Prostate and Seminal Vesicle

Normal Development,
Function, Surgical Anatomy

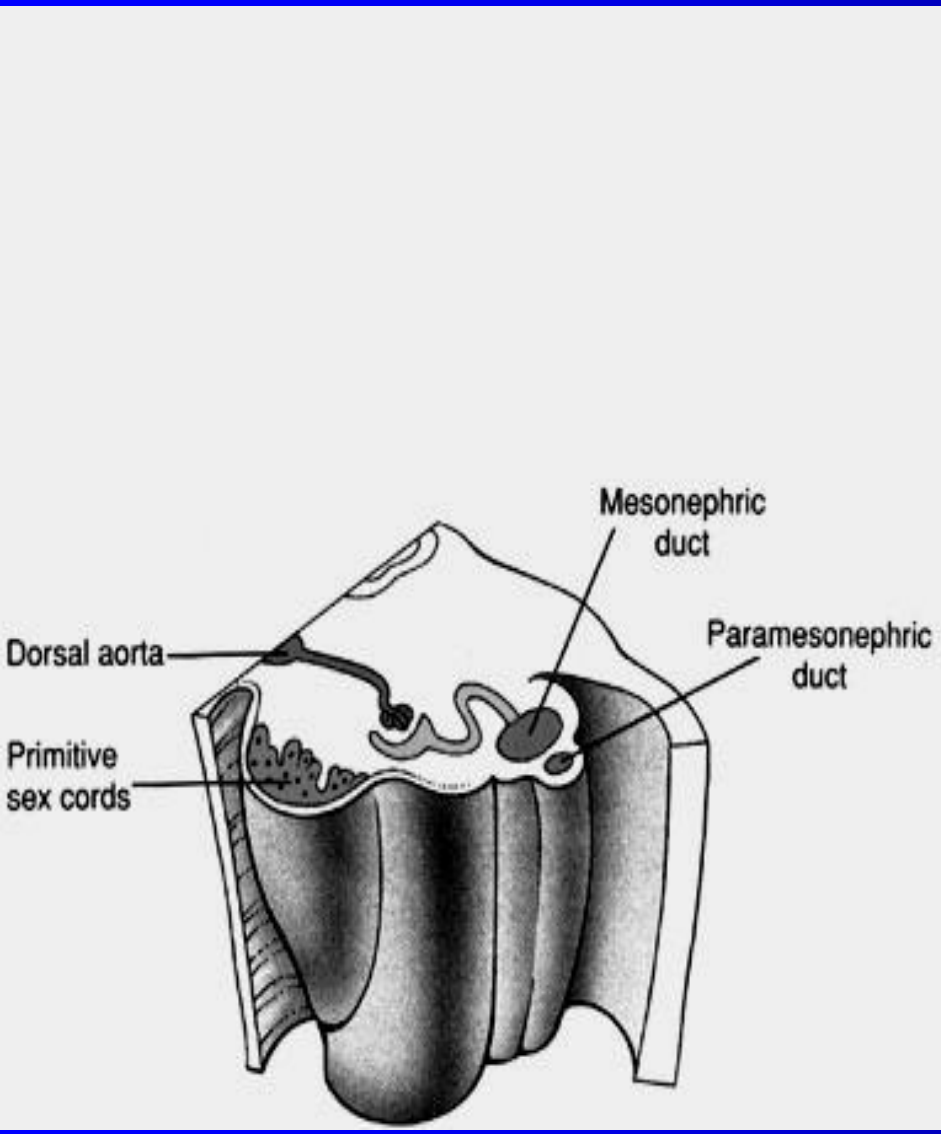
Overview: Prostate & Seminal Vesicle

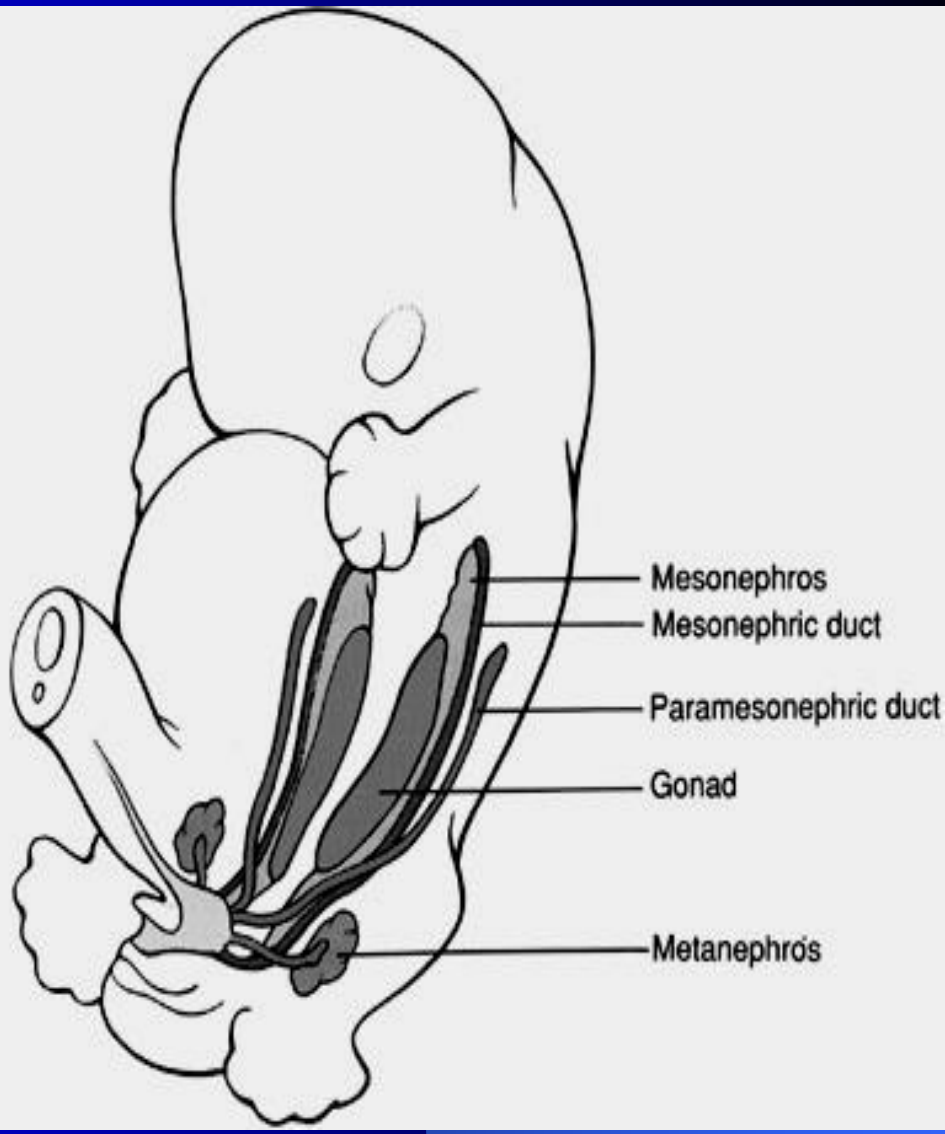
- Developmental Anatomy
- Function
- Surgical Anatomy
- Interactive Discussion

Objectives

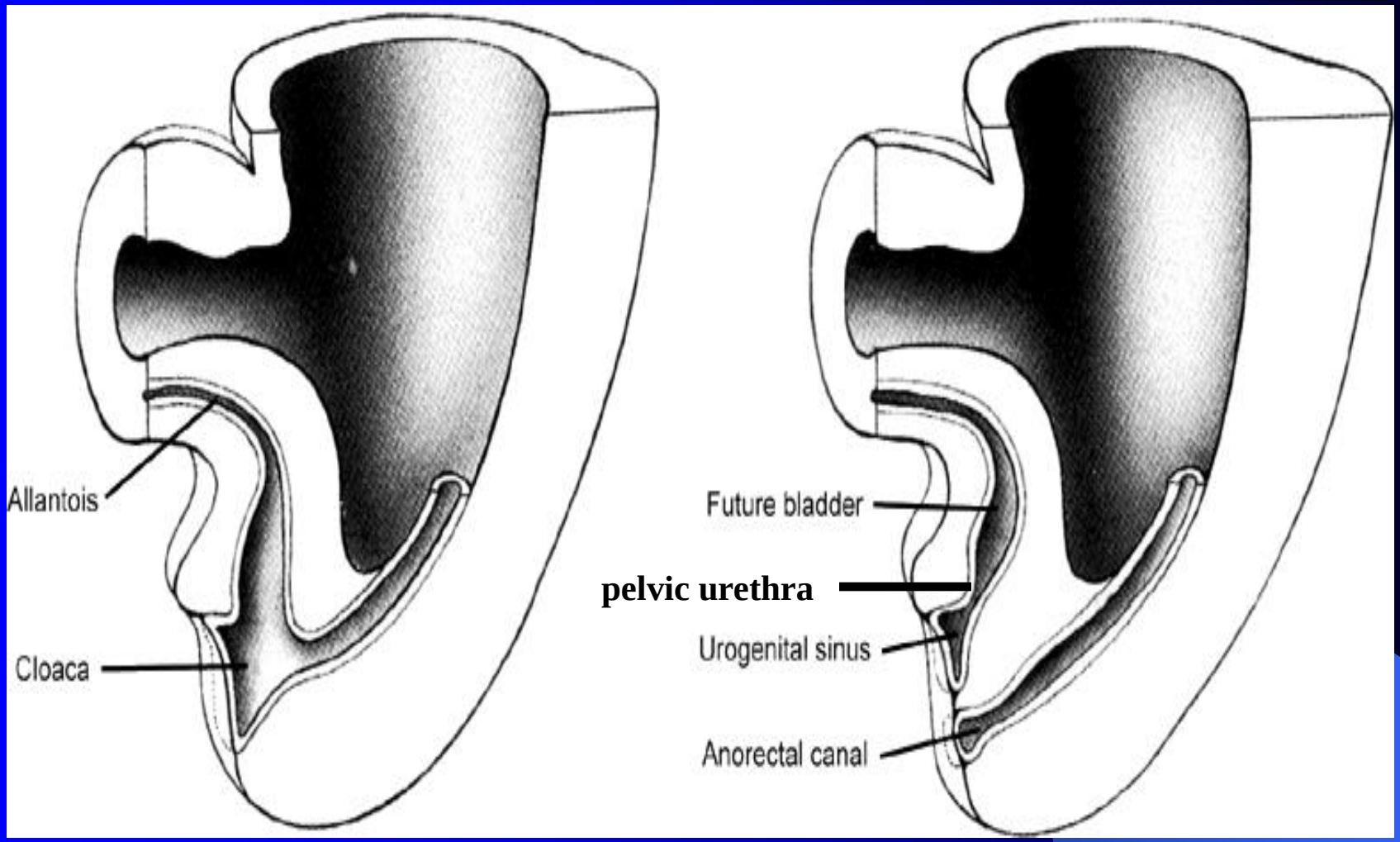
- To comprehend concepts of prostate and seminal vesicle normal development
- To comprehend anatomical and functional anatomy of prostate and seminal vesicle
- To integrate anatomical, functional and surgical concepts of the prostate and seminal vesicles in patient care, medical knowledge, and therapy outcomes

Embryologic Development by 5th Week

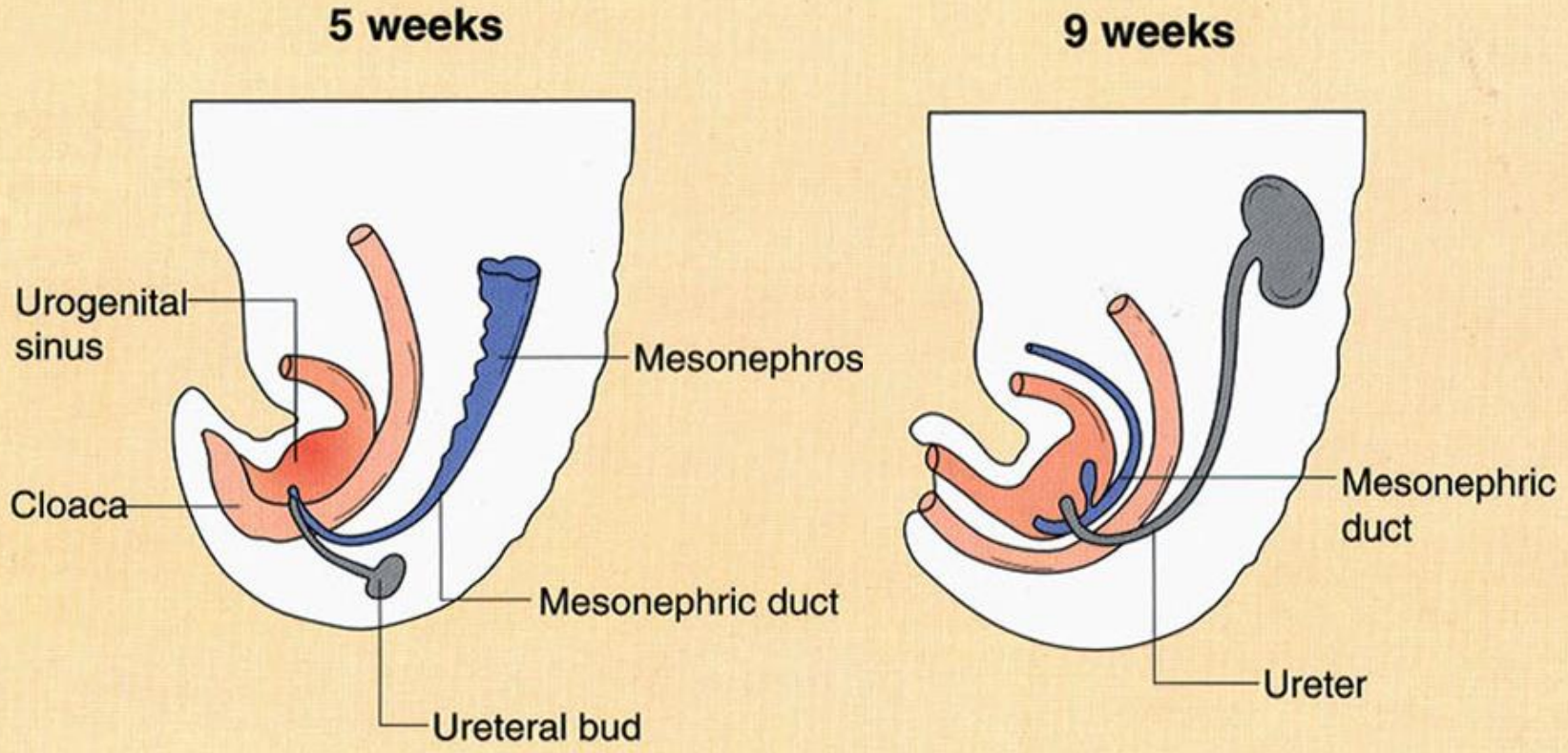




Embryologic Development by 5-6th Weeks

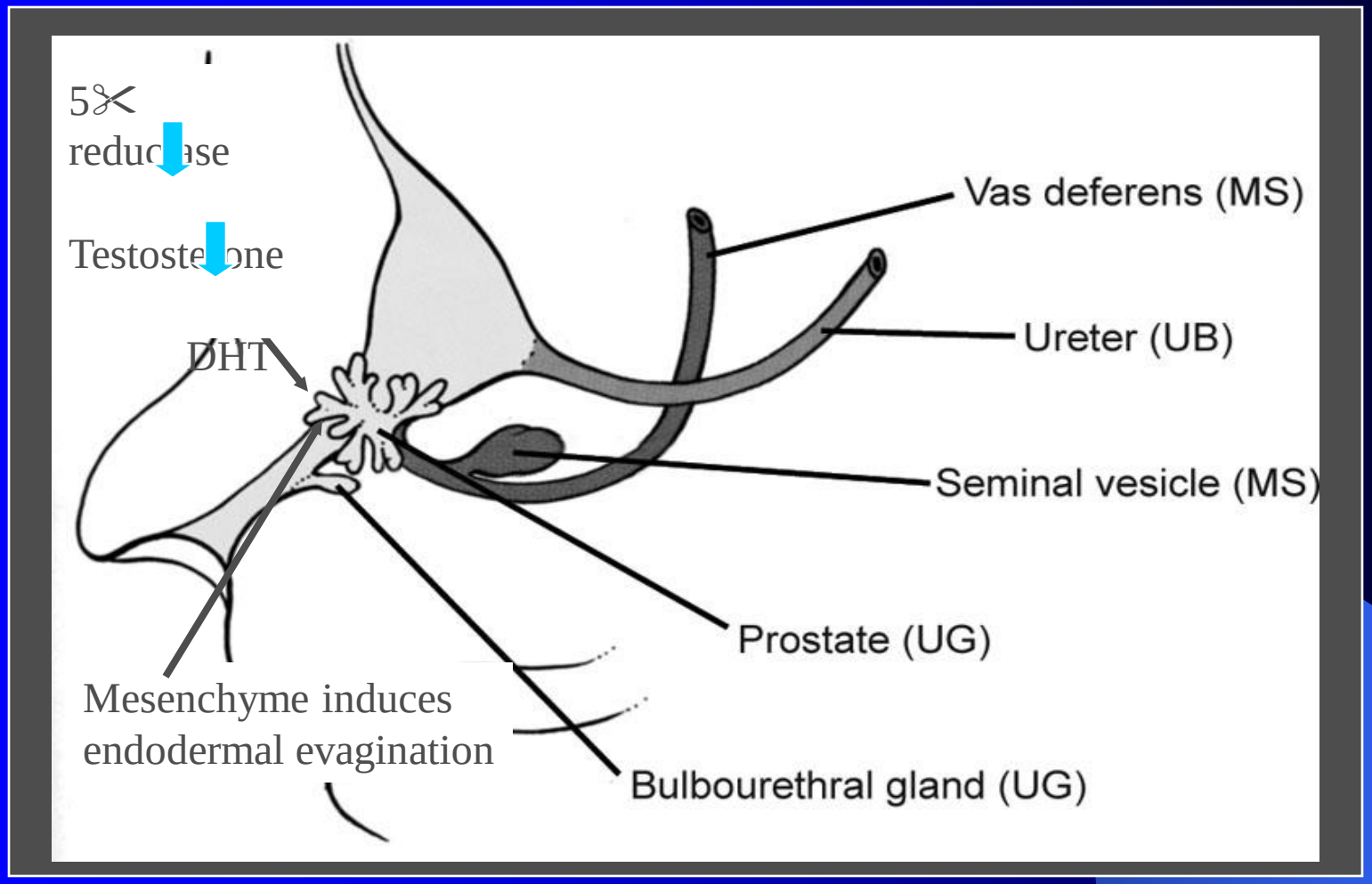


Prostate Anatomy: Embryology



Embryology of the prostate: The gland develops at the base of the bladder as outgrowths from the urethra and coalesce with the surrounding mesenchyme. This interaction forms the basis of the adult gland, which comprises a mixture of epithelium and stroma

Normal Development of Prostate and Seminal Vesicle

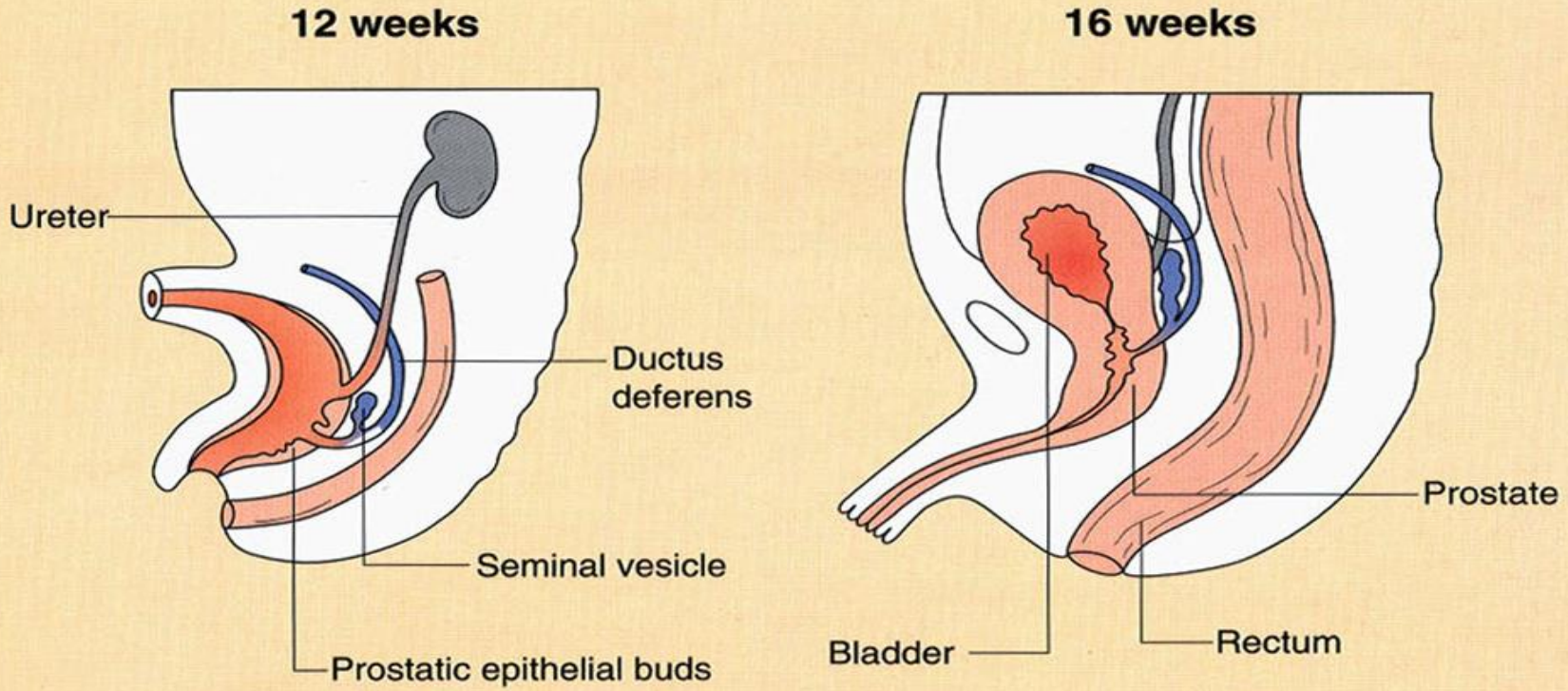


10th week development of male accessory sexual glands

Prostate and Seminal Vesicle Development

- 11th week- 5 independent solid cords of prostatic tissue develop lumens and acini
- 13th week- prostatic acini began to develop secretory activity
- Mesenchyme surrounding prostate develops into muscle and connective tissue

Prostate Anatomy: Embryology



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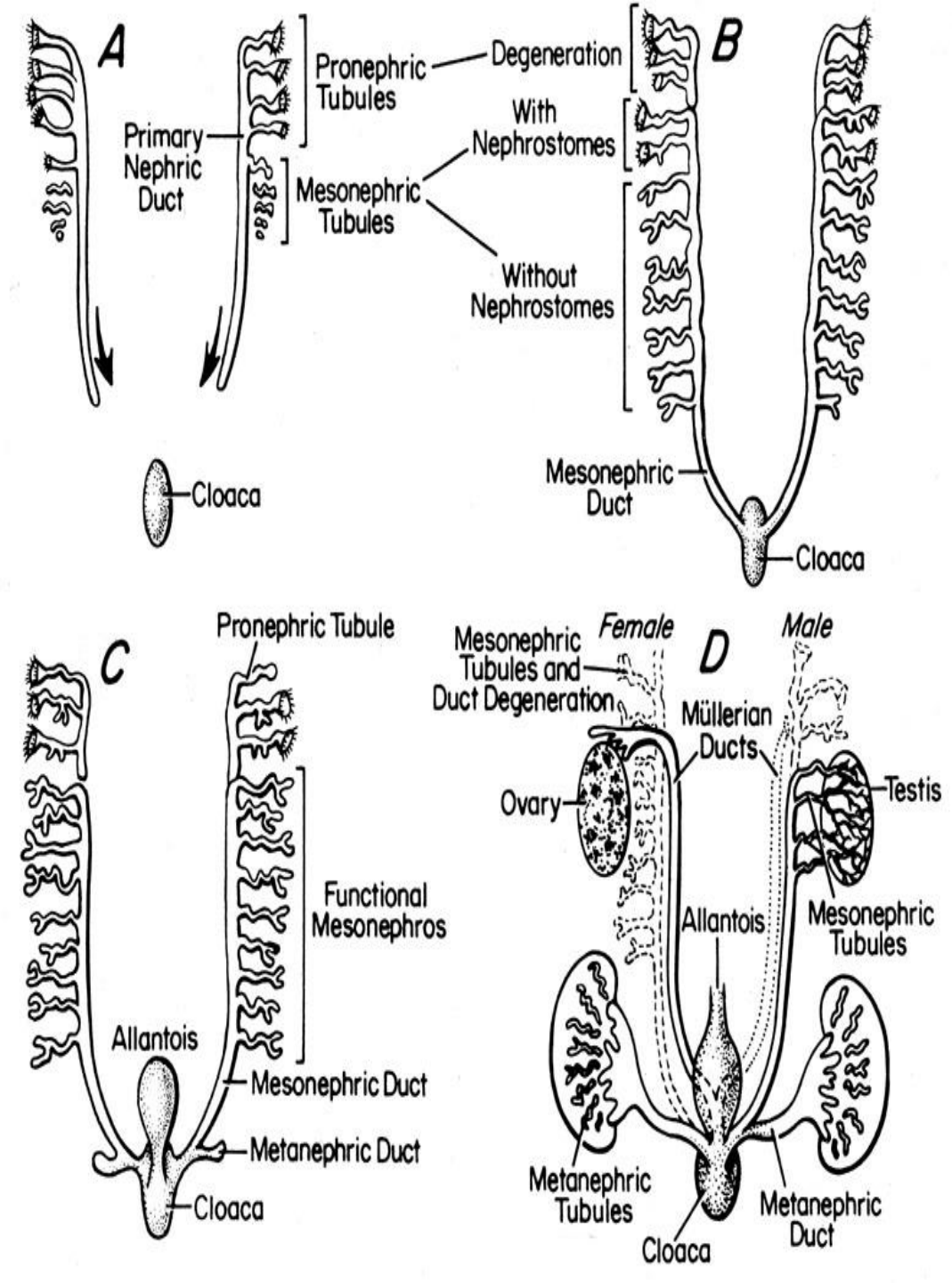
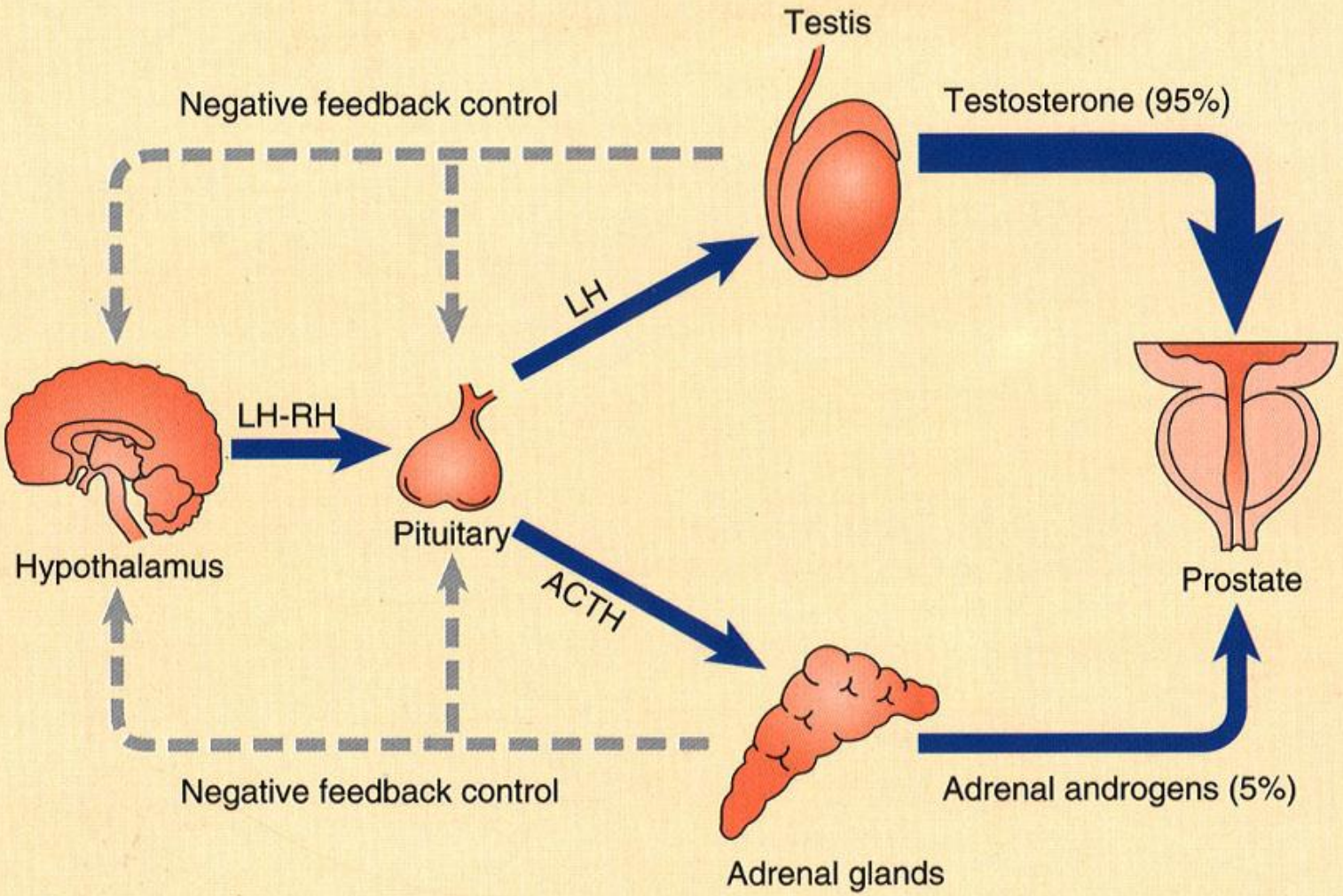
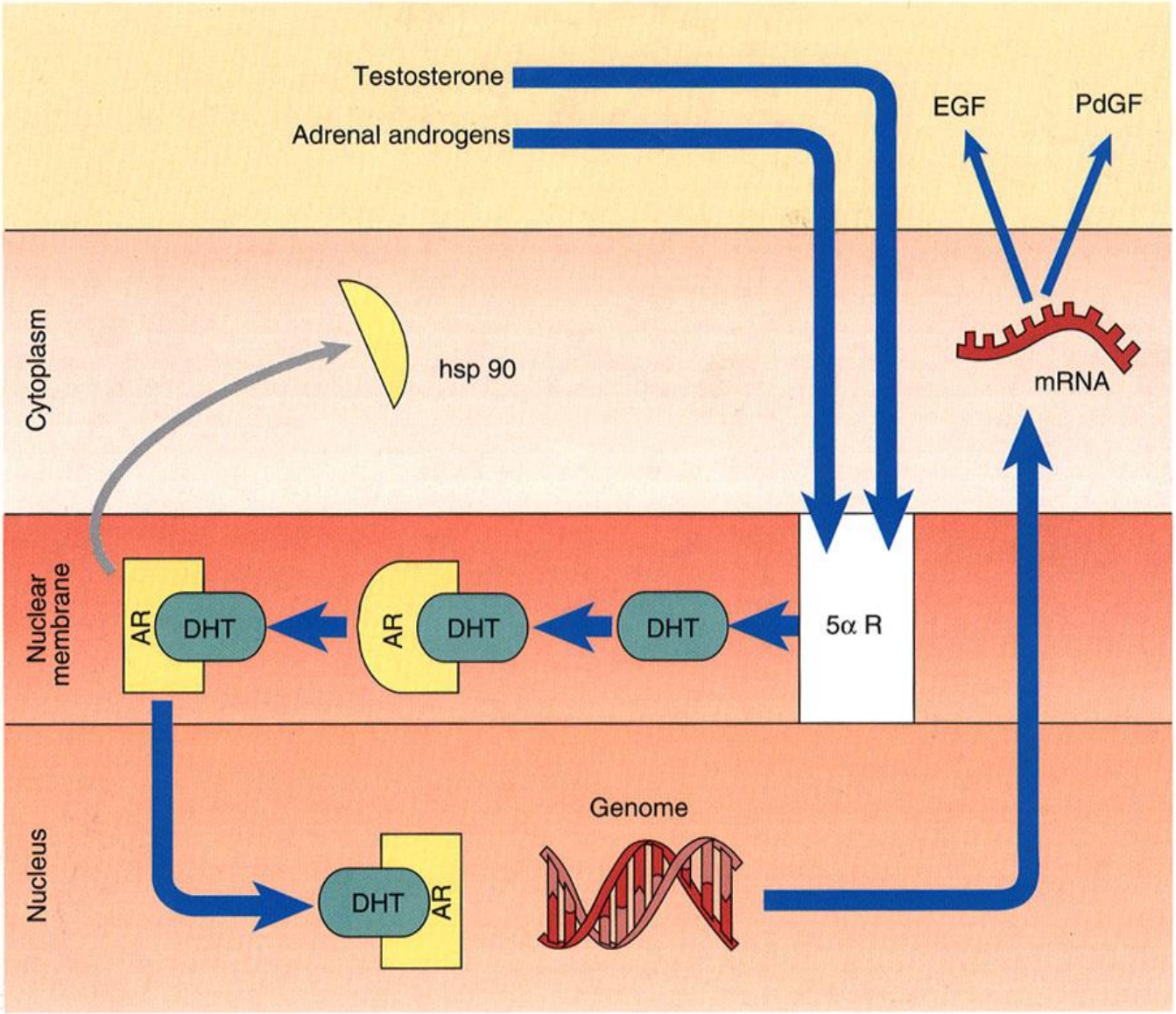
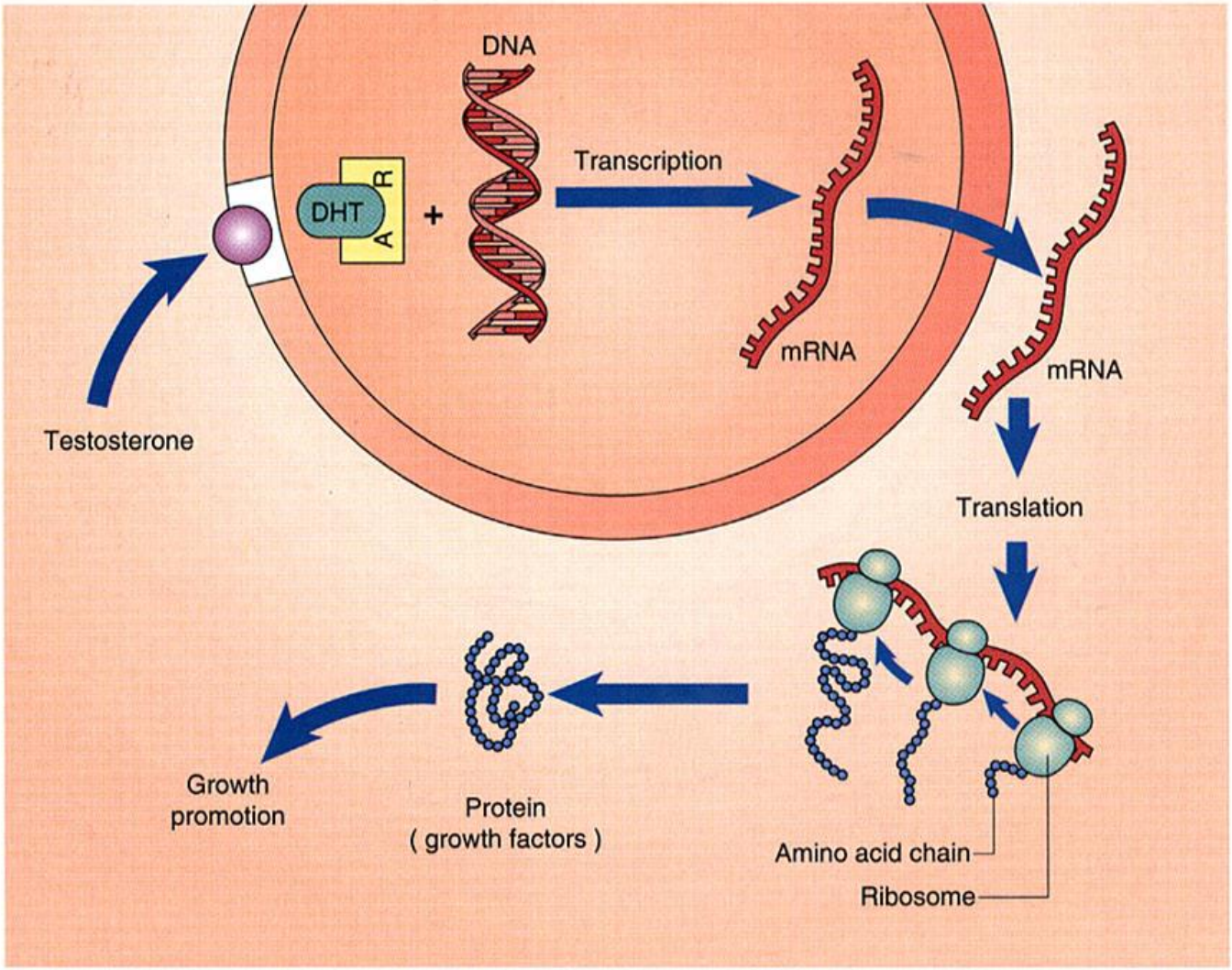


A. Pronephros is group of tubules emptying on either side into the primary nephric ducts, which extend caudad to discharge ultimately into the cloaca. Later in development a second group of tubules arises, more caudal in position than the pronephric tubules. B. Mesonephric tubules in their growth extend toward the primary nephric ducts and open into them. *C.* represents approximately the conditions attained by the human embryo toward the end of the 4th week. *D.* Depicts the conditions after sexual differentiation has taken place: female-left, male-right. Müllerian ducts arise during the 8th week, in close association with the mesonephric ducts. The müllerian ducts are the primordial tubes from which the oviducts, uterus, and vagina of the female are formed. Note that although both mesonephric and müllerian ducts appear in all young embryos, the müllerian ducts become vestigial in

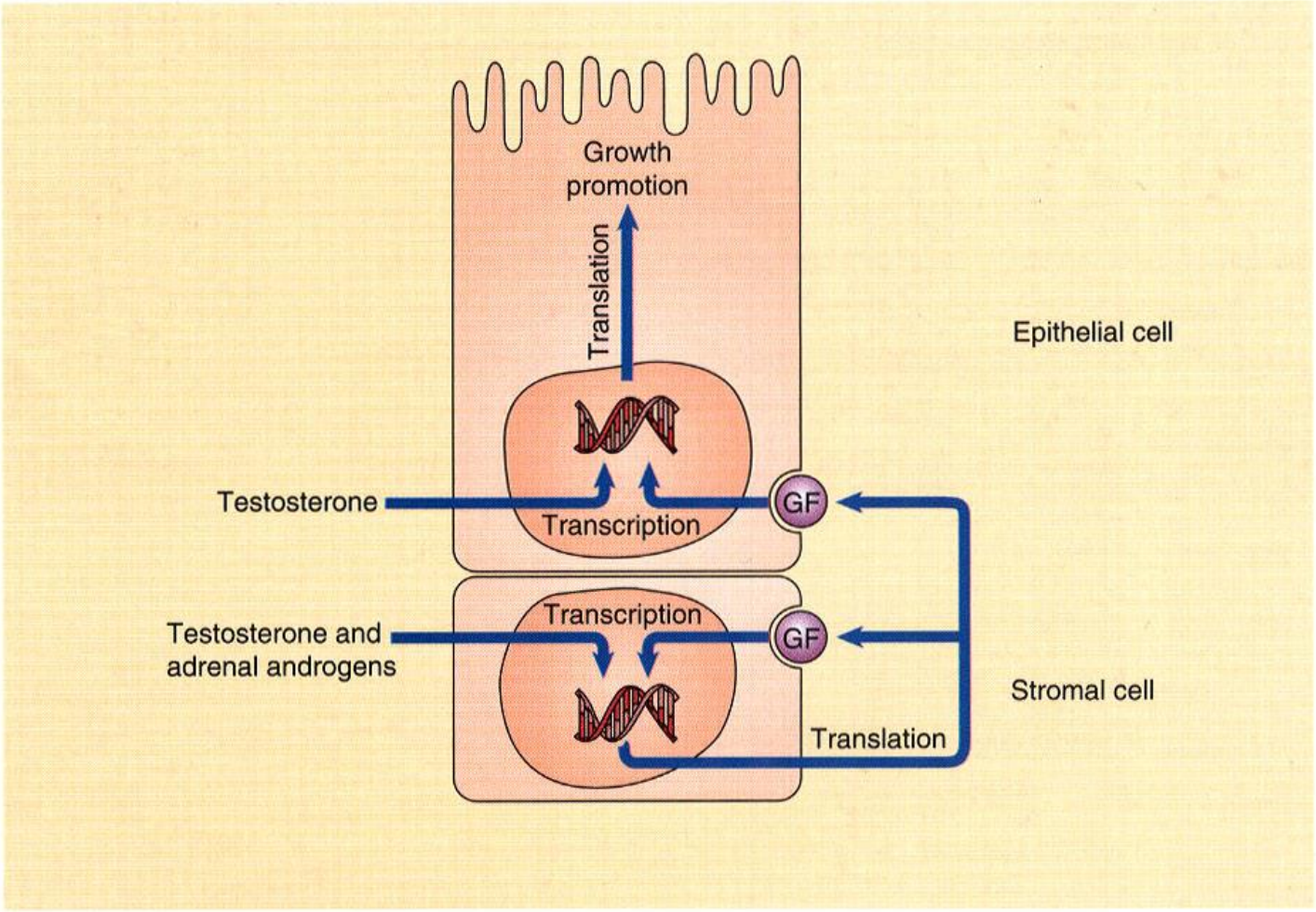

Testis
Negative feedback control
Testosterone (95%)
LH
LH-RH
Hypothalamus
Pituitary
ACTH
Prostate
Negative feedback control
Adrenal androgens (5%)
Adrenal glands



Testosterone (T) enters prostatic cells by simple diffusion. The enzyme 5-alpha reductase type II (5-alpha RII), which is located on the nuclear membrane, metabolizes T to dihydrotestosterone (DHT), a more active androgen. DHT then binds to the androgen receptor (AR) of the genome that releases heat-shock protein 90 (hsp 90) and stimulates the transcription of androgen-inducible genes, including growth factors such as epidermal growth factor (EGF) and platelet-derived growth factor (PdGF)



Following androgen stimulation of the genome, messenger ribonucleic acid (mRNA) is produced and translated into the specific protein sequences that encode growth factors, such as epidermal growth factor (EGF) and platelet-derived growth factor (PdGF). These molecules bind to their specific receptors located on the cell membrane, and induce growth and cell division of prostatic epithelium and stroma.



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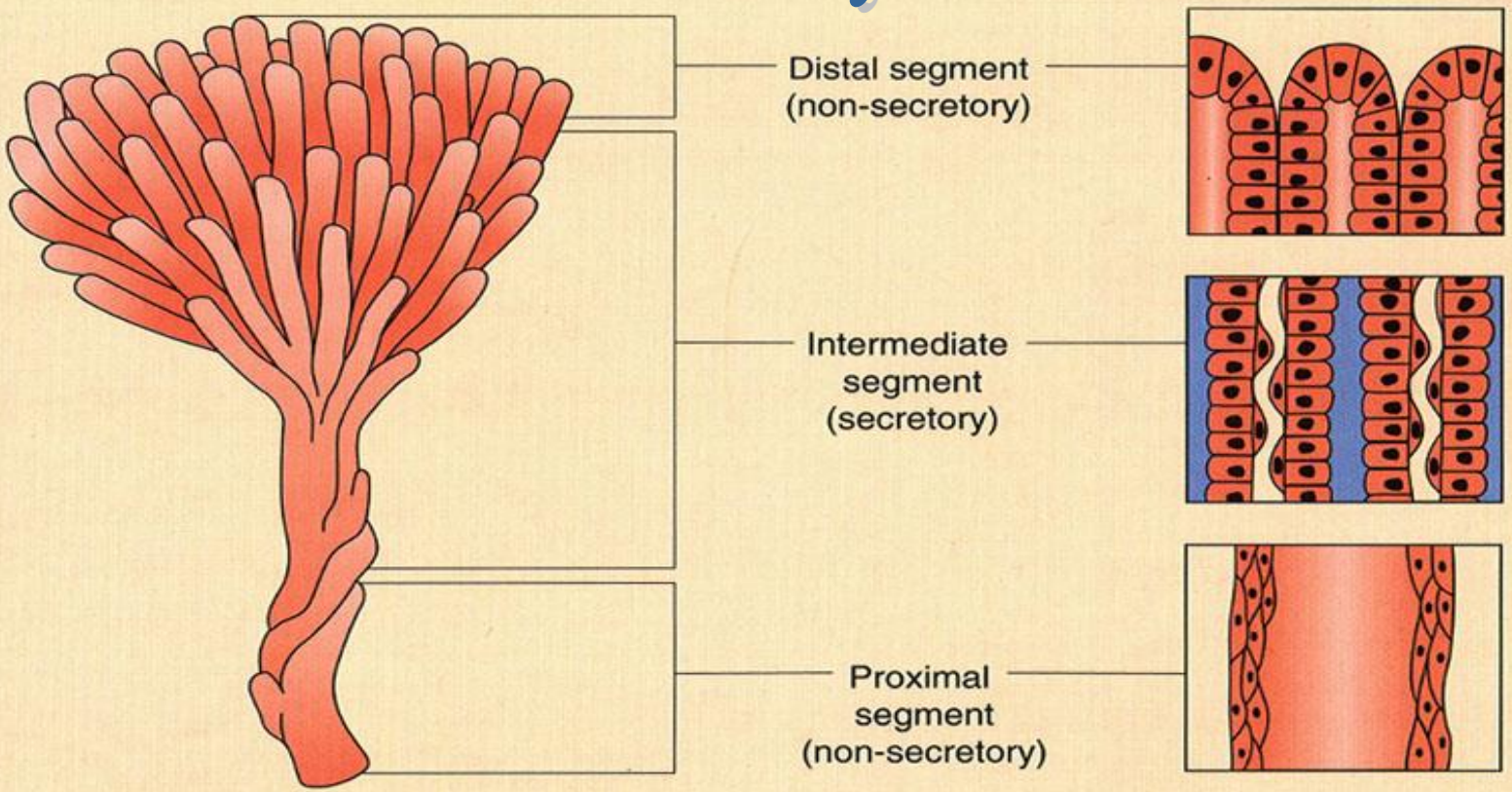
Prostate Anatomy: Arborization



Prostatic ducts arborize throughout the gland and terminate in acini which secrete, among other things, prostate-specific antigen (PSA) into the lumina and thence into the prostatic urethra. New cells are formed in the distal segments of the ducts whereas the intermediate section is secretory in function. In the proximal segment, epithelial cells become flattened and undergo programmed cell death (apoptosis)

SUMMARY OF THE ANATOMY AND CELL BIOLOGY OF THE PROSTATE GLAND

Components	Properties
Development	
Seminal vesicles	From wolffian ducts via testosterone stimulation
Prostate	From urogenital sinus via dihydrotestosterone stimulation
Prostate Zones	
Anterior fibromuscular	30% of prostate mass, no glandular elements, smooth muscle
Peripheral	Largest zone, 75% of prostate glandular elements, site of carcinomas
Central	25% of prostate glandular elements, surrounds ejaculatory ducts, may be of wolffian duct origin, seminal vesicle–like
Preprostatic transition	
	Smallest, surround upper urethra, complex, sphincter
	5% of prostate glandular elements, site of benign prostatic hyperplastic
	15% to 30% of prostate volume
Epithelial Cells	
Basal	Small undifferentiated, keratin-rich (types 4, 5, 6) pluripotent cells, less than 10% of epithelial cell number
Transient proliferating	Incorporate thymidine
Columnar secretory	Terminal differentiated, nondividing, rich in acid phosphatase and prostate-specific antigen. 20 μm tall, most abundant cell, keratin types 8, 18, 19.
Neuroendocrine cells	Serotonin rich, APUD type
Stroma Cells	
Smooth muscle	Actin-rich, myosin
Fibroblast	Vimentin-rich and associated with fibronectin
Endothelial	Associated with fibronectin, alkaline phosphatase–positive
Tissue Matrix	
Extracellular	
Basement membrane	Type IV collagen meshwork, laminin-rich, fibronectin
Connective tissue	Type I and type III fibrillar collagen, elastin
Glycosaminoglycans	Sulfates of dermatan, chondroitin, and heparin; hyaluronic acid
Cytomatrix	Tubulin, actin, and intermediate filaments of keratin
Nuclear matrix	DNA tight-binding proteins, RNA and residual nuclear proteins

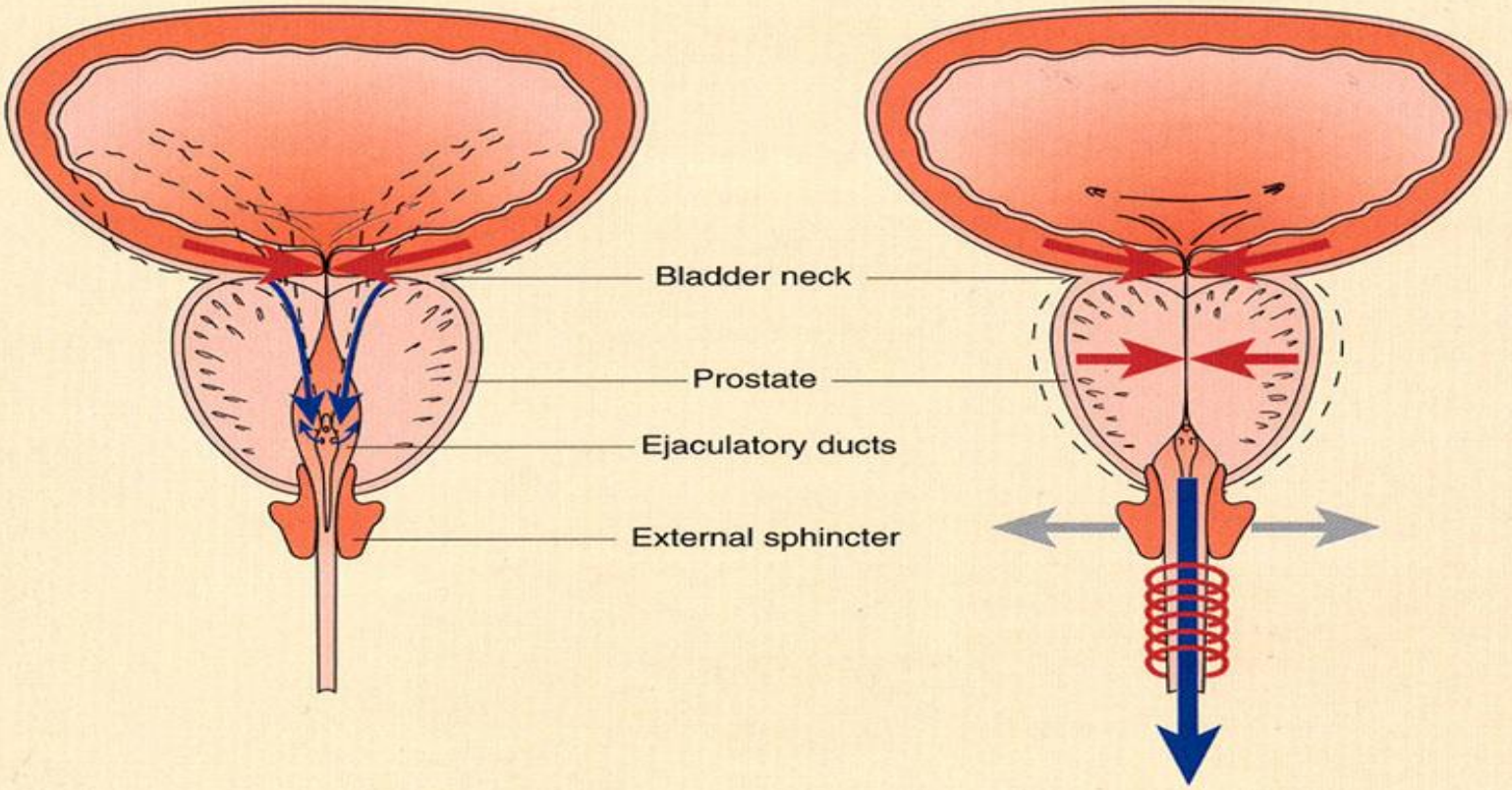
Prostate Function

- Seminal Fluid production… 1st part of ejaculate, 0.5 cc with spermatozoa (1% of total ejaculate)
- PSA spermatozoa motility factor
- Ejaculation
- House urethra
- Conduit for ejaculatory ducts

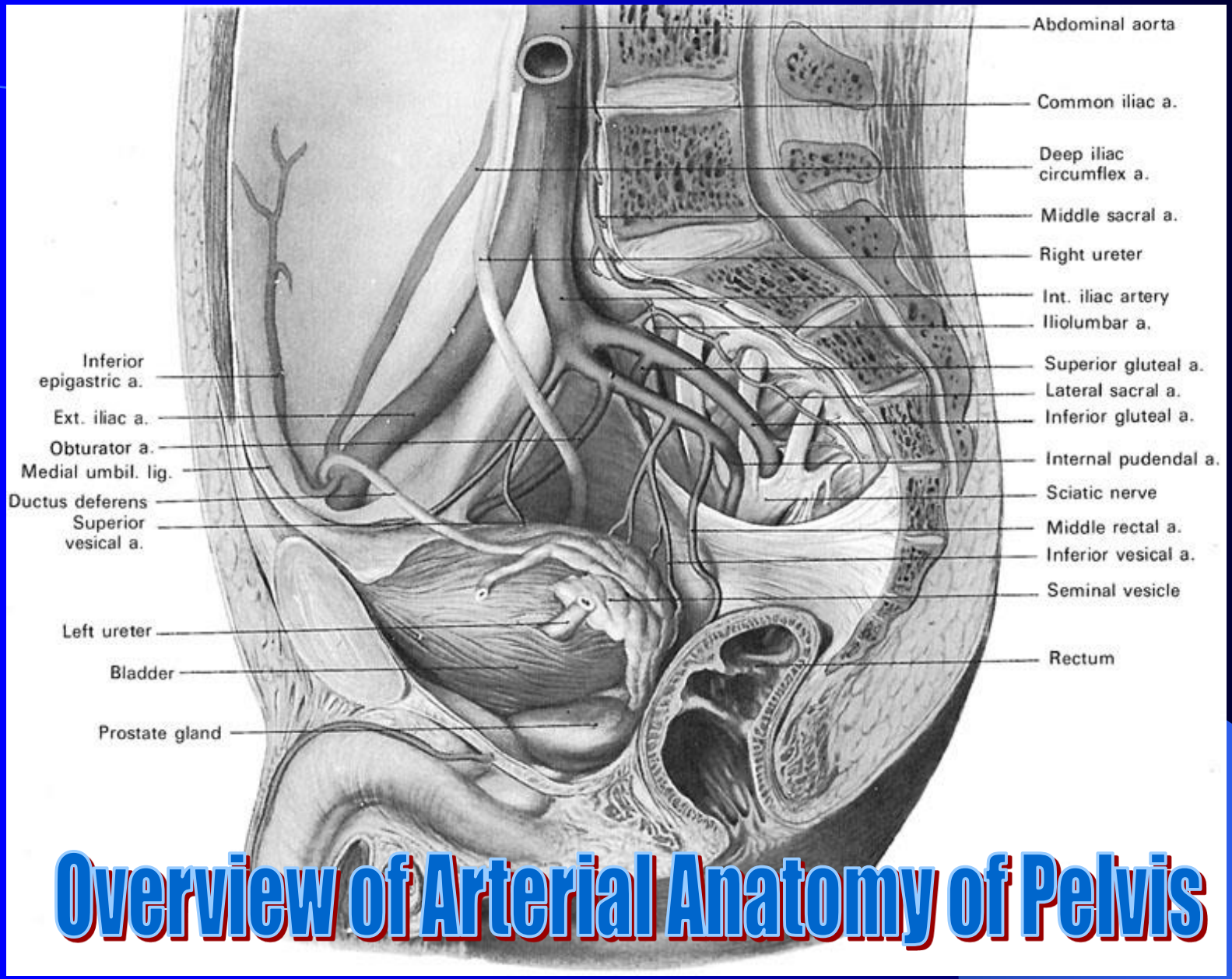
Seminal Vesicle Function

- Seminal fluid production… later fraction of ejaculate, 1.5-2.5 cc
- 50-80% of ejaculate,ph..neutral to alkaline
- fructose production… spermatozoa energy source (ketone reduction > fructose)
- Contains Prostaglandins E, A , B, F and Semenogelin 1 motility inhibitor cleaved by PSA after ejaculation

Prostate/Seminal Vesicle Function:Ejaculation

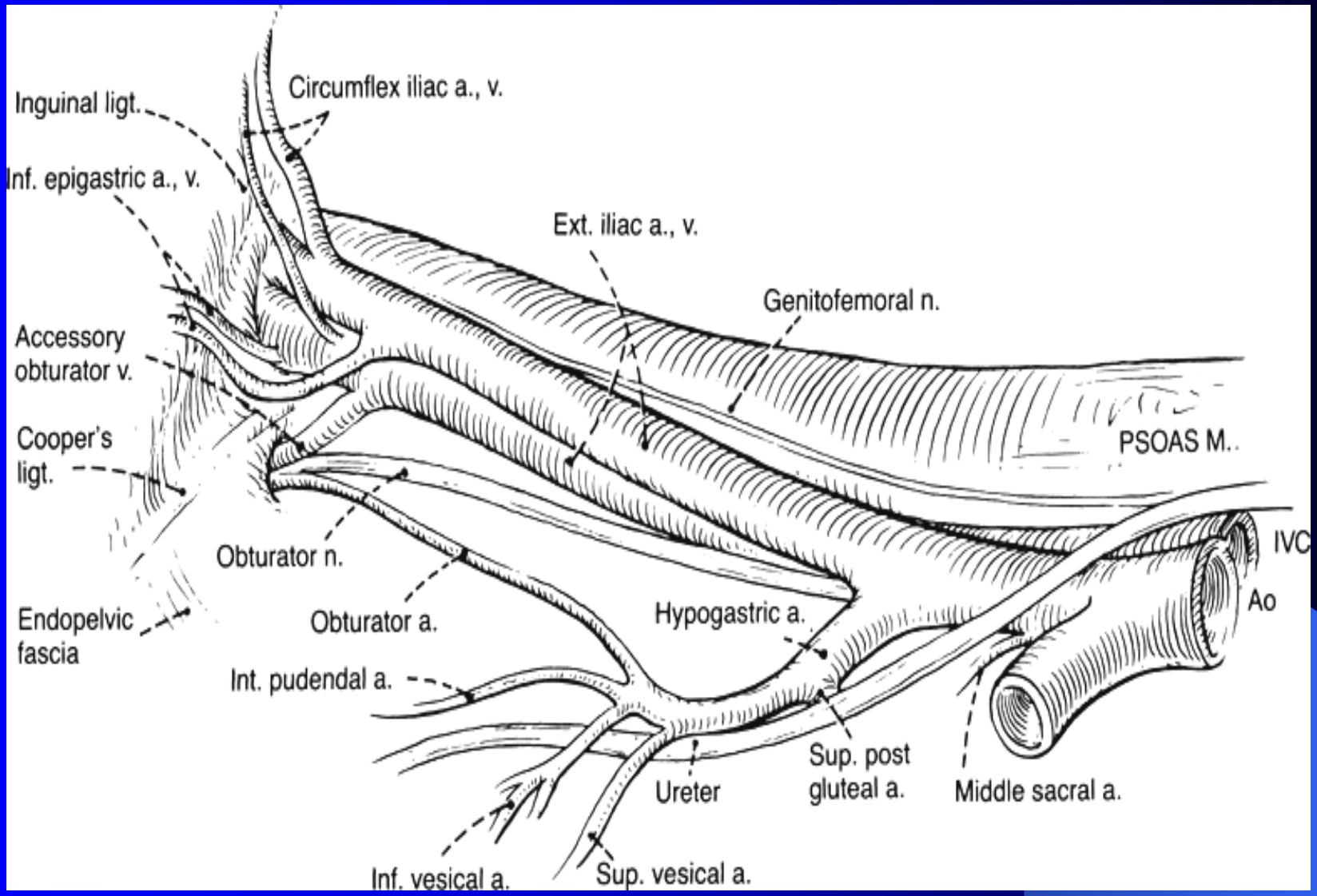


The mechanism of ejaculation is a complex neurophysiological process which involves contraction of the prostate and seminal vesicles, which empty their contents into the prostatic urethra. At the same time, the bladder neck closes to create a 'pressure chamber'. Rhythmic relaxation of the distal urethral sphincter and contractions of the bulbocavernous muscles around the bulbar urethra result in a pulsatile expulsion of a mixture of seminal and prostatic fluid

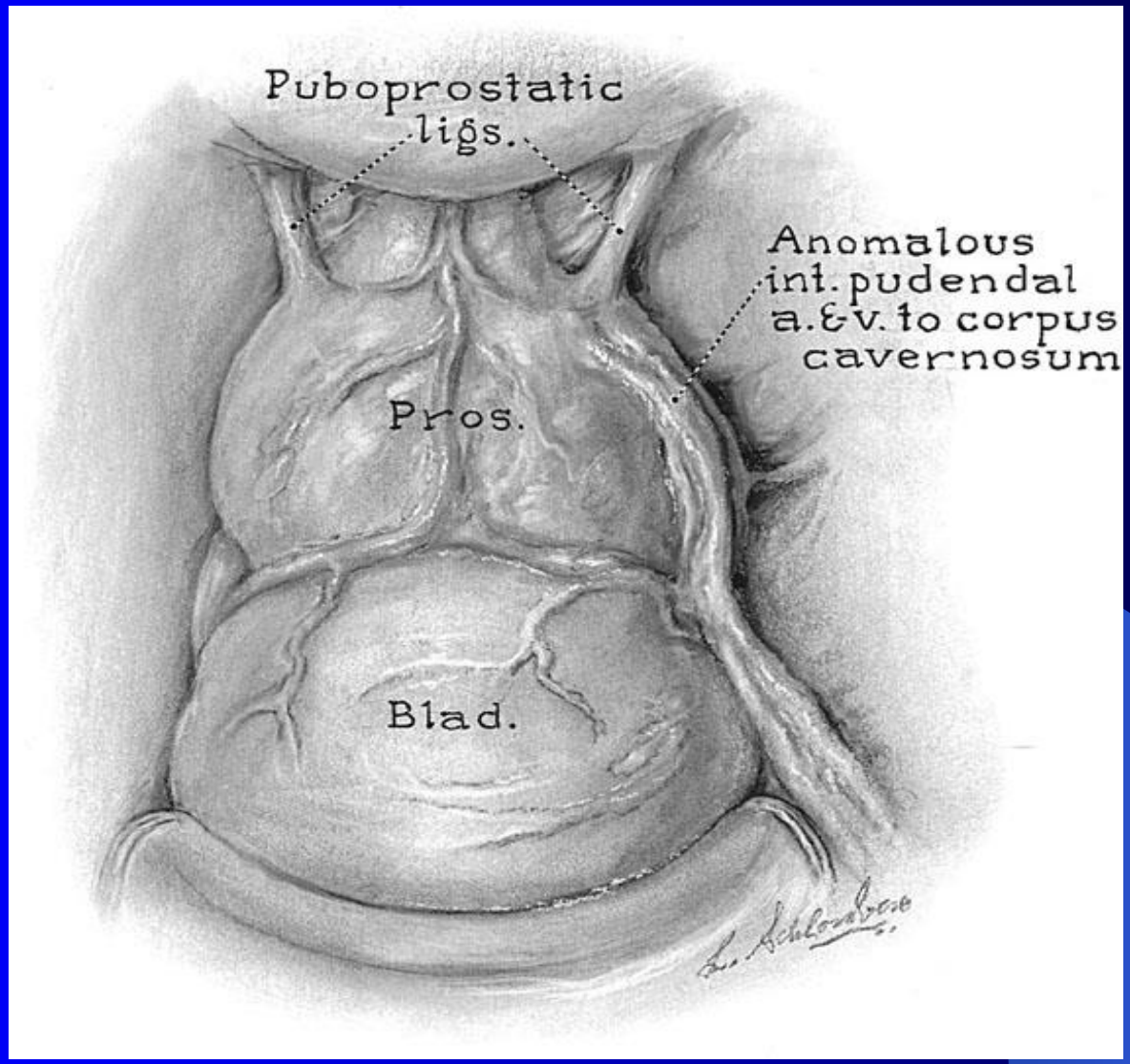


Overview of Arterial Anatomy of Pelvis

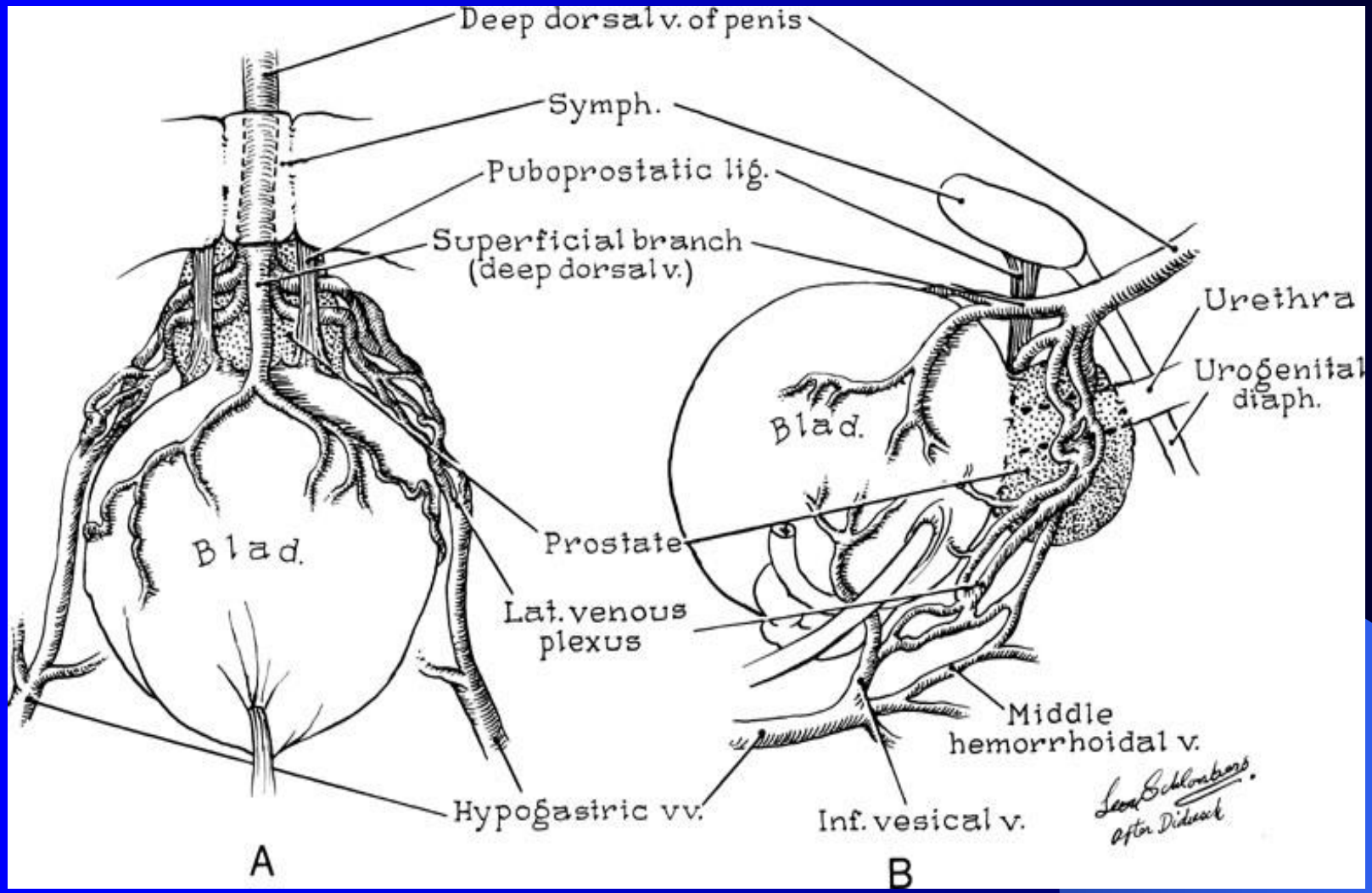
Arterial Anatomy of the Prostate and Seminal Vesicle



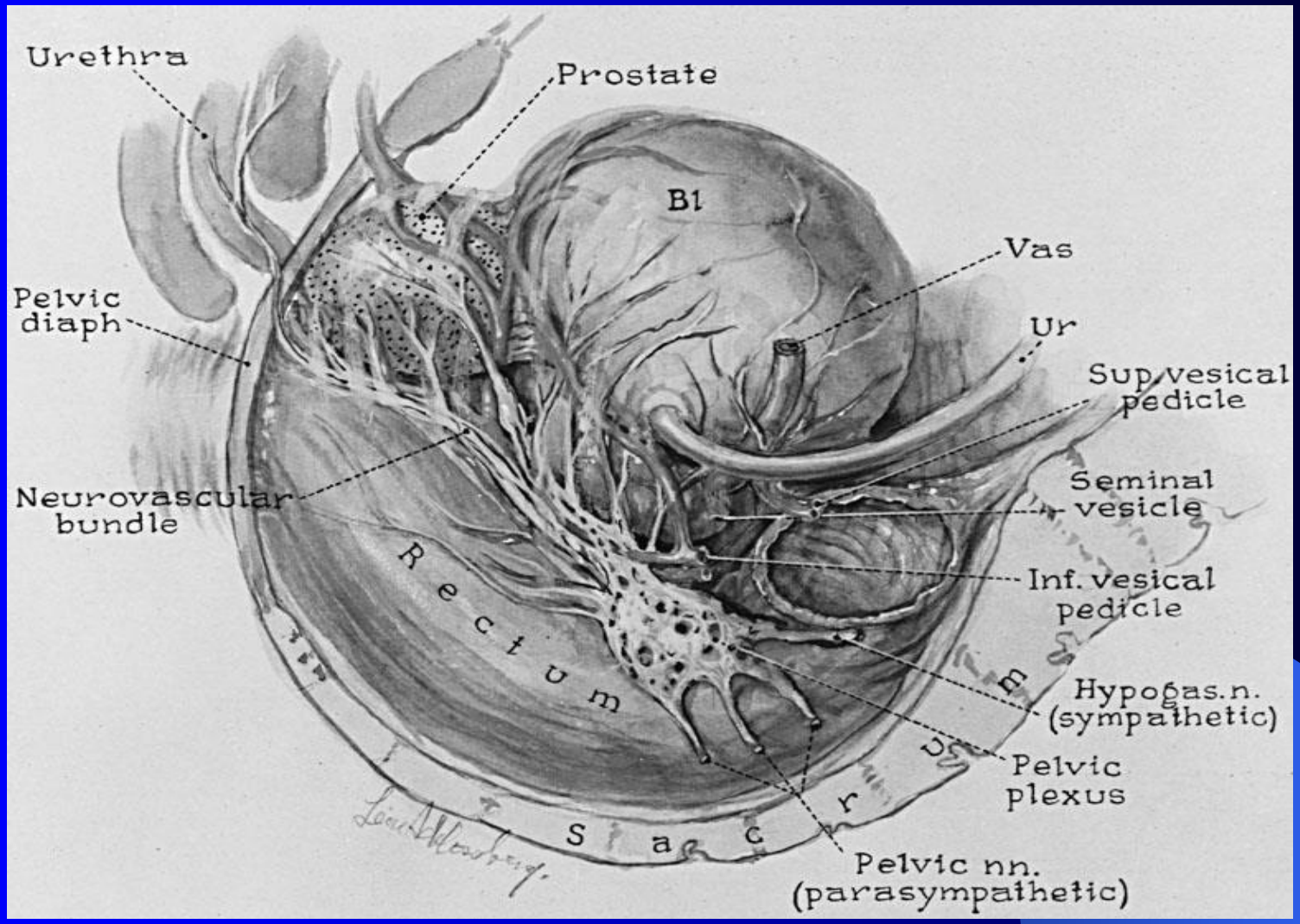
Anterior View… Vascular Anatomy and Anomaly



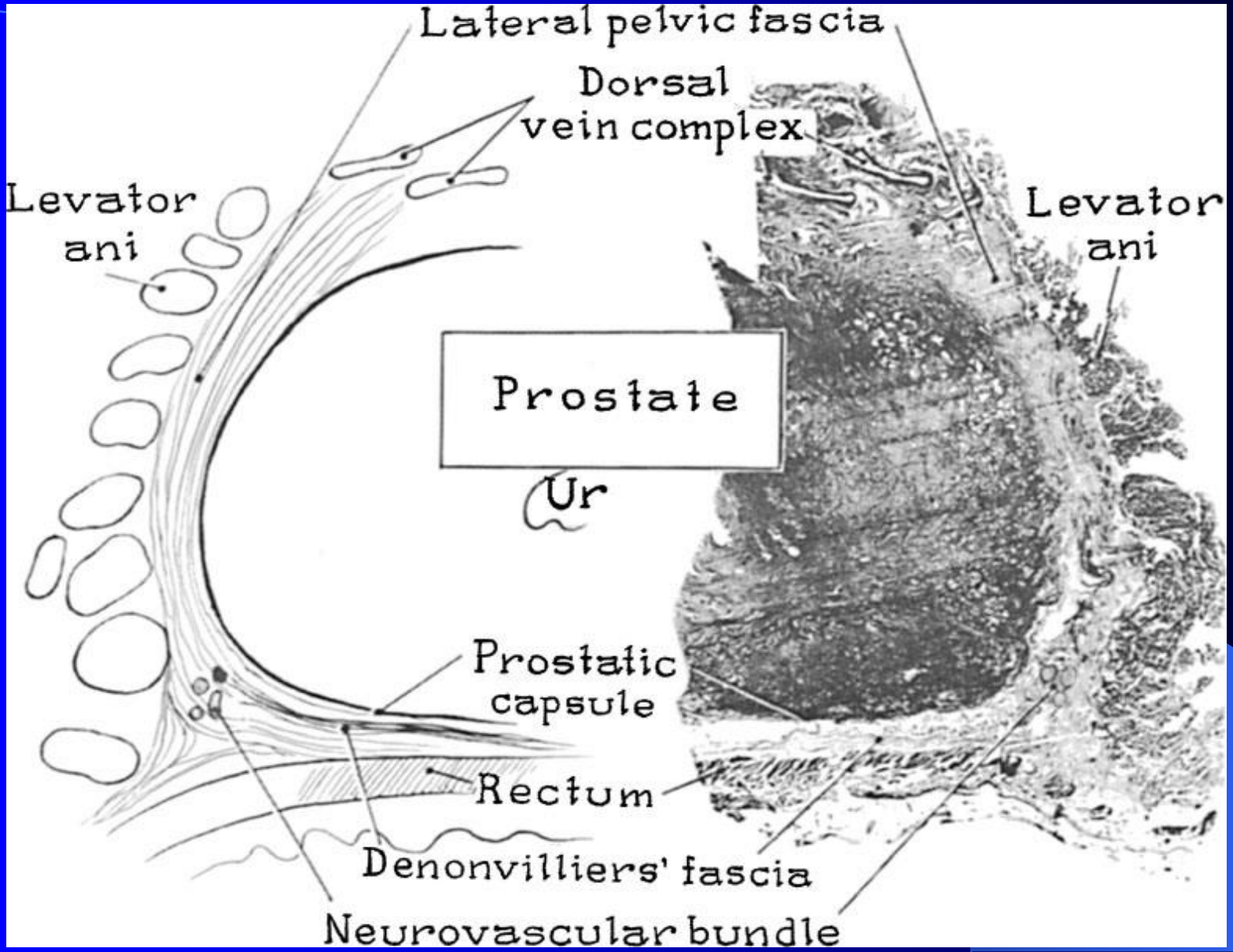
Venous Anatomy of Prostate and Seminal Vesicle



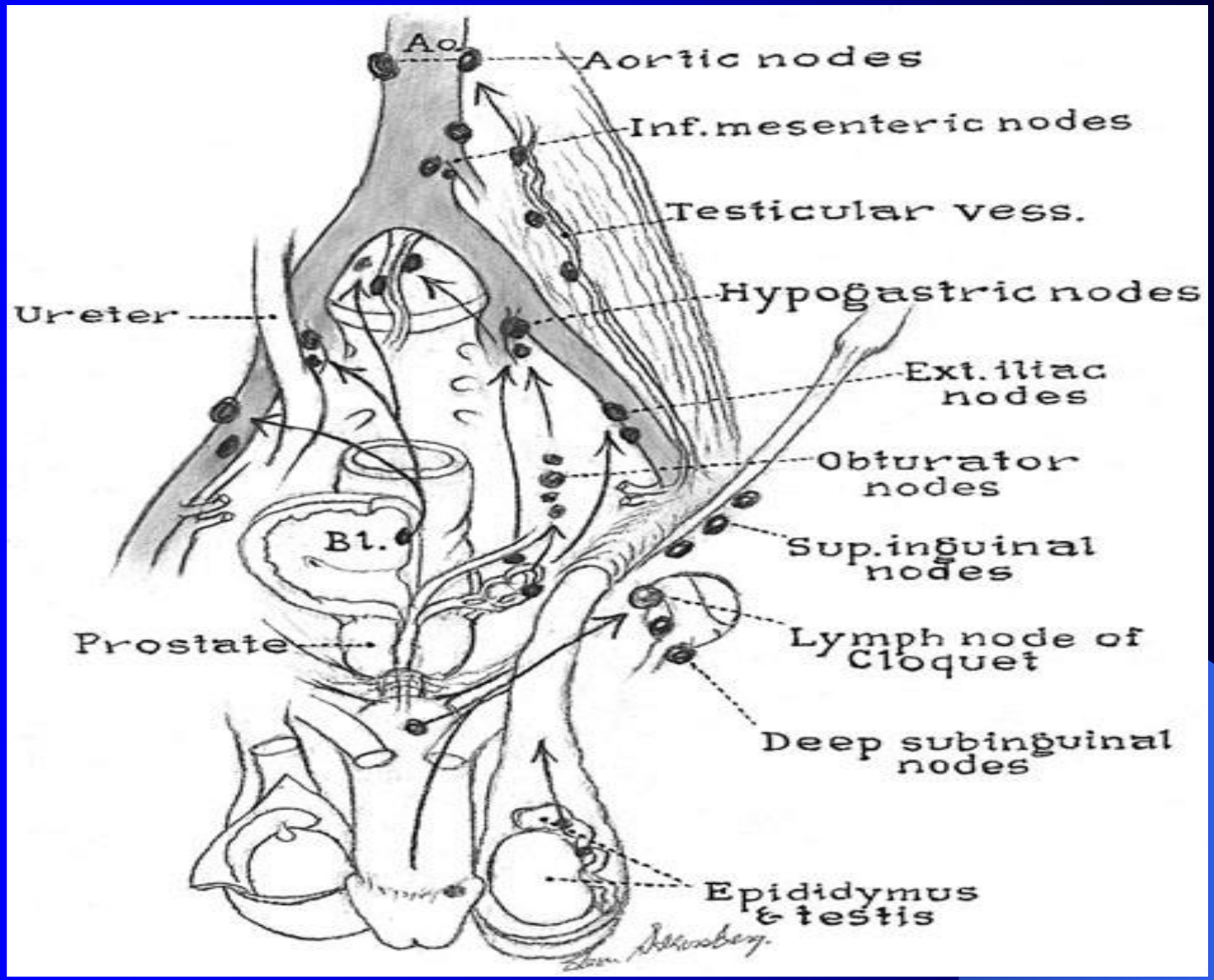
Neurovascular Anatomy of Prostate and Seminal Vesicle



Neurovascular Bundle in Cross-Section



Lymphatic Drainage of Prostate and Seminal Vesicles



Seminal Vesicle…Vascular and General Description

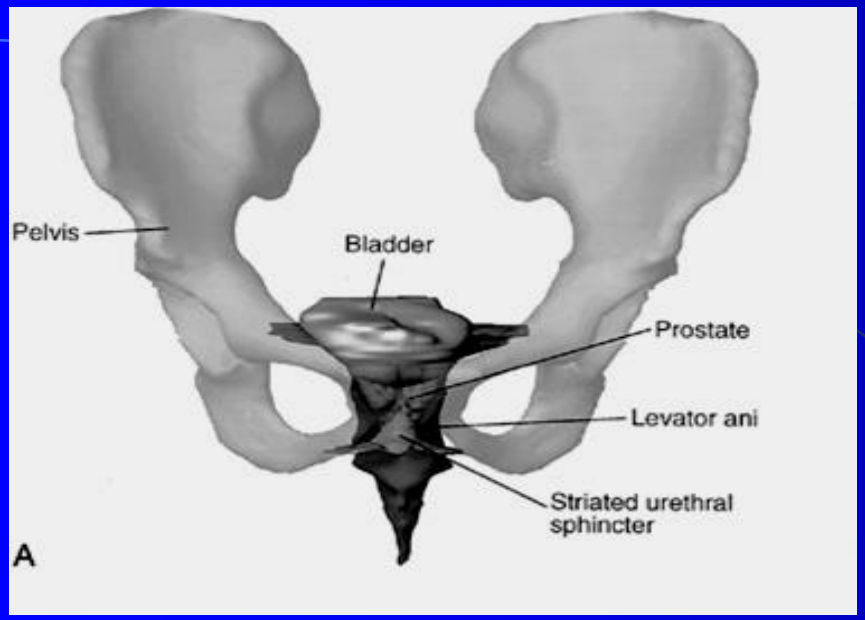
- Five to Ten cm in length and three to five cm in diameter
- Volume averages 13 ml, lumen < 2.3mm nl
- Right gland > Left in 1/3 of men, both decrease with age
- Thick muscular coat does not extend to ejaculatory duct
- Artery from vesiculodeferential artery branch of umbilical artery, vein is same +inferior venous plexus
- Innervation is from pelvic plexis + hypogastric

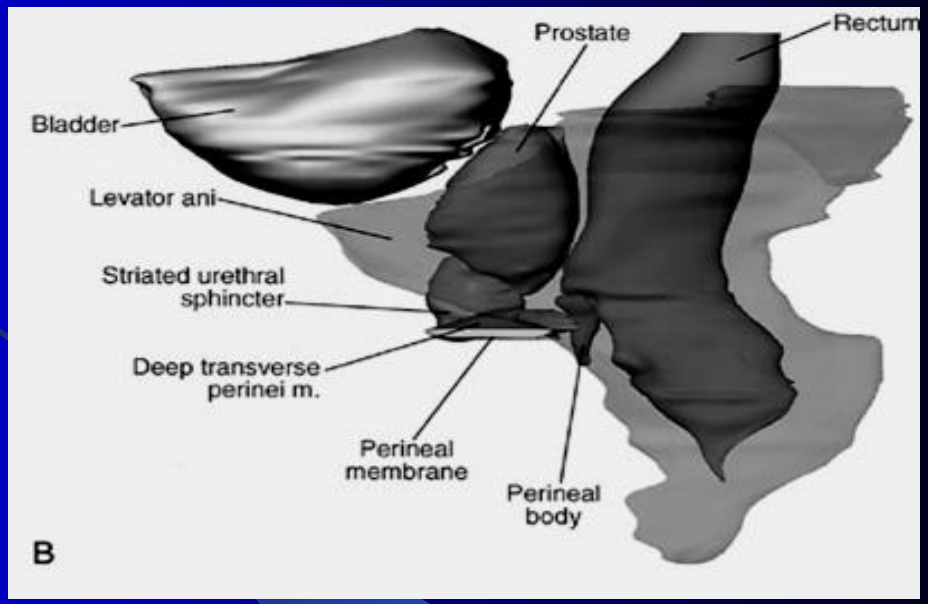
Pelvic Fascia

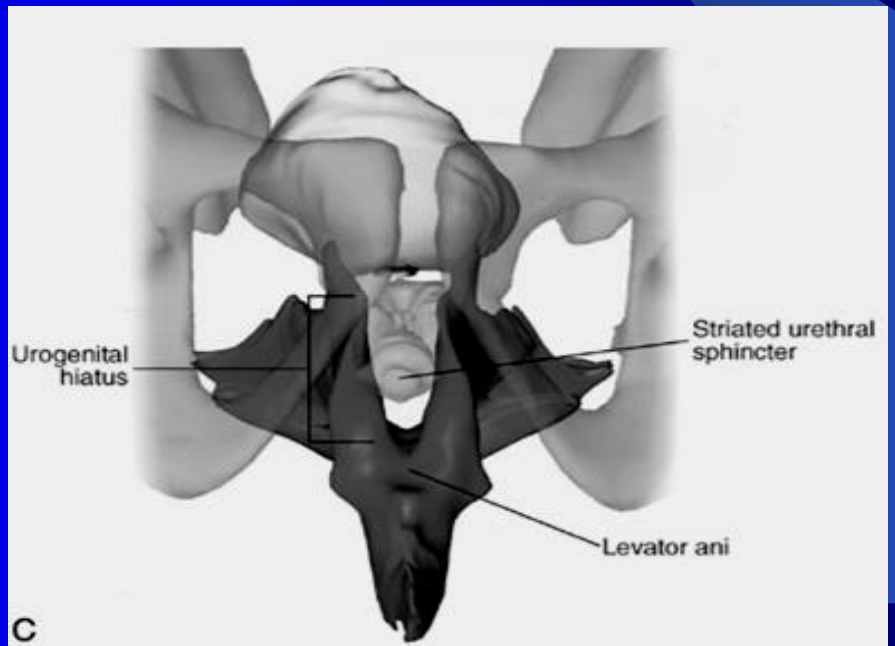
- First, Anteriorly Puboprostatic ligaments attach prostate to pubis
- Second, Laterally arcus tendineus fascia pelvis extends from the puboprostatic ligament to the ischial spine
- Third, Posterior to the ischial spine the fascia fans out to either side of the rectum and attaches to the pelvic side wall as the lateral and posterior vesicle ligaments

See figures 2.10, 2.11, 2.12, 2.13 in Campbell's Urology

Anatomical Relationships to Continence Mechanism







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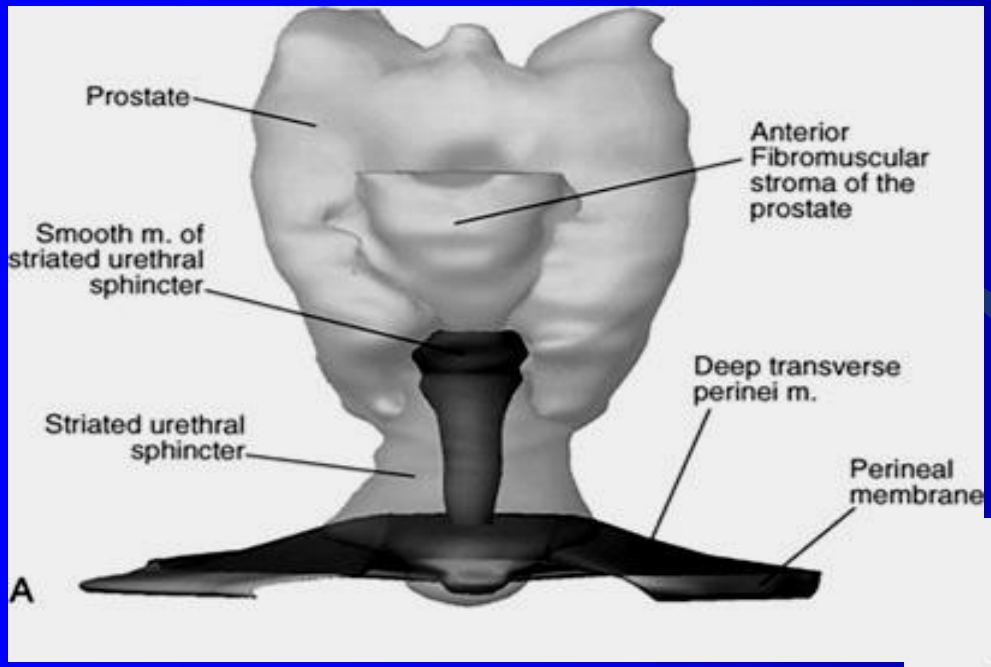
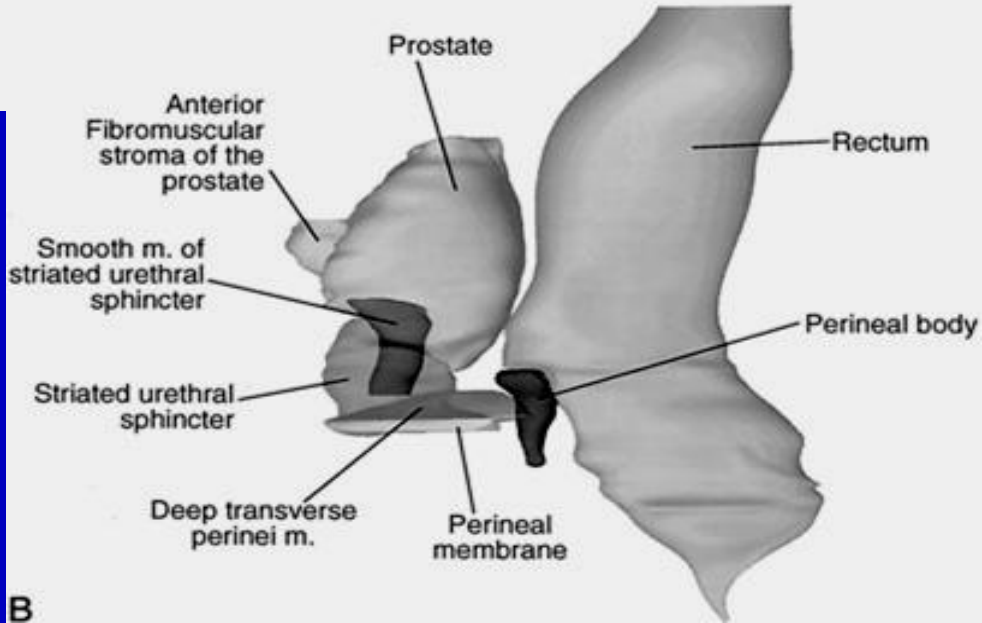




Analysis of 64 gross specimens…. ESUS, RRP, The Apex

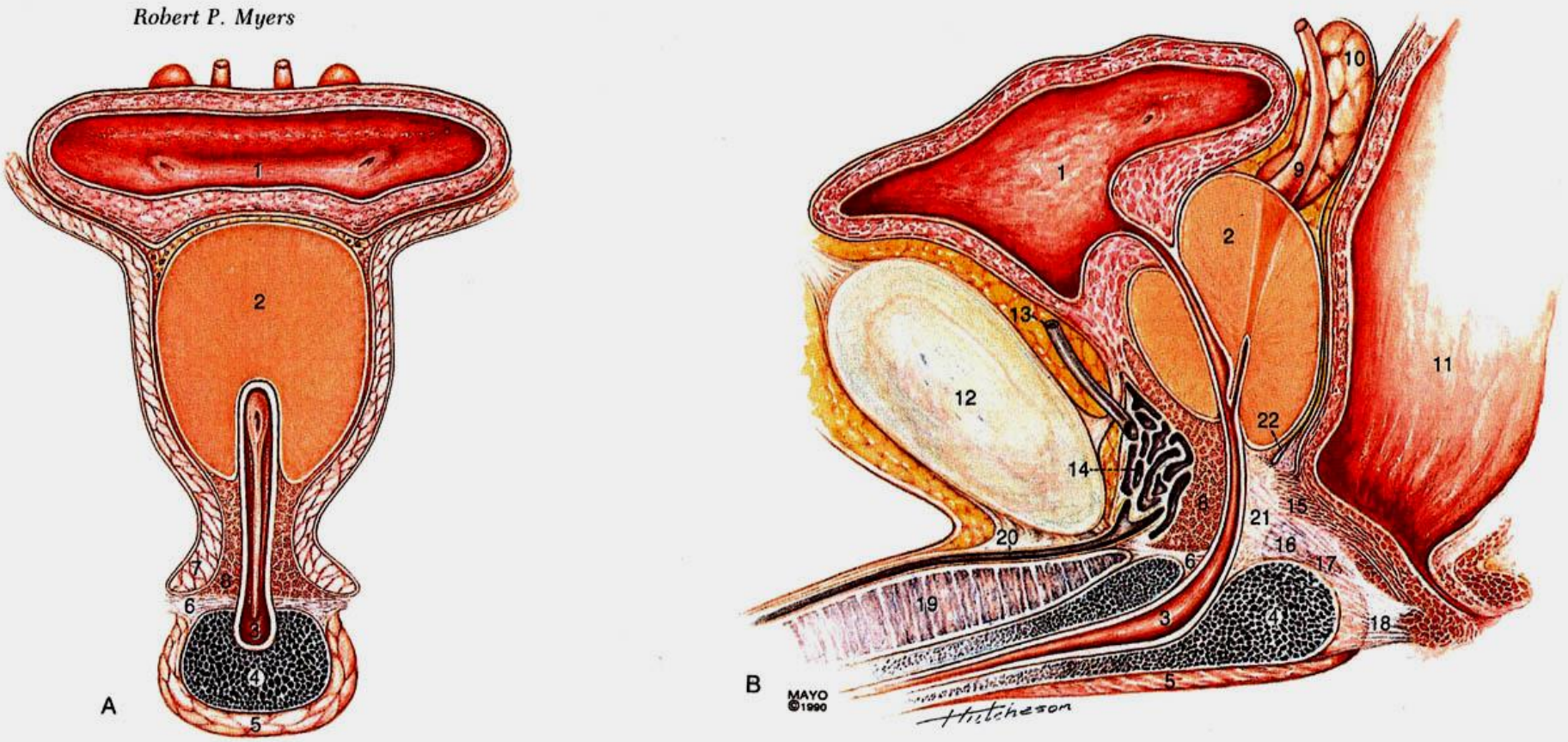
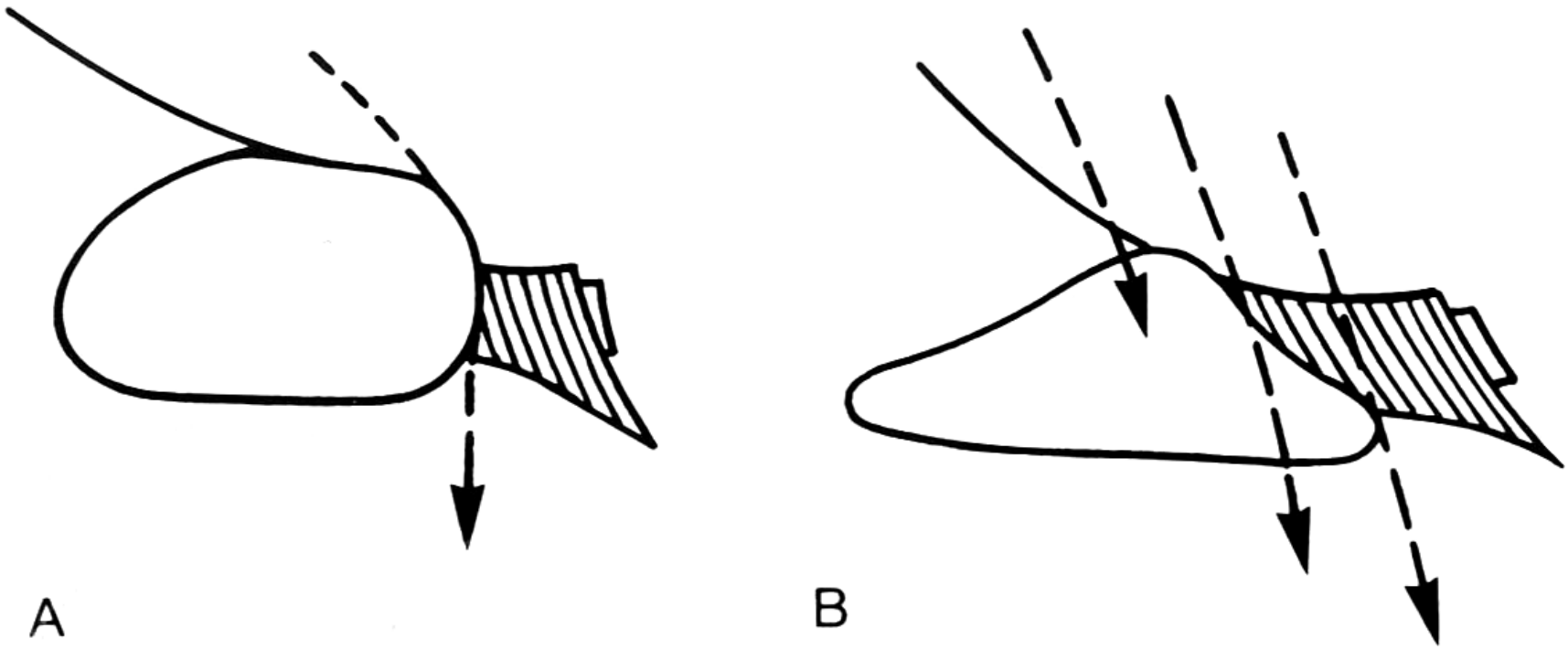


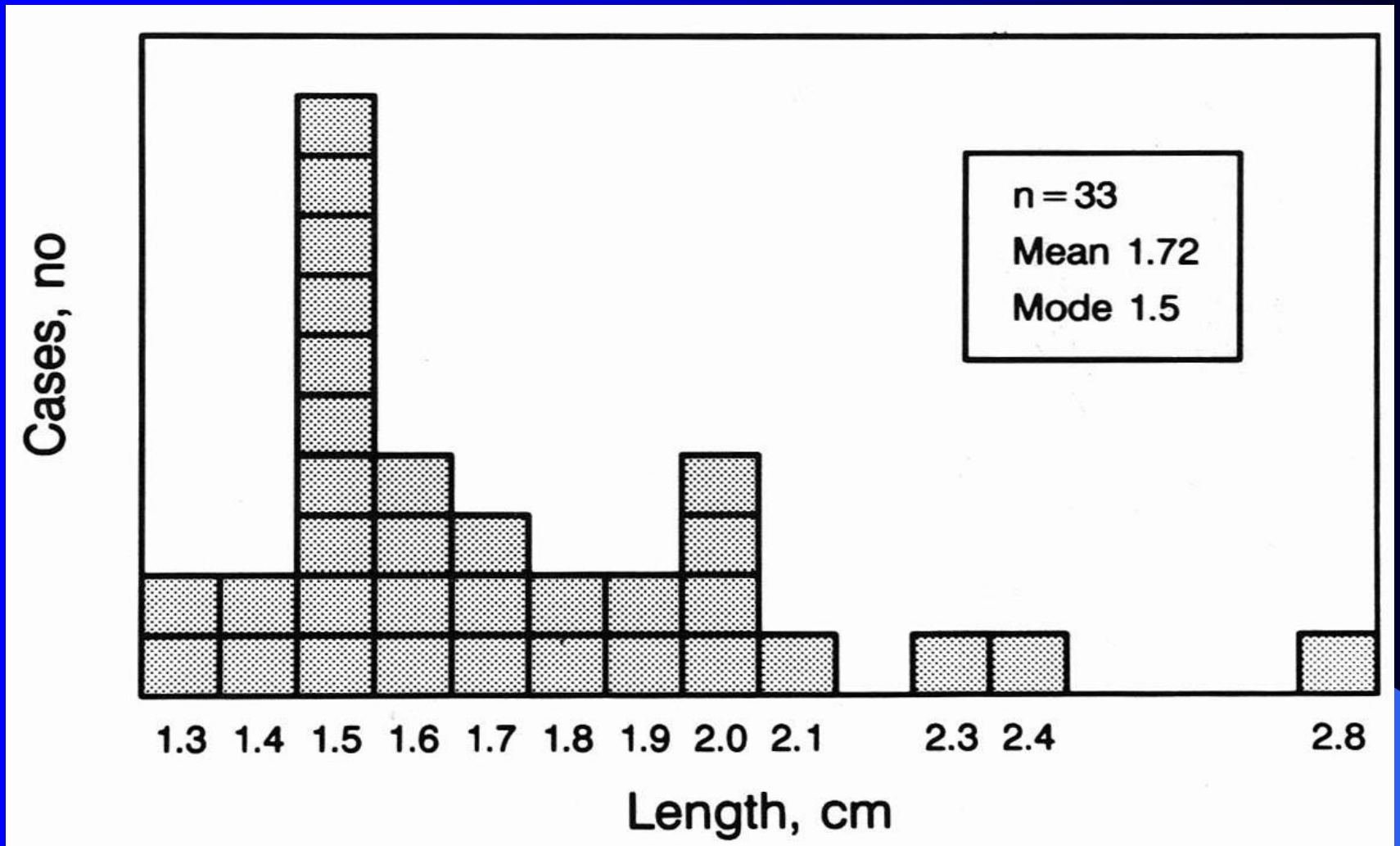
Figure 1. Sections through the prostate. *A*, Coronal. *B*, Sagittal midline. 1 = Urinary bladder, 2 = prostate, 3 = urethra, 4 = corpus spongiosum, 5 = bulbospongiosus muscle, 6 = perineal membrane, 7 = levator ani muscle, 8 = striated urethral sphincter, 9 = ductus deferens, 10 = seminal vesicle, 11 = rectum, 12 = symphysis pubis, 13 = superficial preprostatic vein, 14 = deep venous plexus, 15 = rectourethral muscle, 16 = bulbourethral gland, 17 = deep transverse perineal muscle, 18 = central tendon of the perineum, 19 = corpus cavernosum, 20 = dorsal penile vein, 21 = midline fibrous raphe, 22 = Denonvilliers' fascia. (By permission of Mayo Foundation.)

Meyers, R P, et al; J. Urol., 138: 543-550, 1987.

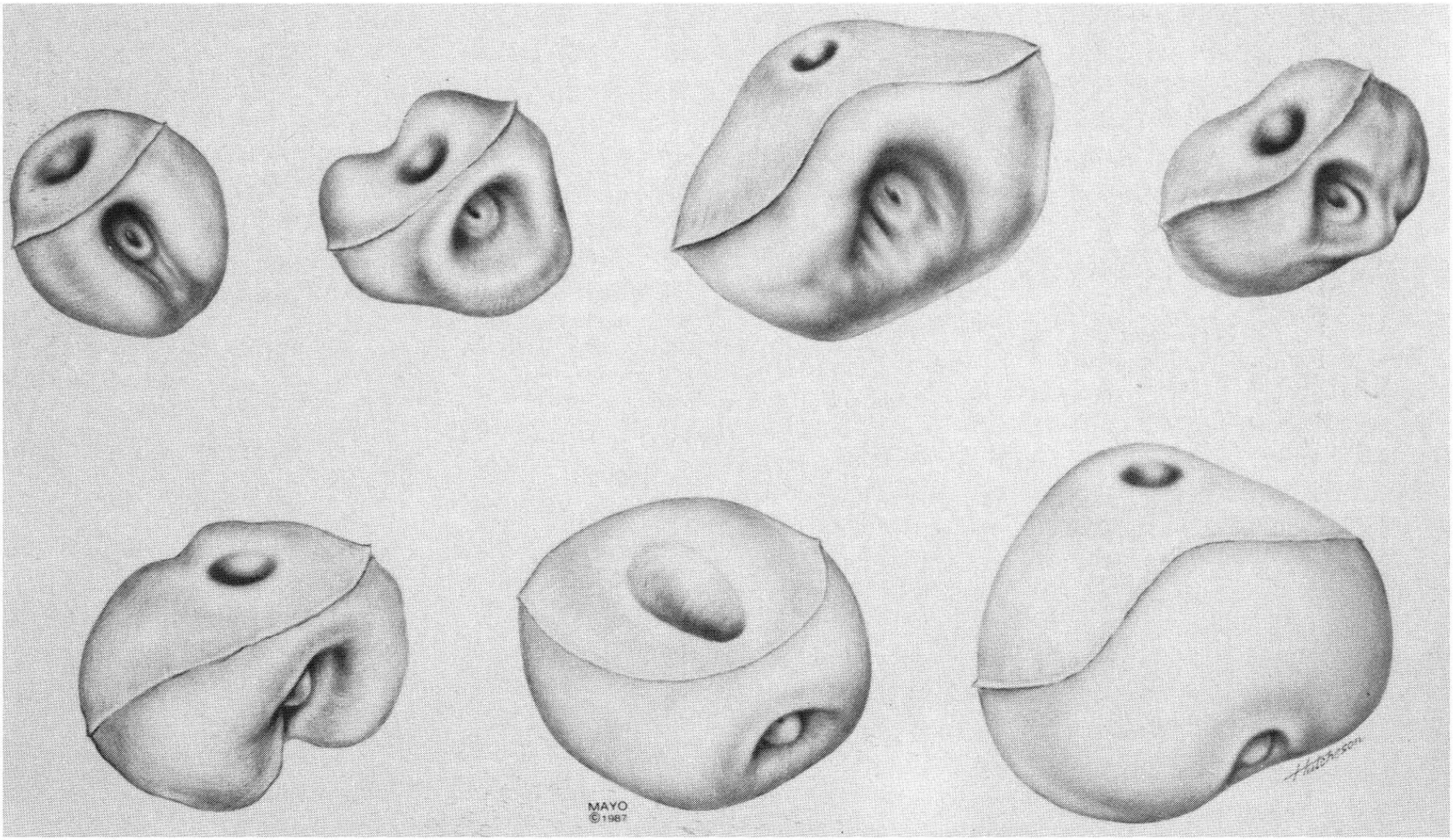


Lateral views of "doughnut" *(A)* and "croissant" *(B)* prostates relative to apical urethral transection. (See text.)

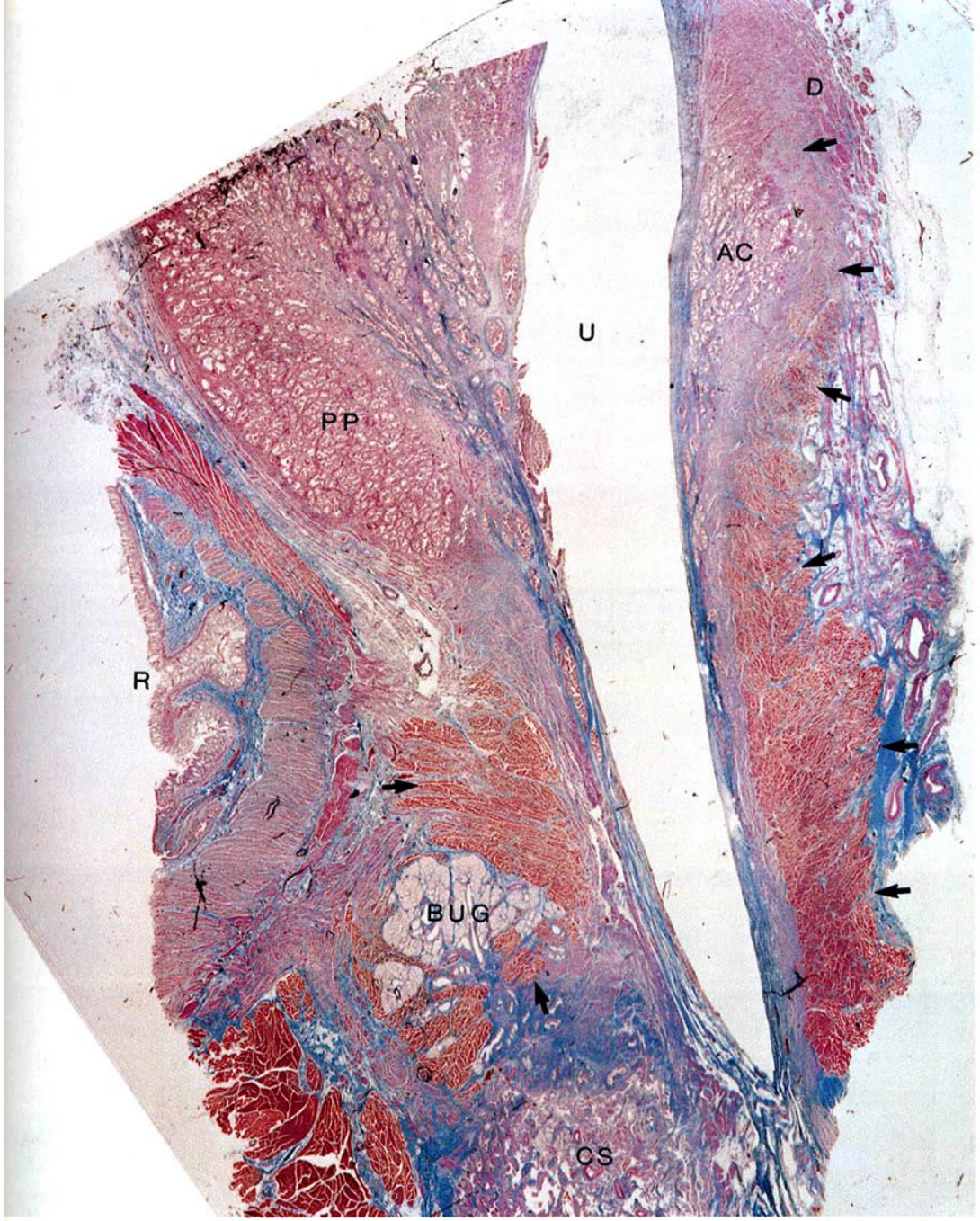
Mean Length of the External Straited Urethral Sphincter (ESUS) in 33 Cadavers



Distribution of anterior lengths of M. sphincter urethrae, NA.

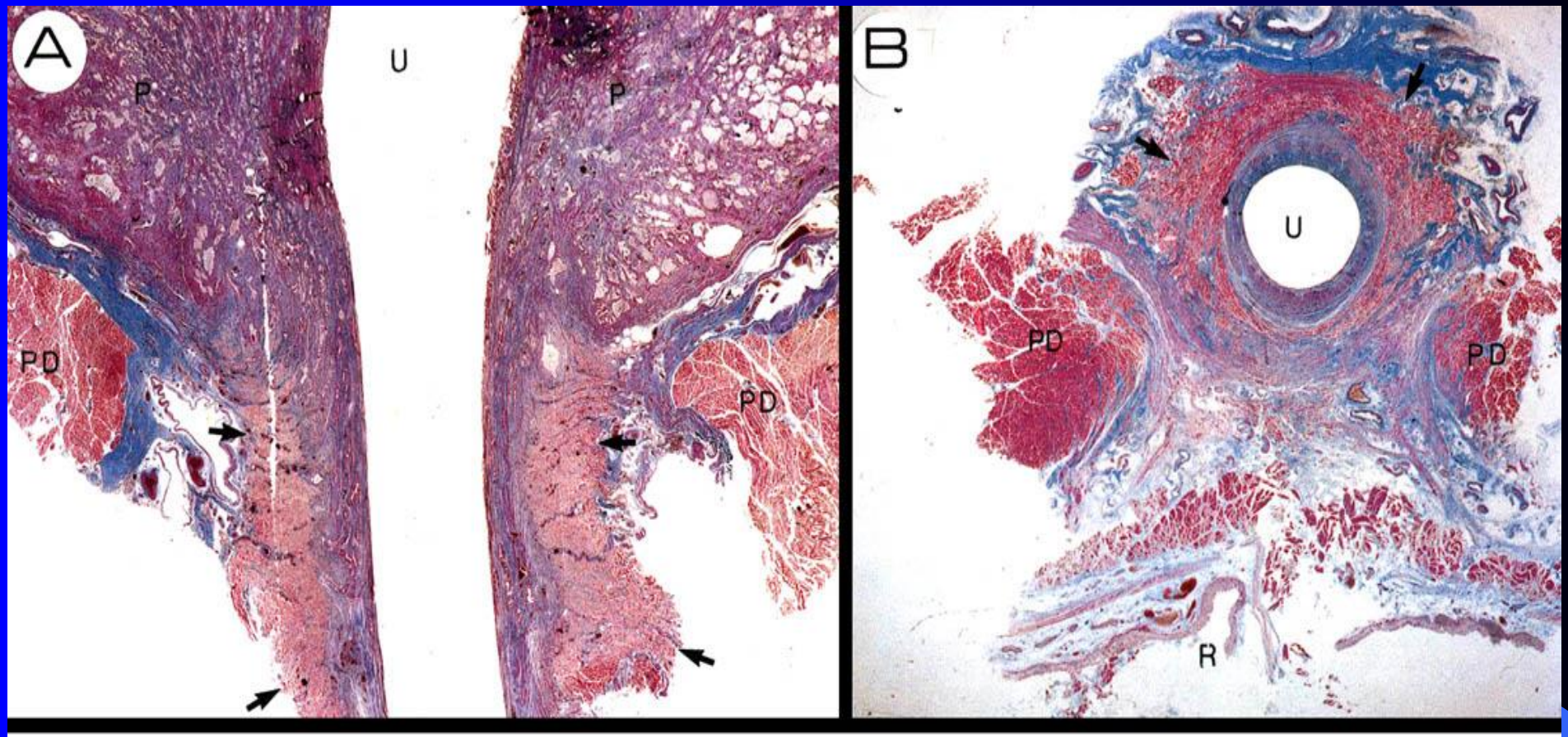


Diversity of prostatic shape. Top row shows prostates with anterior apical notches. Bottom row shows prostates without anterior apical notches. Fascial boundary of prostatovesical junction is delineated on each prostate.

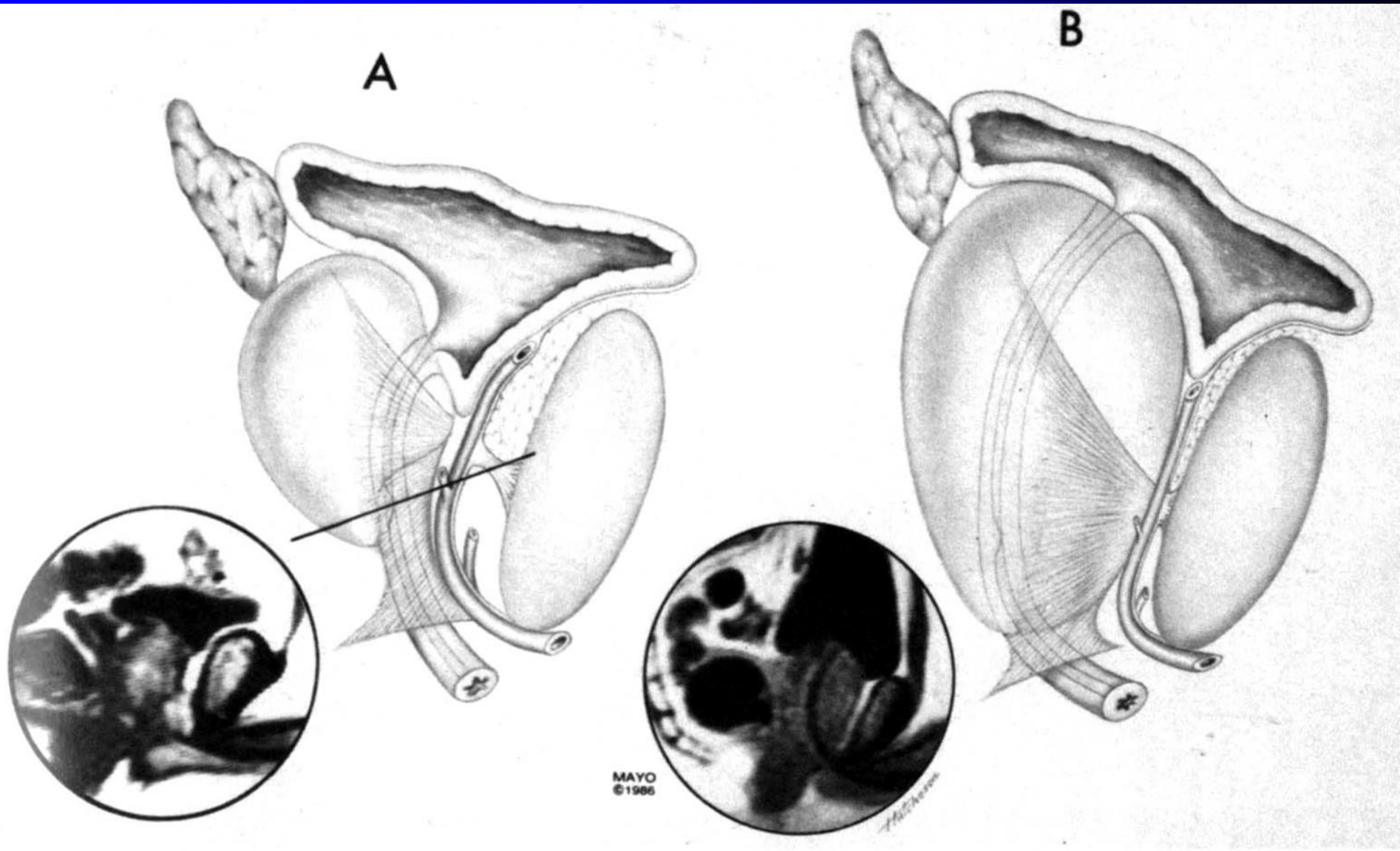


Midline sagittal view from bladder to corpus spongiosum penis (*CS*). At most proximal level external striated urethral sphincter fibers (arrows) are sparse and surrounded by prostatic tissue. At most distal level external striated urethral sphincter is bounded by corpus spongiosum. *AC*, anterior commissure. *BUG*, bulbourethral gland. *D*, detrusor of bladder. *PP*, posterior prostate. *R*, rectum. *U*, urethra.

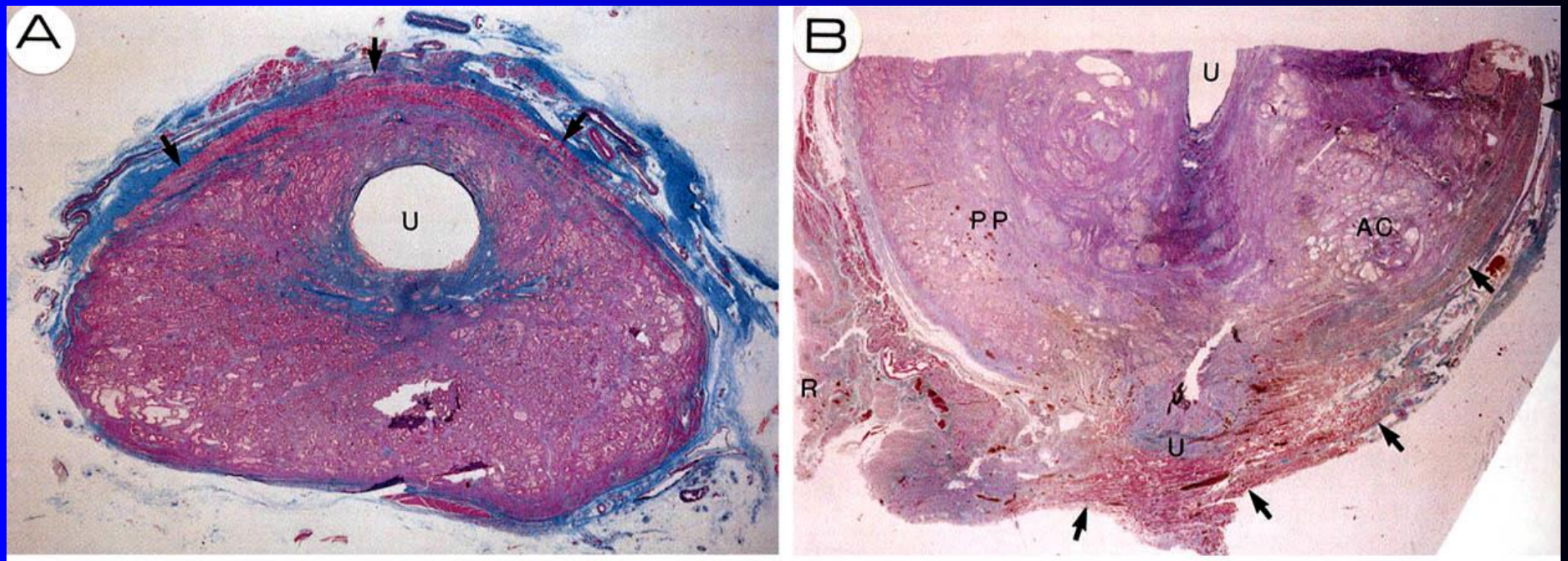
External Striated Sphincter vs Pelvic Diaphragm



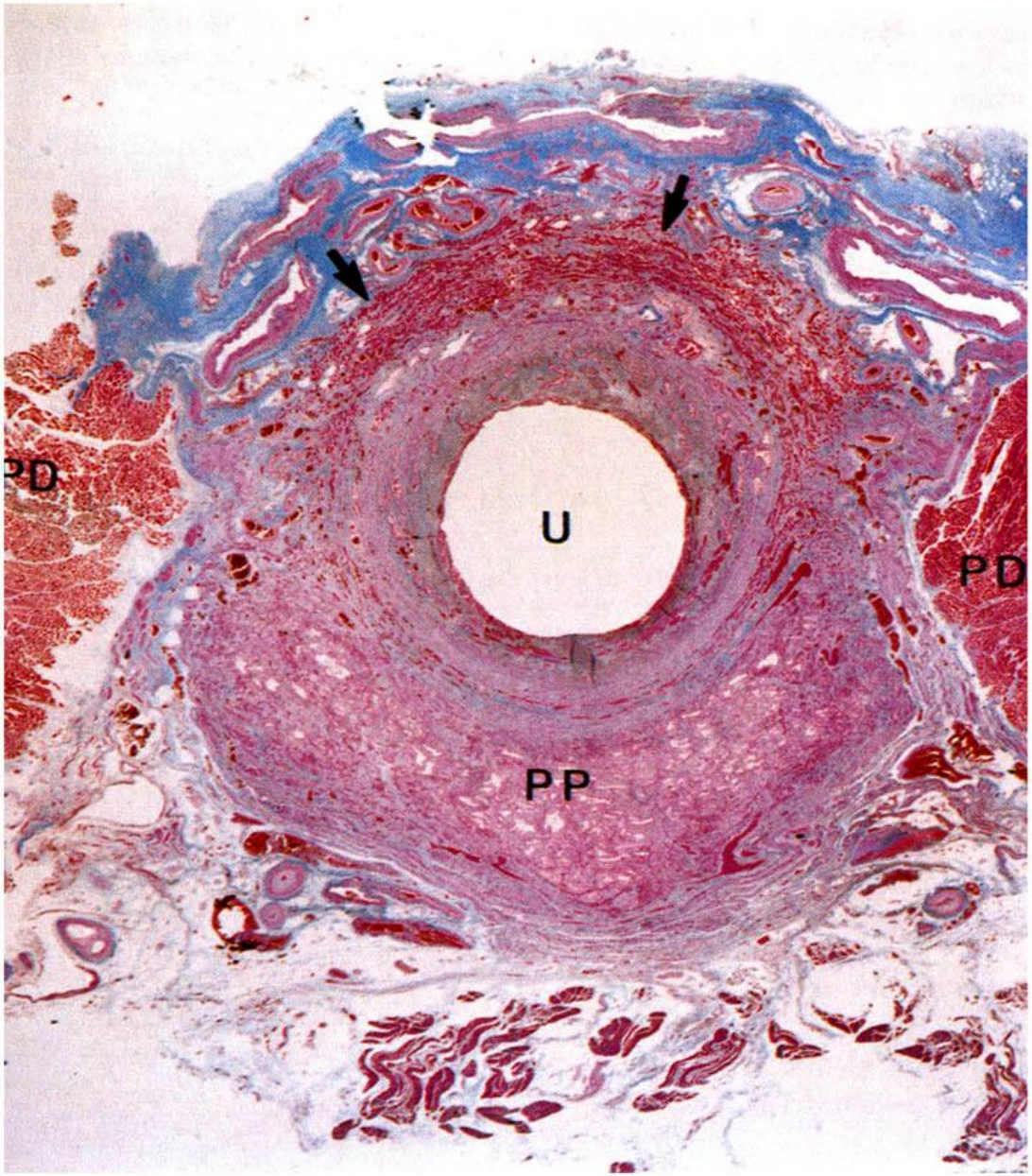
A, coronal section of prostatic apex within urogenital hiatus between leaves of pelvic diaphragm. External striated urethral sphincter (arrows) is separated completely from pelvic diaphragm *(PD)*. *B*, transverse section of urethra immediately distal to prostatic apex in region of rectourethralis muscle. *P*, prostate. *R*, rectum. *U*, urethra.



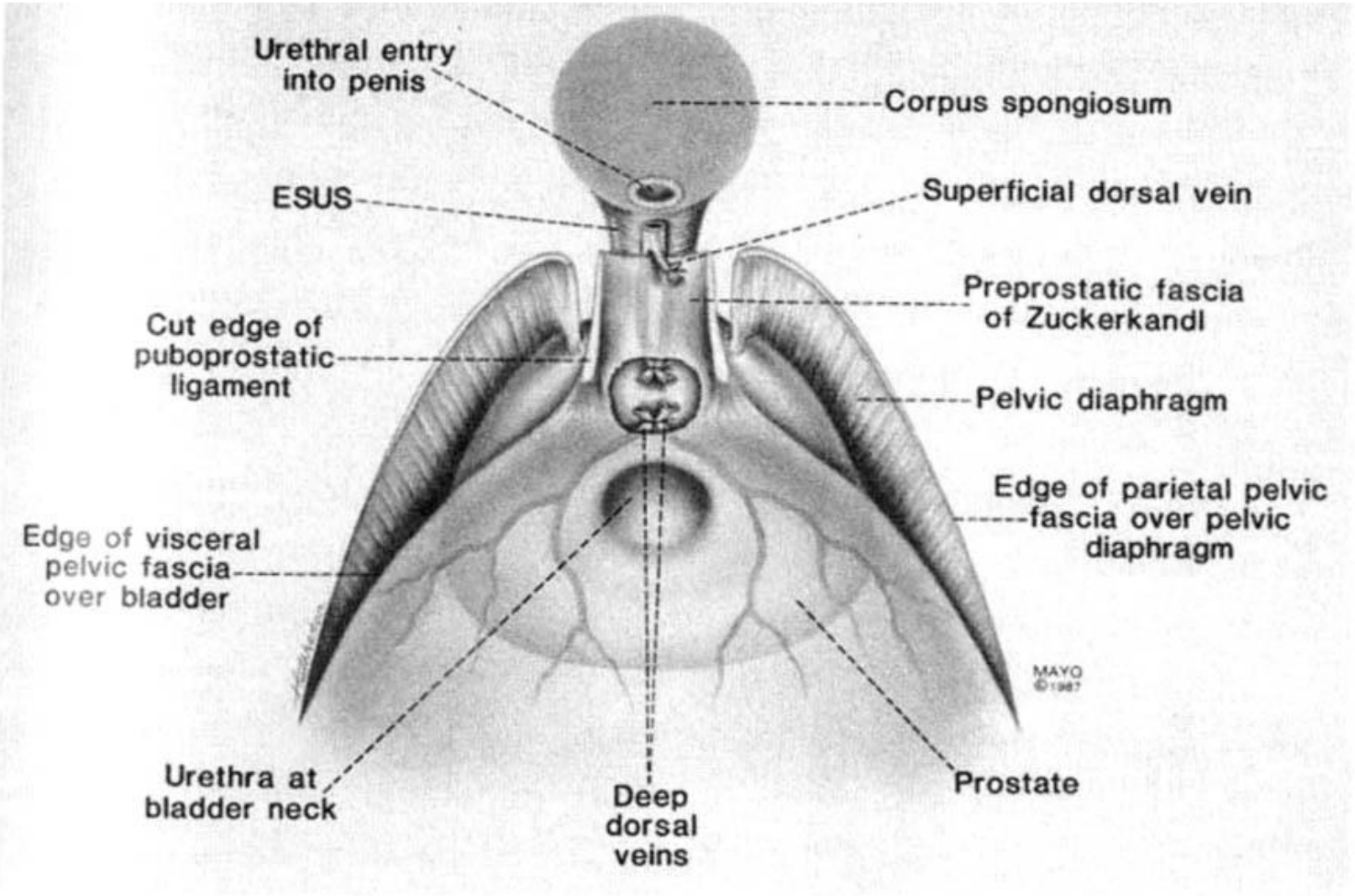
Contrast of small *(A)* and large *(B)* anterior commissures and resultant effect on external striated urethral sphincter. Insets, corresponding magnetic resonance images.



A, transverse section of prostate. External striated urethral sphincter (arrows) is spread across capsular surface above anterior commissure. *B*, paramedial sagittal section of prostate with massive anterior commissure *(AC)* (no anterior apical notch). External striated urethral sphincter (arrows) is displaced distally into transverse configuration. *U*, urethra. *PP*, posterior prostate. *R*, rectum.



Transv3erse section proximal to prostatic apex. External striated urethral sphincter (arrows) engages urethra circumferentially. Section corresponds to straight line proximal to prostatic apex in figure 4, *A*. Note proximity of preprostatic venous plexus anterior to external striated urethral sphincter. *U*, urethra. *PP*, posterior prostate. *PD*, pelvic diaphragm.



Anatomy of prostatic apex from above with bone deleted. Most medial fibeers of pelvic diaphragm (levator prostatae component of pubococcygeus muscle) are caught in prostatic visceral fascia and form lateral boundaries of urogenital hiatus. Precise apical shape obscured by overlying veins and fascia. *ESUS*, external striated urethral sphincter.

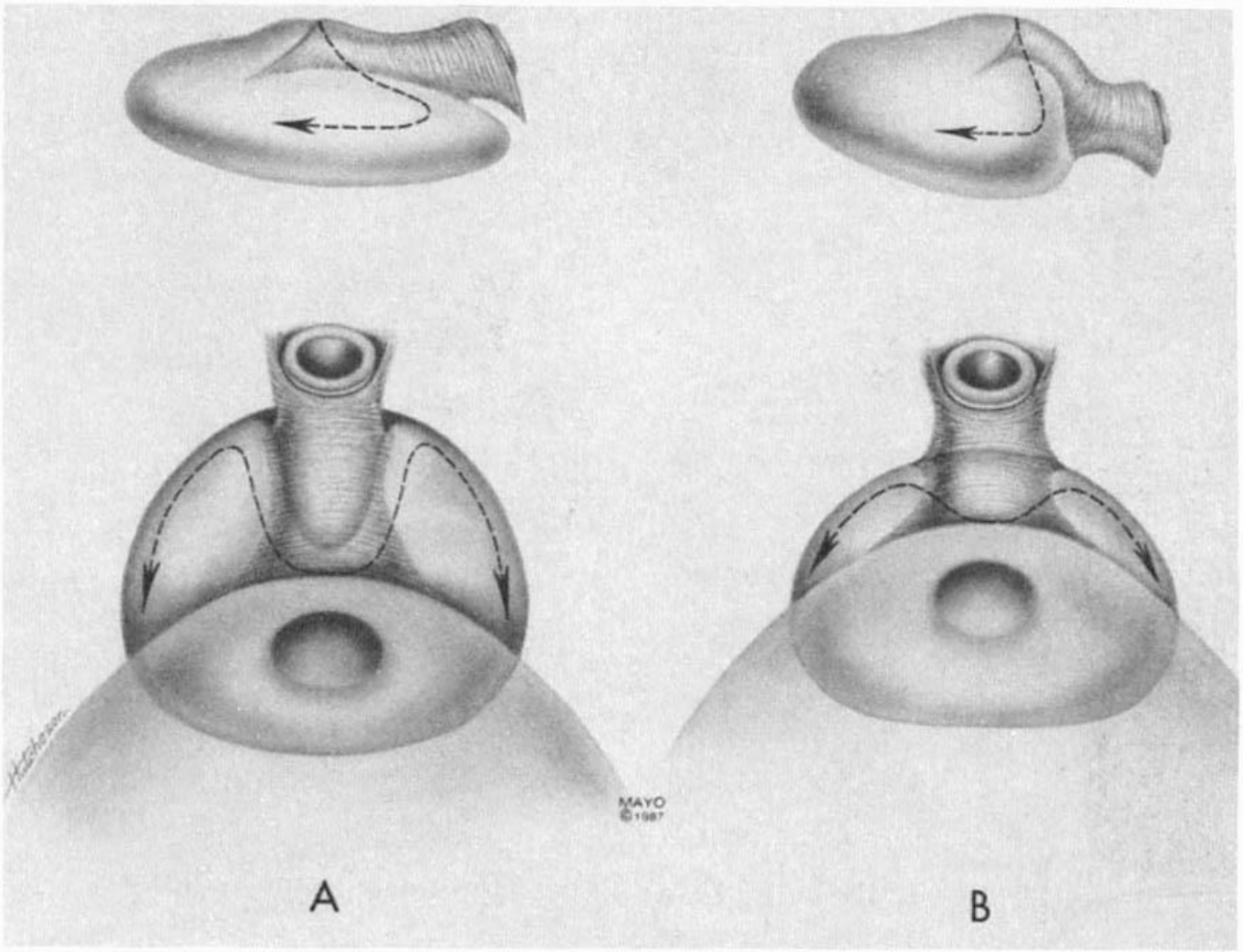
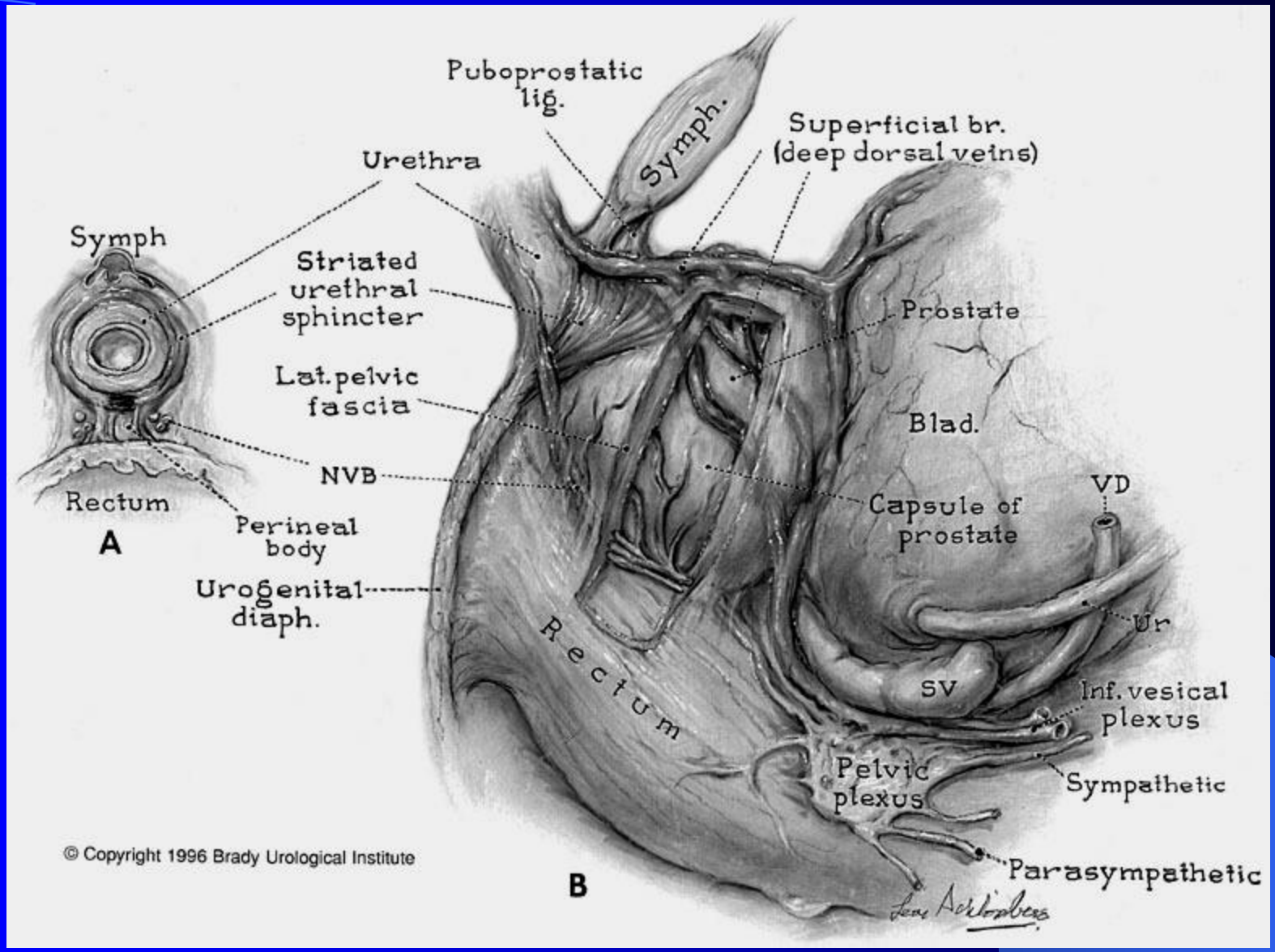


FIG. 8. Beginning apical dissection. Dashed lines with arrows denote line of incision into visceral prostatic fascia in relation to external striated urethral sphincter hidden beneath preprostatic fascia and veins. Views from side and above. *A*, prostate with notch (ghost image of notch is seen beneath external striated urethral sphincter). *B*, prostate without notch.

Anatomic Radical Prostatectomy



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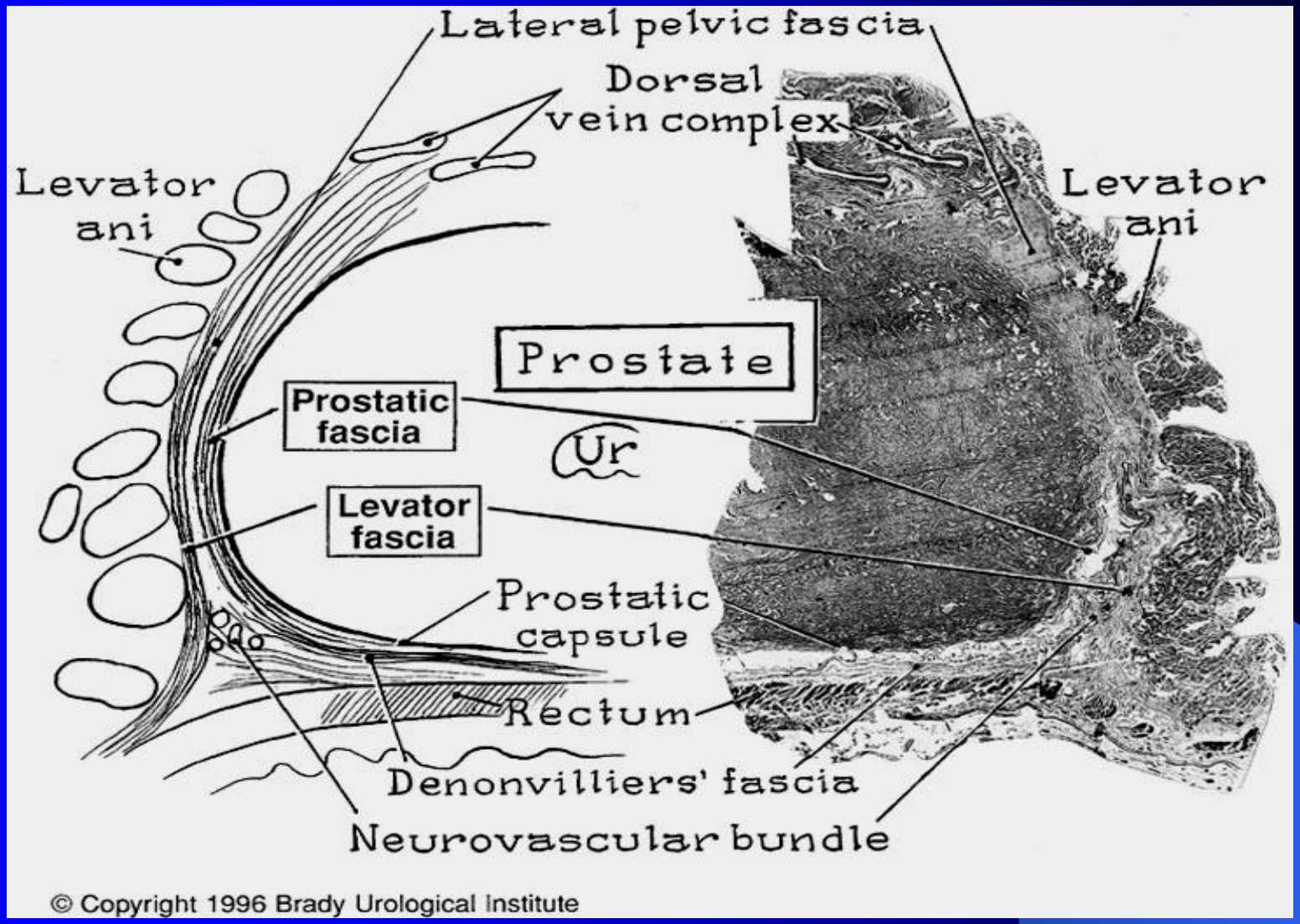

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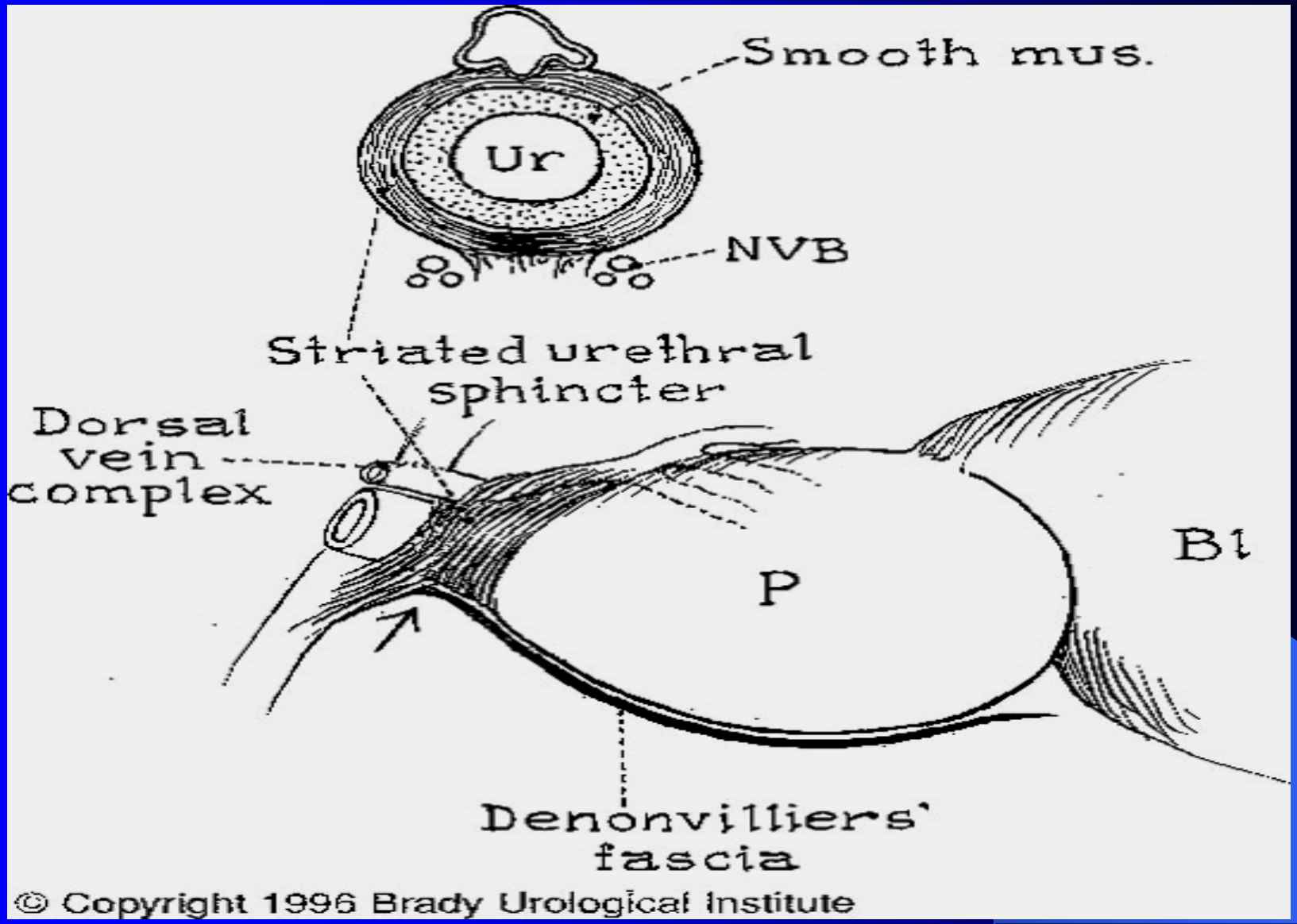
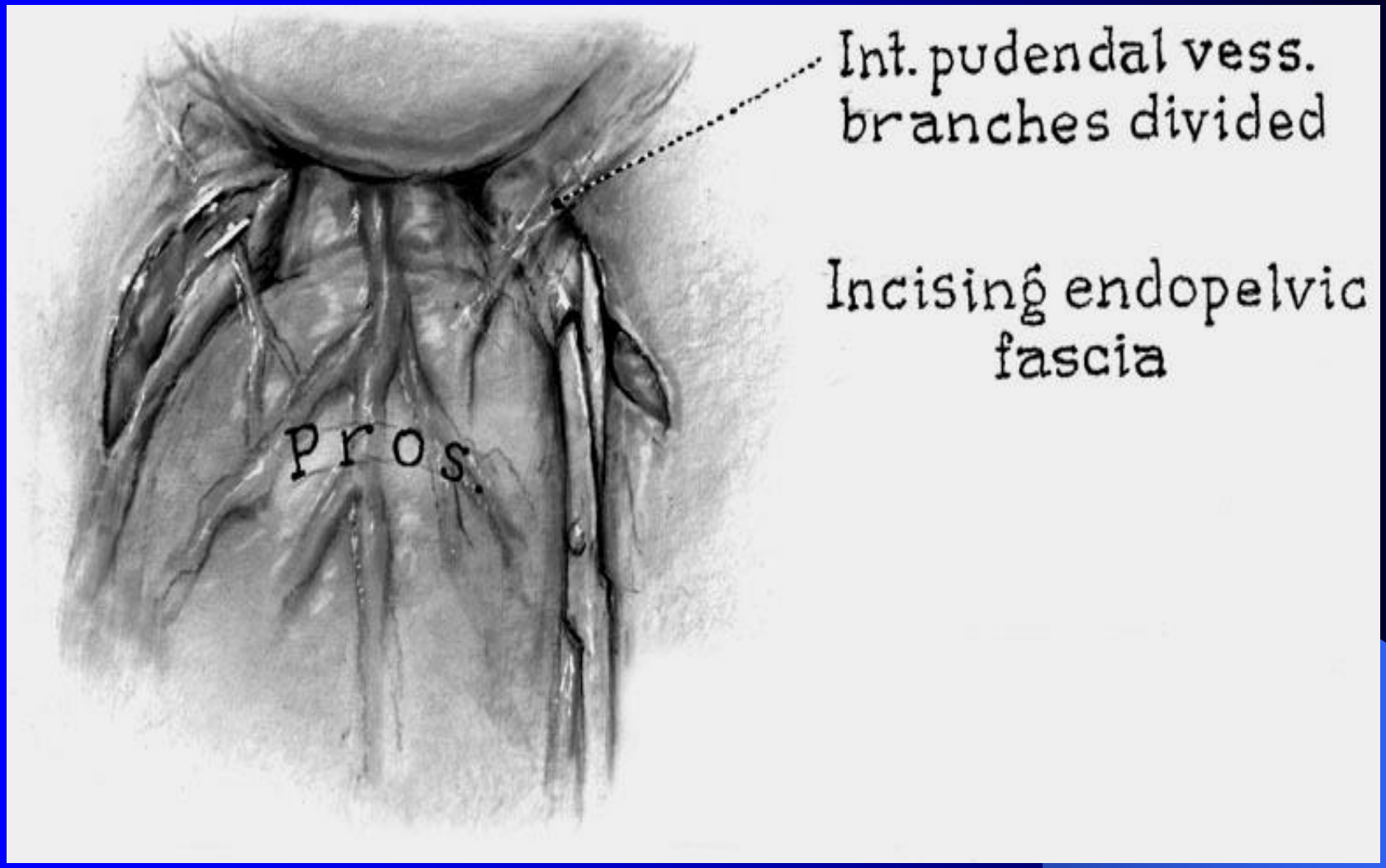
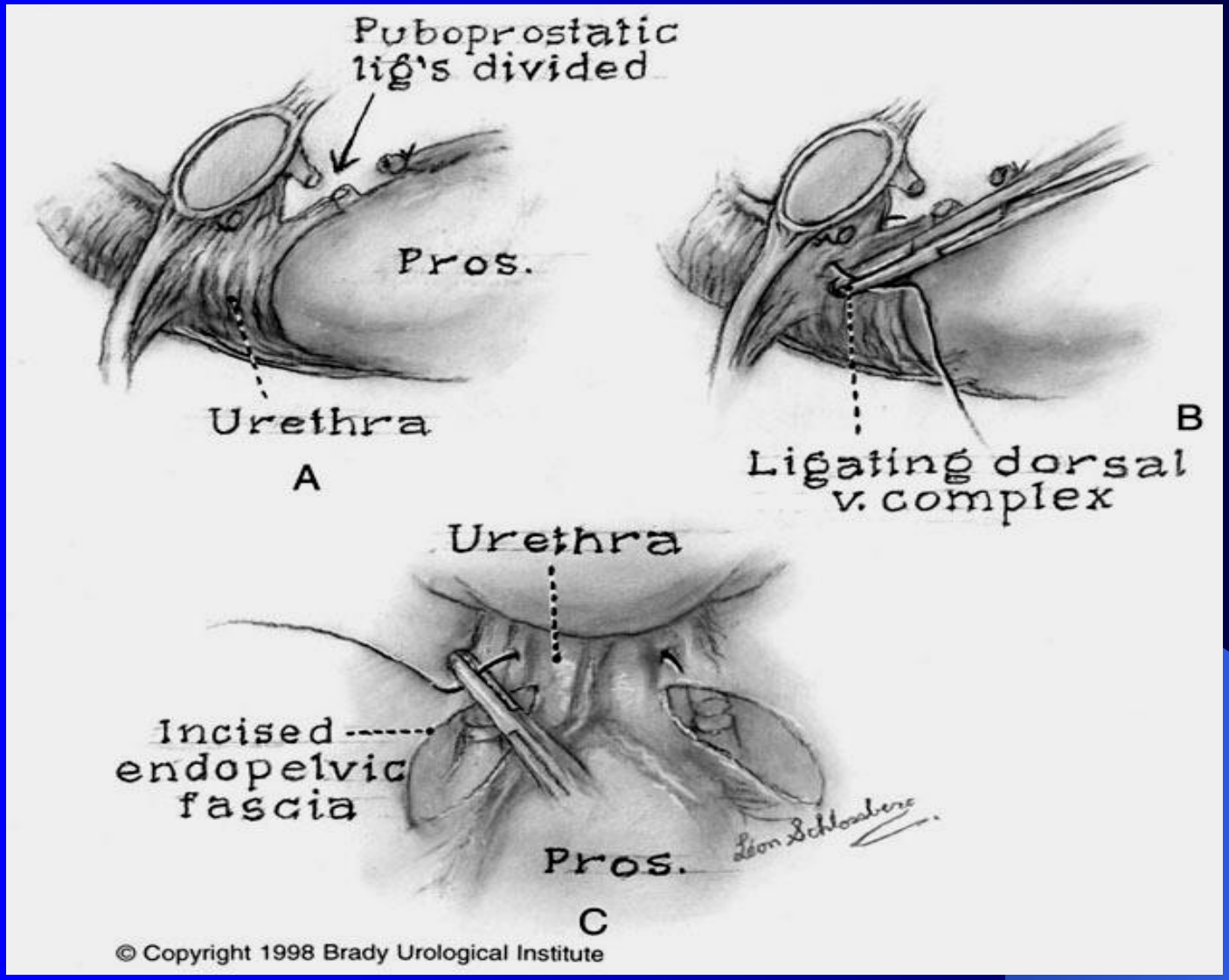


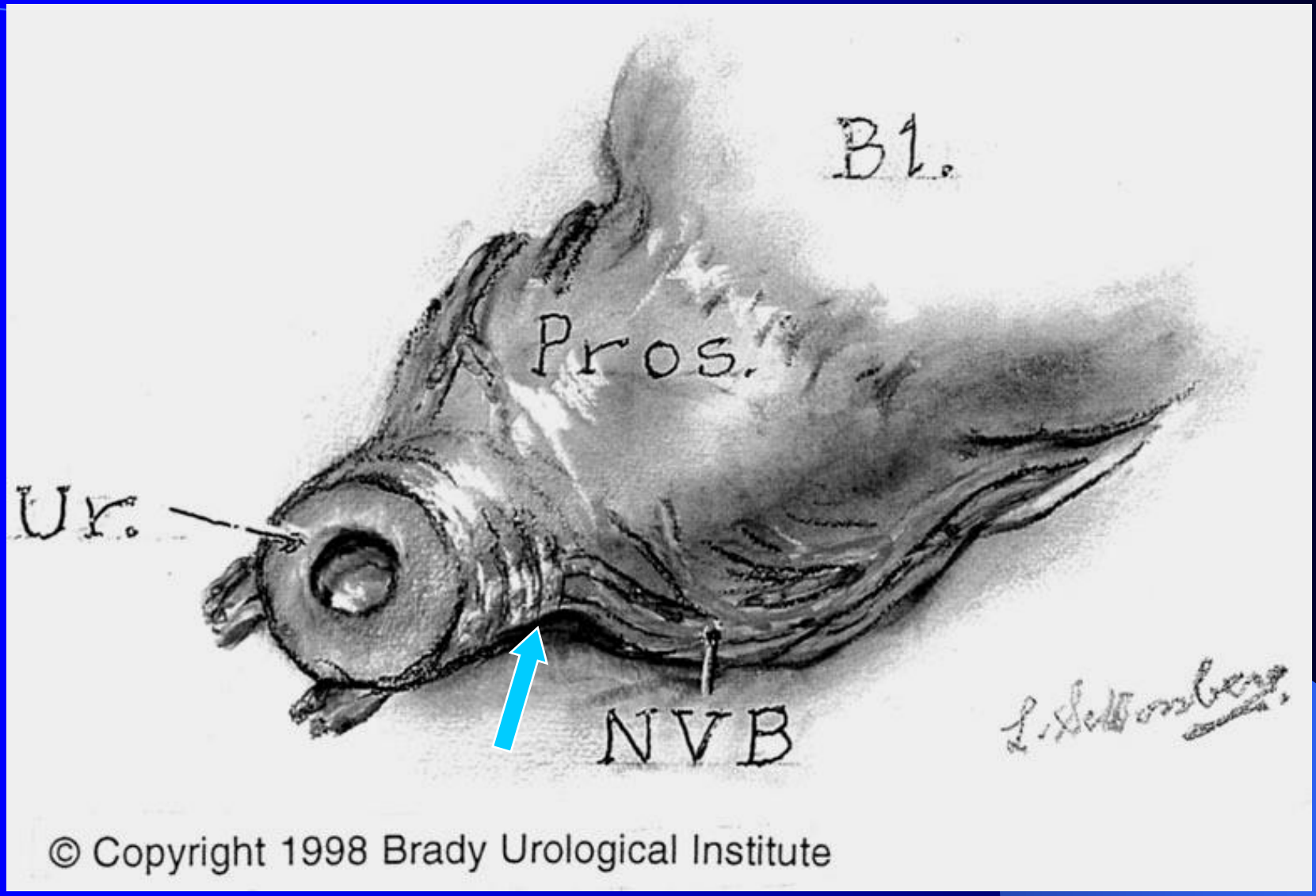
Anatomic Radical Prostatectomy



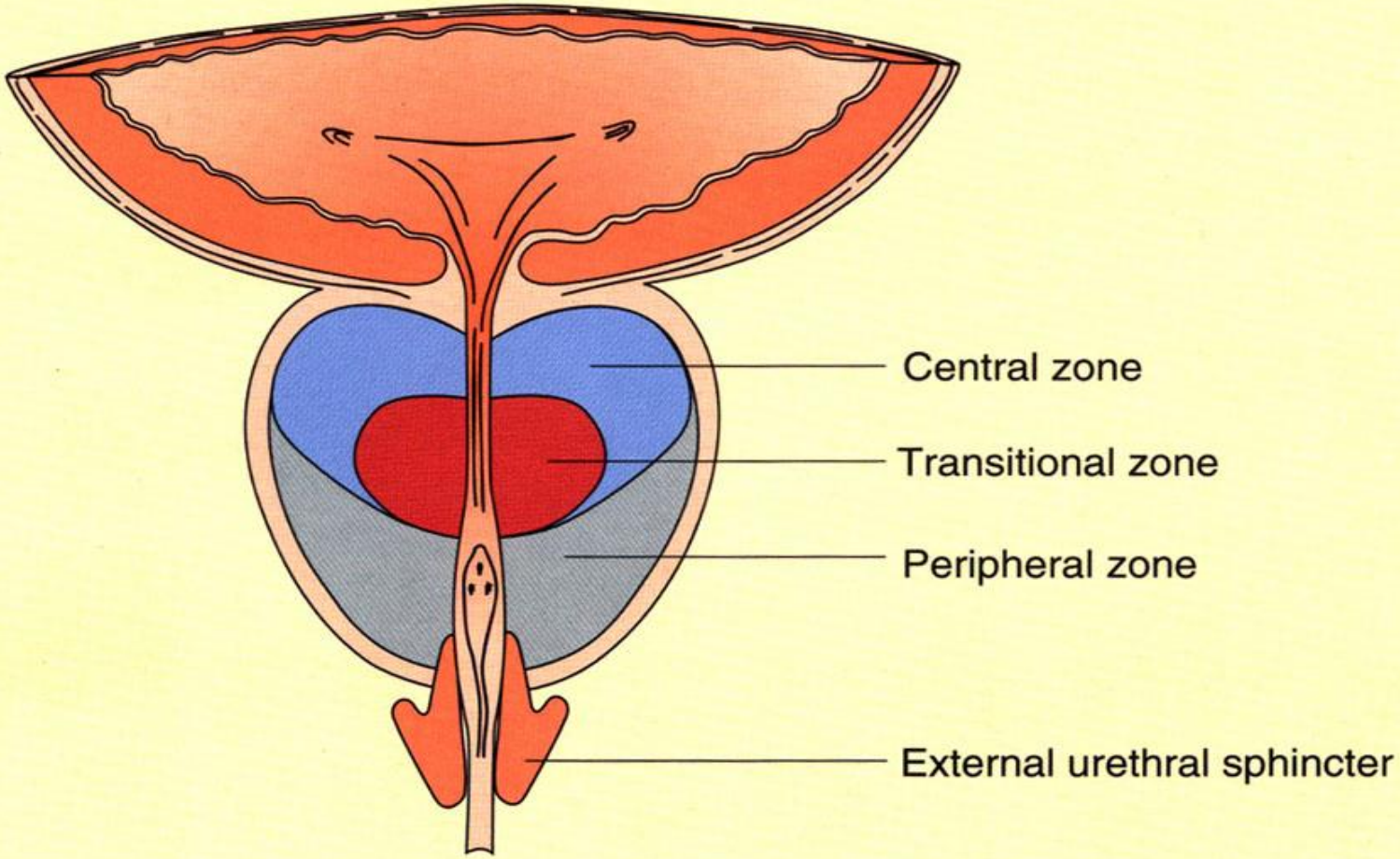
Anatomic Radical Prostatectomy



Neurovascular Injury at Radical Prostatectomy



Prostate Anatomy: Ultrasound Zones



The prostate is composed of three distinct zones: the peripheral zone (PZ); the transitional zone (TZ); and the central zone (CZ) (anteroposterior view). Prostate cancer most commonly originates in the PZ; in contrast, BPH almost exclusively affects the TZ and periurethral tissues

Vascular Anatomy of Prostate