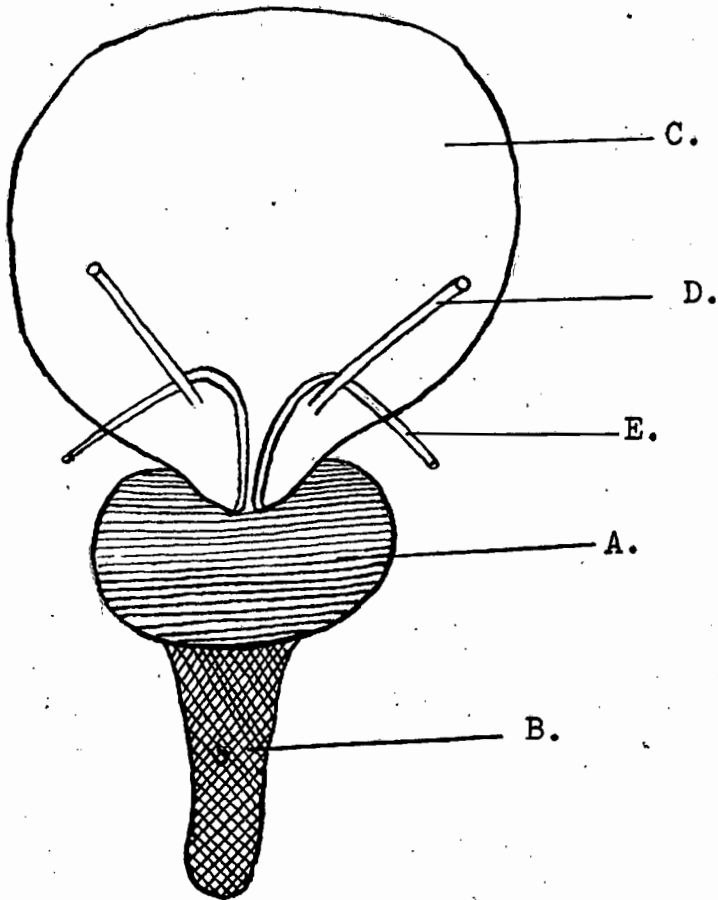


FIG 52 DORSAL ASPECT OF BLADDER AND PROSTATE OF THE DOG.

A. Prostate, B. Urethral Muscle. C. Bladder, D. Ureter
E. Vas Deferens.

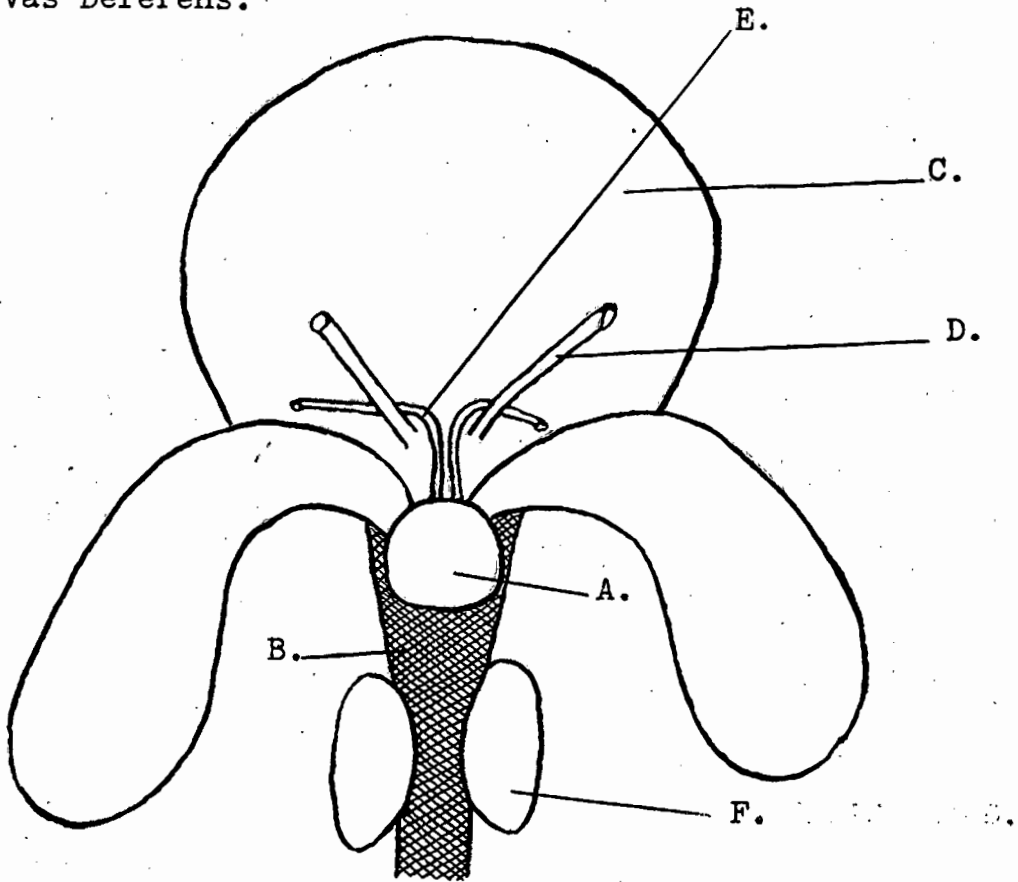


FIG 53 THE DORSAL ASPECT OF BLADDER AND SEX GLANDS OF THE BOAR.

The vesicles have been drawn downwards. A. Prostate;
B. Urethral; Muscle, C. Bladder; D. Ureter;
E. Vas Deferens; F. Cowper's Gland.

The coneys belong to the Hyracoidea. The South African "dassies" or rock rabbits, belong to the same class. These animals all have great, branched seminal vesicles. They have no ampullary glands, and the prostates and bulbo-urethral glands are of small size.

From these examples it is abundantly clear that not one of the accessory sex glands is indispensable, except the prostate gland. One cannot therefore postulate that any one of the glands has a specific function. They all subserve the same purpose. How could the bulbo-urethral glands have a special lubricating function when in some animals they are absent? If the function of the seminal vesicles was to store spermatozoa, and if such a function were vital, then they must be present in all animals.

There is, as would be expected, a direct relationship between the total volume of the seminal ejaculate, and the size and type of the accessory glands, in any given animal. This information is only available in regard to domestic animals. The average volume of the ejaculate of a stallion is 150 cc's, whereas that of a bull is 3 to 4 cc's. The seminal vesicles of a stallion are large, dilated sacs. The corresponding organs of a bull are of moderate size, but they are compact and essentially glandular, with a narrow lumen. The prostates and bulbo-urethral glands of each animal are of similar size and type. It is obvious that the great volume of the ejaculate of the stallion is due to the large capacity of the seminal vesicles. (Fig. 49).

In rams, the average volume of the ejaculate is between 2 and 4 cc's. This animal has vesicular glands, prostate and Cowper's glands of moderate size. On the other hand each ejaculate of a boar averages about 300 cc's. A veterinary surgeon has told me that when a sow is killed immediately after a successful coitus not only the vagina, but also the uterus and fallopian tubes are distended with seminal fluid. As would be expected the accessory glands of the boar are enormous. Each of the seminal vesicles approach the urinary bladder in size. The bulbo-urethral glands too, are large and dilated. (Fig. 53).

If one is familiar with the anatomy of any given animal, one could thus deduce the approximate volume of the ejaculate. What is more one could say which gland contributed the largest share. This is directly applicable to the human. Here the bulbo-urethral glands are small; the prostate is an almost solid organ; the seminal vesicles and the ampullae have dilated lumina. The inference is clear. The secretion of the seminal vesicles with a little from the ampullae, together must largely constitute the volume of the ejaculate.

MALE UROGENITAL SYSTEM IN PRIMATES.

Our concern here is with the anatomy of Primates, other than Man. We will thus consider the condition as found in lemurs, monkeys and apes. In particular the anatomy of the accessory glands of two South African species of primates will be sketched. They are the Chacma baboon, and the Common Vervet monkey.

In this group of animals the testes descend into the scrotum at puberty, which occurs at about the fourth year of life. Thereafter the testes remain in the scrotum; but the processus vaginalis remains patent. In other words there is a free opening between the peritoneal cavity and the tunica vaginalis testis. In the human, as we know, the processus vaginalis is normally obliterated. If it remains patent, it forms a potential hernial sac. The chimpanzee resembles man in this respect. The testes descend into the scrotum soon after birth and the processus vaginalis becomes a fibrous cord. Thus in all mammals (with the exception of the human and the chimpanzee), where the testes descend into the scrotum, the processus vaginalis remains patent. That these quadrupeds so rarely develop an inguinal hernia, is due to their horizontal posture, and well developed abdominal musculature.

The vas deferens of each testis opens into the pelvic urethra on the lateral aspect of the veru montanum. In the lemurs (or half-apes) the duct of the seminal vesicle opens close by, but separately. In all other primates, however, the vas deferens and the duct of the seminal vesicle unite a short distance from the urethra, to form a common ejaculatory duct. This duct runs through prostate tissue before it reaches the urethra.

The seminal vesicles of these animals are always large. Frequently they touch in the midline behind the bladder, and usually extend beyond the bladder anteriorly. Their position is related more to the lateral sides, than to the base of the bladder, as seen in the human.

The prostate is essentially a compact mass, and in this way distinct from the lobed prostates of lower mammals. The prostate always lies on the dorsal aspect of the pelvic urethra, close below the bladder. In none of these animals does it surround the urethra, to form a prostatic urethra as occurs in the human and the dog. Although the prostate appears to be unilobular, one can quite readily demonstrate an incomplete division into a lateral lobe on each side and a cranial lobe above. In the Rhesus monkey, the ejaculatory ducts and the utriculus masculinus are imbedded in the cranial lobe. (Hartman and Straus (66)).

The paired bulbo-urethral glands resemble those of the human as regards shape and position, but they are about twice the size.

The breeding habits of primates are essentially different from those of other animals. They have a menstrual cycle, whereas the lower animals have an oestrus cycle. A female monkey will have a menstrual flow at roughly monthly periods. She ovulates in the mid-menstrual period, and at this time her pudendal skin becomes remarkably hypertrophied, and assumes a bright red colour. The swelling of the pudendal skin is so gross, that at first sight it brings to mind a neoplastic condition.

Actually it is gross local oedema. One day it will be the size of a coconut; two days later it will have completely disappeared.

The primates breed all the year round, and the female will take the male at almost any time of the month. Copulation occurs most frequently when the female has the swollen pudendal skin. The males respond to the females on frequent occasions. The volume of the ejaculate must vary with size of the particular primate. There is no record of it, but in view of the relatively enormous seminal vesicles, we can expect that the volume of the ejaculate will be several times that of the human.

I was unable to find out how long the semen remains coagulated in these animals. That the seminal fluid is coagulated by a specific secretion from the cranial lobe, has been shown to occur in the Rhesus monkey by Van Wagenen (44). There is every reason to believe that coagulability of the semen is a feature of this class. We know also that it occurs in man. The presence of a distinct cranial lobe of the prostate in most lower primates, suggests that the coagulation of the semen is an important physiological function. In humans it may be a rudimentary phenomenon which we have inherited from lower animals. Workers in the field of male infertility suspect that the coagulation and subsequent liquifaction of human seminal fluid is a very essential process. Many facts regarding the process are at present still obscure.

TWO COMMON SOUTH AFRICAN PRIMATES :
CHACMA BABOON (PAPIO PORCARIUS), COMMON VERVET
MONKEY (LASIOPYGA PYGERYTHRA).

The Chacma baboon is the common baboon of South Africa. It inhabits nearly all parts of this country, and chooses by preference to live in rocky mountainous areas. These baboons live in bands, and are a pest to farmers because of their love of wanton destruction. They descend from their hilly fastnesses to destroy crops and even to slaughter young lambs. They are essentially herbivorous.

The Common Vervet, or "blou-aap", is a handsome creature with a soft grey coat. These monkeys inhabit many parts of South Africa, and stick to the wooded areas. The scrotum of the "blou-aap" is a rich cobalt blue, and hence its usual Afrikaans name.

A mature Chacma baboon was available for investigation. This animal weighed 67 lbs. and was in good health. He was killed on 2nd August, 1945. After he had been anaesthetized with chloroform, he was given an intravenous injection of 3% trypan blue solution, (90 cc's.) His tongue, gums, conjunctivae and skin became obviously blue. The vas deferens was isolated on each side just outside the superficial inguinal ring, and was severed. The right femoral artery was then opened and the animal died within a minute.

The Vervet monkey was killed in the same way. This animal was also an adult male. He was given 30 cc's of 3% trypan blue solution intravenously. The vasa deferentia were severed as in the previous animal. This animal weighed $11\frac{3}{4}$ lbs.

There were three main objects in view :

- (a) To record the anatomy of the accessory genital glands.
- (b) To determine where spermatozoa are stored.
- (c) To get an idea of the lymphatic supply of particularly the seminal vesicles. It was to this end that the intravenous trypan blue was used.

A. ANATOMY : CHACMA BABOON.

Soon after the baboon had died, the abdomen was opened by a midline incision. The bladder and lower rectum, together with the accessory sex glands, were removed in one mass.

On doing this dissection two points regarding the seminal vesicles were noted. The glands project but slightly into the peritoneum in the space between the bladder and rectum. In other words only a small portion of each gland is covered by pelvic peritoneum. On the other hand the seminal vesicles are readily exposed in their entirety, when dissection is made from the prevesical space (Cavum Retzius) towards the lateral aspects of the bladder. These organs are thus easily approached by an inguinal incision, and by dissection which remains extra-peritoneal. Each vesicle lies mainly on the dorsi-lateral aspect of the bladder. (See Fig.54).

The seminal vesicles of this animal are noteworthy for their size. They are just as long, or longer, than the half-filled bladder. They are about one third as wide as they are long. In the fresh state each vesicle measured approximately 3 inches by 1 inch.

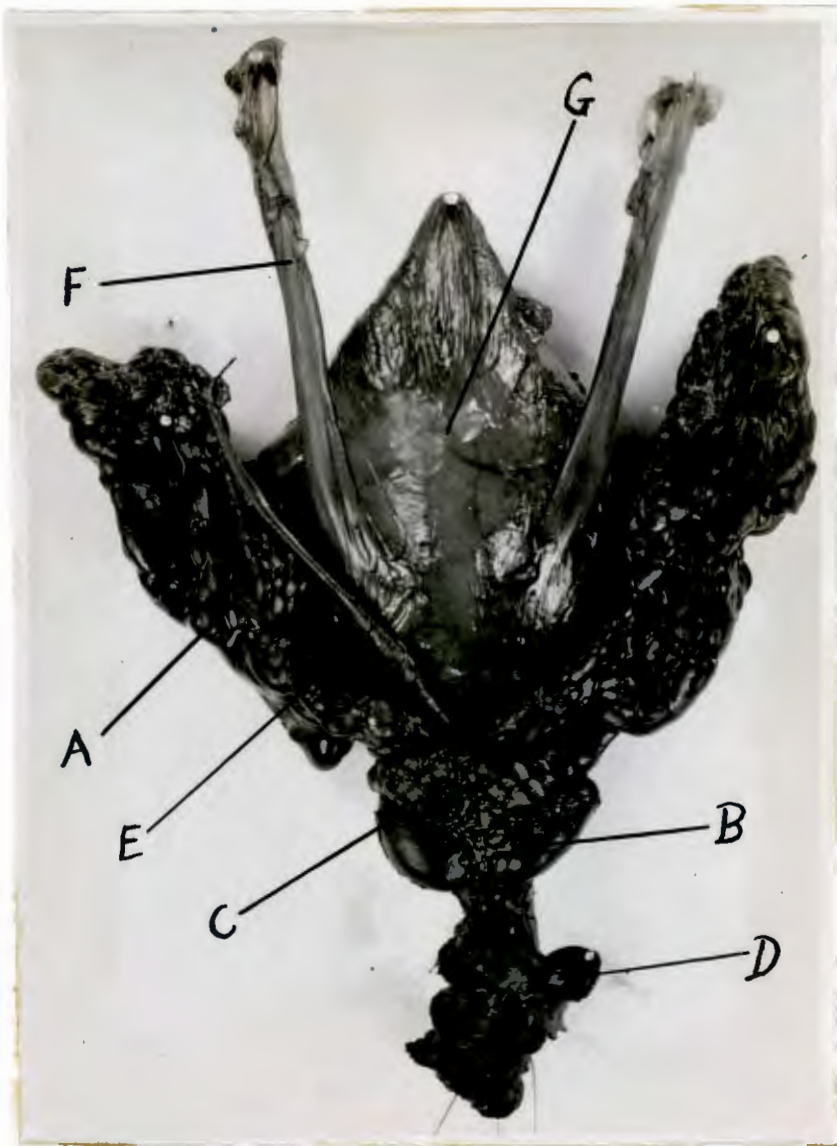


FIG. 54 BLADDER AND ACCESSORY SEX GLANDS OF CHACMA
BABOON. DORSAL ASPECT x 1½.

The right vas deferens has been removed. Note the large size of seminal vesicles. The cranial lobe of the prostate is shown. There is no ampulla of the vas deferens.

- A. Seminal Vesicle, B. Prostate (lateral lobe),
 C. Prostate (cranial lobe), D. Cowper's Gland,
 E. Lower end of Vas Deferens, F. Ureter,
 G. Bladder.
-

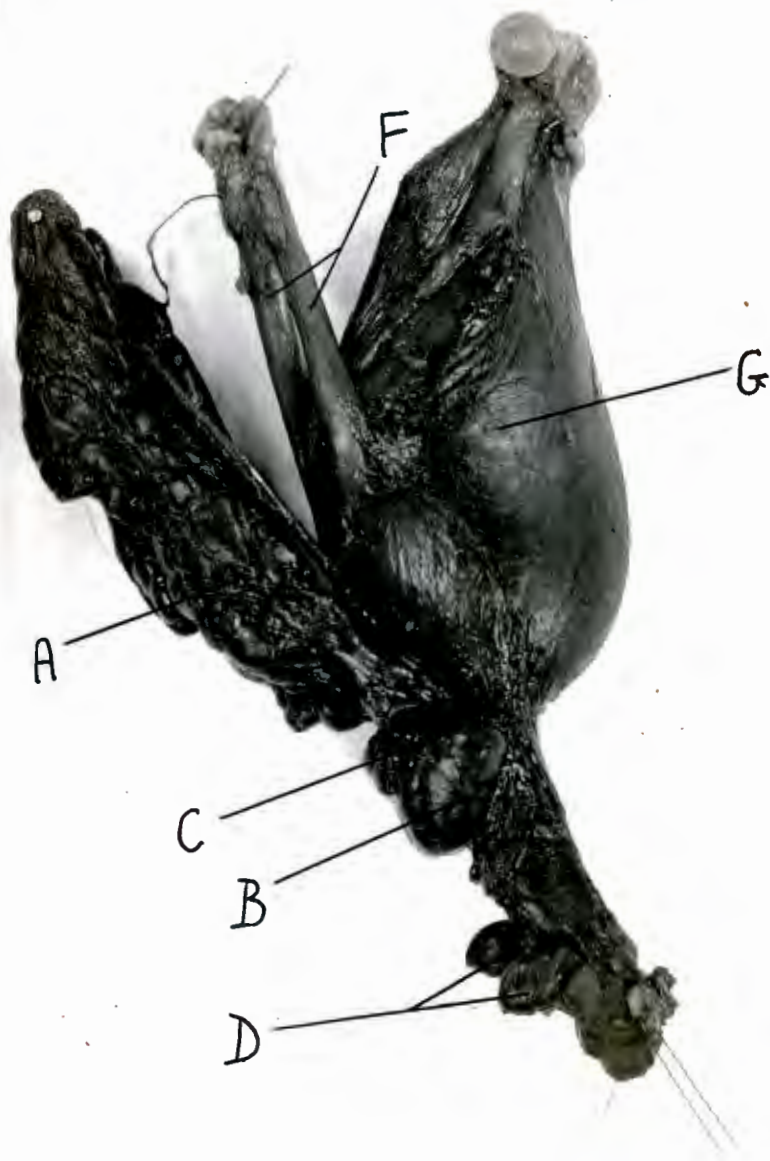


FIG 55 BLADDER AND ACCESSORY SEX GLANDS OF CHACMA

BABOON. LATERAL ASPECT. x 1½

The prostate lies completely on the dorsal aspect of the urethra. The bladder is about half-filled.

- A. Seminal Vesicle.
- B. Lateral Lobe Prostate.
- C. Cranial Lobe Prostate.
- D. Cowper's Glands.
- F. Ureters.
- G. Bladder.

The vesicle on each side is closely adherent to the wall of the bladder and is held in this position by fibrous tissue. This fibrous tissue extends between both vesicles, so as to form a fascial compartment for the vesicles and the lower ends of the vasa deferentia, which lie between them. This fascial layer also separates these organs from the anterior wall of the rectum.

Apart from this fascial compartment, the fascia is also condensed around each vesicle separately, so as to form an adventitious fibrous coat. It is not until this latter layer is dissected off, that the lobulated nature of the vesicle becomes striking. Moreover this fascial sheath sends numerous septa into the glands between the component lobules. These septa carry the blood and lymphatic vessels, and the nerves to all parts of the gland.

When the fibrous septa are carefully dissected free, the glandular portion of the vesicles can be unravelled. It shows a tube of surprising length, with numerous branches and irregular outpocketings. The vesicle is essentially a hollow muscular organ, with a lining of secretory epithelium. The lumen is moderately dilated throughout, the diameter at the widest points being one twelfth of an inch. The content of the seminal vesicles is a sticky, glairy fluid. It was not accurately measured, but estimated at about one desertspoonful from each vesicle.

In Fig. 56, the right seminal vesicle has been

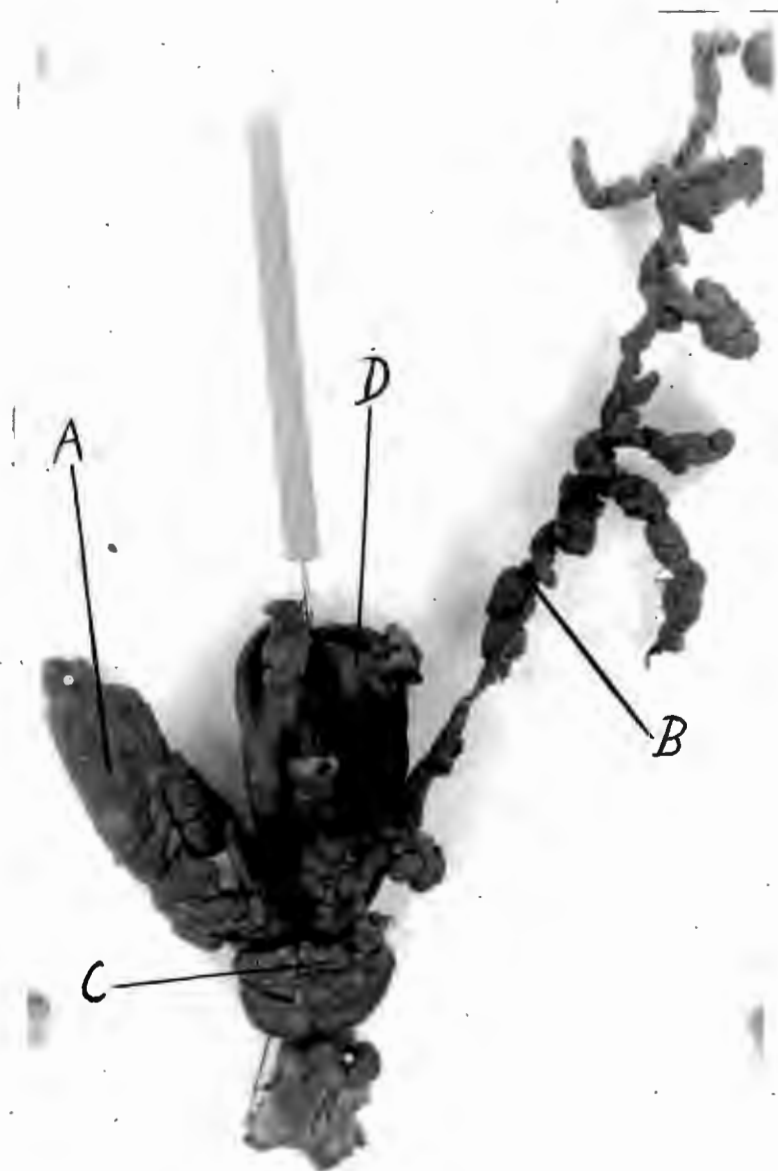


FIG. 56 DORSAL ASPECT OF BLADDER AND SEX
GLANDS OF CHACMA BABOON. ABOUT NATURAL SIZE.

The right seminal vesicle has been unravelled to show its ramifications. The cranial lobe of prostate shows clearly.

- A. Left seminal vesicle.
 - B. Right seminal vesicle (unravelled).
 - C. Cranial lobe of prostate.
 - D. Bladder.
-

unravalled to demonstrate its ramifications and extent. In Fig. 57 , the bladder and urethra have been split on the ventral aspect, and show the veru montanum. This structure is relatively smaller than in the human.

The lower end of the vas deferens shows no evidence of enlargement or dilatation. This is clearly shown in Figs. 54 and 55 . Hartman and Straus record a similar finding in the Rhesus monkey. I found also in the Common Vervet monkey that there was no ampulla of the vas deferens present. It seems to be the usual finding in lower Primates, and in this respect different from the human. I do not know whether the higher apes have an ampulla or not.

The prostate gland in the Chacma baboon was found to be about the size of a flattened cherry. Its position is clearly indicated in Figs. 54 and 55 . It lies entirely on the dorsal aspect of the urethra. Although the gland is roughly unilobular, it was easily possible to demonstrate, that in actual fact there are three lobes. Two lateral and one cranial lobe. Each of these is indicated in the photograph.

The cranial lobe lies mainly distal to the point where the seminal vesicles and vasa deferentia converge on the urethra. But with dissection it can be shown that the lower ends of the vesicles and vasa are surrounded by lobules of the cranial lobe. There is thus some prostatic tissue in front of these structures, corresponding in position to the human prespermatic (middle) lobe.

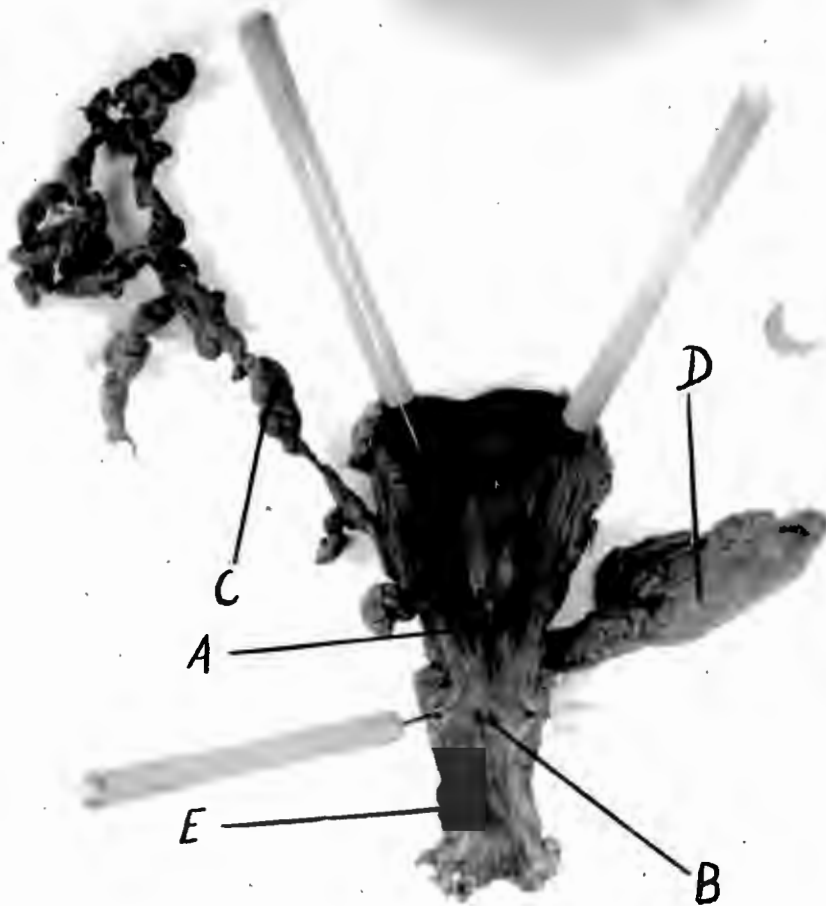


FIG 57 BLADDER OF CHACMA BABOON OPENED ON THE
VENTRAL ASPECT.

A small stilette emerges from the Right ureteric orifice and the right ejaculatory duct.

- A. Trigone Area,
 - B. Veru Montanum,
 - C. Unravelled Right Seminal Vesicle,
 - D. Left Seminal Vesicle,
 - E. Urethra.
-

Whereas the external surface of the cranial lobe has a lobulated appearance, the surface of each lateral lobe is smooth. This is not clearly illustrated in the photographs.

If position is important, then from this description of the cranial lobe, it seems that the human homologue must include both the median and posterior lobes. I am awaiting an opportunity of dissecting these parts in some of the larger apes. It is possible that the problem may then be elucidated.

Paired bulbo-urethral glands are present. They lie in close relation to the sphincter urethrae membranaceae. They are each the size of a large pea. The excretory duct was not dissected out, but there is no reason to suppose that it did not open into the cavernous urethra, as in all other animals.

The *Musculus urethralis* was plainly visible as an external coat of the urethra. The muscle was thickest on the dorsal aspect. The fact that it was composed of striated voluntary muscle was proved histologically. This muscle is not as prominent in the baboon and the monkey, as in animals like the horse. The fact, however, that it is quite definite in lower primates is of interest, because in adult humans it is apparently absent. Only remnants of it can be recognized microscopically as taking a share in the formation of the internal vesical sphincter.

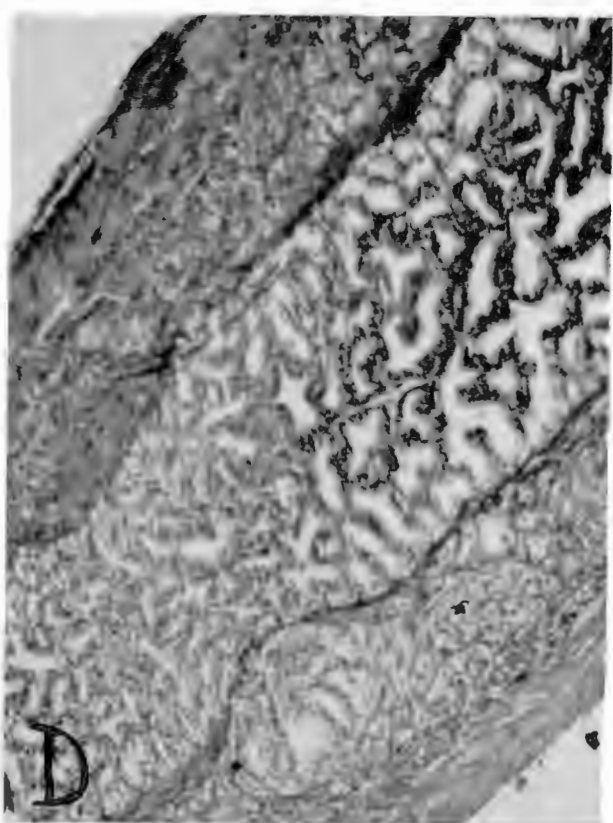
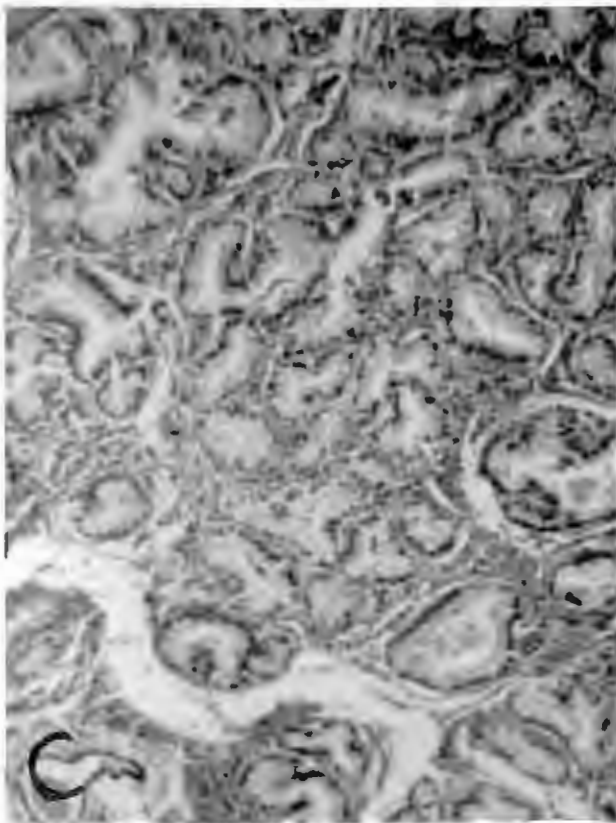
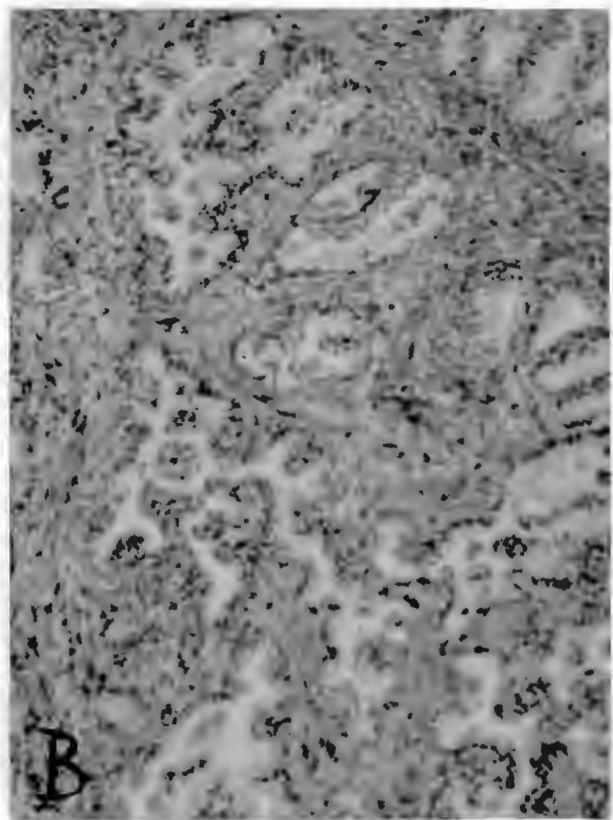
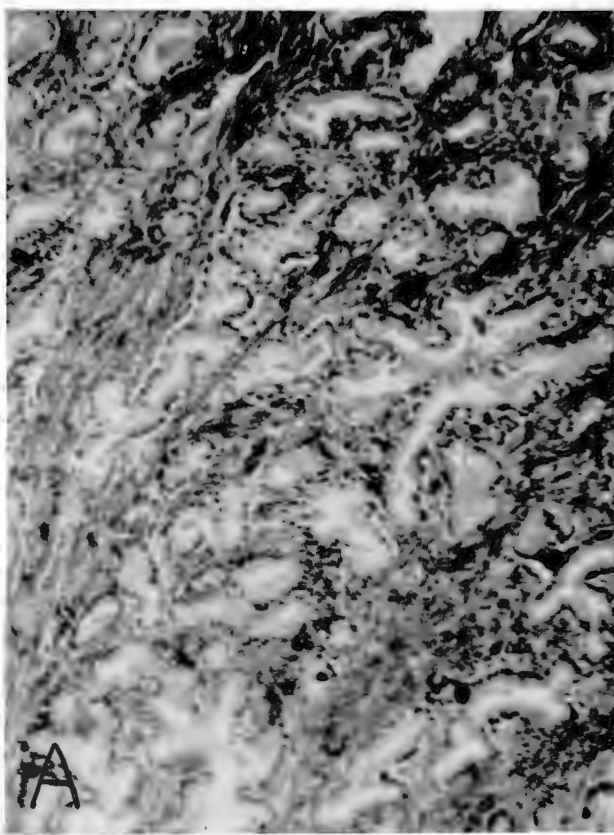


FIG. 58.

A. Prostate of Baboon. Lateral Lobe x 105.

B. Human Prostate x 105.

C. Cranial Lobe of Baboon x 105.

The Histological appearance of the Cranial and Lateral Lobes of the Baboon Prostate are essentially similar.

D. Lower End of Vas Deferens of a Monkey x 90.

The secretory nature of the lining epithelium is clearly shown.

ANATOMY - VERVET MONKEY.

The accessory glands of this animal bear a close resemblance to those of the Chacma baboon. The photographs in Figure 59 gives a clear idea of the anatomy. The seminal vesicles if anything are relatively larger than in the baboon. The cranial lobe of the prostate and the Cowper glands can clearly be seen.

As in the Chacma baboon, the veru montanum in the Vervet monkey is relatively smaller than in the human.

B. SPERMATOZOA.

What was found in both the baboon and the monkey will be discussed here. The object being to determine at which site the spermatozoa are stored in these animals.

As previously mentioned the vasa deferentia were severed to exclude the possibility of post-mortem migration of spermatozoa. The content of the bladder, seminal vesicles, vas deferens, caput and cauda of the epididymis was examined. Fresh smears were made of these secretions, and stained with methylene blue solution.

The findings are recorded in tabular form Spermatozoa were either absent or present. When present, they were either abundant (++++), in moderate numbers (+++) few (++) or very sparsely scattered (+).

C H A C M A . B A B O O N .

ORGAN EXAMINED.	SPERMATOZOA.
Bladder content (not centrifuged)	+++
Seminal vesicles	Sperms absent
Lower end vas deferens	+++
Caput Epididymis	++
Cauda Epididymis	++++

C O M M O N . V E R V E T . M O N K E Y .

ORGAN EXAMINED.	SPERMATOZOA.
Bladder content (not centrifuged)	++
Seminal vesicles	++
Lower end of vas deferens	+++
Caput Epididymis	++
Cauda Epididymis	++++

From the examination of the baboon and the monkey certain conclusions can be made.

Spermatozoa are present in their greatest numbers in the tail of the epididymis. A few drops of milky white fluid could be expressed from this region, which teemed with spermatozoa.

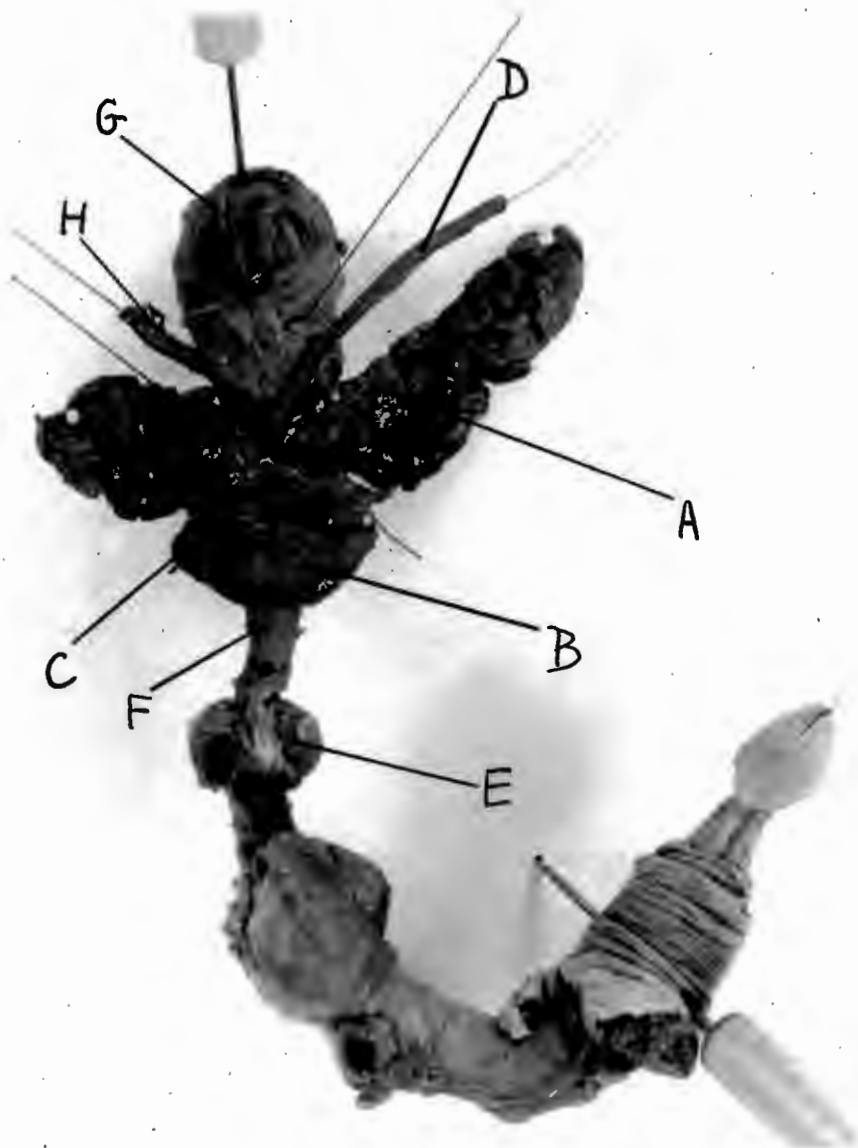


FIG 59 BLADDER AND ACCESSORY SEX GLANDS OF COMMON
VERVET MONKEY. x 1½

The glans penis shows clearly. The Right ureter and Left vas deferens are absent but their position is marked by stillettes. Half of the left seminal vesicle has been amputated.

- A. Seminal Vesicle, B. Lateral Lobe Prostate,
 C. Cranial Lobe Prostate, D. Vas Deferens,
 E. Cowper's Gland, F. Pelvic Urethra,
 G. Bladder, H. Left Ureter.

Spermatozoa are present in the head of the epididymis, but not in great numbers. No obvious fluid could be expressed from this part.

The lower end of the vas deferens, which corresponds to the human ampulla, contained a little secretion in both these animals which had a moderate number of spermatozoa.

The seminal vesicle of the Chacma baboon had no sperm, whereas a few were found in the vesicles of the Vervet monkey. The urine in both animals contained a fair number of spermatozoa.

These facts support the general conclusion that spermatozoa are stored in the tail of the epididymis. From there they migrate continuously into the urethra to be shed with the urine. Their presence in the seminal vesicles is as adventitious as their presence in the urine. The vesicles do not function essentially as reservoirs for spermatozoa. The chief function is as a gland with an external secretion.

C. LYMPHATIC SUPPLY.

The findings were similar in both the Chacma baboon and the Vervet monkey.

There are many ways in which lymphatic channels may be delineated. One investigator recommends intravenous trypan blue injection (30). He claims that the dye rapidly perfuses from the blood into the lymphatic

fluid. If the animal is then killed a short while after the injection has been given, all the lymphatic channels will stand out clearly. I may have given too large a dose, because I found that almost the whole animal became blue. Nevertheless certain features were clear.

1. The mucous membrane of the mouth, the conjunctiva, the skin, the gut, the bladder, the accessory sex glands, the peritoneum, the vas deferens, and all lining surfaces were stained a deep blue. This list is not complete, but it shows that all epithelial surfaces, glands and hollow muscular organs must have a rich lymphatic net work. The colour of the gut was as blue as that of the seminal vesicles.
2. Fat was stained a deep grey colour. This applied to subcutaneous fat as well as to the fat of the omentum. This suggests that fatty tissue has a poor lymph supply.
3. Muscular tissue was stained an intermediate colour. Plain muscle was stained deeper than striated muscle.
4. Fascial planes were densely stained. This is probably due to the fact that lymphatic channels frequently run in the fascial sheets. This was well seen in the fascia surrounding the seminal vesicles, and sheaths of lymphatic trunks could be seen coursing up the side walls of the pelvis towards the iliac and hypogastric lymph glands. All lymph glands were stained a deep blue.

The experiment performed is a rather rough and ready one. I was prompted to try it because of the contention by some urologists, that the lymph supply of the seminal vesicles is exceptionally rich. The results of this experiment suggest that the lymphatic network of the vesicles is no richer than that of many other viscera.

C O N C L U S I O N .

The seminal vesicles begin to develop in the human foetus of 13 weeks, as diverticuli from the mesonephric ducts. They are sexual glands, essential to reproduction, and occur only in males. At puberty they rapidly increase in size to assume adult proportions and with old age they gradually atrophy.

The seminal vesicles function chiefly, if not solely, as glands with an external secretion, which is derived from the lining epithelium.

Those features of the anatomy and function which have a practical bearing both on the examination and the pathological conditions of the vesicles, have been stressed. With this knowledge the diagnosis and treatment of diseases of the seminal vesicles must be more rational and consequently more effective.

THE END.

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