

Spermiyogenez ve testis boşaltım yolları

Dr. Sinan Özkavukcu

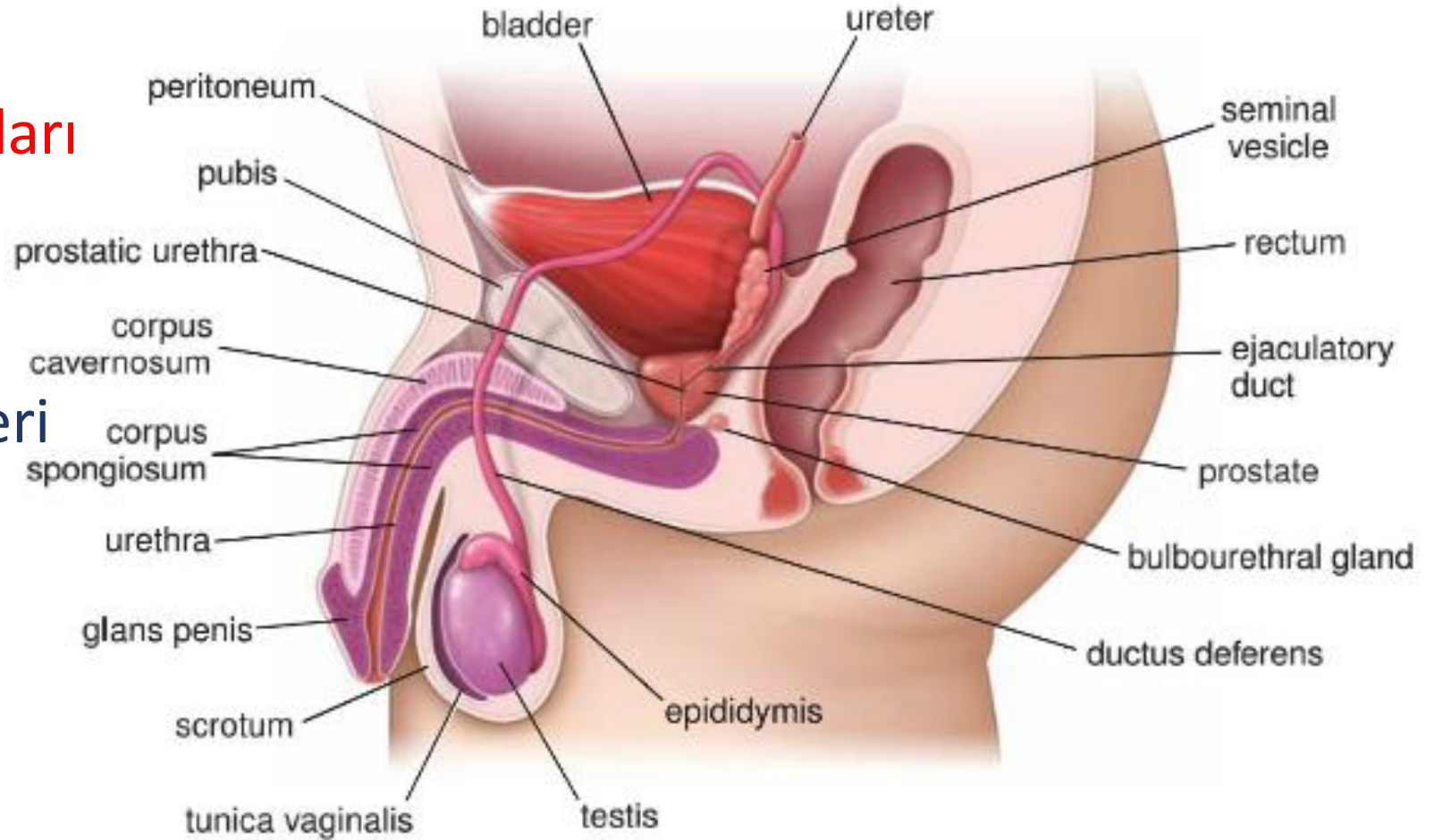
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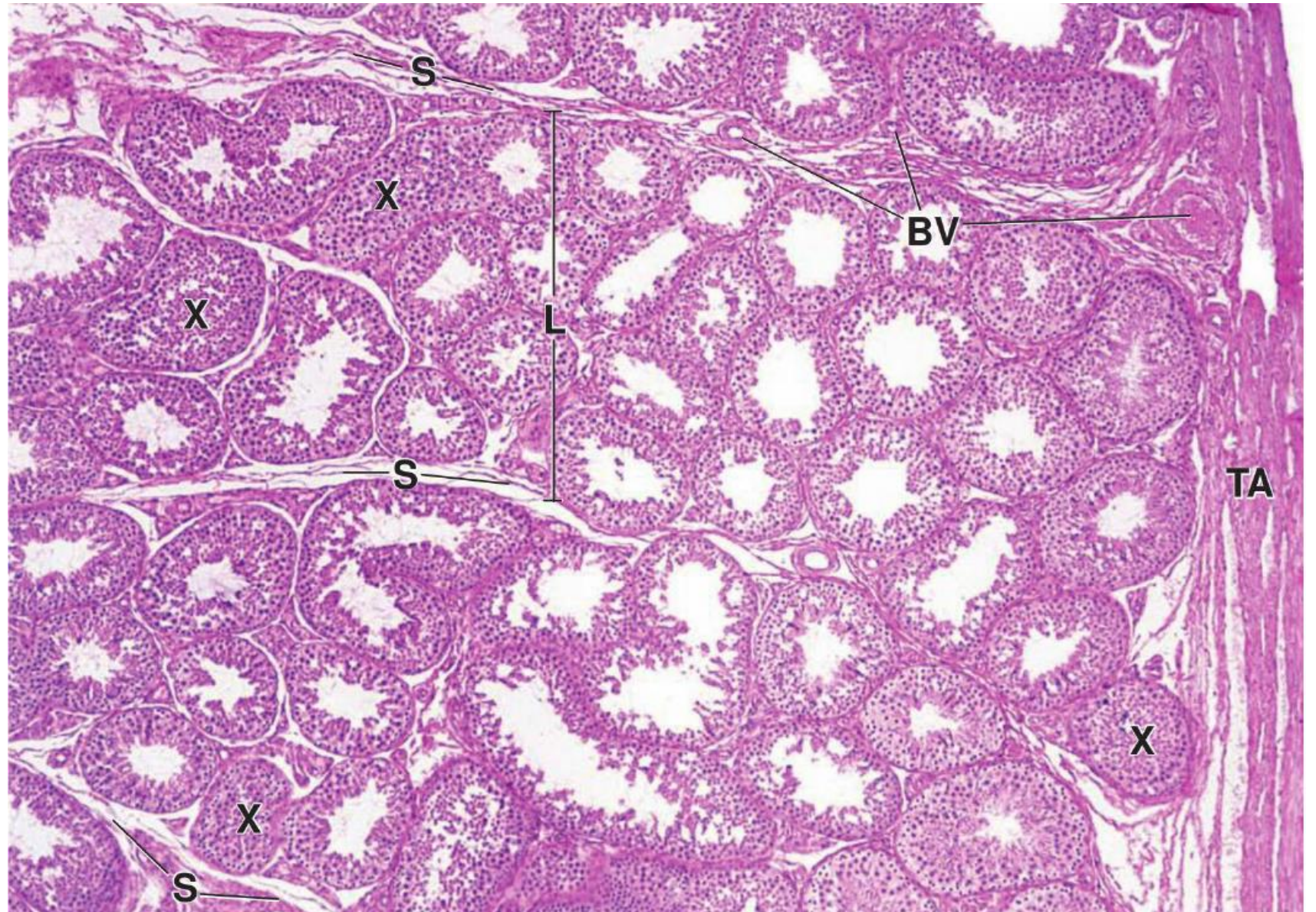
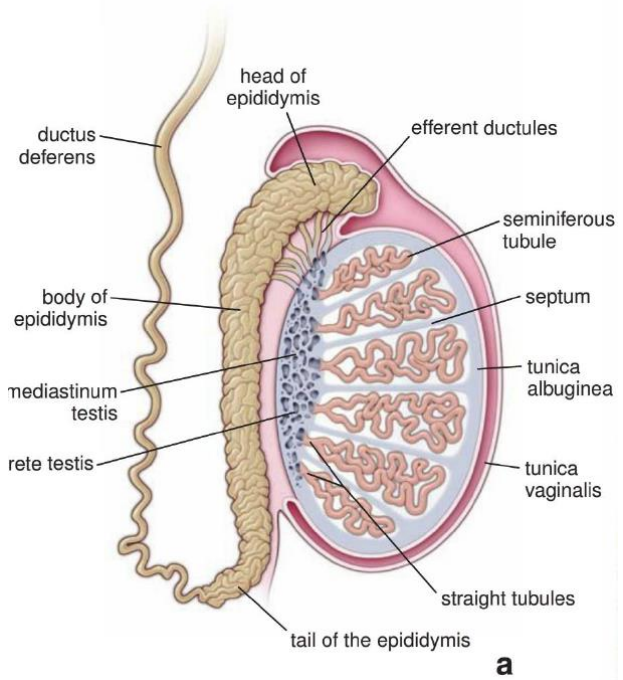
Histoloji-Embriyoloji Anabilim Dalı

Lab Sorumlusu – Üremeye Yardımcı Tedavi ve Eğitim Merkezi

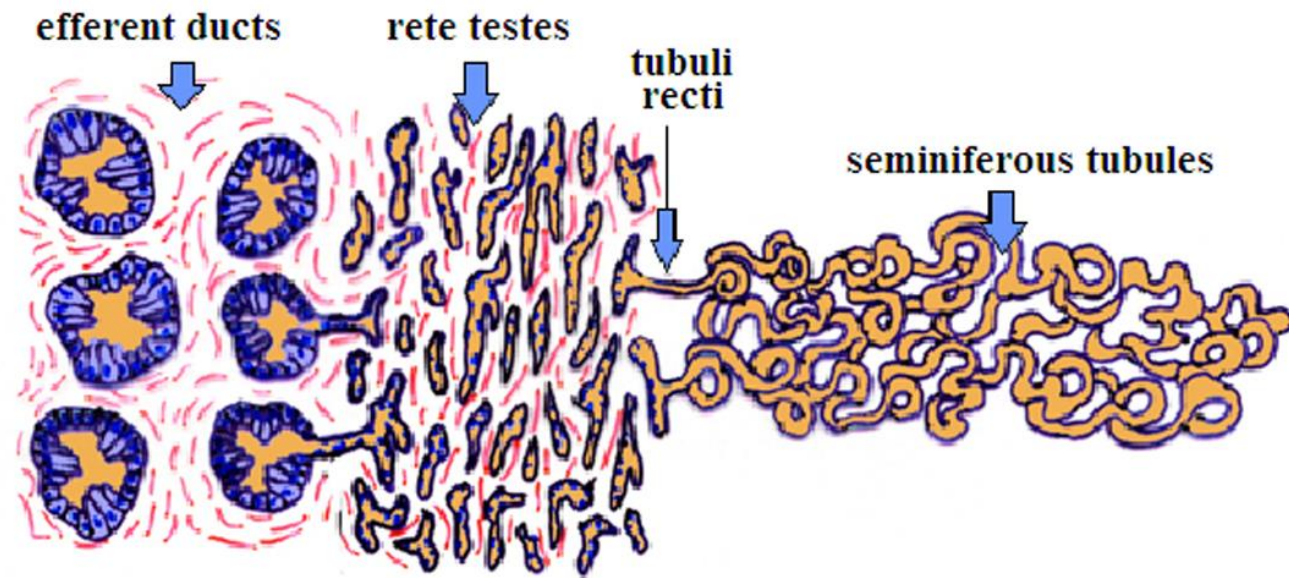
Erkek Üreme Sistemi

- Testisler
- Genital boşaltım kanalları
 - Duktuli efferentes
 - Duktus epididimisi
 - Duktus deferens
- Aksesuar cinsiyet bezleri
 - Seminal veziküller
 - Prostat
 - Bulboüretal bezler
- Dış genital organlar
 - Penis
 - Skrotum

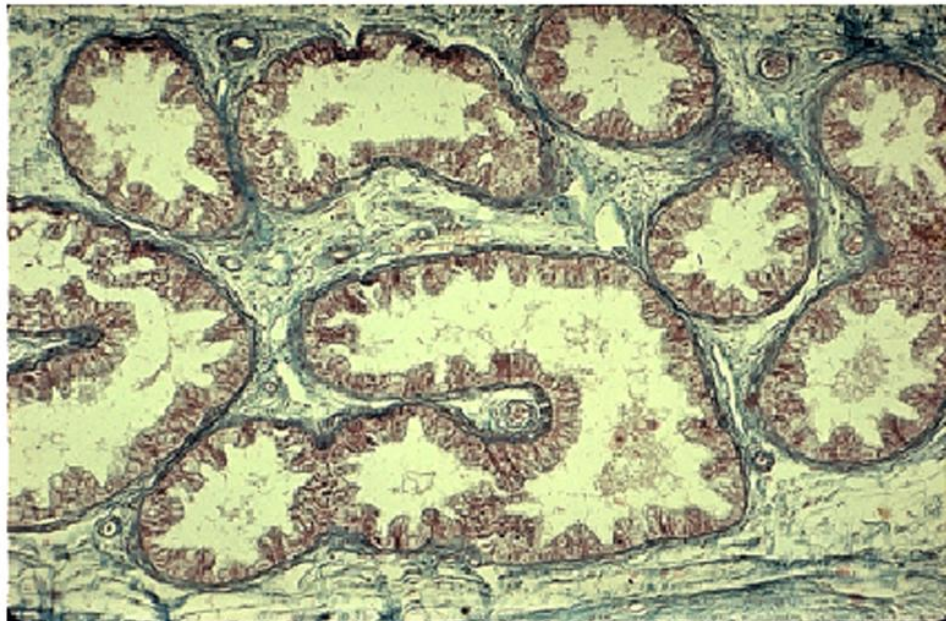




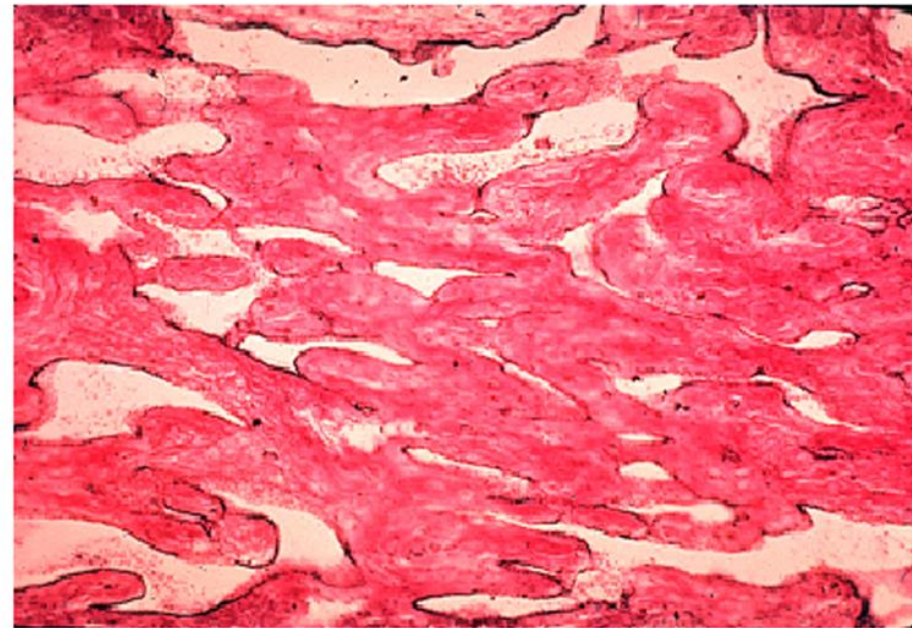
RETE TESTES AND EFFERENT DUCTS



DUCTULI EFFERENTES



RETE TESTES



Intra-testiküler kanallar

- Her seminifer túbülün sonunda, **düz túbüllere veya tubuli recti'ye** ani bir geçiş olur.
- Seminifer túbülün bu kısa terminal bölümü **sadece Sertoli hücreleri** ile kaplanmıştır.
- Sonlanmaya yakın, düz túbüller daralır ve epitel örtüsü **basit kübik epitele** dönüşür.
- Düz túbüller rete testise boşalır, **rete testis**; mediasten testisin yüksek vasküler bağ dokusu içinde bir dizi karmaşık birbirine bağlı kanallar sistemidir.

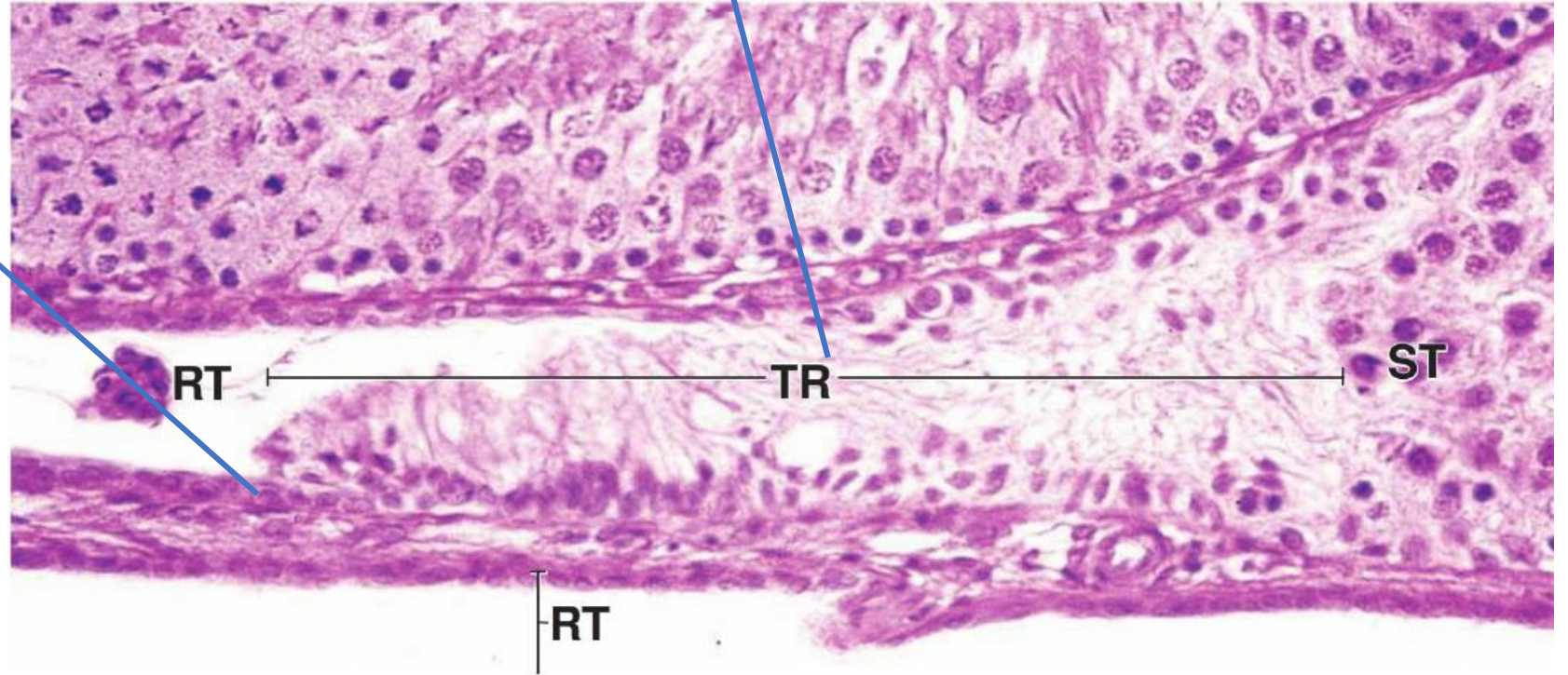
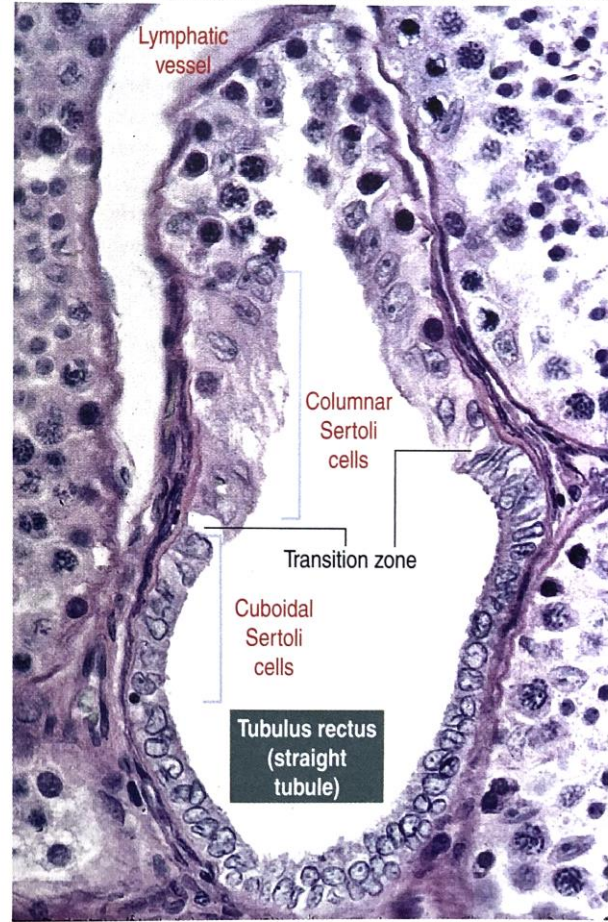
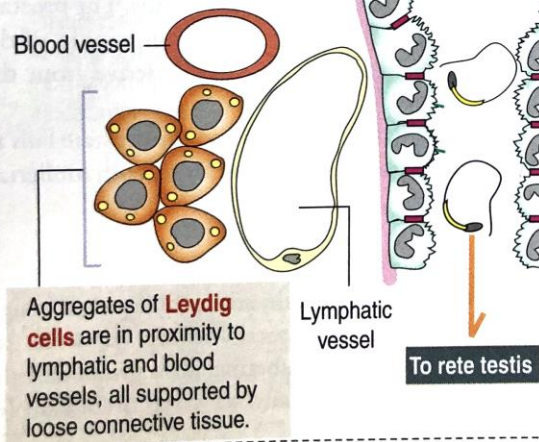


Figure 21-3. Sperm transport from testis to rete testis via straight tubules

Columnar Sertoli cells mark the transition from the seminiferous epithelium to the tubulus rectus.

Basal tight junctions between **columnar Sertoli cells** change into apical tight junctions between **cuboidal Sertoli cells** at the tubulus rectus and rete testis. The apical domain of the cuboidal Sertoli cells displays **microvilli** and an occasional **primary cilium**.



Seminiferous epithelium

Seminiferous epithelium



Rete Testis

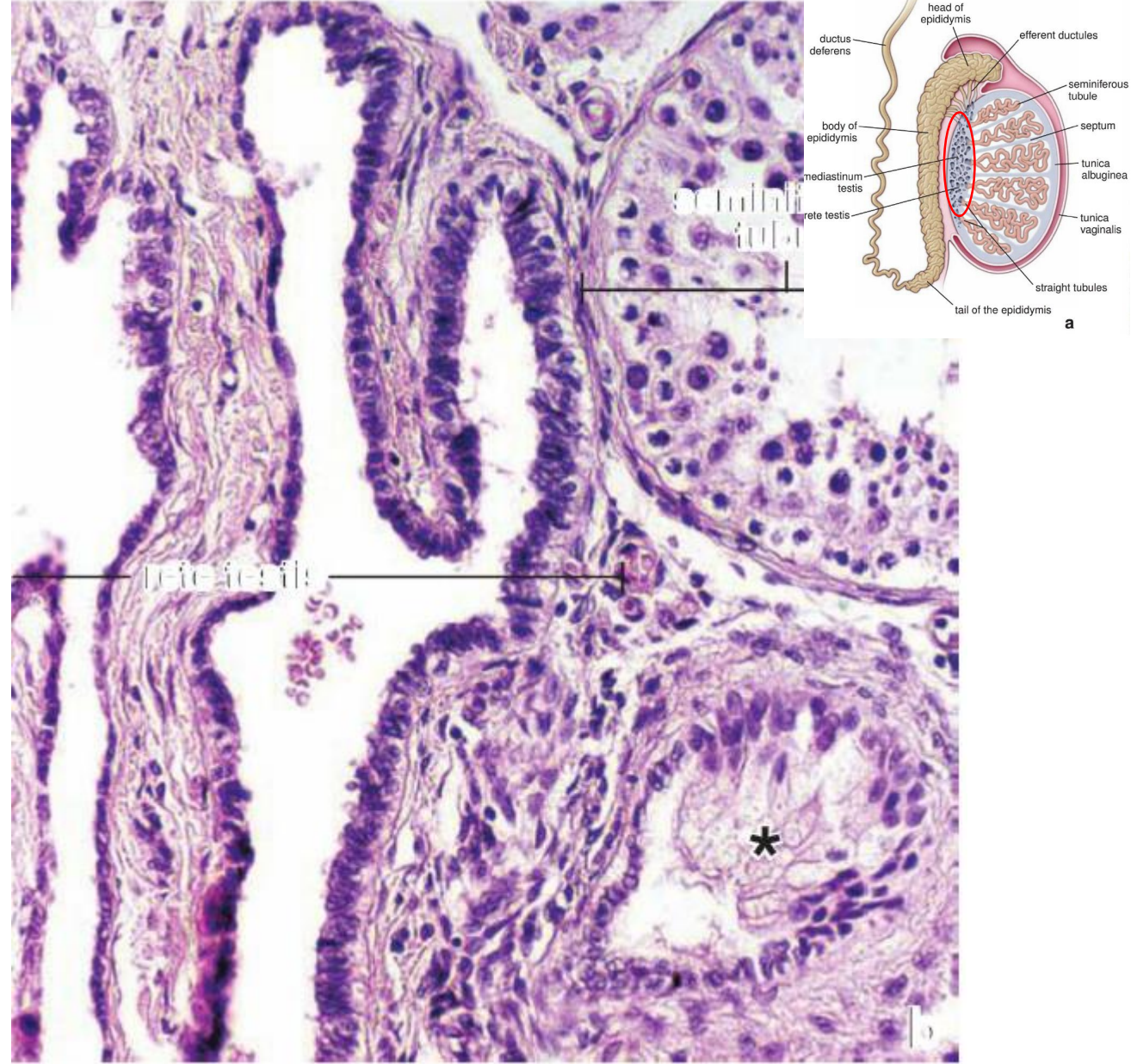
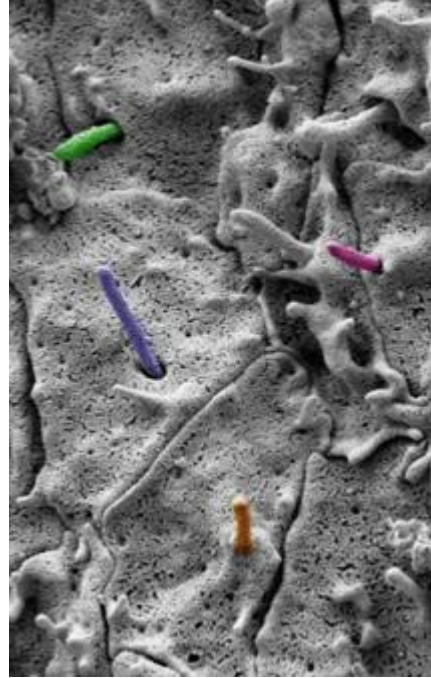
- **Basit kübik veya alçak kolumnar epitel**, rete testisin kanallarını kaplar.
- Bu hücreler, **tek bir apikal silyuma ve nispeten az sayıda kısa apikal mikrovillusa** sahiptir.

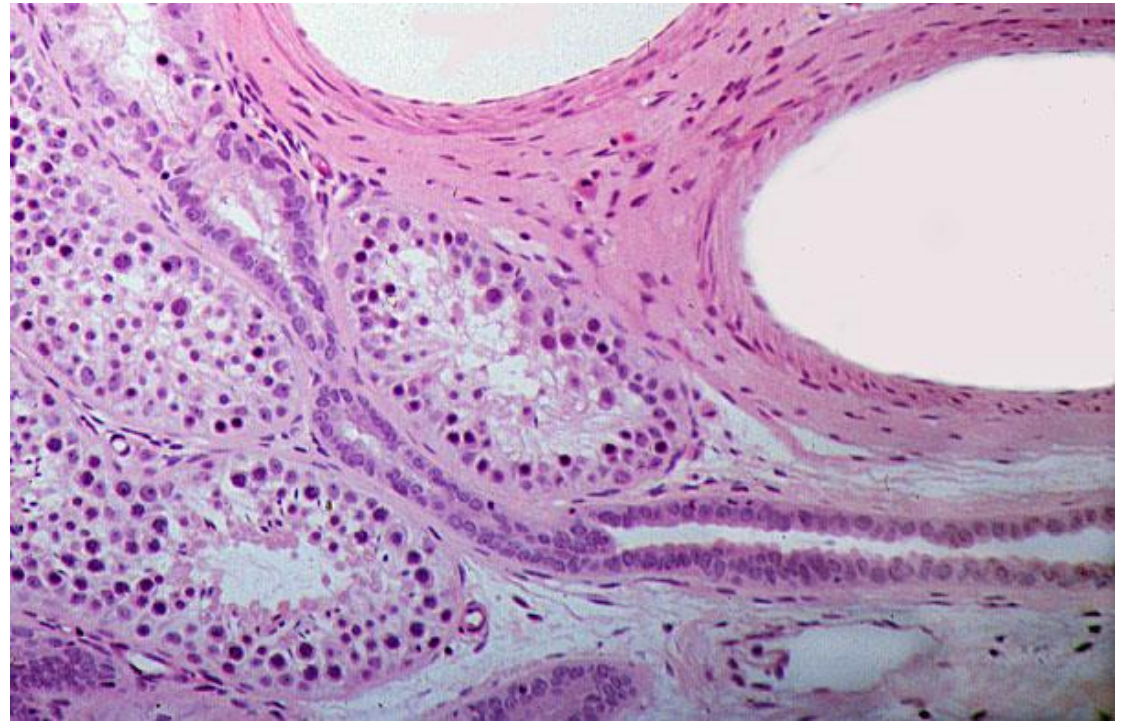
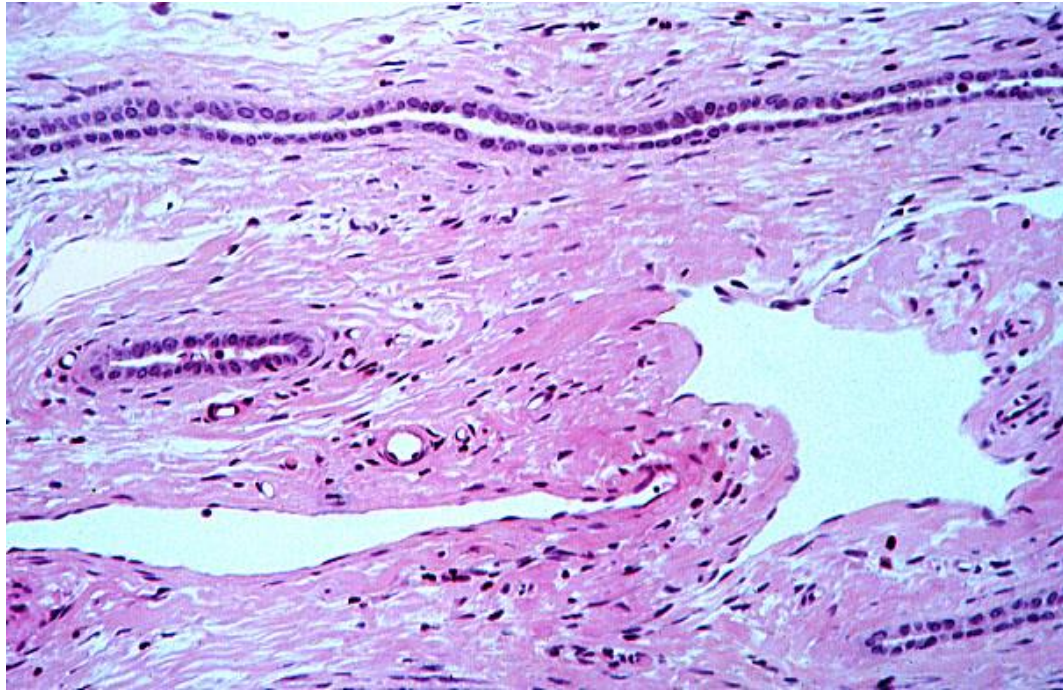
Epitel, nispeten kalın bir bazal laminanın üzerine oturur, altında kolajen ve elastik lifler içinde birkaç fibroblast ve miyoid hücre yer alır.

Rete birden çok işlevi yerine getirir:seminifer tübüllerin içeriği için bir karıştırma odası olarak,Seminifer tübüller ve epididim arasında bir basınç gradyanı olarak,seminal sıvının henüz bilinmeyen bileşenlerinin olası bir kaynağı olarak,lümen içeriğinden yeniden emici bir protein bölgesi olarakThe epithelium sits on a relatively thick basal lamina, beneath which are a few fibroblasts and myoid cells intermixed with collagen and elastic fibers.

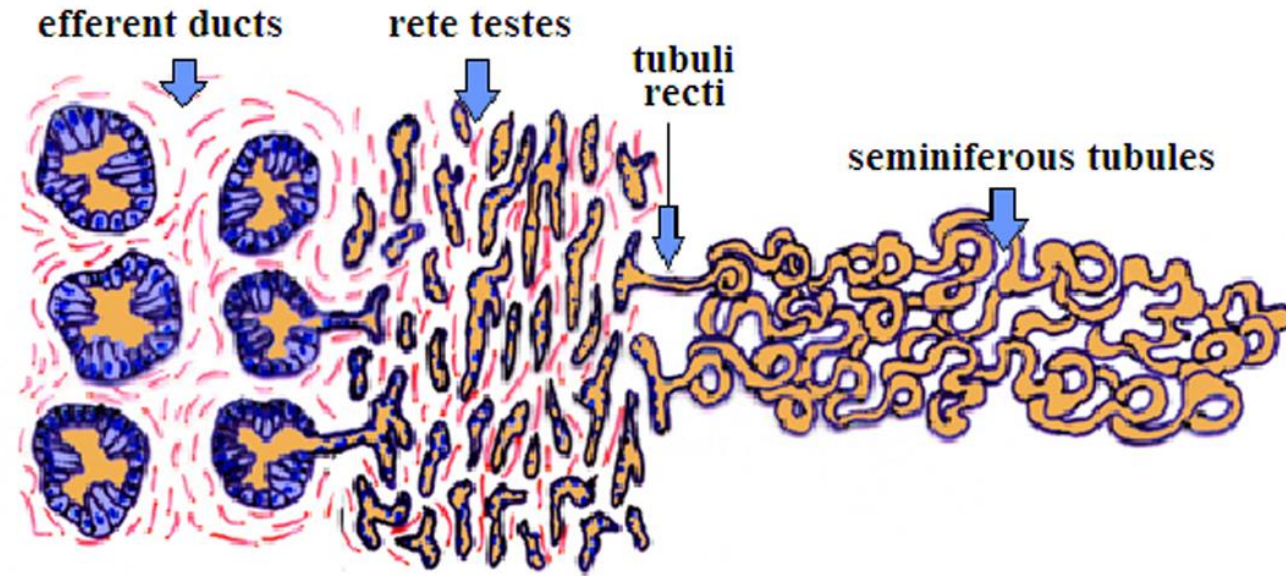
The rete serves multiple functions:

- as a mixing chamber for the contents of

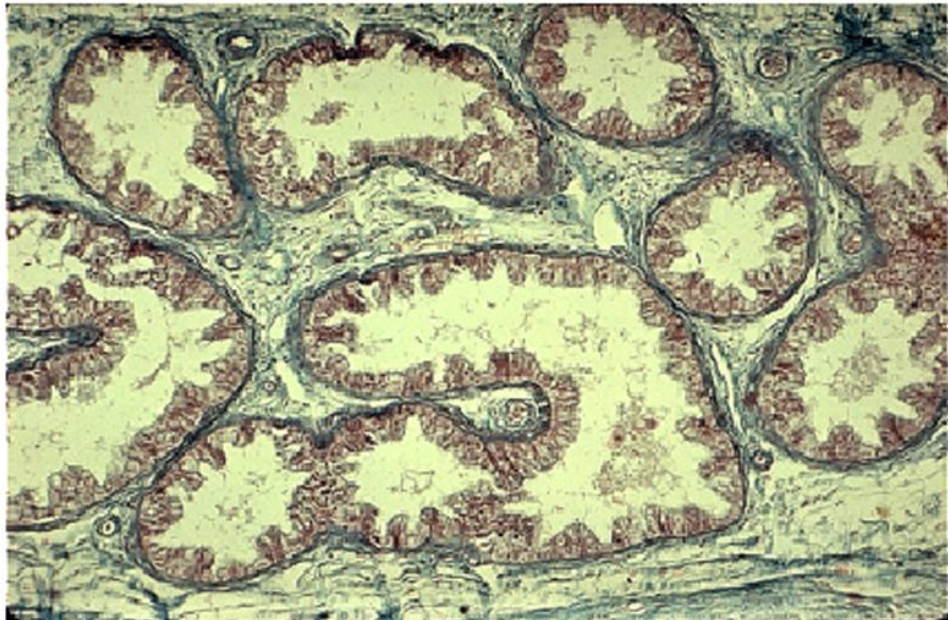




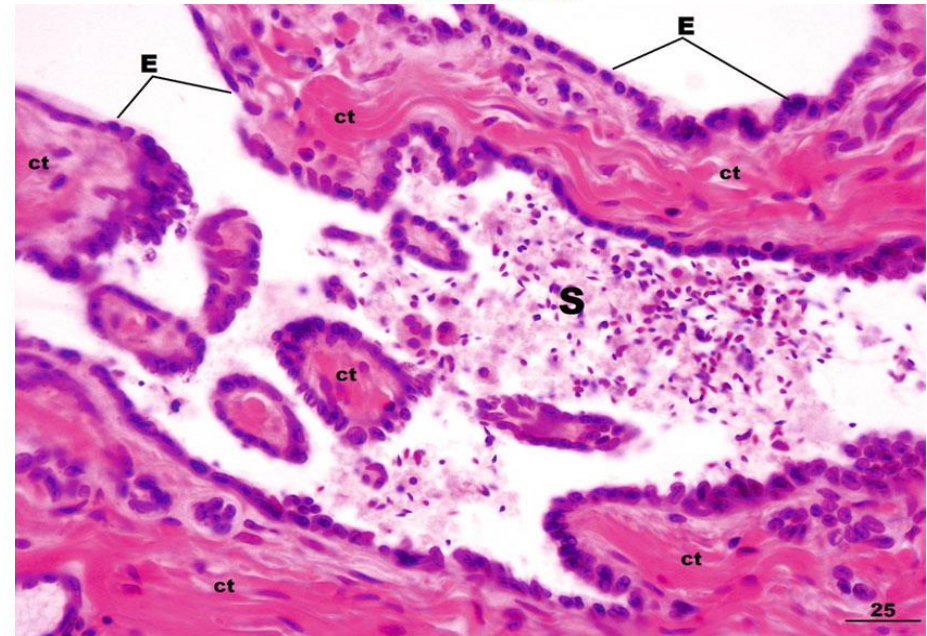
RETE TESTES AND EFFERENT DUCTS



DUCTULI EFFERENTES

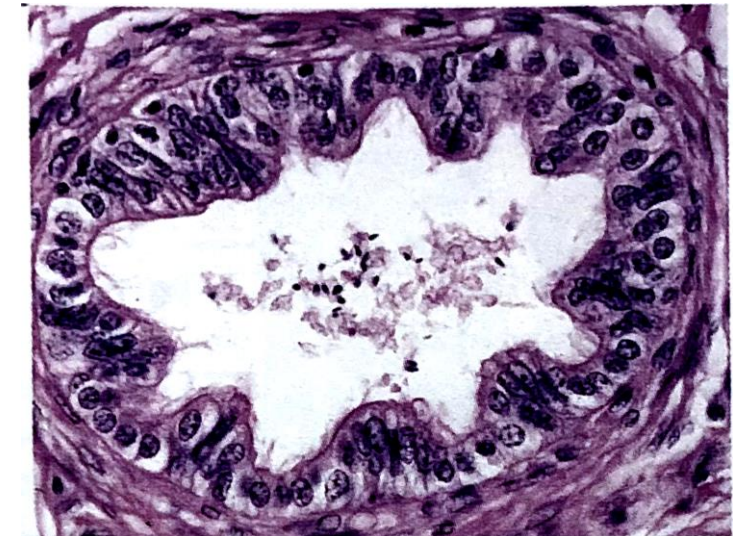
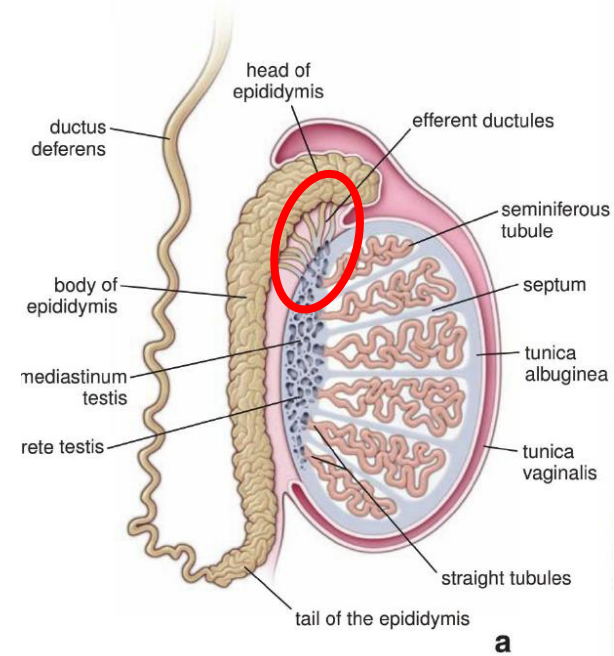


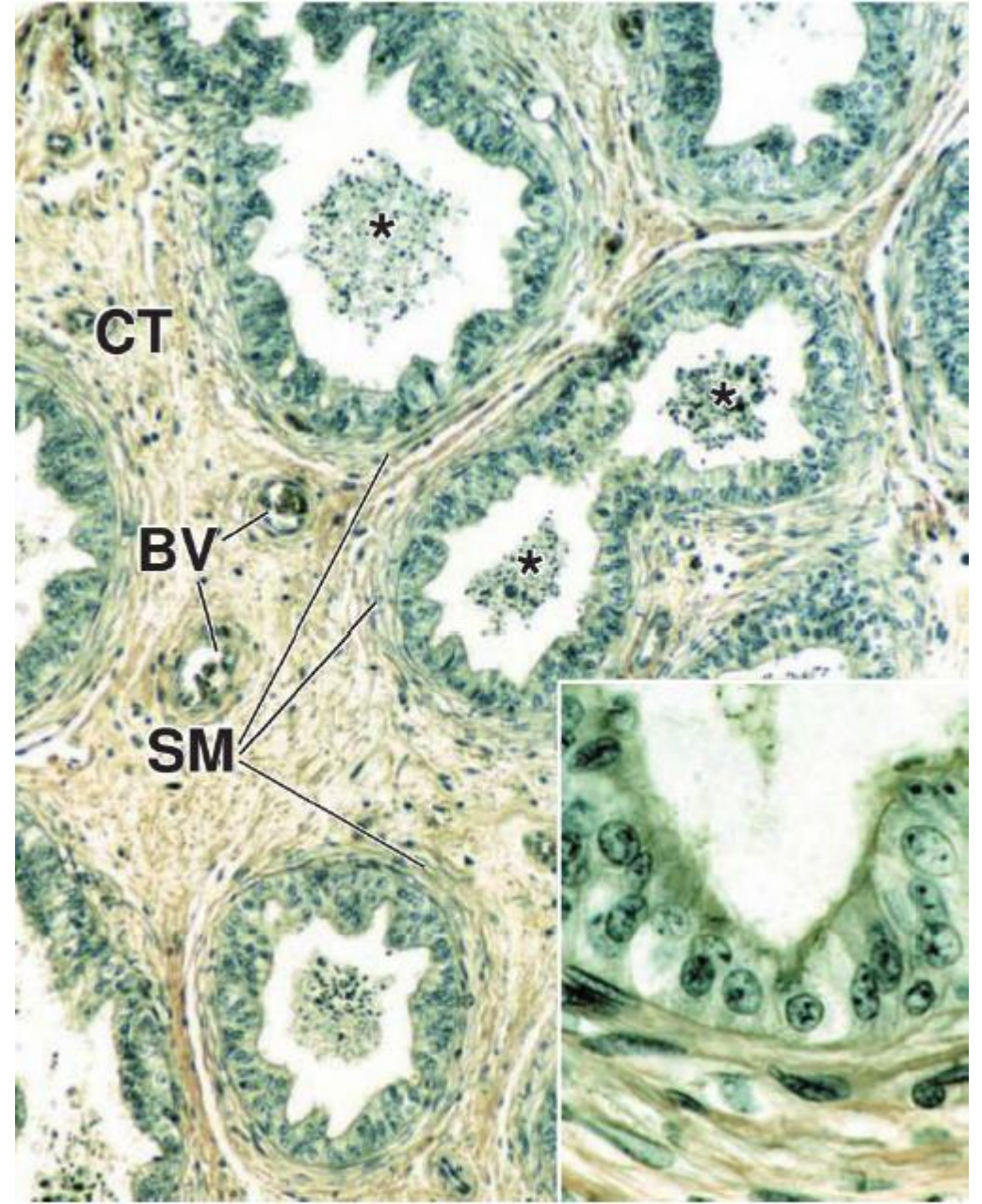
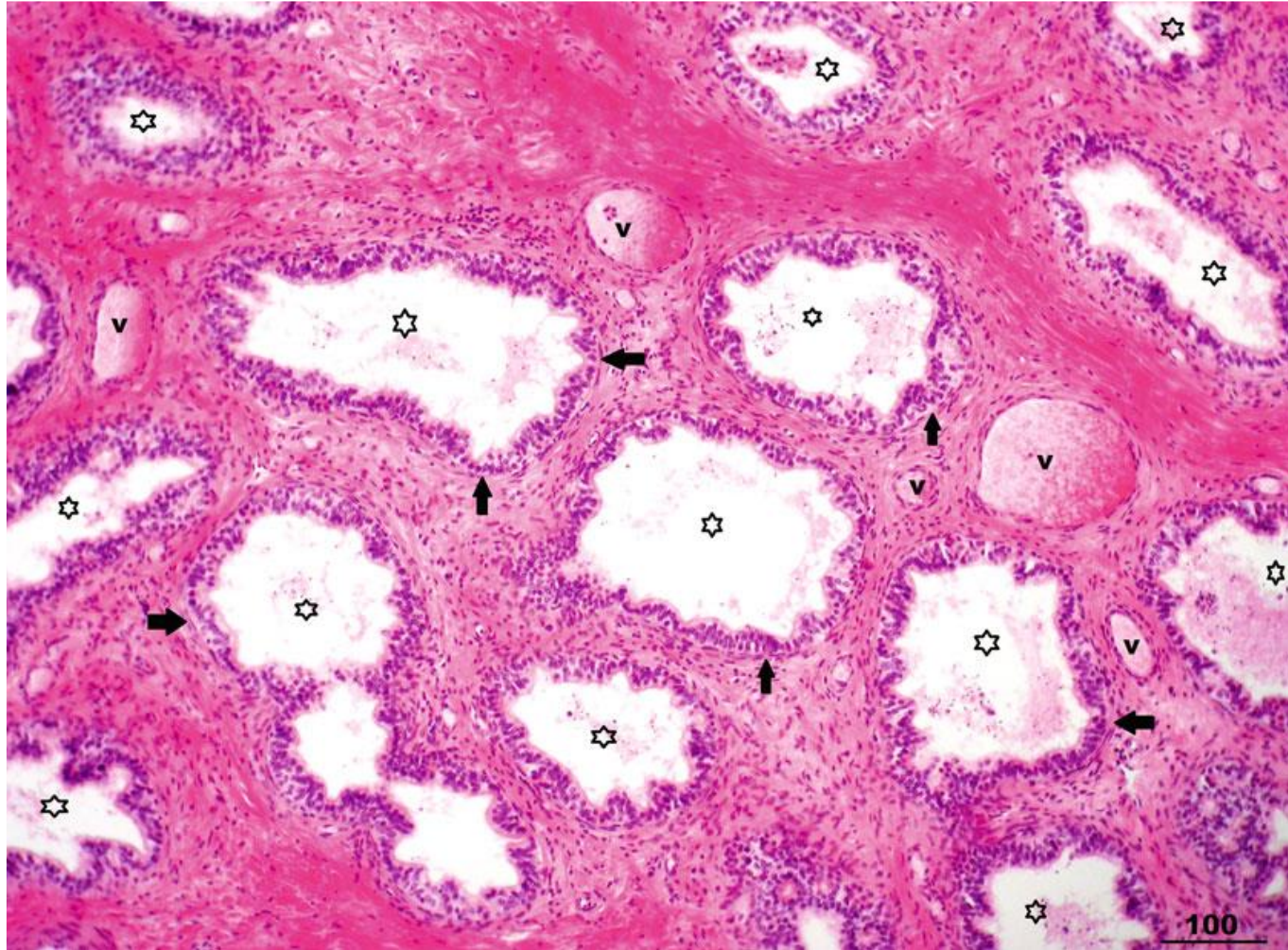
RETE TESTES



Ductuli efferentes

- In man, approximately 10-20 efferent ducts connect the channels of the rete testis at the superior end of the mediastinum to the proximal portion of the duct of the epididymis.
- The efferent ductules are lined with a **pseudostratified columnar epithelium** that contains clumps of tall and short cells, giving the luminal surface a **saw-tooth or star** appearance
- Interspersed among the **columnar cells** are occasional **basal cells** that serve as epithelial stem cells. The tall columnar cells are ciliated. The short nonciliated cells have numerous microvilli and canalicular invaginations of the apical surface as well as numerous pinocytotic vesicles, membrane-bounded dense bodies, lysosomes, and other cytoplasmic structures associated with endocytotic activity.
- **Most of the fluid secreted in the seminiferous tubules is reabsorbed in the efferent ductules.**
- A **smooth muscle layer** in the excurrent ducts first appears at the beginning of the efferent ductules. Interspersed among the muscle cells are elastic fibers.
- Transport of the sperm in the efferent ductules is affected largely by both ciliary action and contraction of this fibromuscular layer.

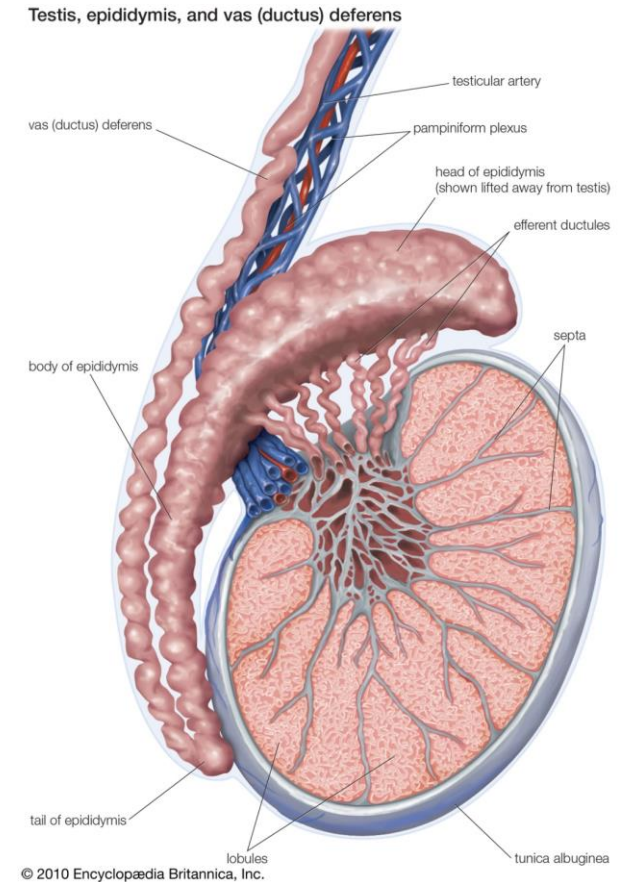




Extra-testicular genital ducts

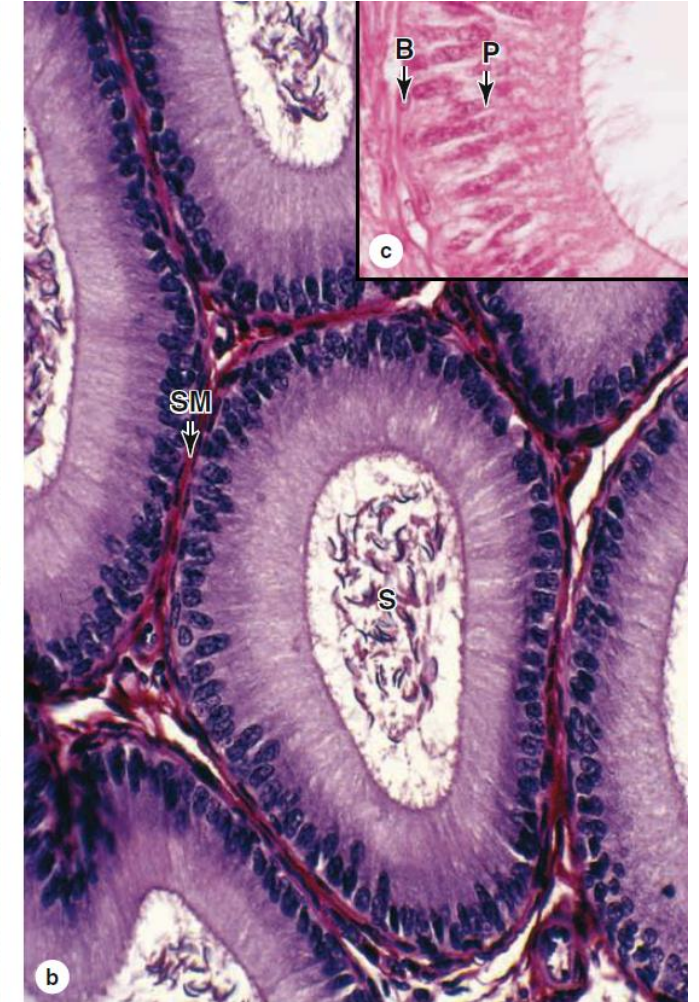
Epididymis (Ductus epididymis)

- The epididymis is a crescent-shaped structure that lies along the superior and posterior surfaces of the testis.
- It measures about 7.5 cm in length and consists of the efferent ductules and the duct of the epididymis and associated vessels, smooth muscles, and connective tissue
- The duct of the epididymis is a highly coiled tube measuring 4 to 6 m in length.
- **The epididymis is divided into a head (caput), a body (corpus), and a tail (cauda)**



Epididymis (Ductus epididymis)

- The duct of the epididymis is lined with a **pseudostratified columnar epithelium** with two types of cells:
 - **Principal cells** that vary from about 80 μm in height in the head of the epididymis to about 40 μm in height in the tail. Numerous long, modified microvilli called **stereocilia** extend from the luminal surface of the principal cells
 - **Basal cells** that represent small, round cells resting on the basal lamina. They are the stem cells of the duct epithelium.
- In addition, **migrating lymphocytes** called **halo cells** are often found within the epithelium
- The epididymis plays an important role in sperm transport, sperm maturation, including the **acquisition of motility, sperm concentration, and sperm storage**. The average sperm transit time through the epididymis in humans is 12 days. Most of the sperm are stored in the caudal segment until ejaculation occurs



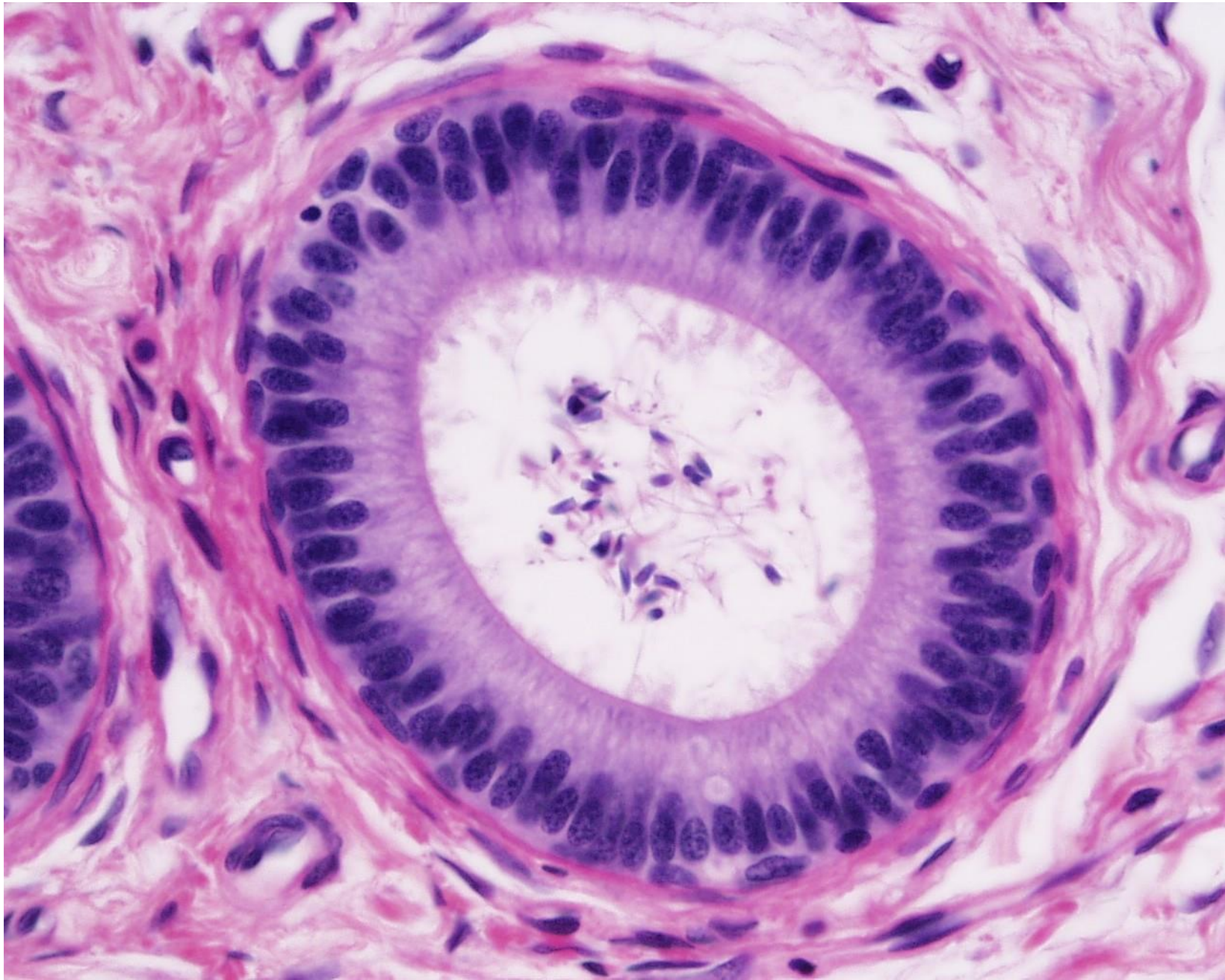


Figure 27-8 Epididymis

Principal cells secrete **carnitine, sialic acid, glycoproteins,** and **glycerylphosphorylcholine** into the epididymal lumen. The epididymal epithelium is androgen-dependent.

The **apical domain** of the columnar principal cells displays nonmotile long microvilli, called **stereocilia**. Stereocilia are long and branching in the head region of the epididymis. Their height decreases in the tail region.

Structures present in the apical cytoplasm

- Pinocytotic vesicle
- Multivesicular body
- Lysosome
- Lipid droplet

A prominent and multiple Golgi apparatus is present in the supranuclear region.

Intraepithelial lymphocytes are abundant in all regions of the epididymal duct.

Lymphocyte

The nucleus is elongated and folded

Basal cells rest on the basal lamina. They contain few organelles. Their function has not been clearly determined.

Basal cell

The rough endoplasmic reticulum is present in the basal cytoplasm.

Basal lamina

Principal cell

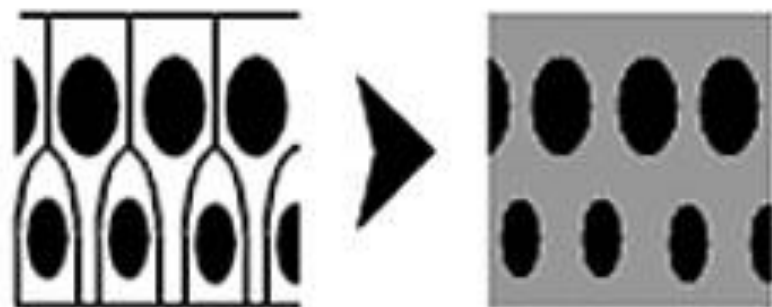
The **principal cells** have the following structural features: (1) They are tall in the caput and decrease in height along the epididymal duct to become low-columnar to cuboidal in the cauda region. (2) Branching stereocilia arise from the apical domain. (3) The Golgi complex at a supranuclear location is very prominent. (4) Secretion of glycoproteins, endocytosis, and pinocytosis are prevalent. (5) About 90% of the testicular fluid is absorbed in the ductuli efferentes and epididymis by principal cells.

The **basal cells** are associated with the basal lamina.

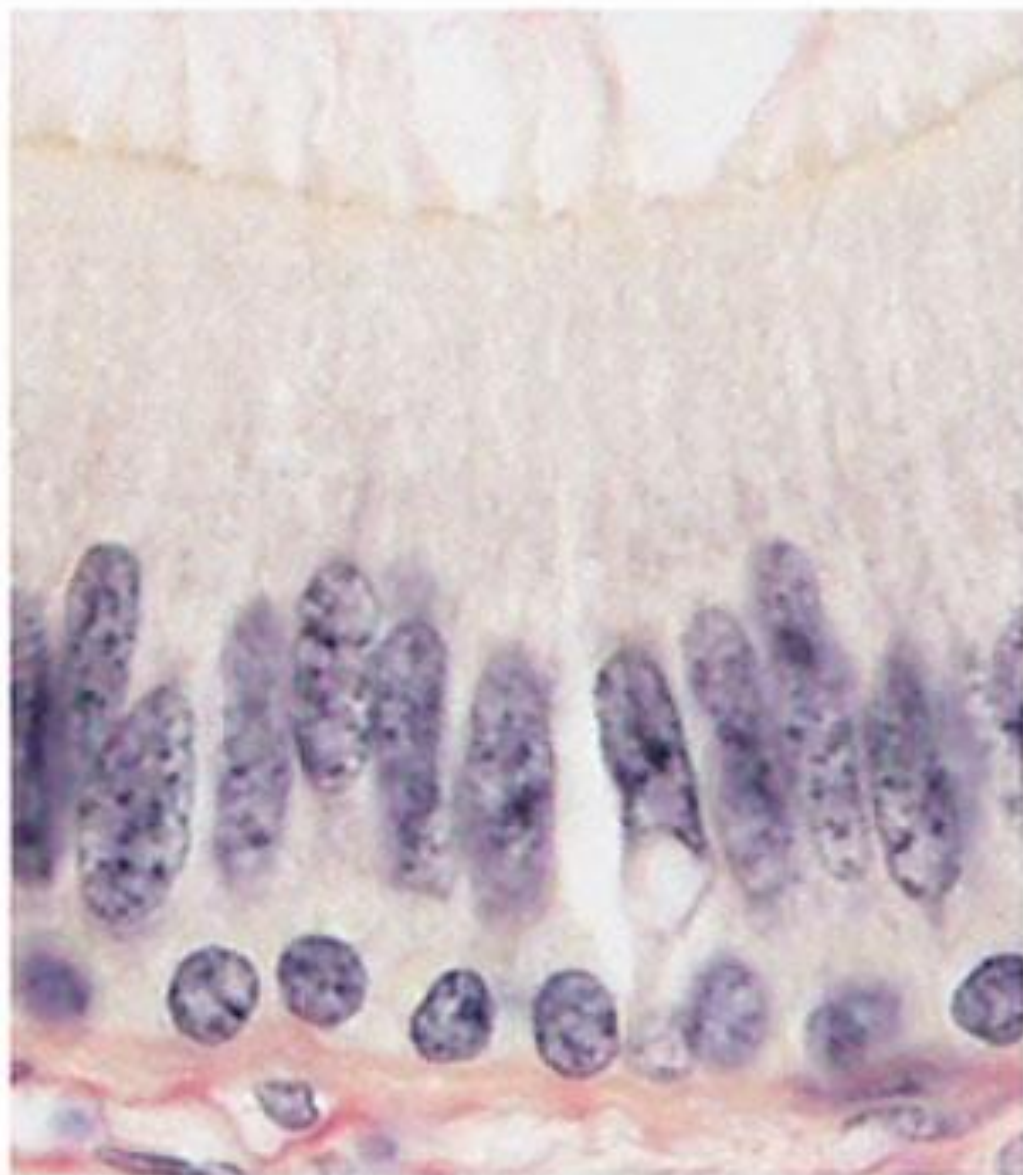
Circular smooth muscle cell layer



**pseudostratified
epithelium**



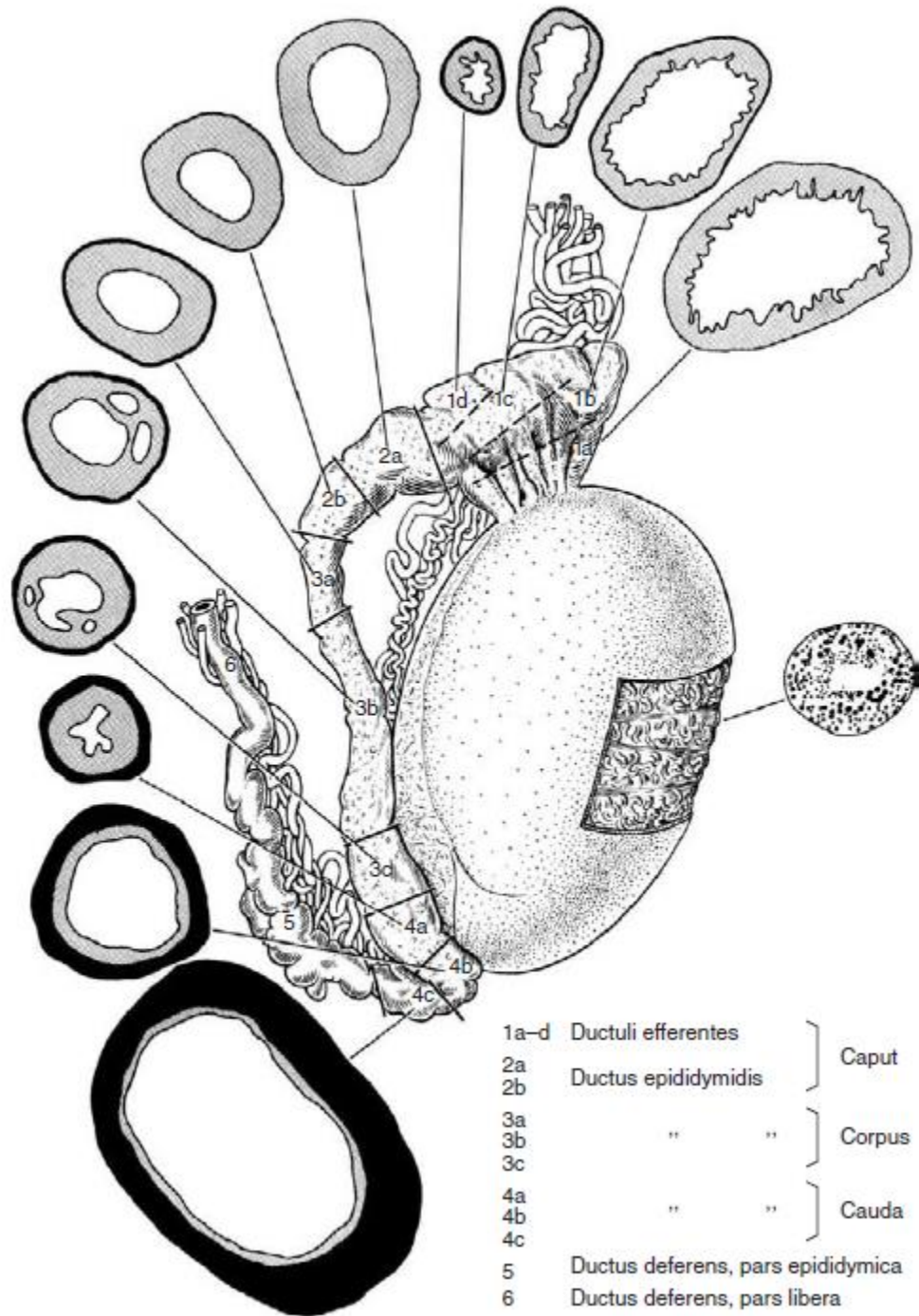
Epididymis van Gieson



Epididymis (Ductus epididymis)

- Newly produced sperm, which enter the epididymis from the testis, mature during their passage through the duct of the epididymis, **acquiring motility** and the ability to fertilize an oocyte. This is an androgen-dependent maturation process
- the head of the sperm is covered by epididymal fluid glycoconjugates. This process, called **decapacitation**, inhibits the fertilizing ability of the sperm in a reversible manner.
- This is later released during capacitation that occurs in the female reproductive tract just before fertilization.

In the head of the epididymis and most of the body, the smooth muscle coat consists of a thin layer of circular smooth muscle resembling that of the efferent ductules. **In the tail, inner and outer longitudinal layers are added.**



Sperm maturation in epididymis

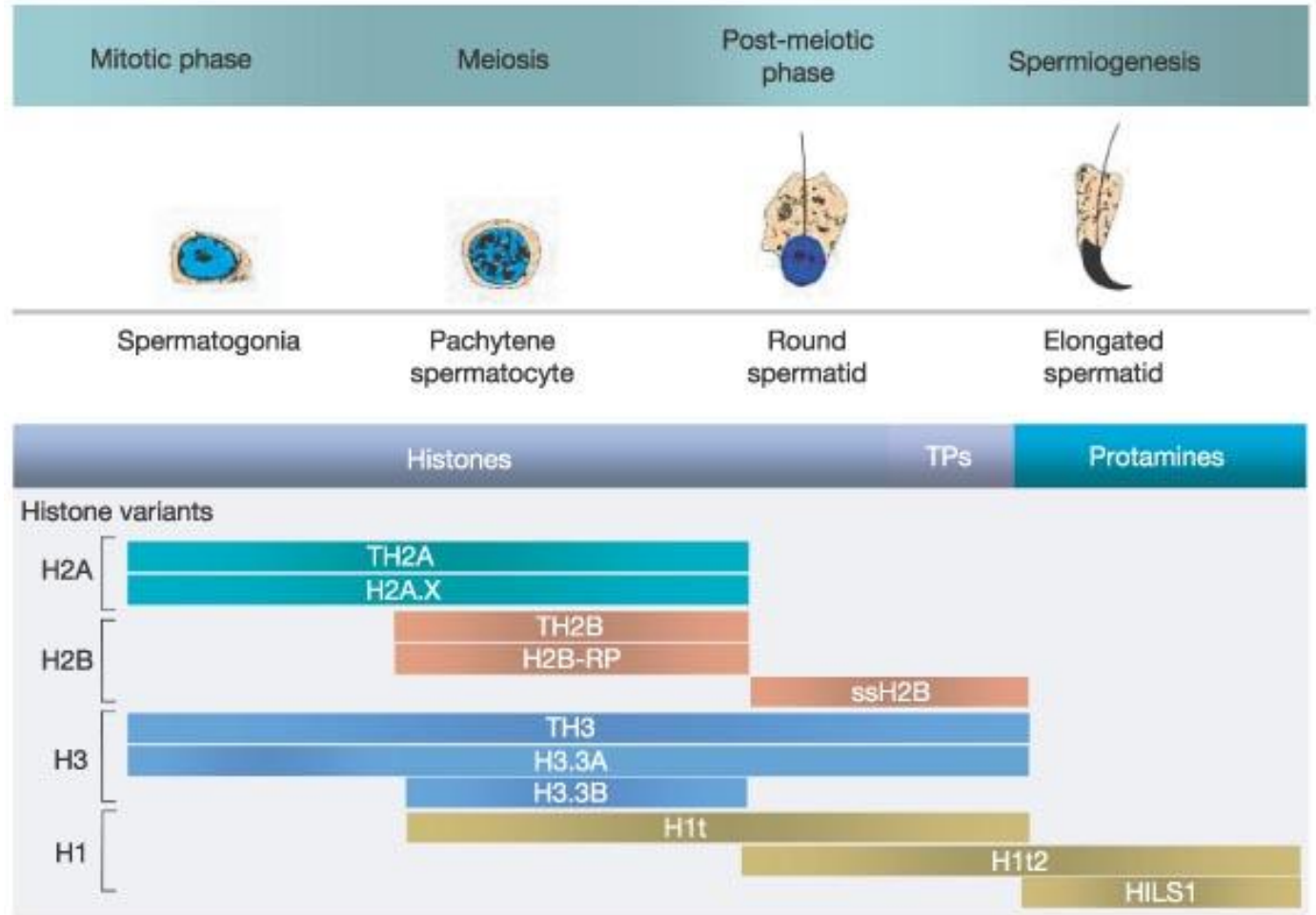
- Mammalian spermatozoa leaving the testis are not capable of fertilizing oocytes.
- They gain this ability while passing down the epididymis, a process known as epididymal maturation.
- The epididymis is divided into different regions: the caput is the upper third, formed by efferent ductules that are lined by pseudostratified columnar ciliated epithelium.
- **The vasa efferentia tubules unite to form the single coiled tubule of the corpus**
- It starts to form a muscular wall toward the **cauda**, where the lumen is wider, and **spermatozoa can be stored** prior to ejaculation.
- During its journey through the different regions of the epididymis, the head of the spermatozoon acquires the ability to interact with the zona pellucida, with **an increase in net negative charge**. Many antigens with a demonstrable role in oocyte binding and fusion are synthesized in the testis as precursors, and then activated at some point in the epididymis either through direct biochemical modification, through changing their cellular localization or both.
- Examples of such antigen processing include a membrane-bound **hyaluronidase, fertilin, proacrosin, 1,4-galactosyltransferase (GalTase)** and putative **zona ligands sp56 and p95**.
- Spermatozoa from the caput epididymis begin to display motility, and by the time they reach the cauda they are capable of full progressive forward motility.
- Demembration and exposure to ATP, cAMP and Mg²⁺ triggers movement, which suggests that the ability to move is probably regulated at the level of the plasma membrane.

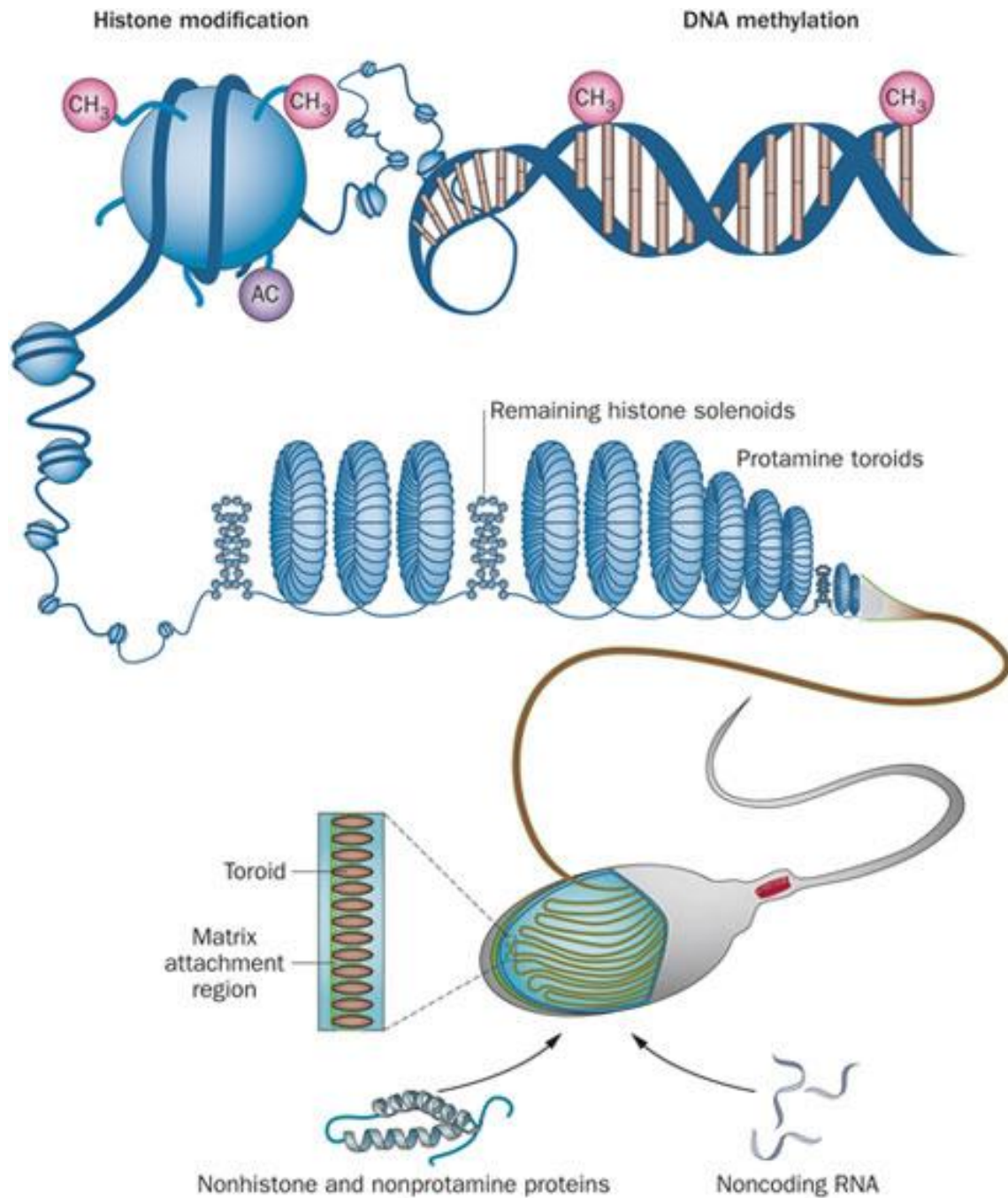
DNA Packaging in Sperm

- The amount of DNA in the sperm nucleus (approximately 1m in length) has to be packaged into a volume that is typically less than 10% of the volume of a somatic cell nucleus; a different mechanism of packaging is required.
- Somatic cell DNA is packaged into nucleosomes by a process of primary compaction that uses **histones**. A 10-nm fiber is supercoiled into the 30-nm solenoid, and supercoiled again into loops. These loops are the major structural form of interphase chromatin in all cell types.
- During spermatogenesis, DNA is **initially packaged by histones** but following meiosis, at the **secondary spermatocyte** stage of spermiogenesis, histones are replaced first by **transition proteins** and then by **protamines**.
- The solenoid structure is replaced by **torroids** (doughnut shapes), which are in turn supercoiled into torroidal loops. This highly compacted structure **shuts down transcription** during spermiogenesis.

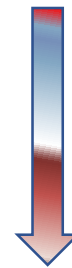
«A special packaging is needed for the most precious cargo in the world»

ISO





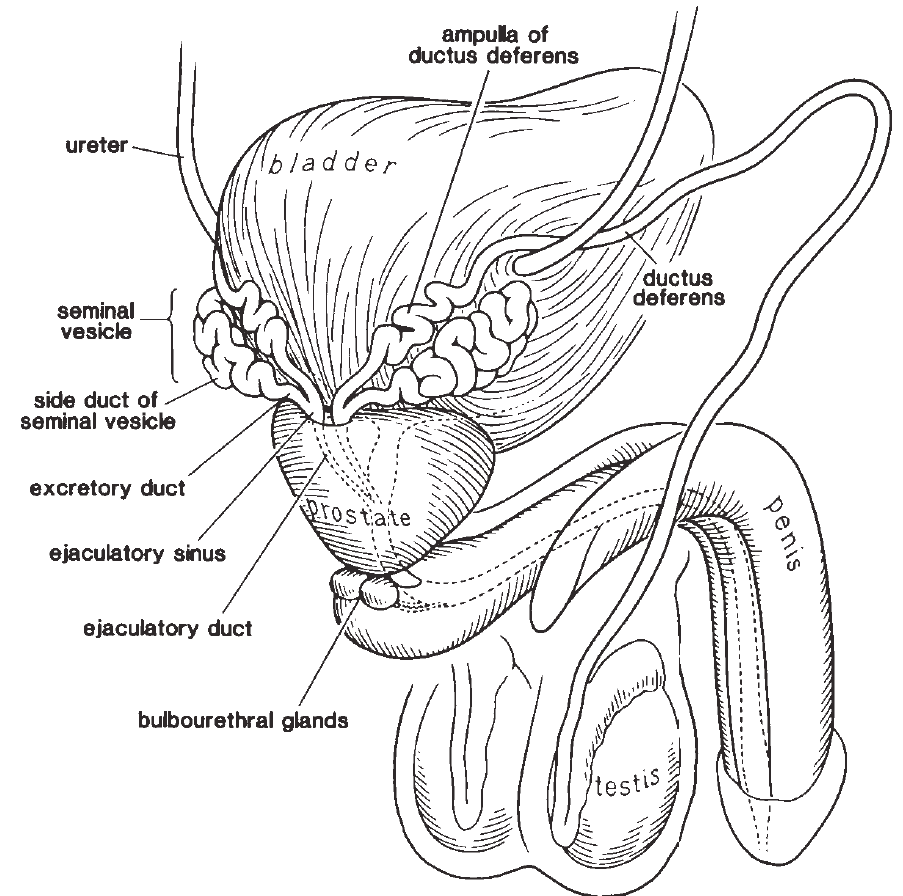
HISTONE



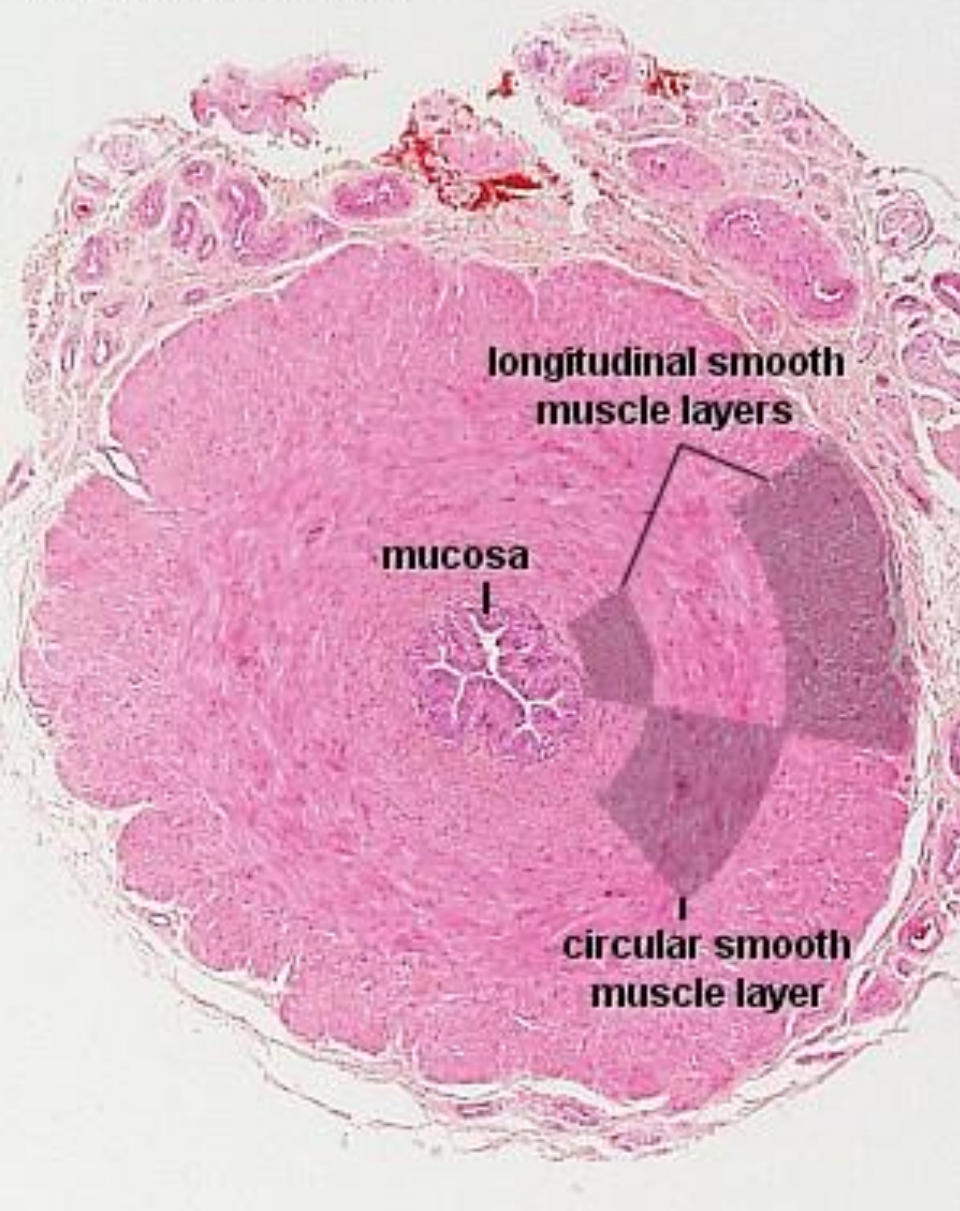
PROTAMINE

Ductus deferens (vas deferens)

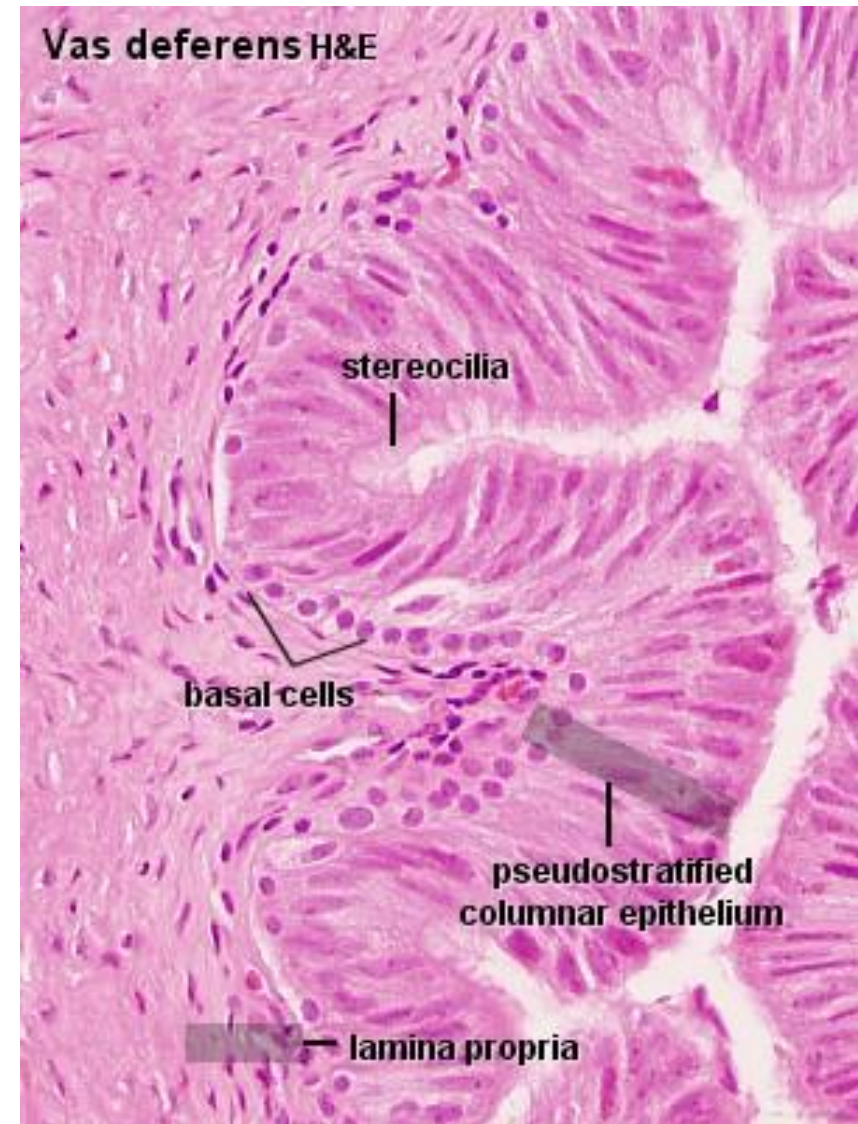
- The ductus (vas) deferens, a tubular structure arising from the caudal portion of the epididymis, measures about 40 cm in length. The distal 4 to 7 cm portion is enlarged to form the **ampulla**. The latter joins the excretory duct of the seminal vesicle to form the ejaculatory duct
- The **ampulla of ductus deferens** has taller, branched mucosal folds that often show glandular diverticula.
- The muscle coat surrounding the ampulla is **thinner** than that of the rest of the ductus deferens, and the longitudinal layers disappear near the origin of the ejaculatory duct.
- The epithelium of the ampulla and ejaculatory duct appears to have a **secretory** function. The cells contain large numbers of yellow pigment granules.
- The wall of the ejaculatory duct does not have a muscularis layer; the fibromuscular tissue of the prostate substitutes for it.

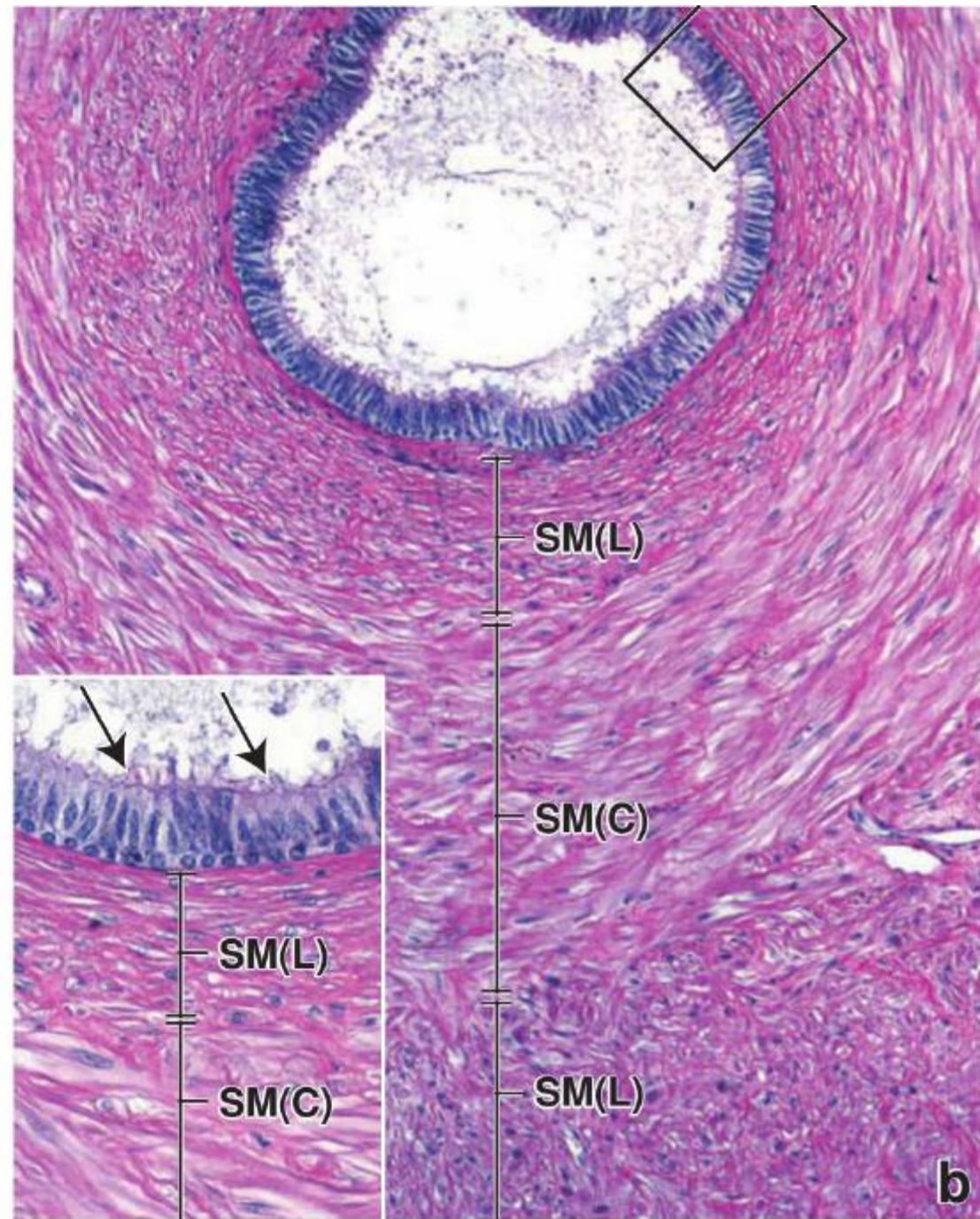
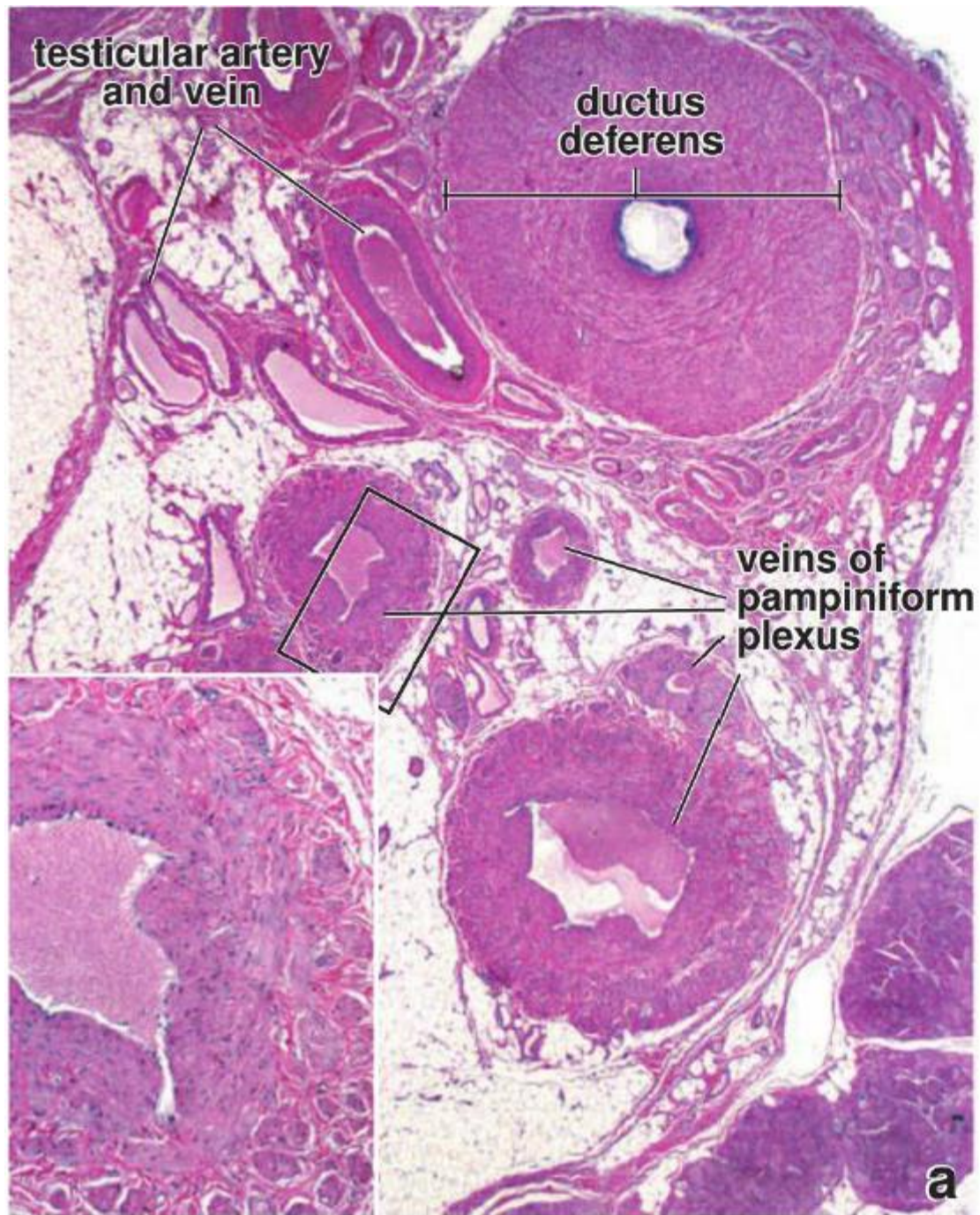


Vas deferens H&E



- The ductus deferens is lined with a **pseudostratified columnar epithelium** that closely resembles that of the epididymis .
- The **tall columnar cells** also have **stereocilia** that extend into the lumen. The **rounded basal cells** rest on the basal lamina.
- Unlike the epididymis, however, the lumen of the duct does not appear smooth. In histologic preparations, it appears to have deep longitudinal folds throughout most of its length, probably because of contraction of the **thick (1 to 1.5 mm) 3 layered muscular coat** of the duct during fixation.

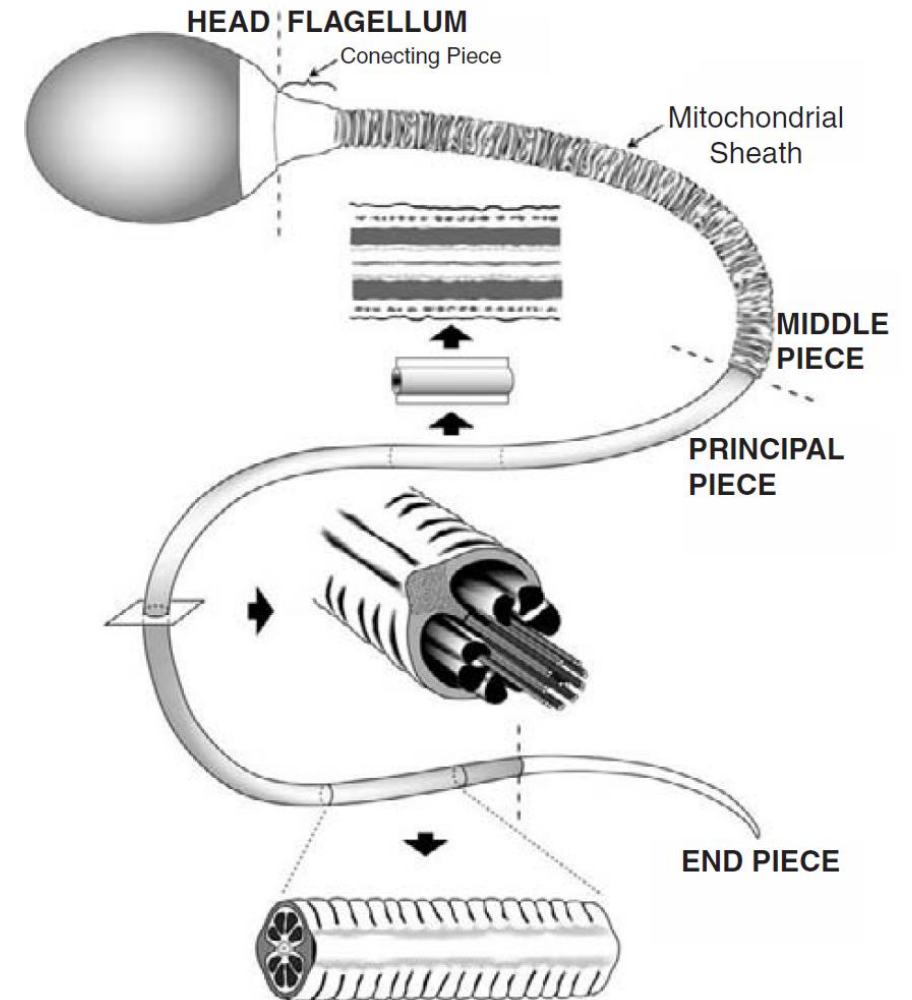




	Location	Epithelium	Support Tissues	Function(s)
Seminiferous tubules	Testicular lobules	Spermatogenic, with Sertoli cells and germ cells	Myoid cells and loose connective tissue	Produce sperm
Straight tubules (tubuli recti)	Periphery of the mediastinum testis	Sertoli cells in proximal portions, <u>simple cuboidal</u> in distal portions	Connective tissue	Convey sperm into the rete testis
Rete testis	In mediastinum testis	<u>Simple cuboidal cells with microvilli and single cilia</u>	Dense irregular connective tissue	Channels with sperm from all seminiferous tubules
Efferent ductules	From rete testis to head of epididymis	<u>Alternating patches of simple cuboidal nonciliated and simple columnar ciliated</u>	Thin circular layer of smooth muscle and vascular loose connective tissue	Absorb most fluid from seminiferous tubules; convey sperm into the epididymis
Epididymal duct	Head, body, and tail of the epididymis	<u>Pseudostratified columnar, with small basal cells and tall principal cells bearing long stereocilia</u>	Circular smooth muscle initially, with inner and outer longitudinal layers in the tail	Site for sperm maturation and short-term storage; expels sperm at ejaculation
Ductus (vas) deferens	Extends from epididymis to ejaculatory ducts in prostate gland	<u>Pseudostratified columnar, with fewer stereocilia</u>	Fibroelastic lamina propria and three very thick layers of smooth muscle	Carries sperm by rapid peristalsis from the epididymis to the ejaculatory ducts
Ejaculatory ducts	In prostate, formed by union of ductus deferens and ducts of the seminal vesicles	<u>Pseudostratified and simple columnar</u>	Fibroelastic tissue and smooth muscle of the prostate stroma	Mix sperm and seminal fluid; deliver semen to urethra, where prostatic secretion is added

The sperm cell: Spermatozoon (pl. Spermatozoa)

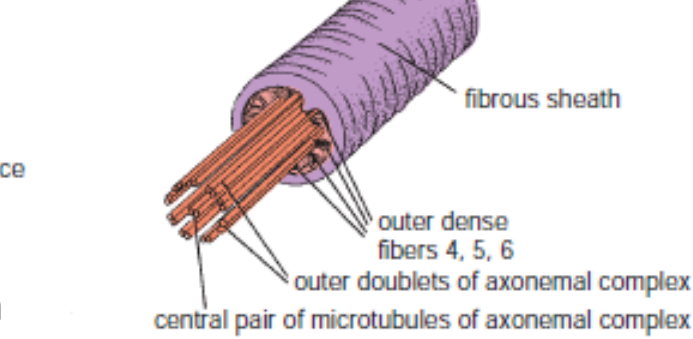
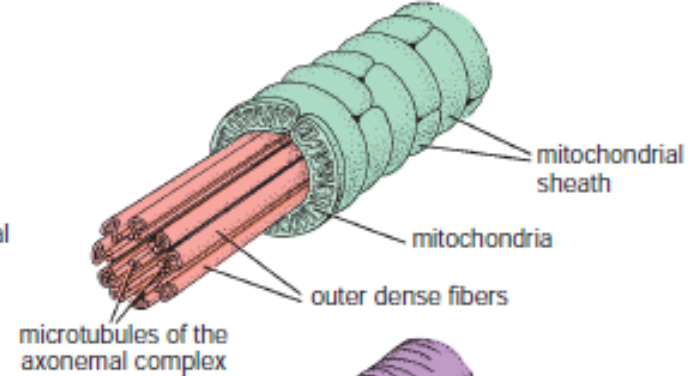
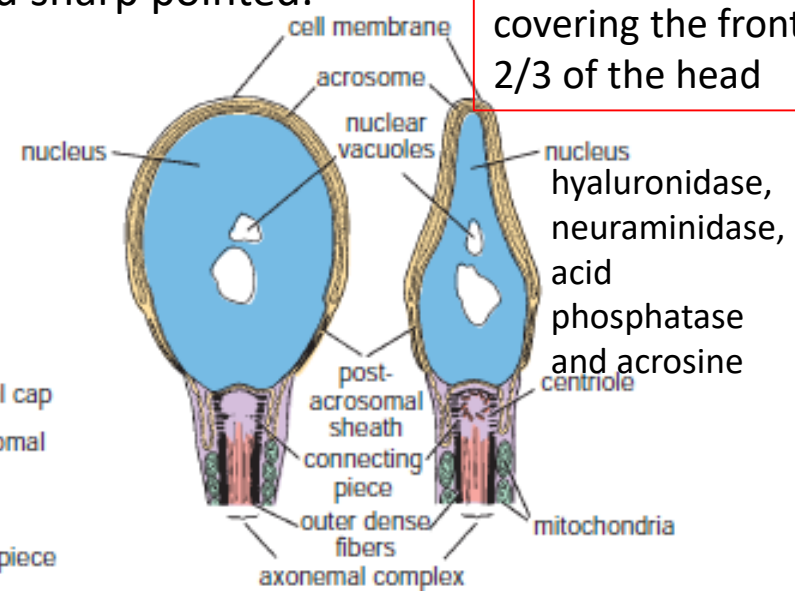
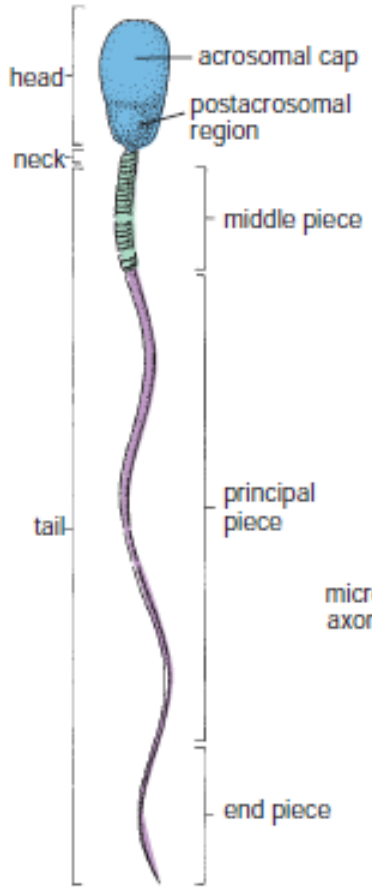
- The spermatozoon is the end product of the process of spermatogenesis proceeding through successive mitotic, meiotic and postmeiotic phases within the seminiferous tubules of the testis
- Postmeiotic phase is characterized by extensive remodeling of spermatids into sperm by formation of the acrosome, nuclear condensation, flagellar development, and loss of most of the cytoplasm.
- The two main components of a sperm are the **head and flagellum**, joined by the *connecting piece*. The head contains the **nucleus, acrosome, cytoskeletal structures, and a small amount of cytoplasm**. The *nucleus* contains highly condensed chromatin and is capped anteriorly by the **acrosome**, a membrane enclosed cytoplasmic vesicle containing hydrolytic enzymes.
- From the connecting piece, the flagellum is divided successively into the **midpiece, principal piece and end piece** regions. It contains a central complex of microtubules forming the *axoneme*, surrounded in turn by **outer dense fibers** extending from the neck into the principal piece. The midpiece contains the **mitochondrial sheath**, a tightly wrapped helix of mitochondria.



The head is flat and sharp pointed.

Height 4.5 μm,
Width 3 μm,
Thickness 1 μm

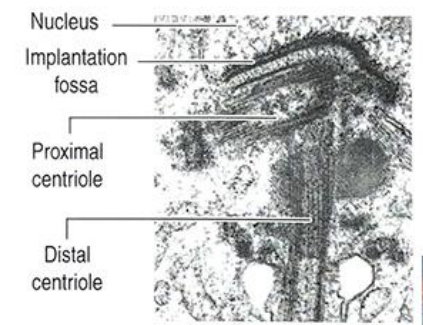
Acrosome covering the front 2/3 of the head



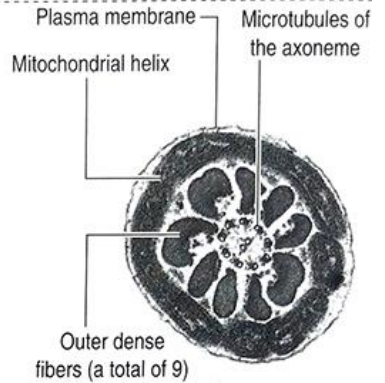
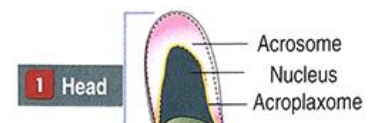
Cell length 60 μm

Figure 20-15. Sperm structure: Head and tail components

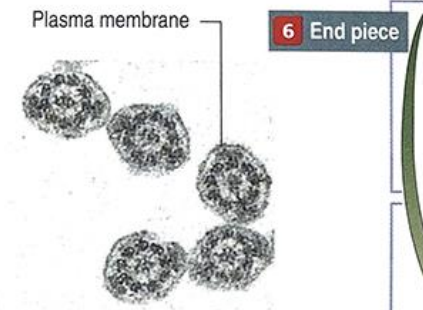
2 The head-tail coupling apparatus (developing spermatid) comprises the proximal centriole attached to the nucleus (implantation fossa) and the distal centriole that generates the axoneme.



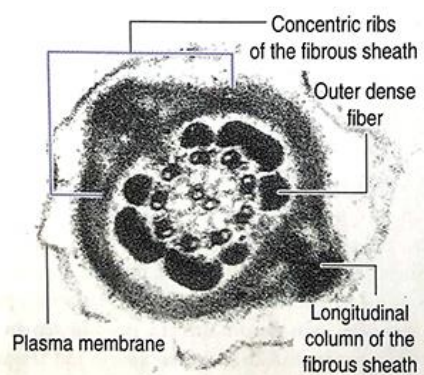
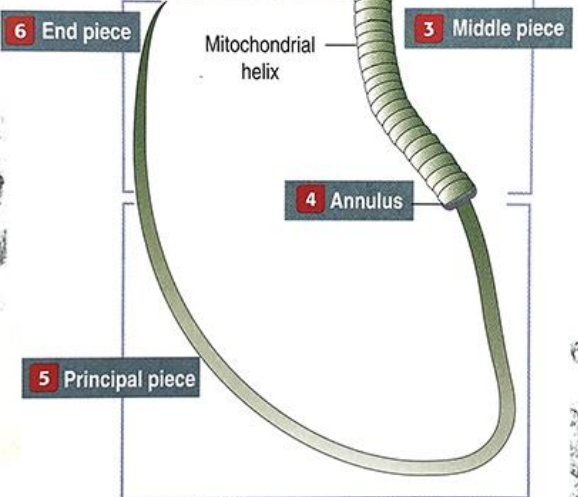
1 The head consists of two components: (1) the nucleus and (2) the acrosome. Both components are surrounded by a plasma membrane.



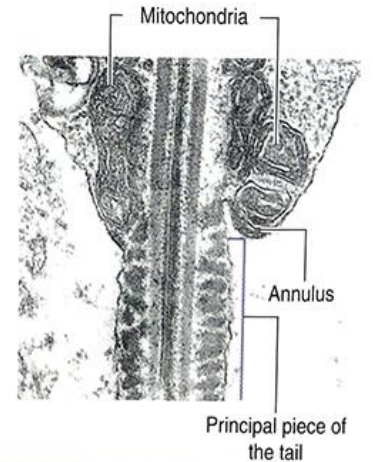
3 The middle piece of the sperm tail extends from the head to the end of the helically arranged mitochondrial sheath. The 9 + 2 microtubular axoneme occupies the center of the tail. Between the mitochondrial helical sheath and the axoneme are nine outer dense fibers.



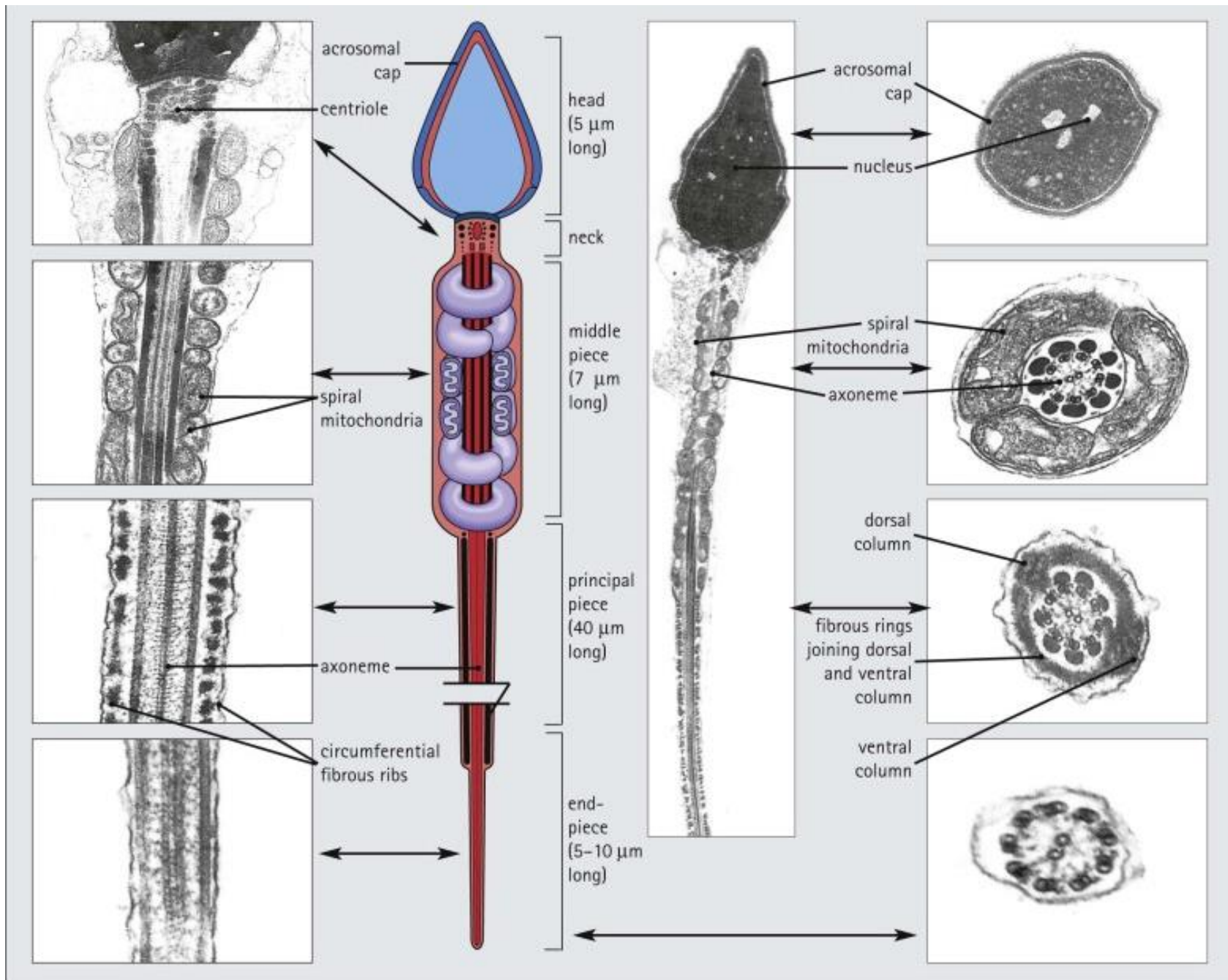
6 The end piece includes the 9 + 2 microtubular axoneme, surrounded only by the plasma membrane.

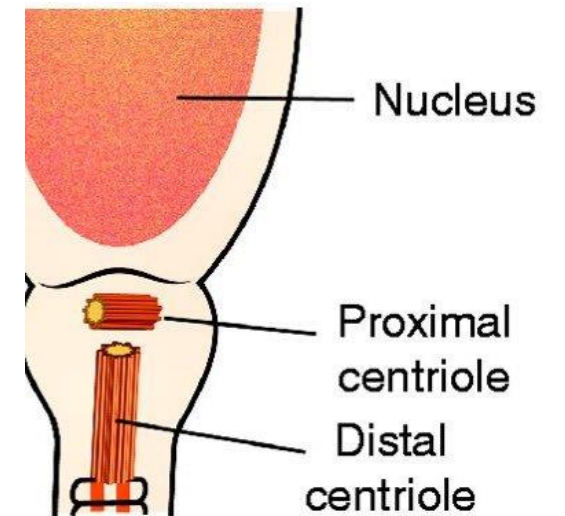
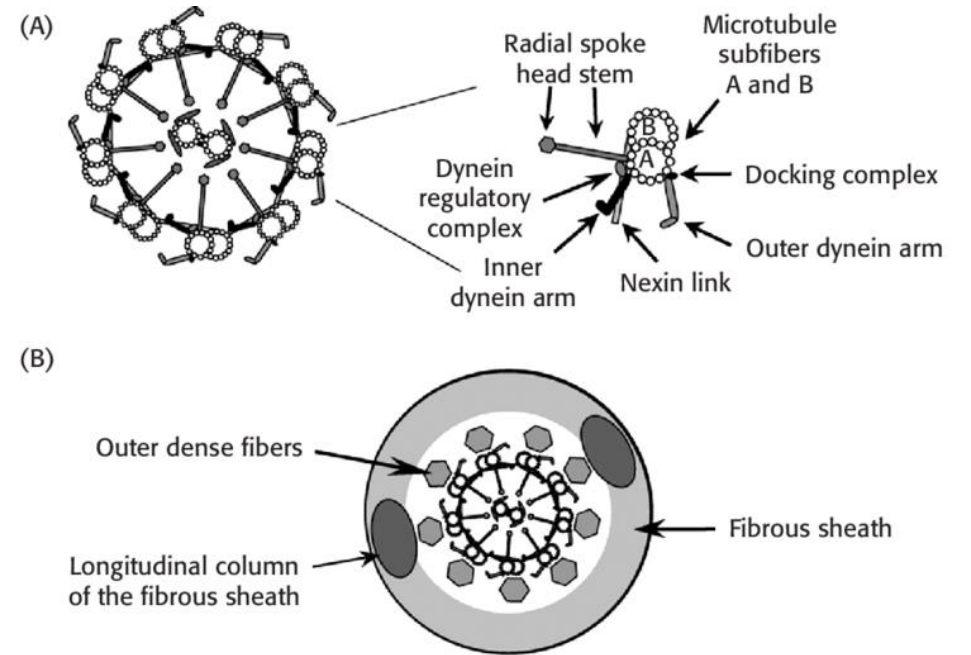
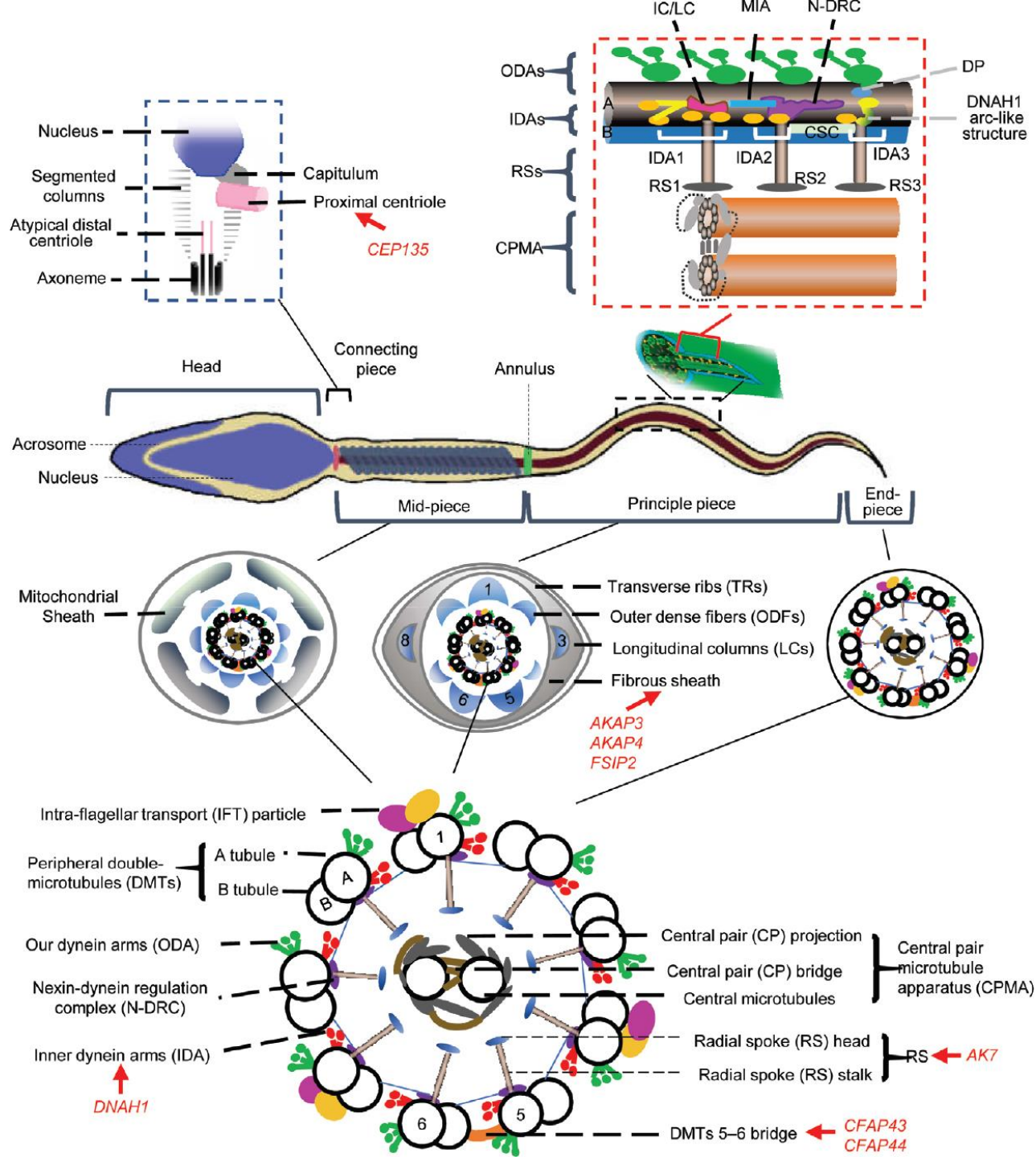


5 The principal piece, extending beyond the annulus, lacks a mitochondrial helix. It consists of (1) concentrically oriented ribs of the fibrous sheath, anchored to two longitudinal columns; (2) seven outer dense fibers; and (3) the central axoneme. As the sperm tail tapers, outer dense fibers, circumferential ribs, and longitudinal columns become thinner and disappear a short distance from the tip (the end piece of the tail).



4 The annulus, a dense ring subjacent to the last turn of the mitochondrial helix, is the site where the middle piece changes into the principal piece. Septin 4 is a component of the annulus.



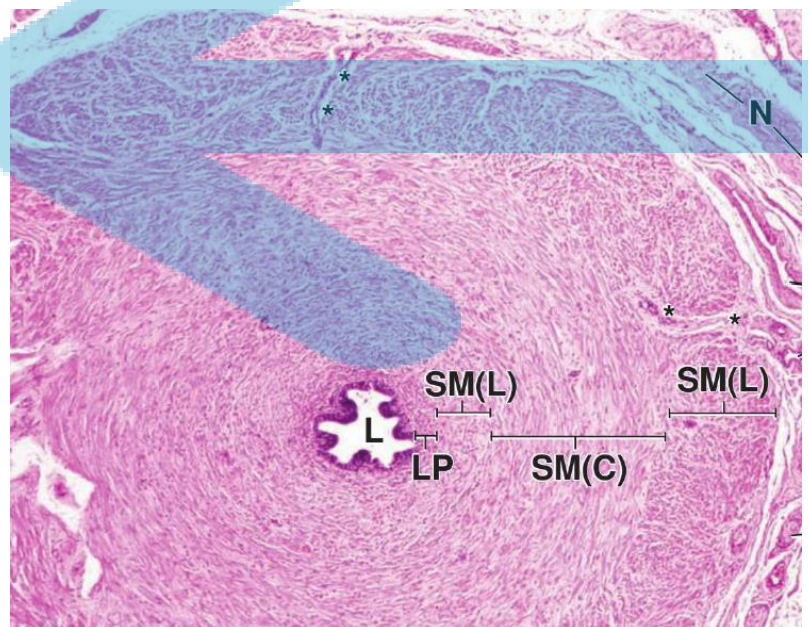
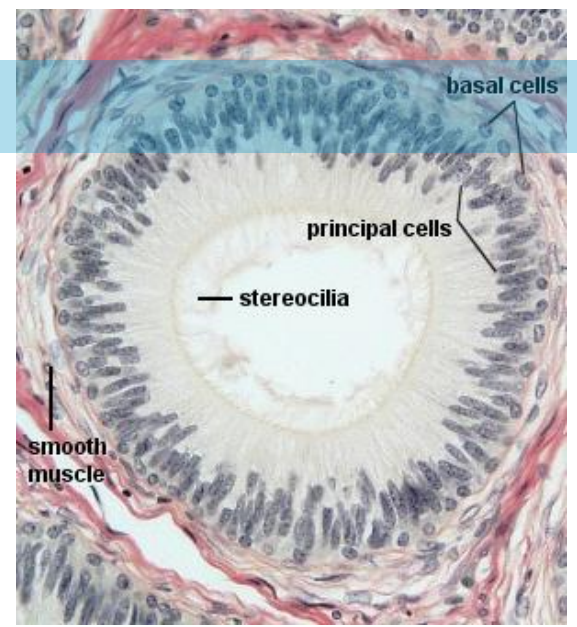
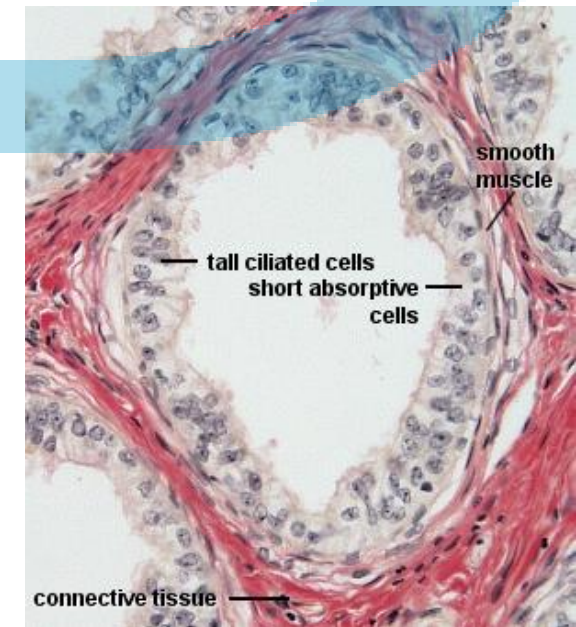
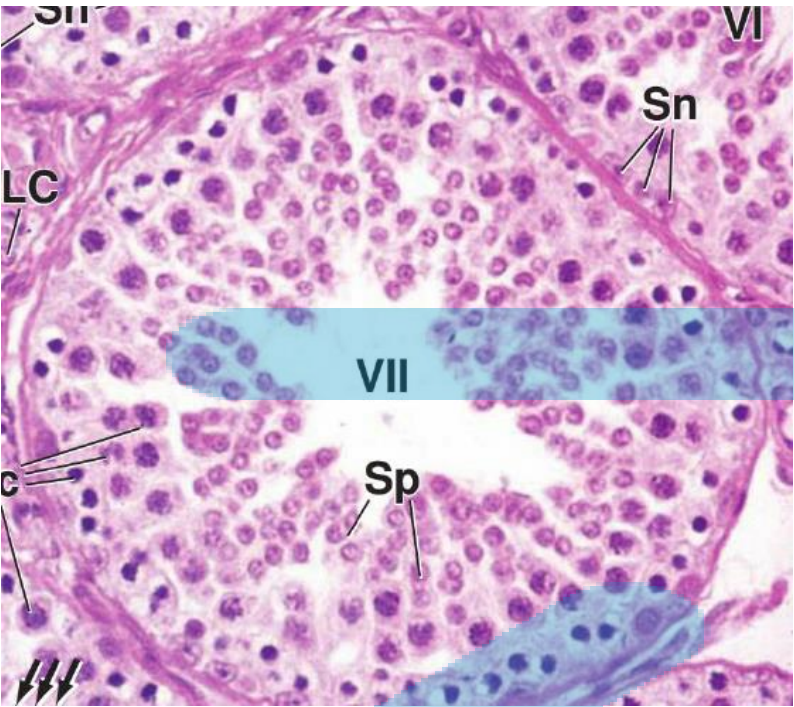
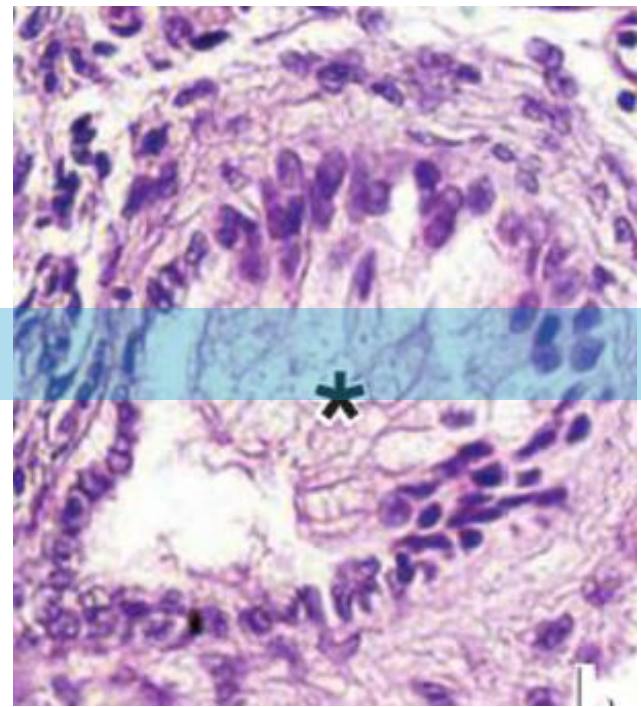
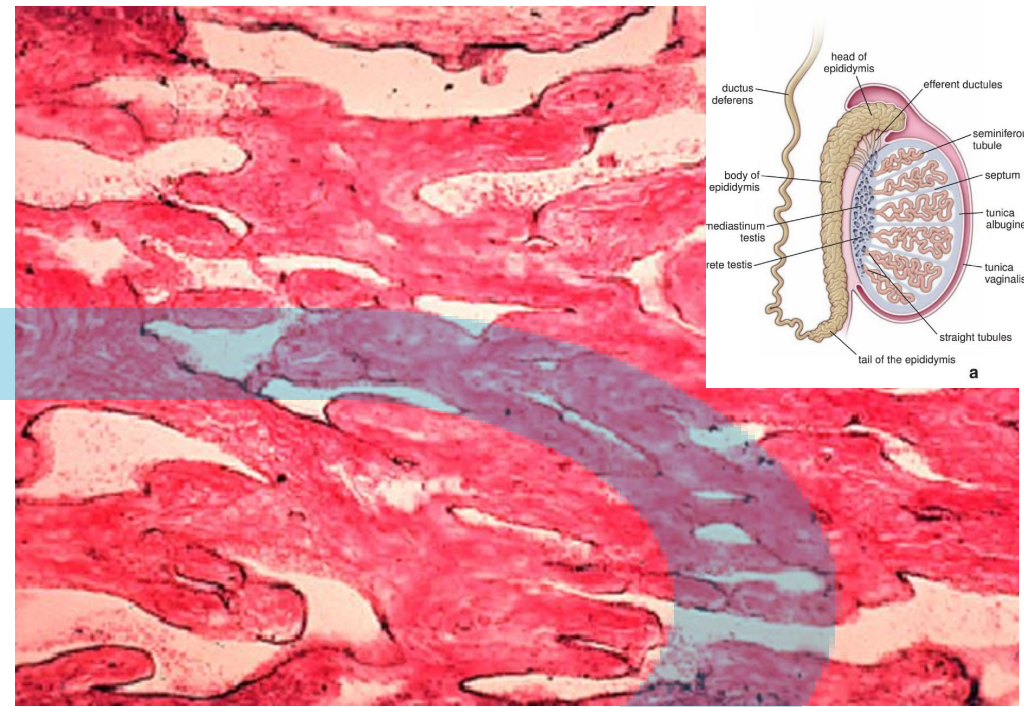
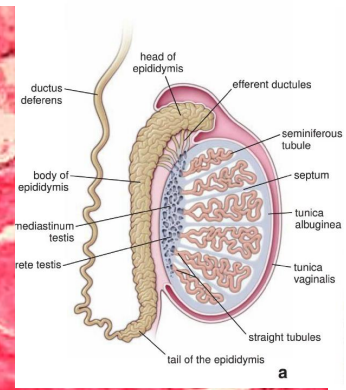


SEMEN PARAMETERS: THE BASIC SPERMIOGRAM

WHO laboratory manual for the Examination and processing of human semen

FIFTH EDITION

Parameter	Lower reference limit
Semen volume (ml)	1.5 (1.4–1.7)
Total sperm number (10^6 per ejaculate)	39 (33–46)
Sperm concentration (10^6 per ml)	15 (12–16)
Total motility (PR+NP, %)	40 (38–42)
Progressive motility (PR, %)	32 (31–34)
Vitality (live spermatozoa, %)	58 (55–63)
Sperm morphology (normal forms, %)	4 (3.0–4.0)



Thank you...

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