

Biology 224

Human Anatomy and Physiology II

Week 7; Lecture 1; Monday

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Development and Structure of the Excretory System

The Nephron

DEVELOPMENT
AND
STRUCTURE OF
EXCRETORY
SYSTEM

EXCRETORY SYSTEM REVIEW

- Kidneys derived from INTERMEDIATE MESODERM.
- Kidney starts out as a SEGMENTAL STRUCTURE.
- Bladder, as part of embryonic gut tube: lining derived from endoderm.
- Note, this is EXCRETION, NOT “ELIMINATION.”

EARLY KIDNEY DEVELOPMENT

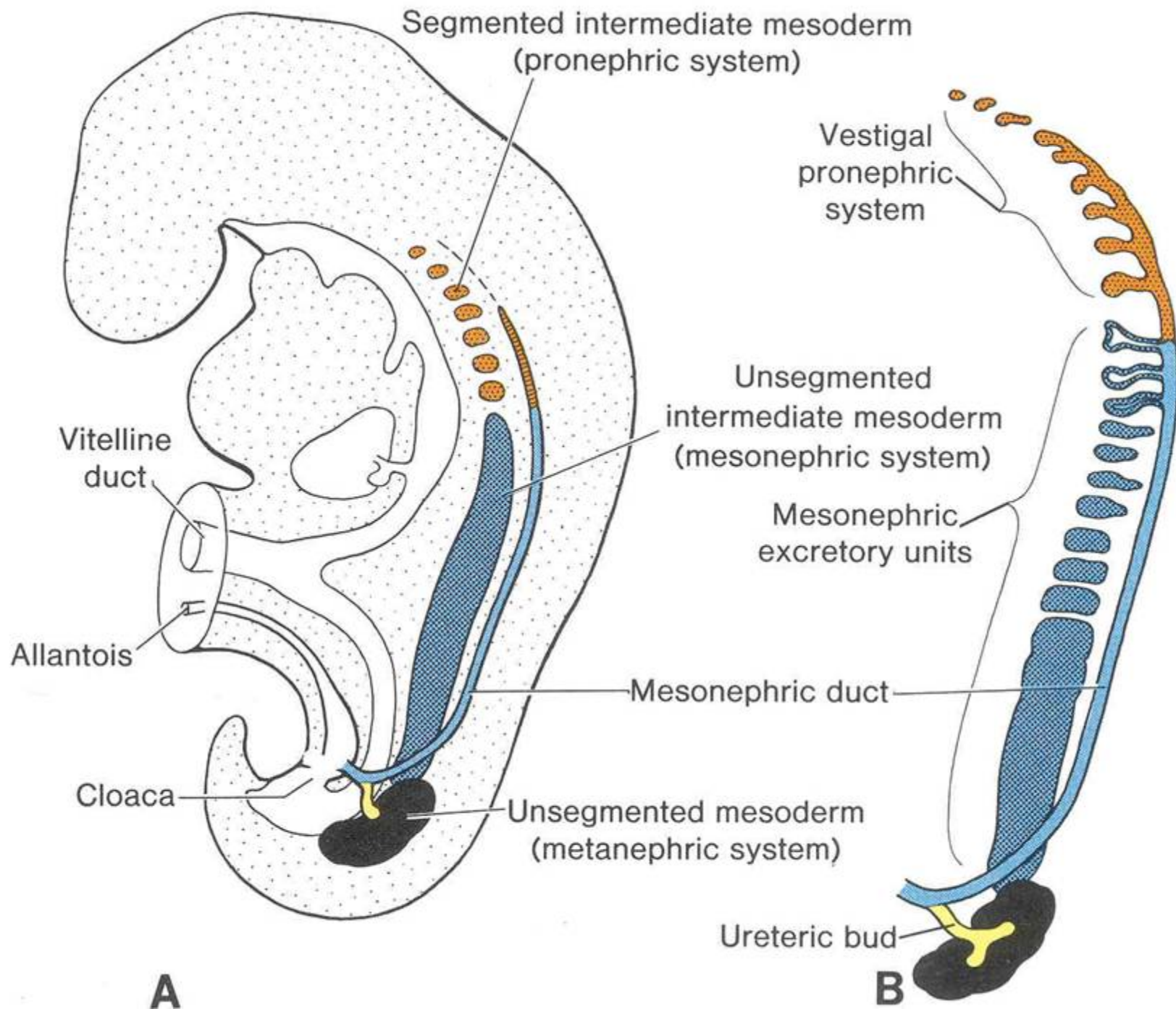
- There is a segment of intermediate mesoderm for every body segment.
- Earliest kidney appears in the cervical region of the body! (About week 3.)
Called the PRONEPHROS.
- Develop very close to the gonads. (They battle it out for the nearby ducts.)

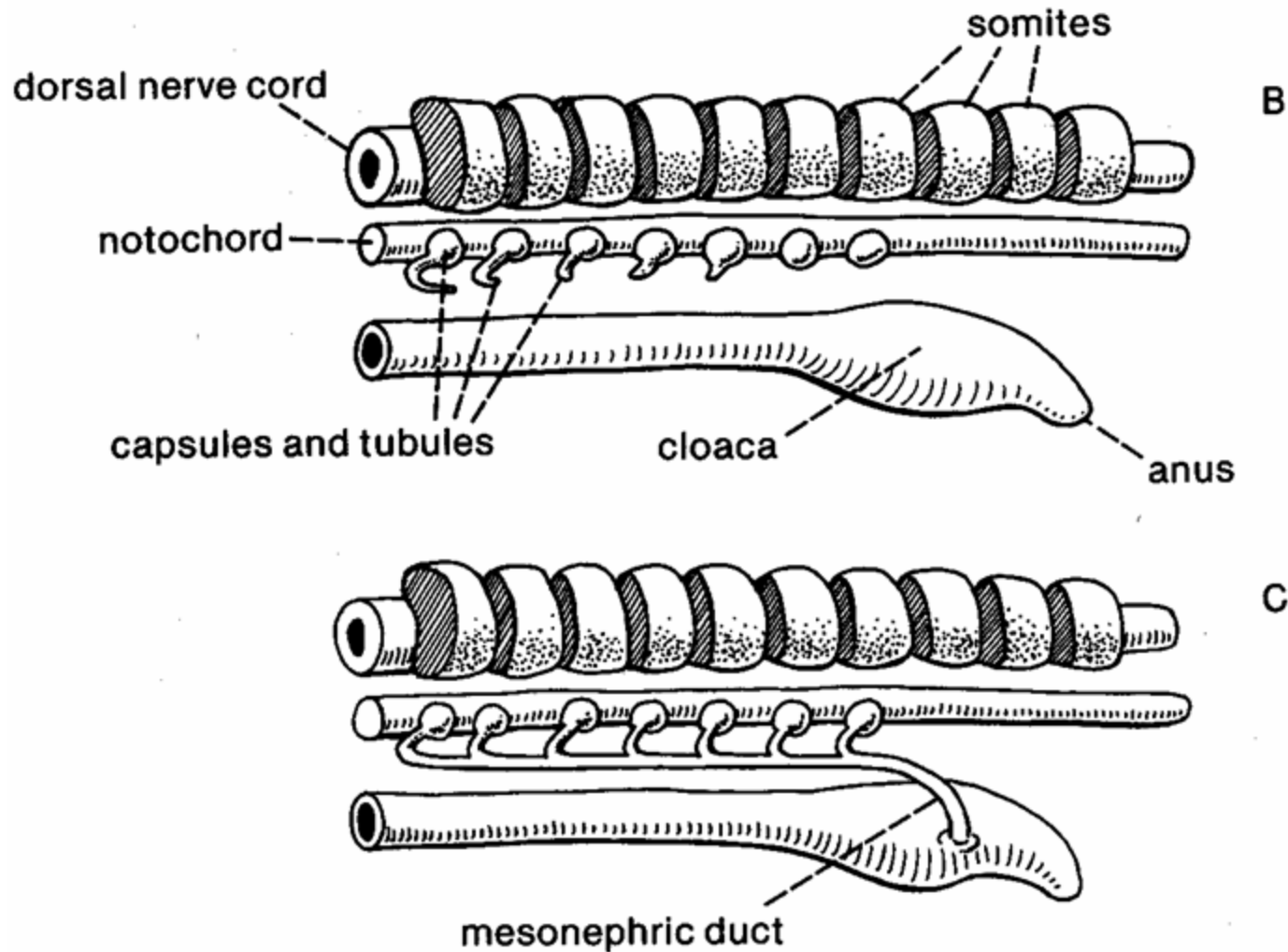
THE PRONEPHROS

- The early anteriorly developed kidney parts.
- Has NO EXCRETORY FUNCTION.
- Functions to INDUCE DEVELOPMENT of middle segments of intermediate mesoderm into the MESONEPHROS.

THE MESONEPHROS

- Some think it is the functioning embryonic kidney. Some think it has no excretory function.
- WE DO KNOW that the duct that attaches to it (THE MESONEPHRIC DUCT) is very important in INDUCING DEVELOPMENT OF THE CAUDAL KIDNEY SEGMENTS (the METANEPHROS).

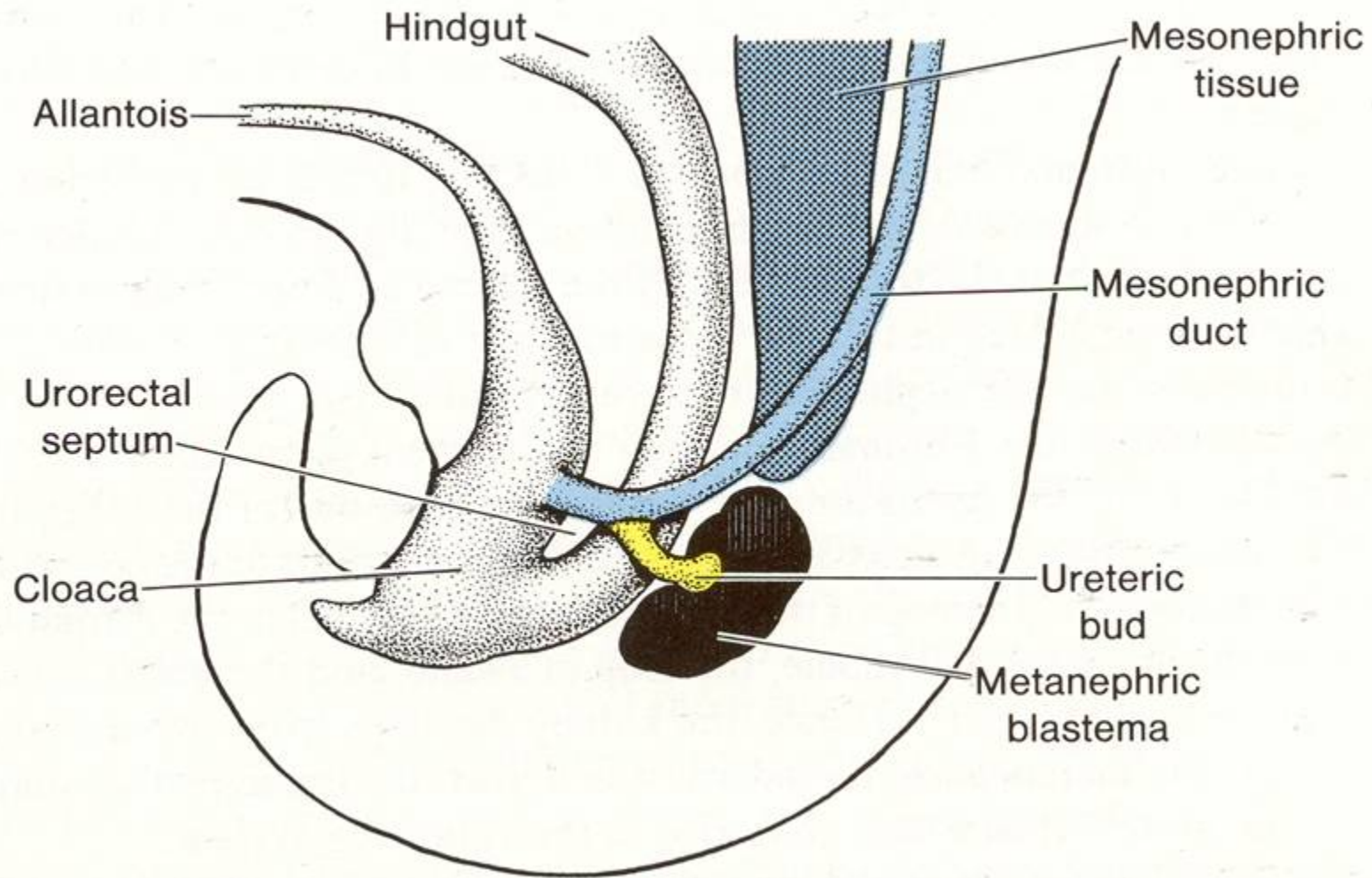




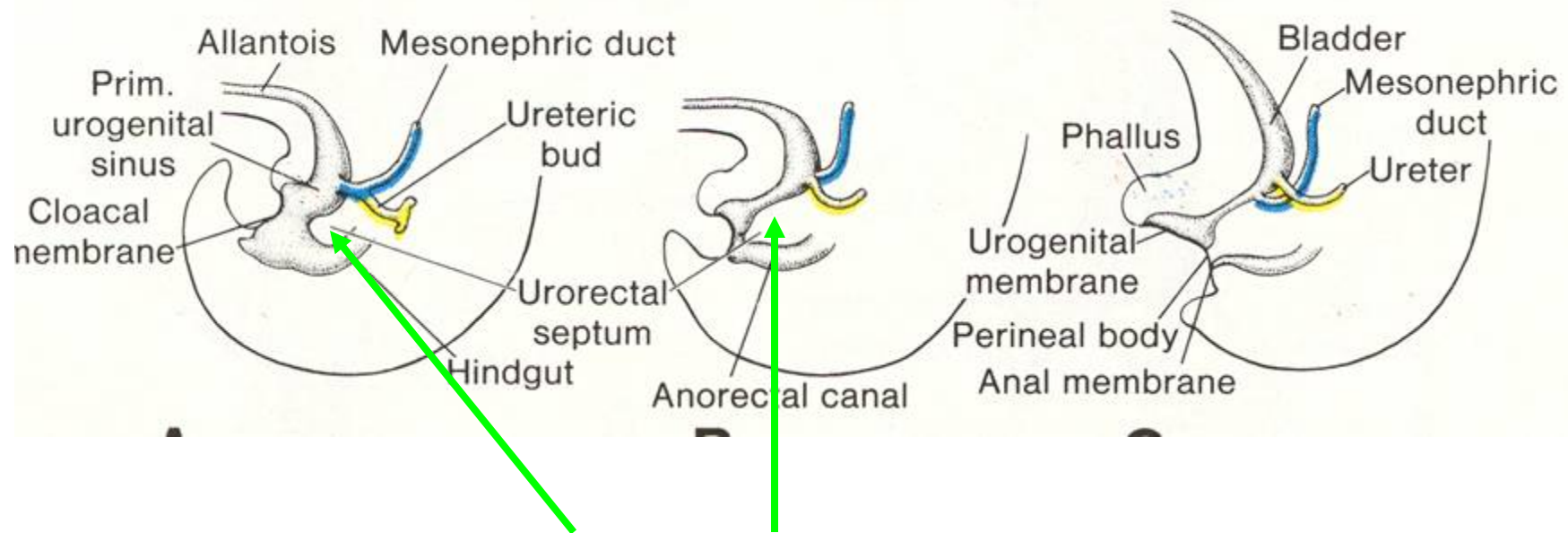
Mesonephric Duct reaches all the way to end of gut tube (cloaca).

We need to...

- Attach the ducts to the hindend kidney (the metanephros).
- Split the bladder away from the gut tube.

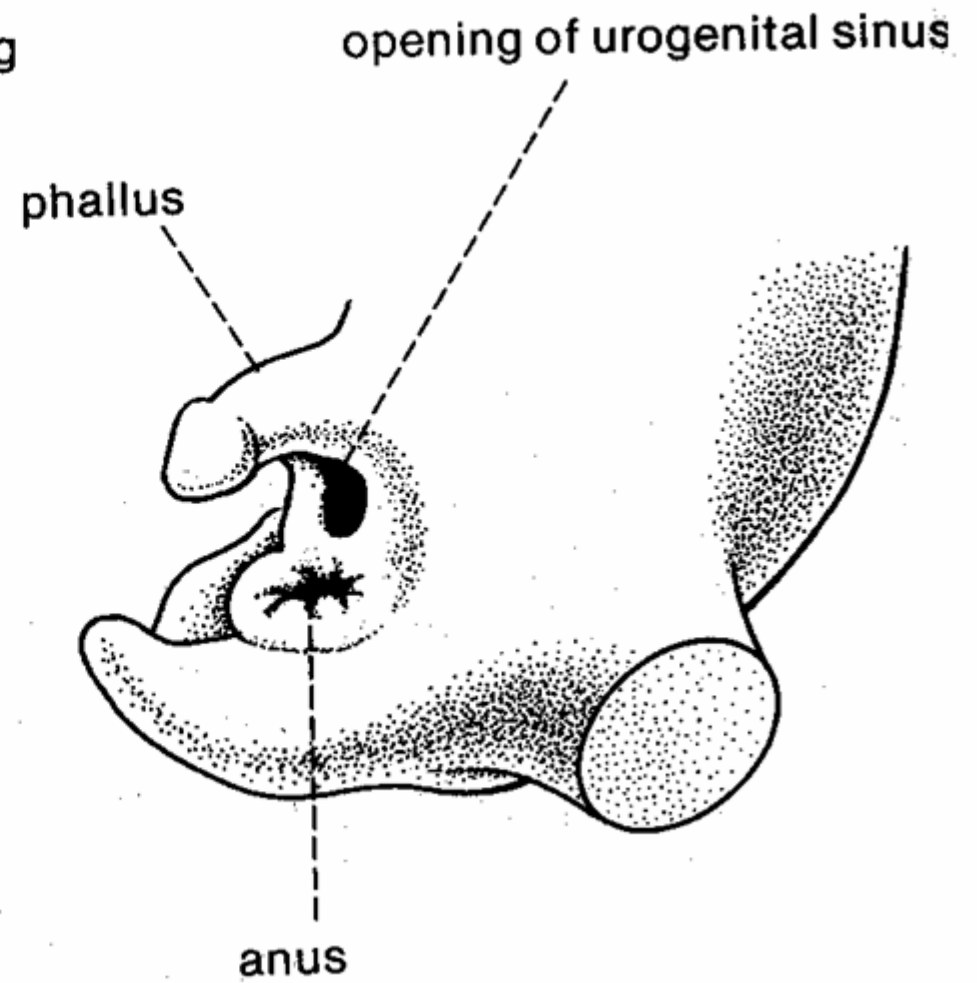
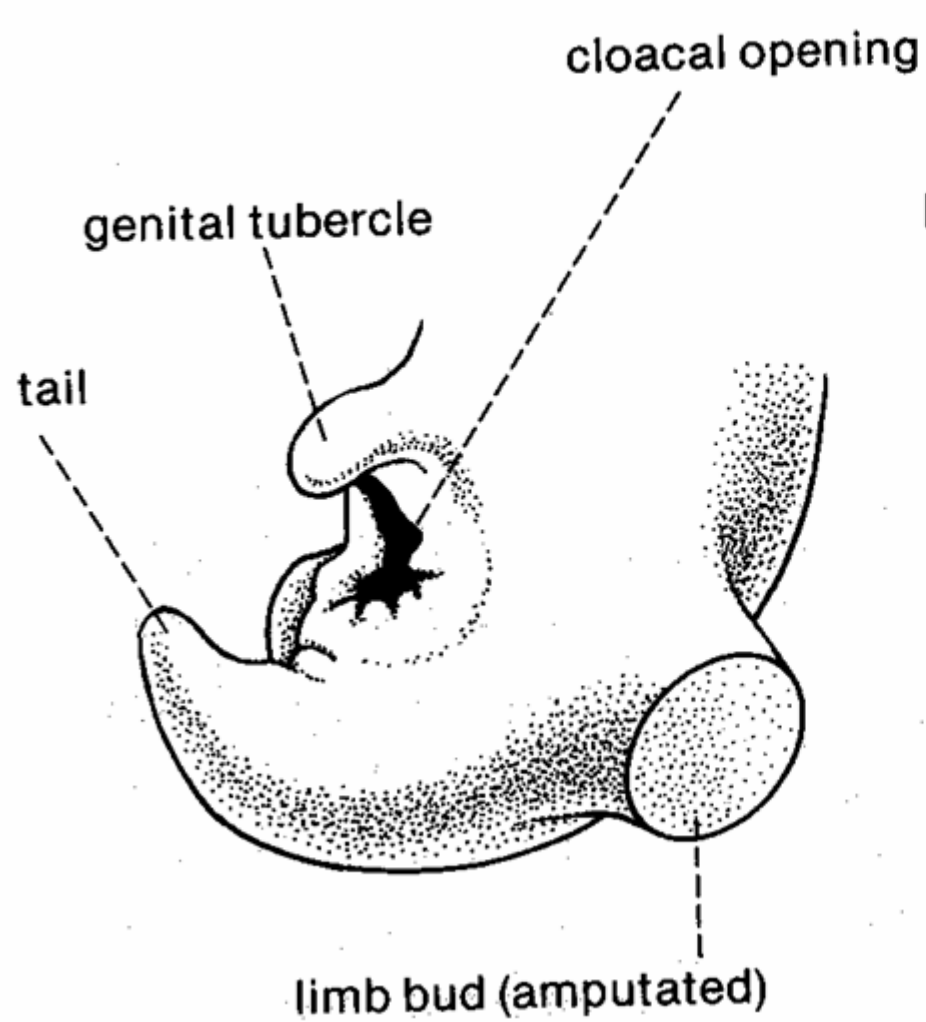


After the mesonephric duct attaches to cloaca, the embryonic URETER grows from caudal to cranial to attach to mass of metanephric kidney.



A septum, the **URORECTAL SEPTUM**, grows between the more dorsal part of the gut tube and the more ventral part that will become the bladder.

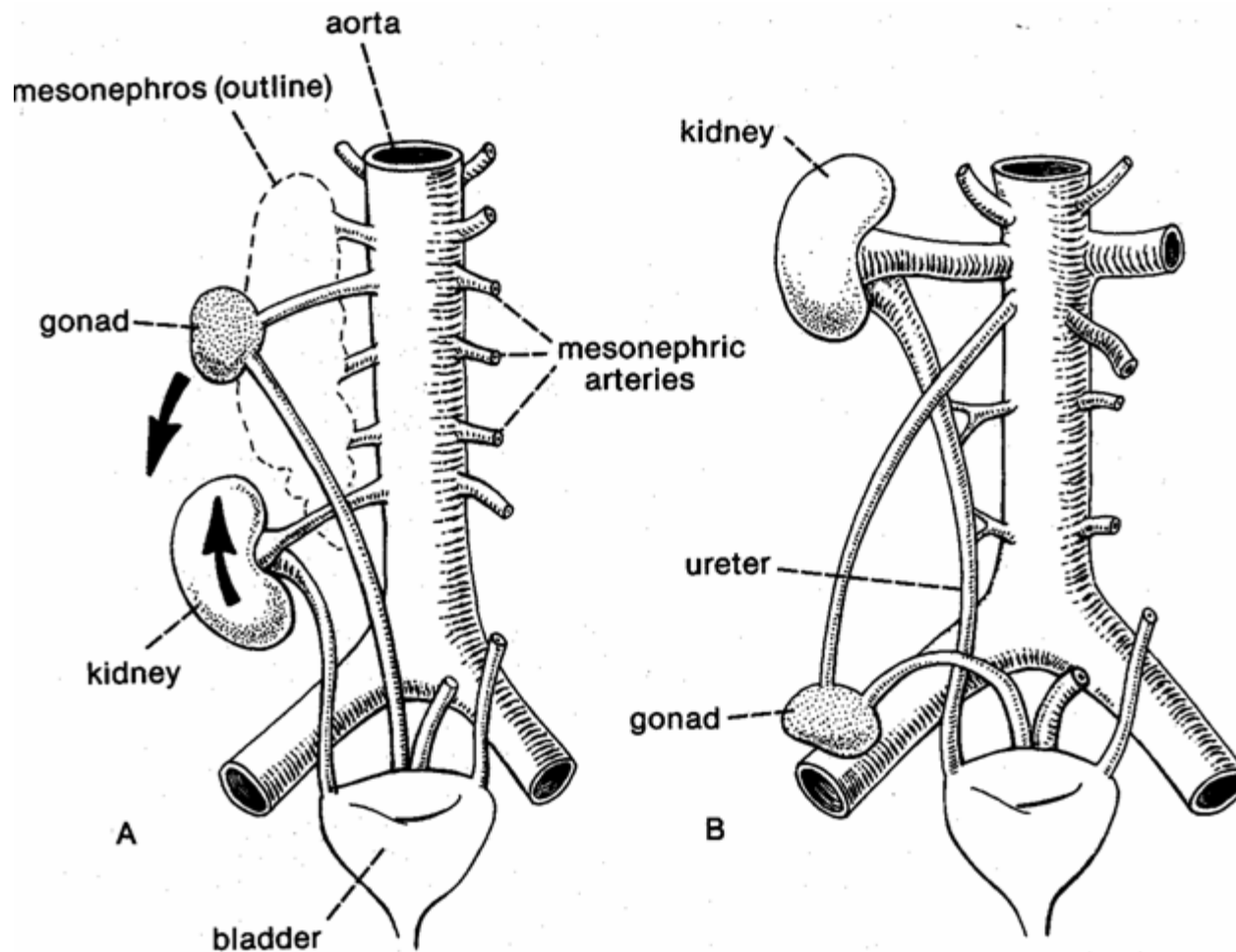
Note that attached to the bladder are right and left ueters, the allantois (an extraembryonic membrane).



So, like the heart,
and the lungs, the
bladder is ventral
to your gut tube.

ASCENT OF THE KIDNEYS

- Kidneys don't stay at caudal end of body.
- They “ascend” to a position just caudal to diaphragm and liver.
- Right kidney is a bit lower due to mass of liver.
- They work their way up by attaching to successive segmental arteries.



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BASIC KIDNEY STRUCTURE

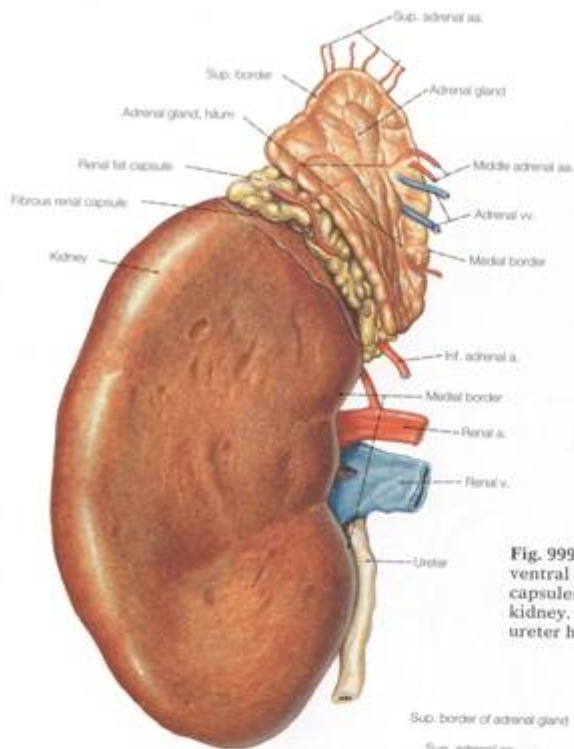


Fig. 999 The right kidney and adrenal gland, ventral aspect. Parts of the fatty and fibrous renal capsules remain on the superior extremity of the kidney. The renal artery and vein as well as the ureter have been sectioned.

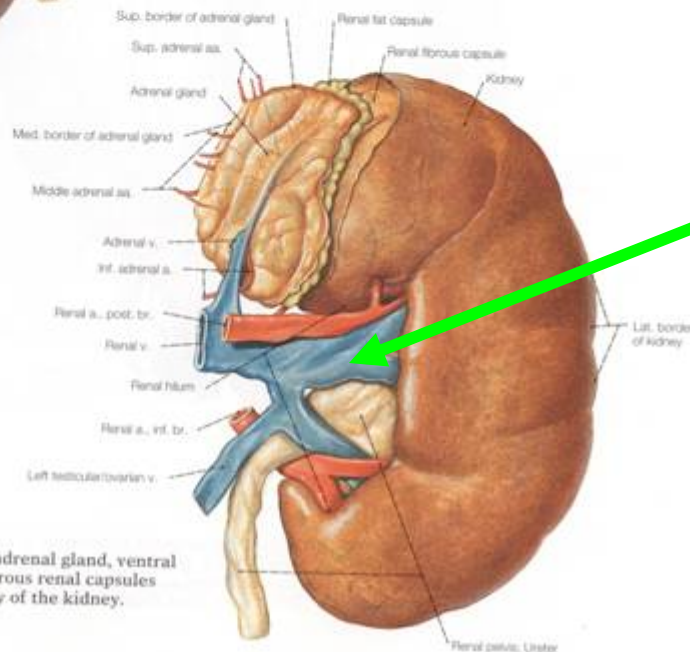
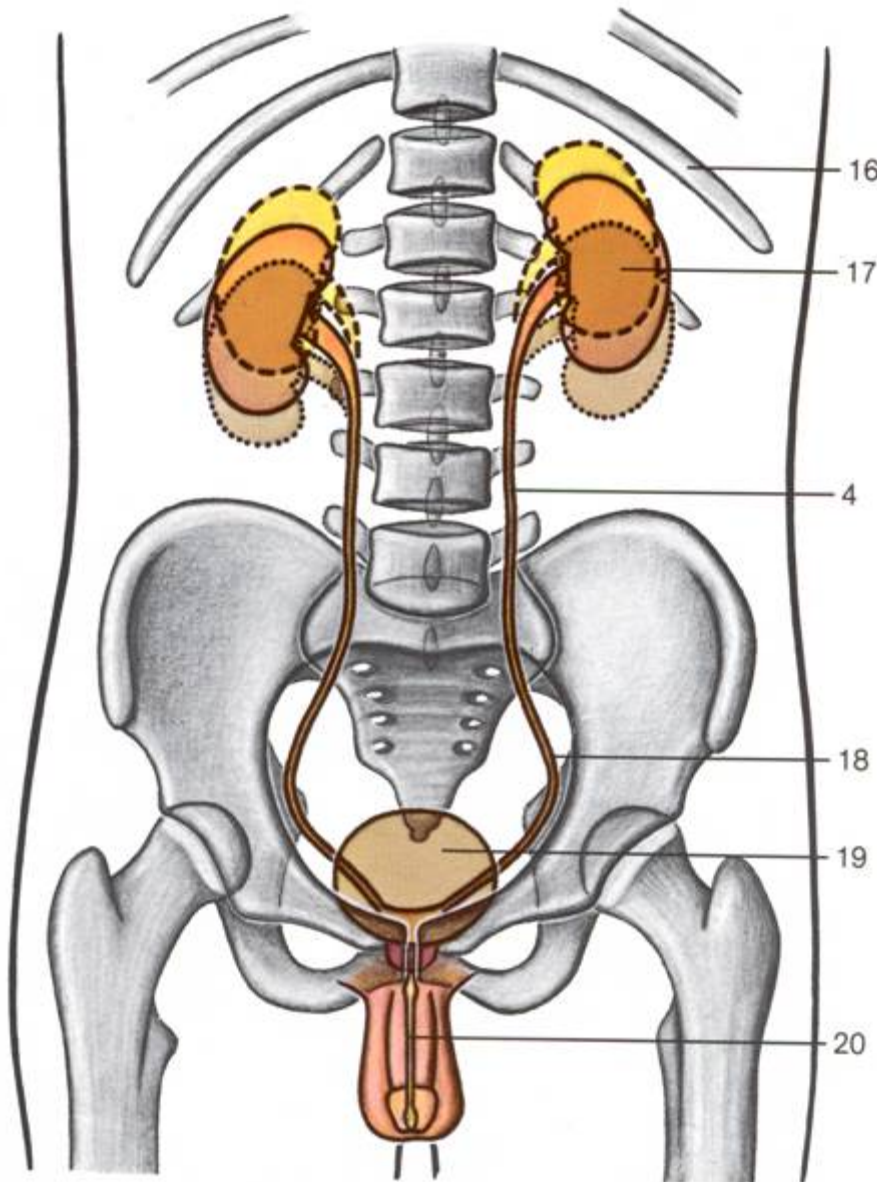


Fig. 1000 The left kidney and adrenal gland, ventral aspect. Parts of the fatty and fibrous renal capsules remain on the superior extremity of the kidney.

Note: Large
vessels usually
ventral to ureter
exit.

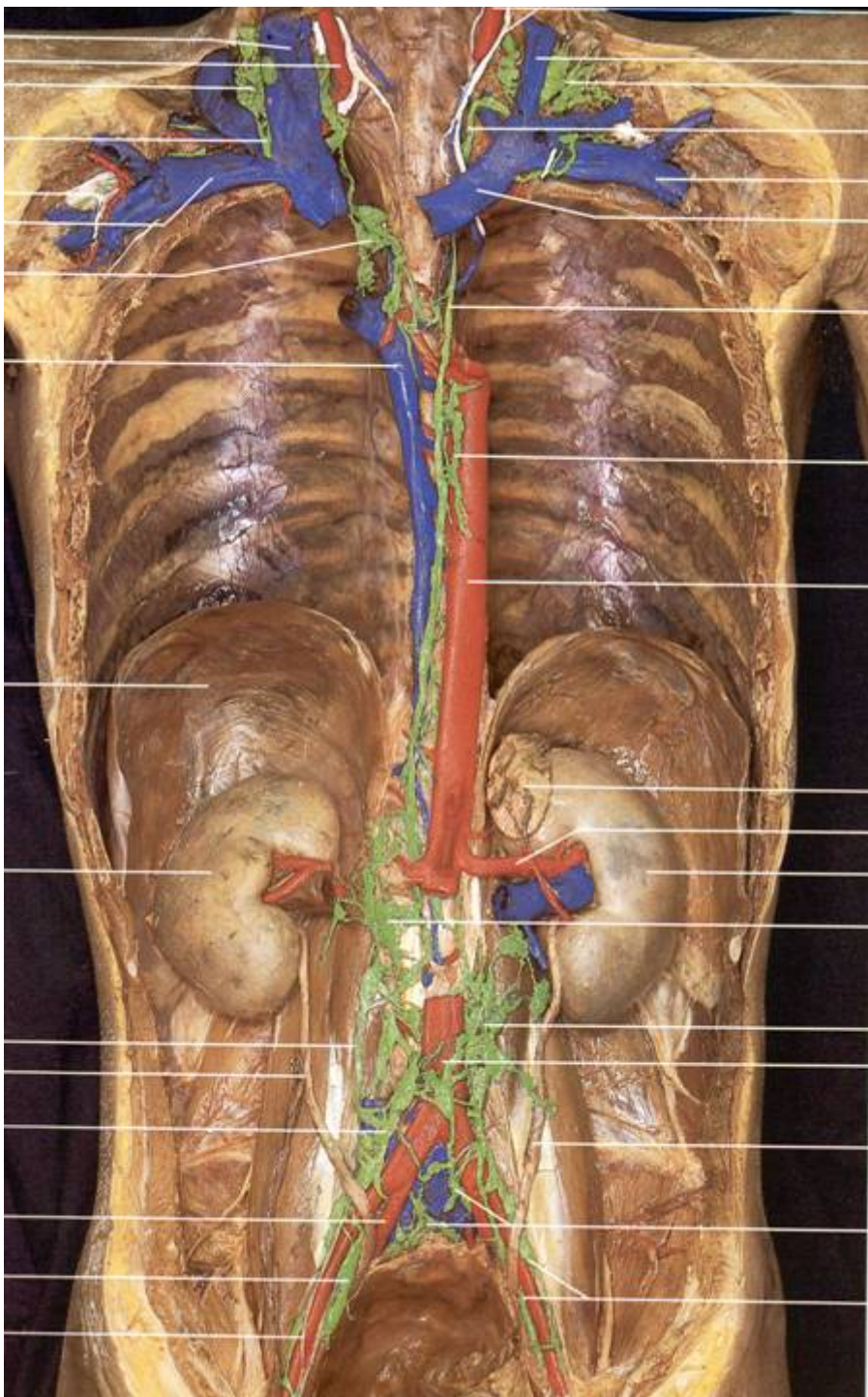


Position of kidneys and urinary system

KIDNEYS ARE RETROPERITONEAL!!

(They do move a reasonable amount when you breathe. -- This is why they can REALLY hurt when they have problems.

Retroperitoneal pain can be extreme.)



KIDNEY IN SECTION:

Outer CORTEX

Inner MEDULLA

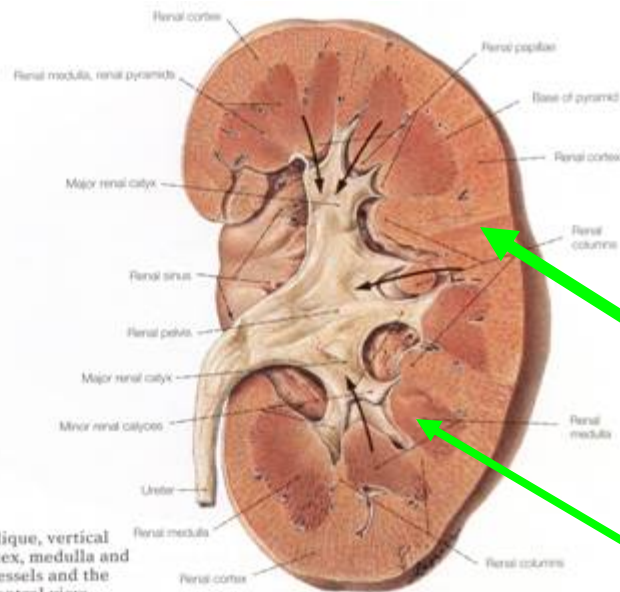


Fig. 1001 The left kidney. An oblique, vertical hemisection showing the renal cortex, medulla and pelvis after removal of the blood vessels and the adipose tissue of the renal sinus, ventral view.

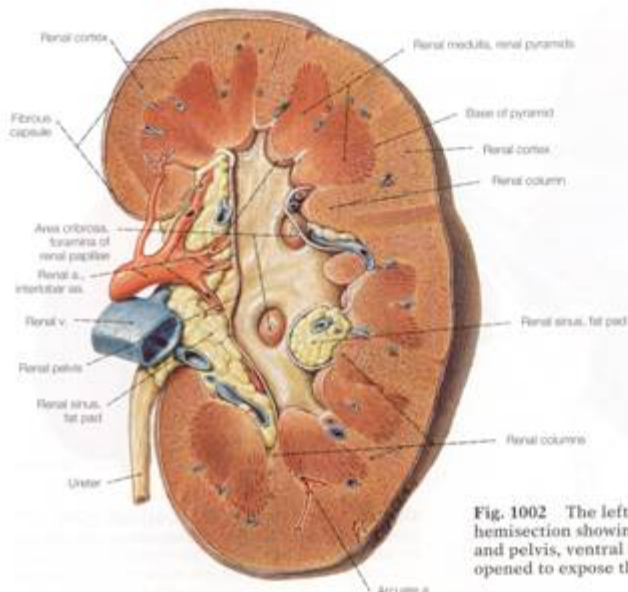
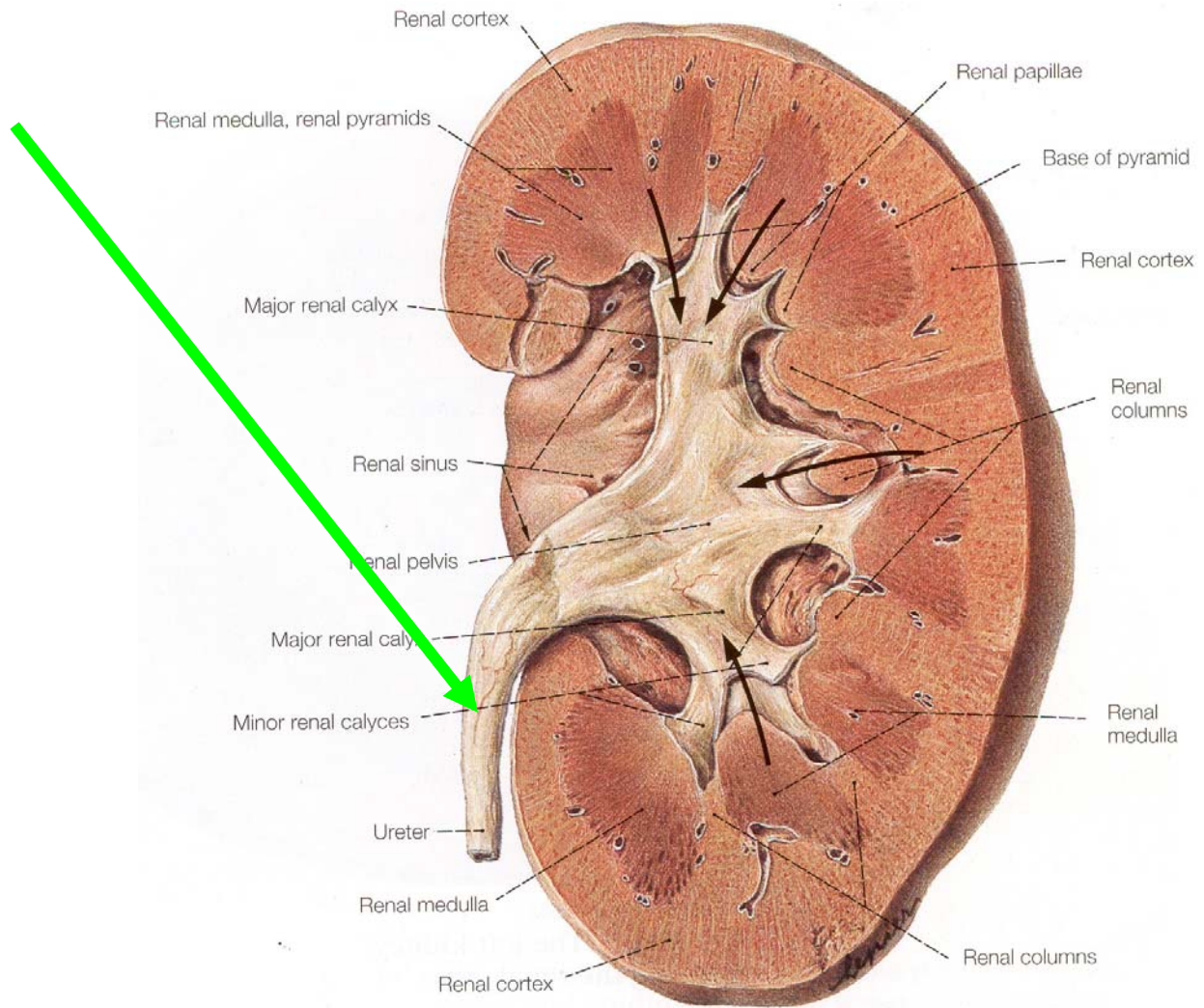


Fig. 1002 The left kidney. An oblique, vertical hemisection showing the renal cortex, medulla, and pelvis, ventral view. The renal pelvis has been opened to expose the hilum of the kidney.

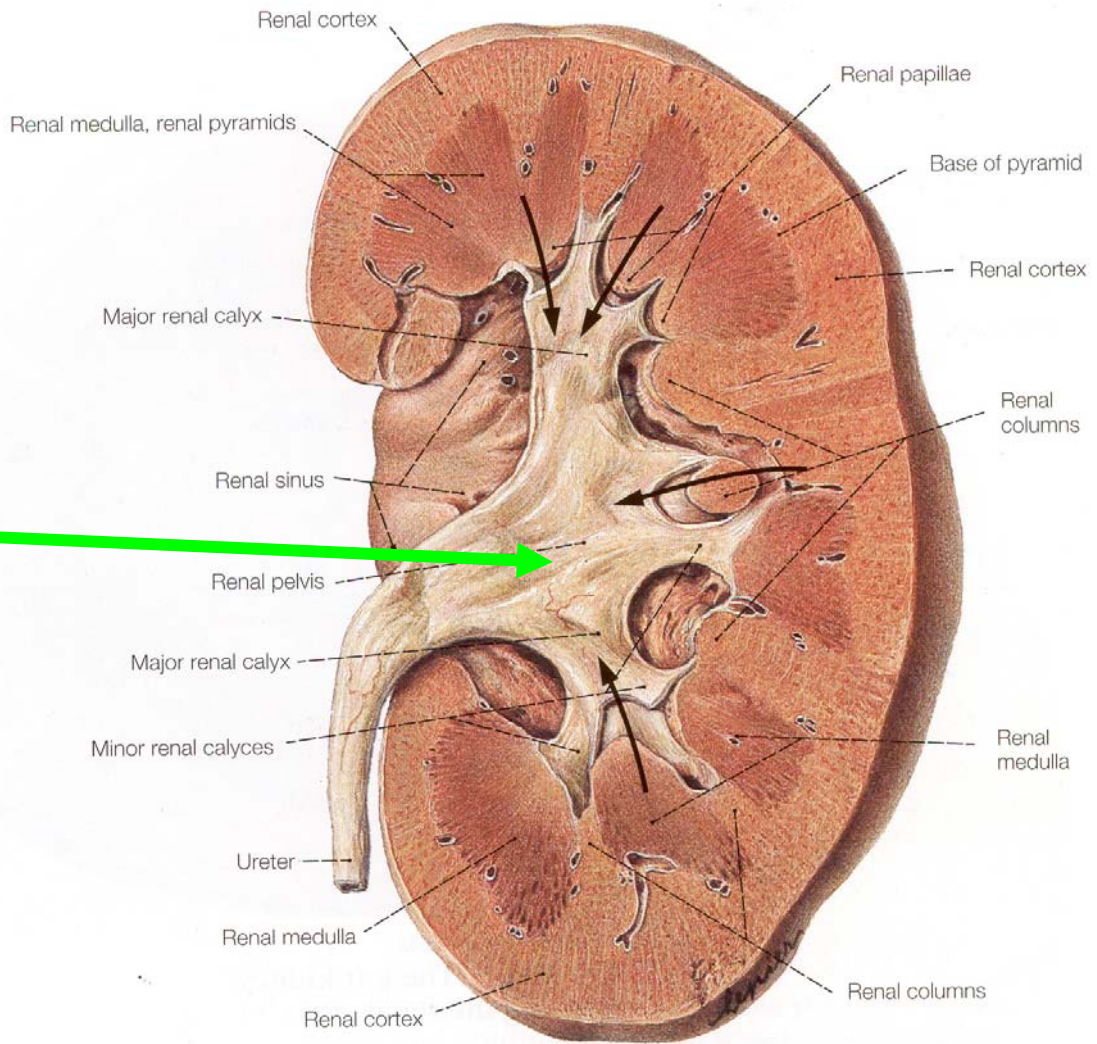
DUCT SYSTEM OF KIDNEYS

- URETER runs from kidneys to urinary bladder.
- Ureter ends in a dilated RENAL PELVIS.
- Renal pelvis branches into structures called the MAJOR CALYCES (singular = calyx).
- Major calyces divided into MINOR CALYCES.
- Minor calyces receive fluid outflow from many microscopic collecting tubules.

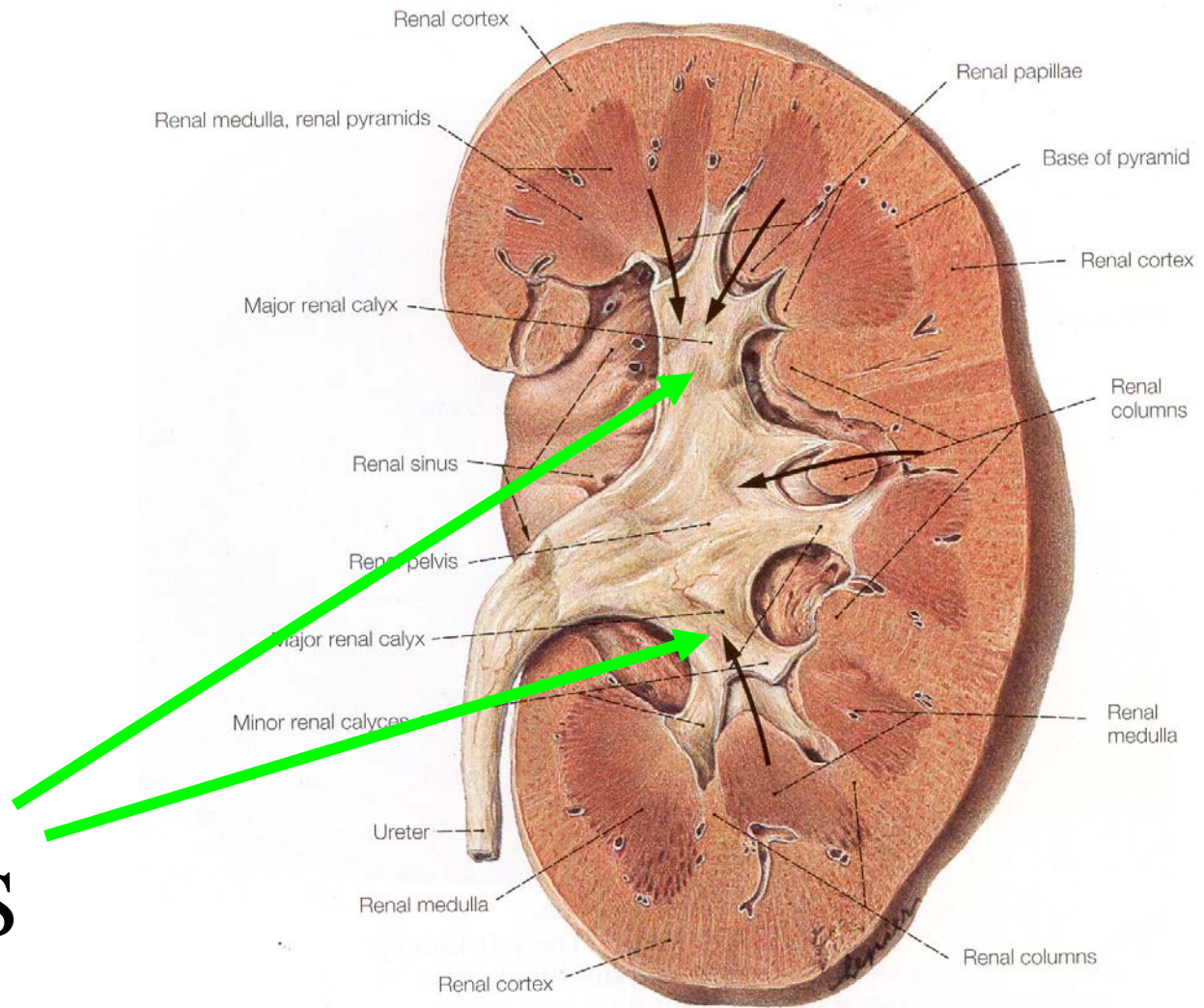
URETER
runs from
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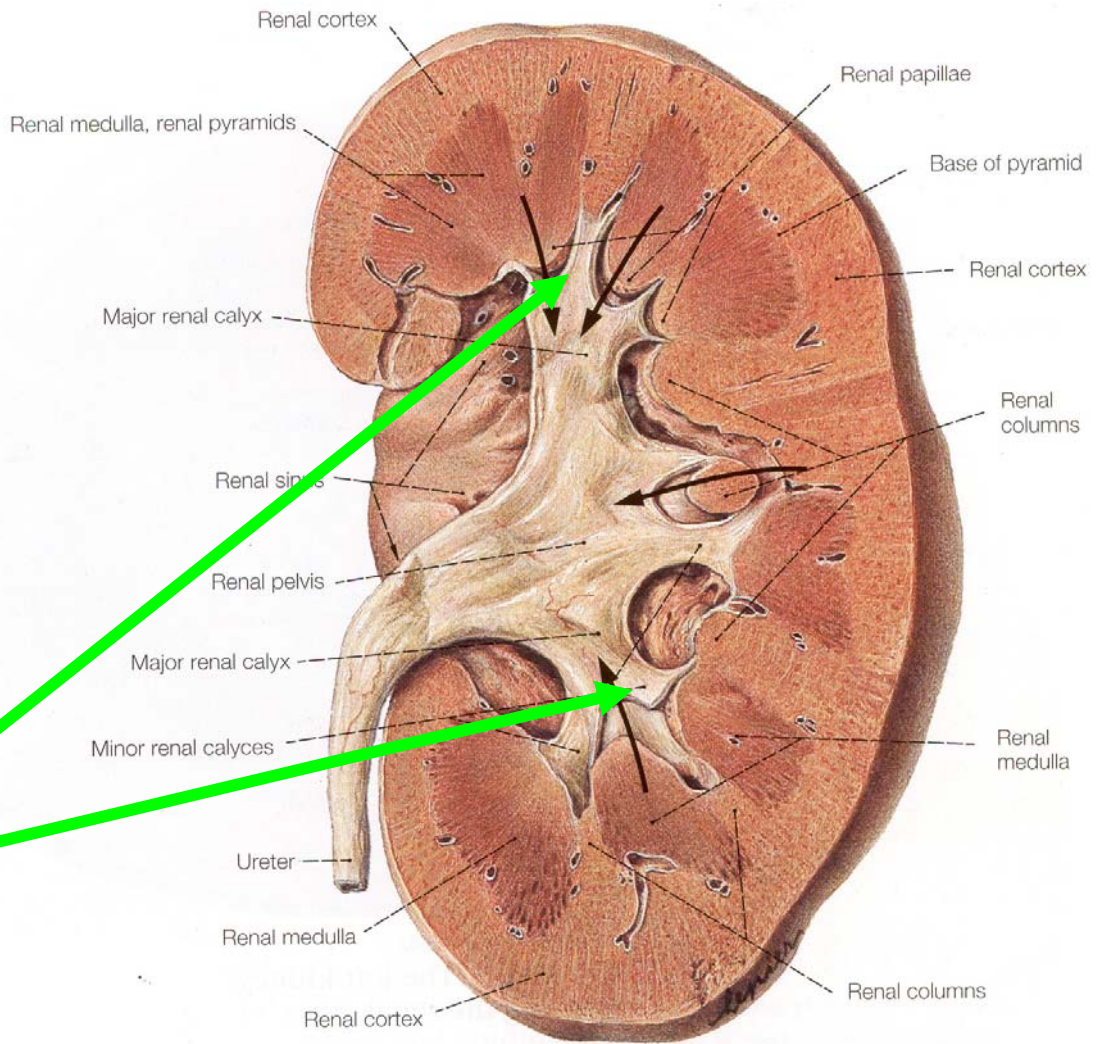
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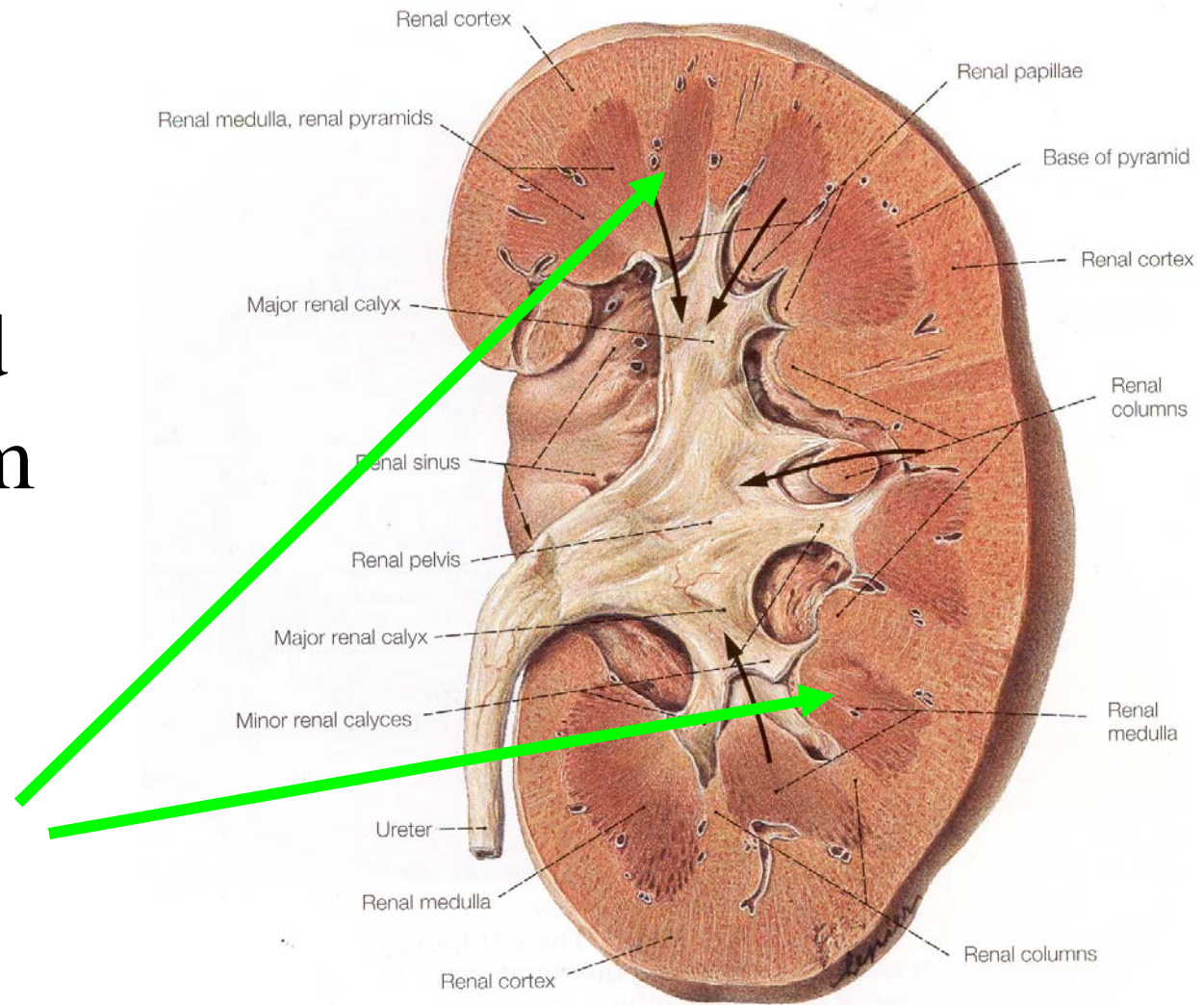
Renal
pelvis
branches
into
structures
called the
**MAJOR
CALYCES**



Major
calyces
divided into
**MINOR
CALYCES.**



Minor
calyces
receive fluid
outflow from
many
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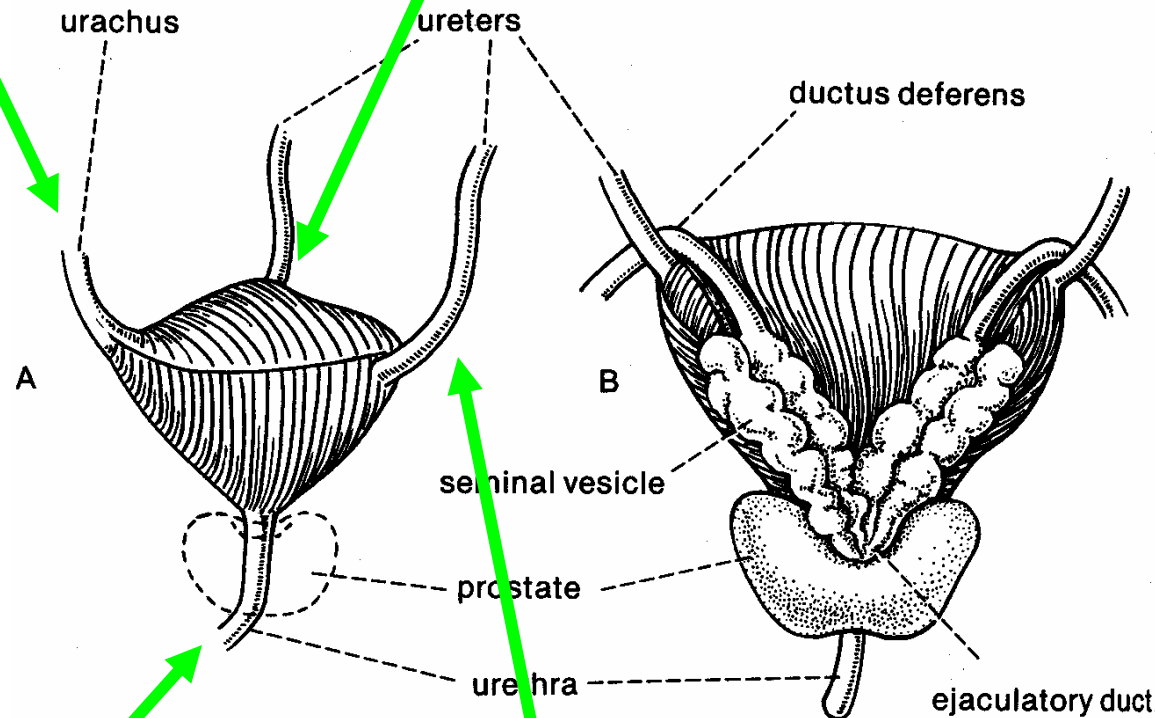


STRUCTURE OF THE BLADDER

- Sort of a bulging tetrahedron in shape.
- **4 ATTACHMENTS - one at each corner.**
- One corner lies at top edge of pubic symphysis (here, vestigial URACHUS holds it down)
- Right and left URETERS dump in cranio-dorsally.
- URETHRA exits caudally (inferiorly).

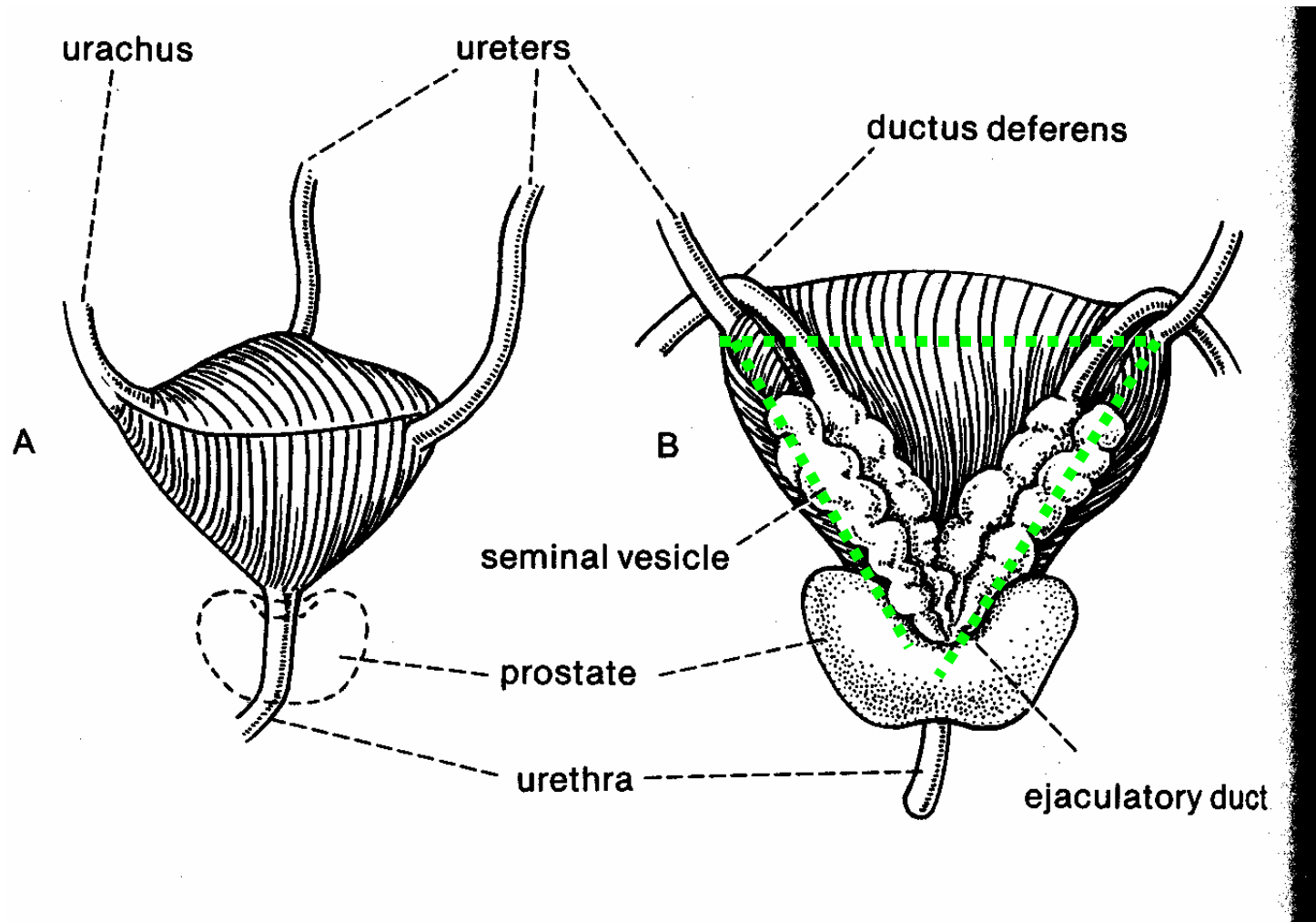
1. Urachus

2. Right Ureter

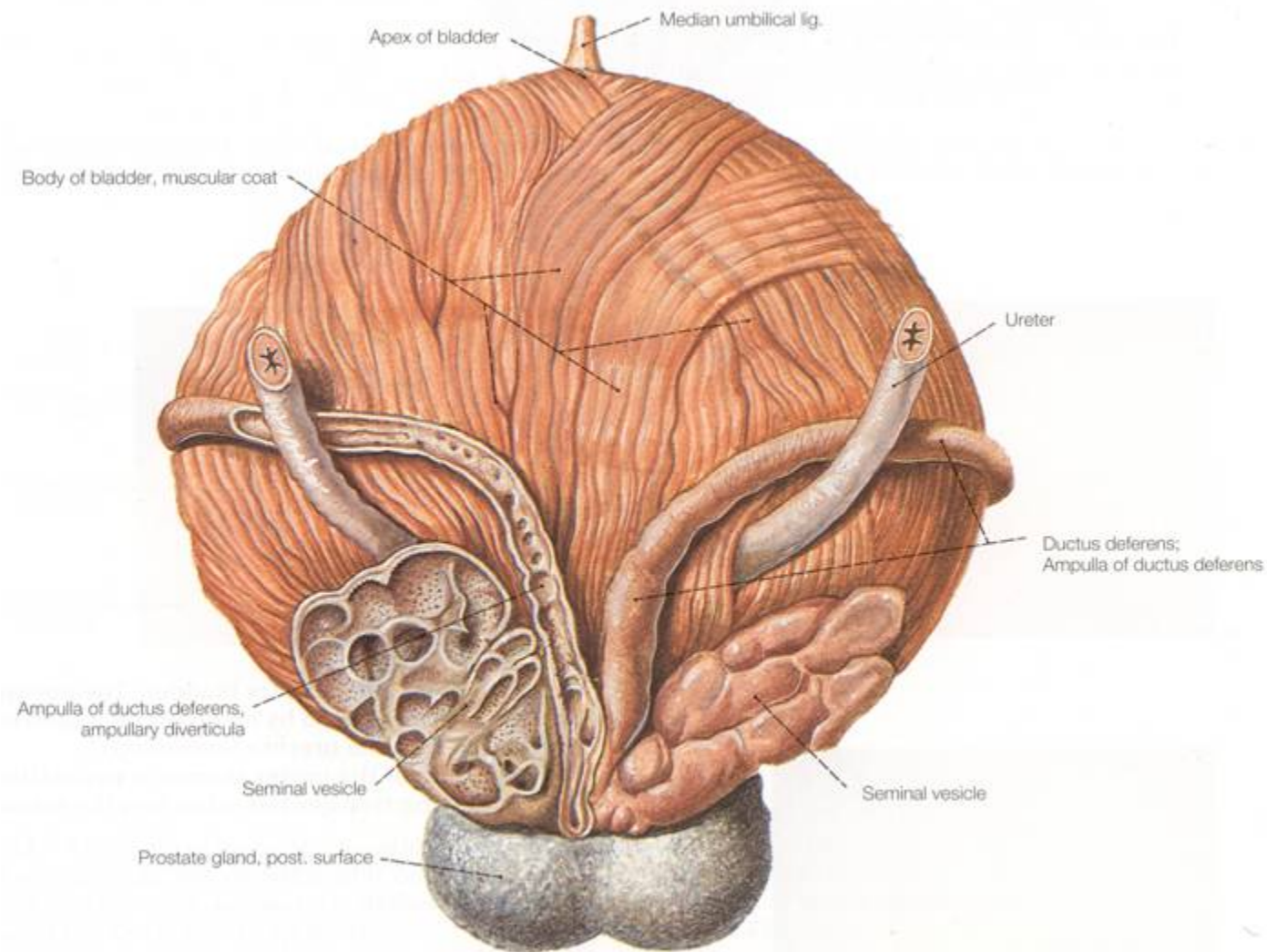


4. Urethra

3. Left Ureter



The triangle defined by the connection of the two ureters and the exit of the urethra is **NOT ELASTIC**. It is known as the **TRIGONE OF THE BLADDER**.



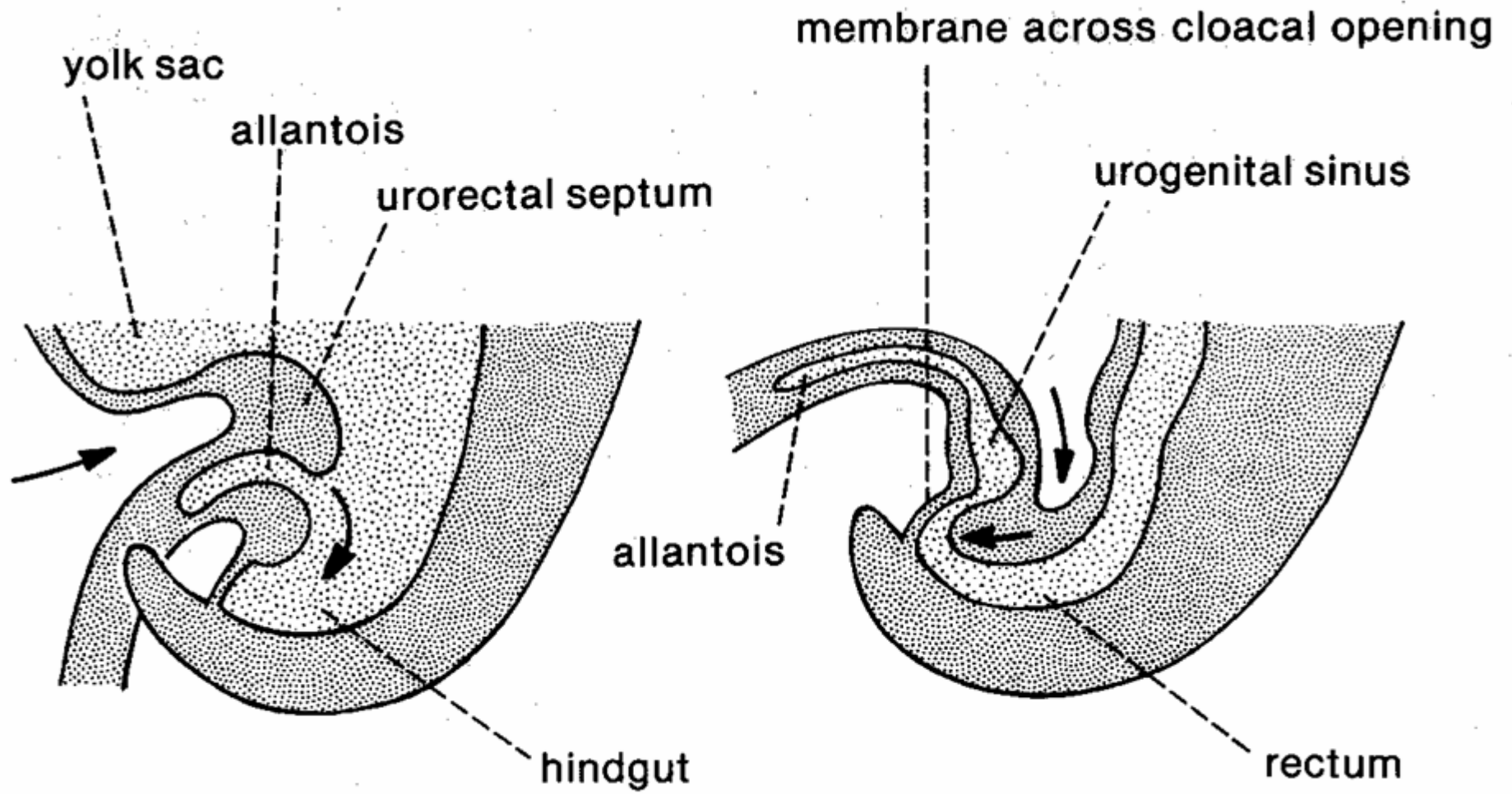
017 The male urinary bladder, ductus

The external musculature of the urinary bladder

The bladder is lined by a special type of epithelium:
TRANSITIONAL EPITHELIUM (it's stretchy).

URETER ATTACHMENT

- Traverse the bladder obliquely.
- So, when bladder is full, they get squeezed flat.
- There is no valve, but this passive closing prevents urine from backing up into the kidneys.

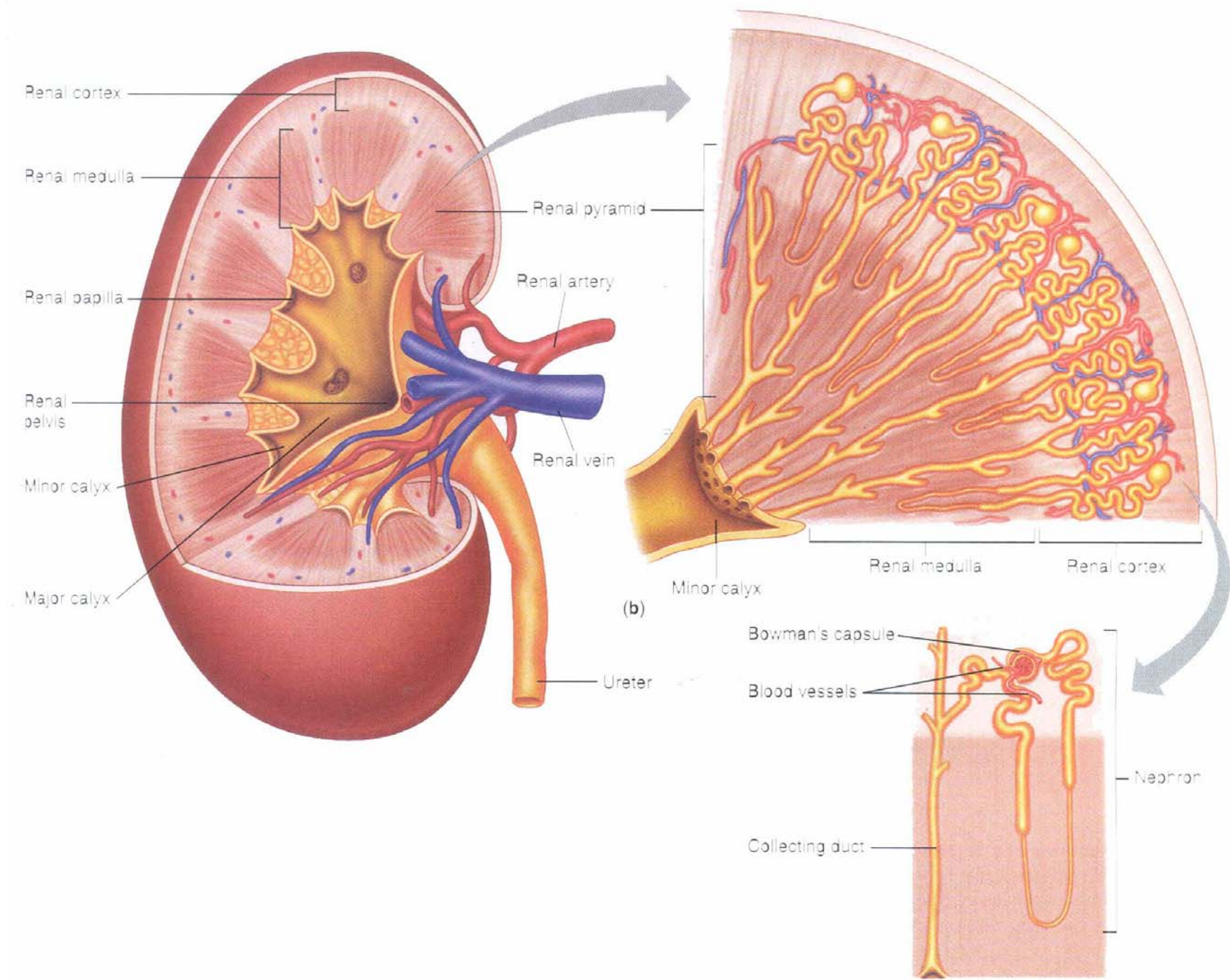


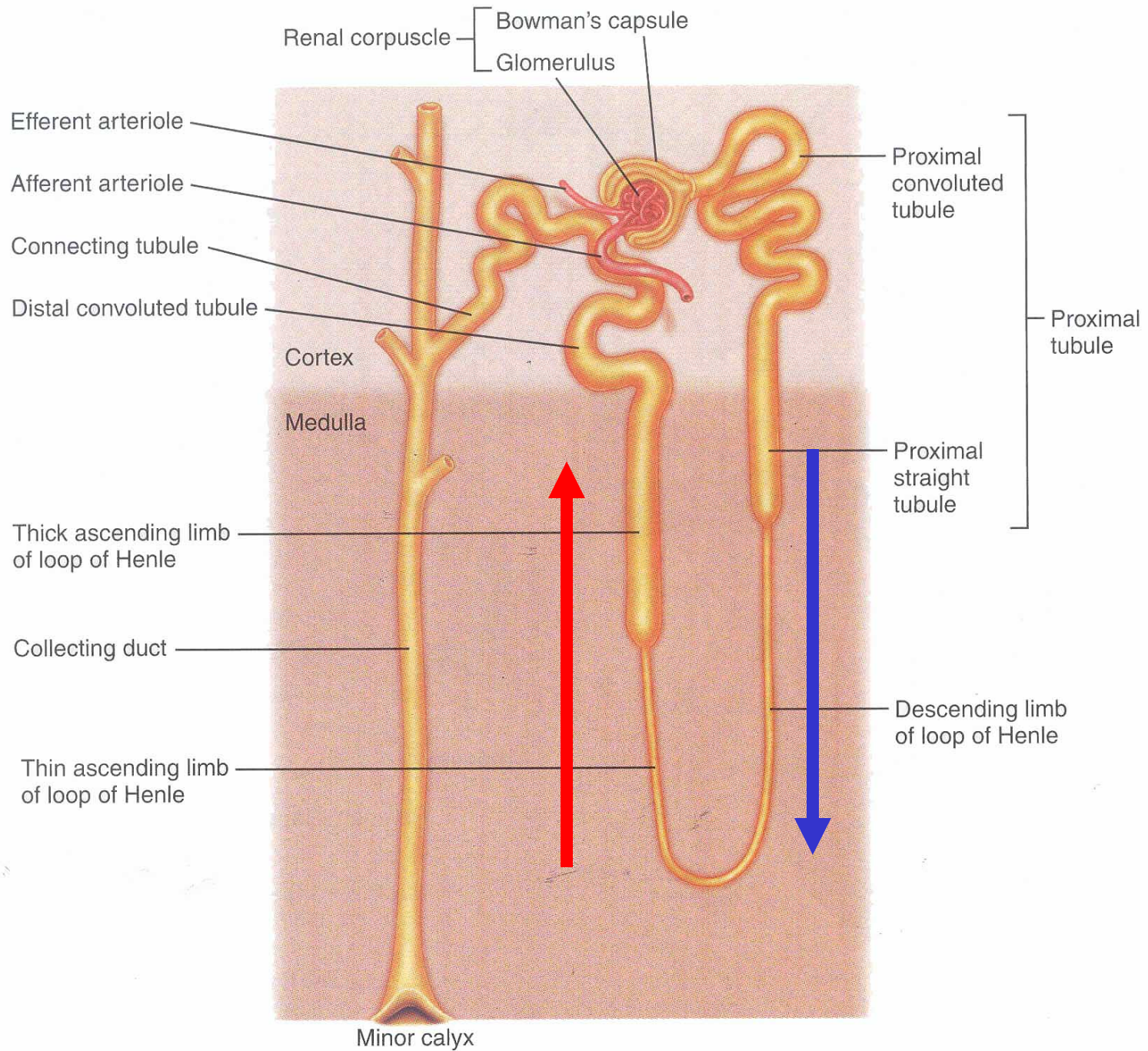
THE NEPHRON AND COUNTERCURRENT EXCHANGE:

Countercurrent Exchange is one of the most important physiological phenomena in all of nature. (Among other things) It allows hyperconcentration of substances.

Definition:

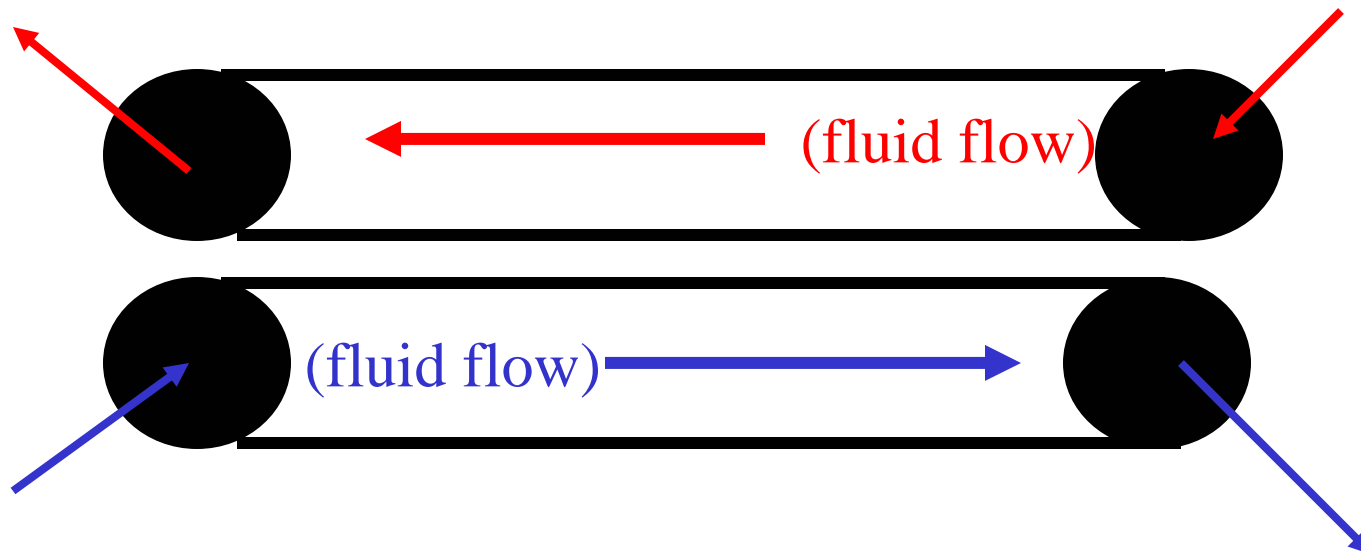
COUNTERCURRENT EXCHANGE – a pair of adjacent channels or tubes containing *fluids flowing in opposite directions* and having an energetic gradient directed between one channel and the other. (In other words, stuff can flow between the tubes.)





Low concentration out

High concentration in



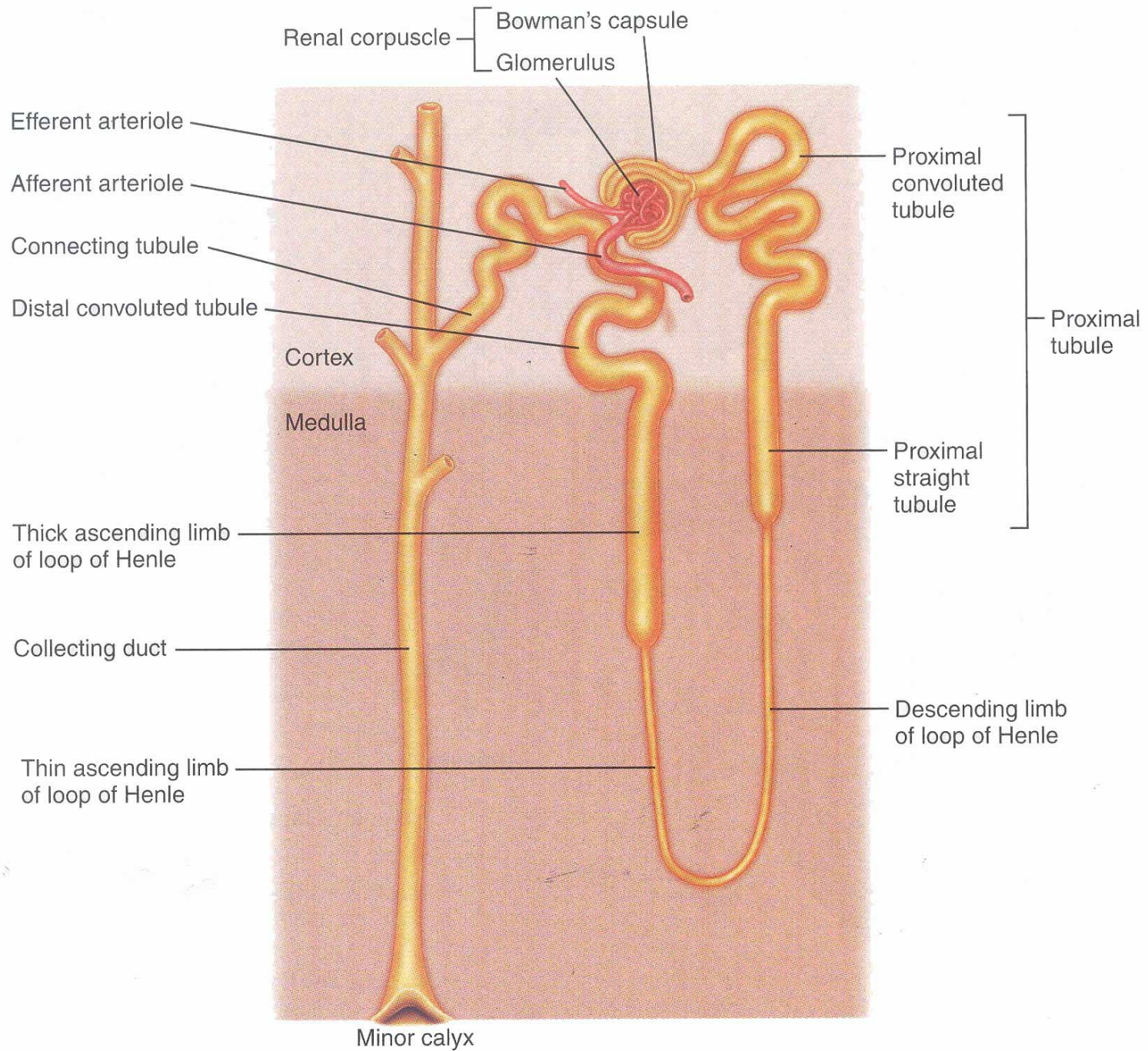
Low concentration in

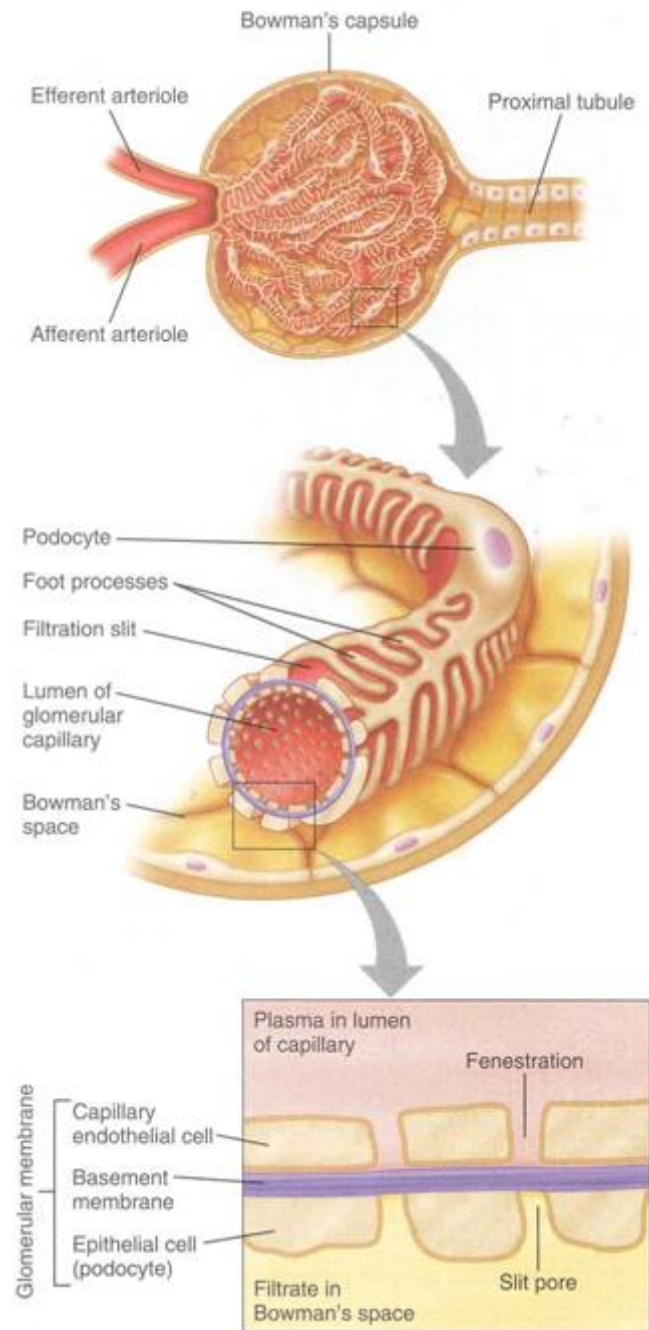
High concentration out

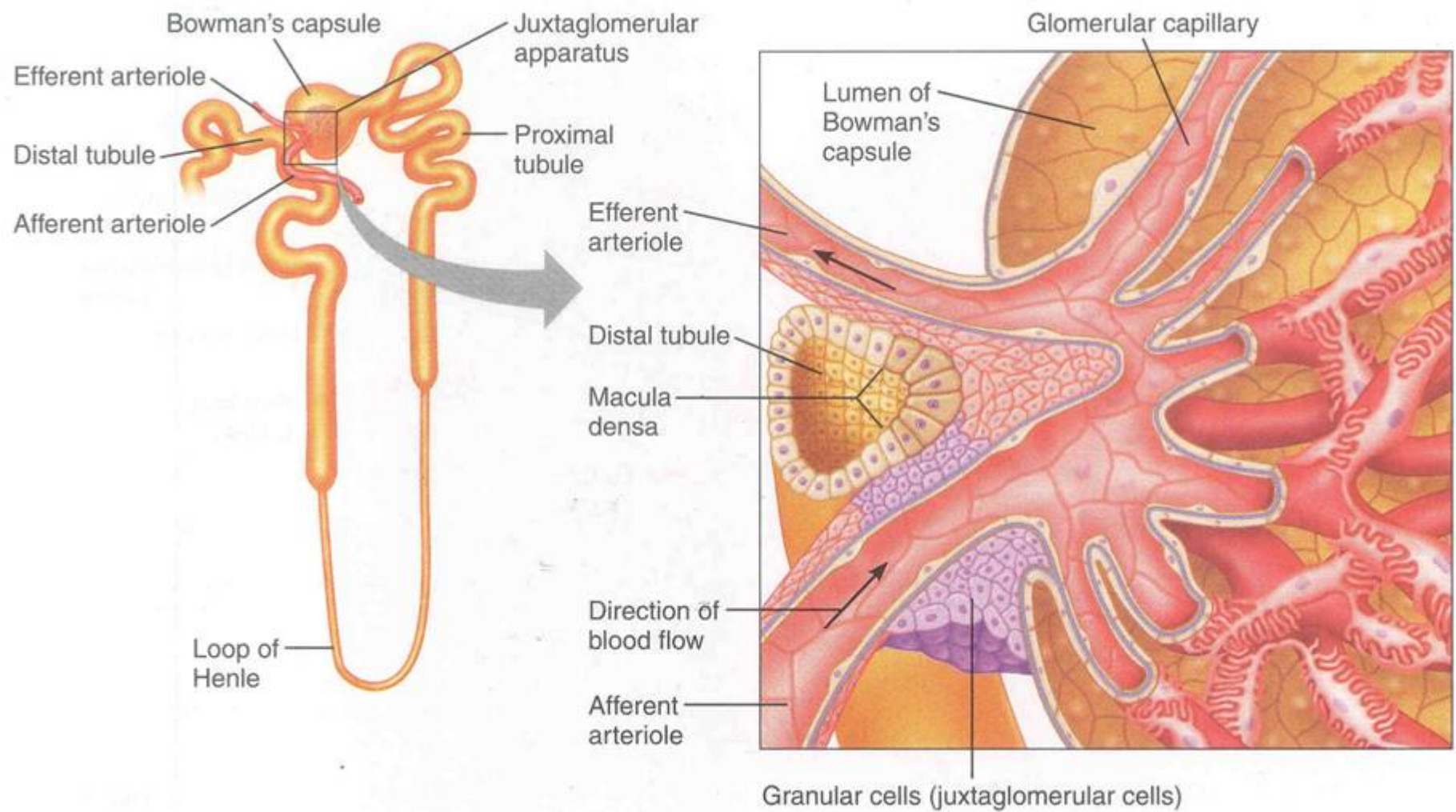
The arrangement of tubes in **OPPOSITE FLOW DIRECTIONS** means that even as the tube starts with lower concentration and picks up solutes, even when it get to the end it can still pickup a bit, as it is encountering the highest concentration of adjacent tube.

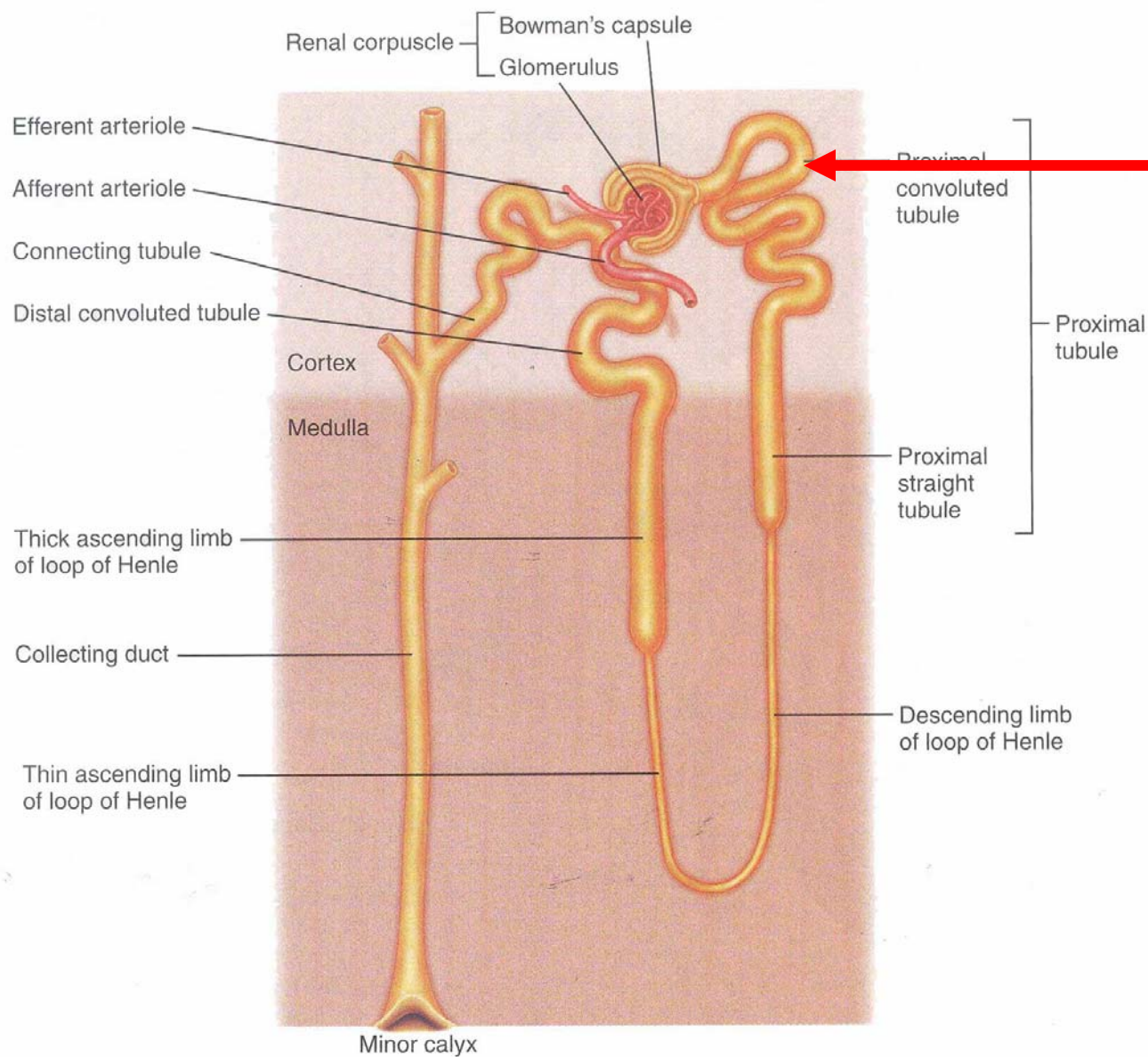
A COUNTERCURRENT EXCHANGE SYSTEM can only work if there is an asymmetry in the system.

In this case, there is active transport in only one direction. In the case of the kidney, salts are being transported to concentrate salts in the urine.









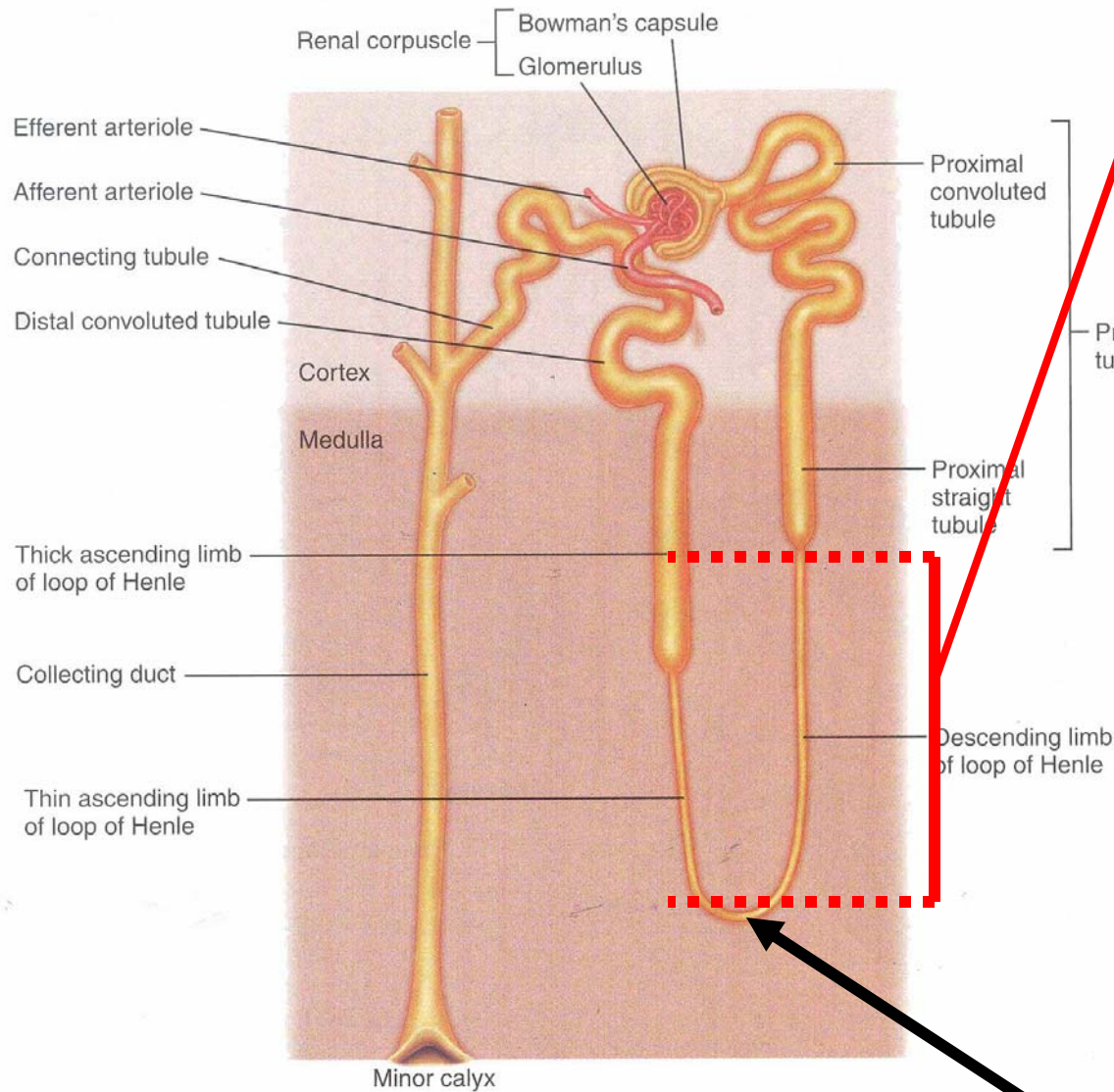
Proximal Convolved Tubule:

Initiate concentration of glomerular filtrate.

About 75% of sodium removed by active transport here, and chlorine follows passively.

Remaining fluid in nephron tube is about same concentration as that of surrounding interstitial fluid.

Remaining fluid reduce to about 25% original volume



Loop of Henle:

Acts in manner of counter current exchanger. Note that each limb of loop has fluid moving in opposite directions (even though connected at one end).

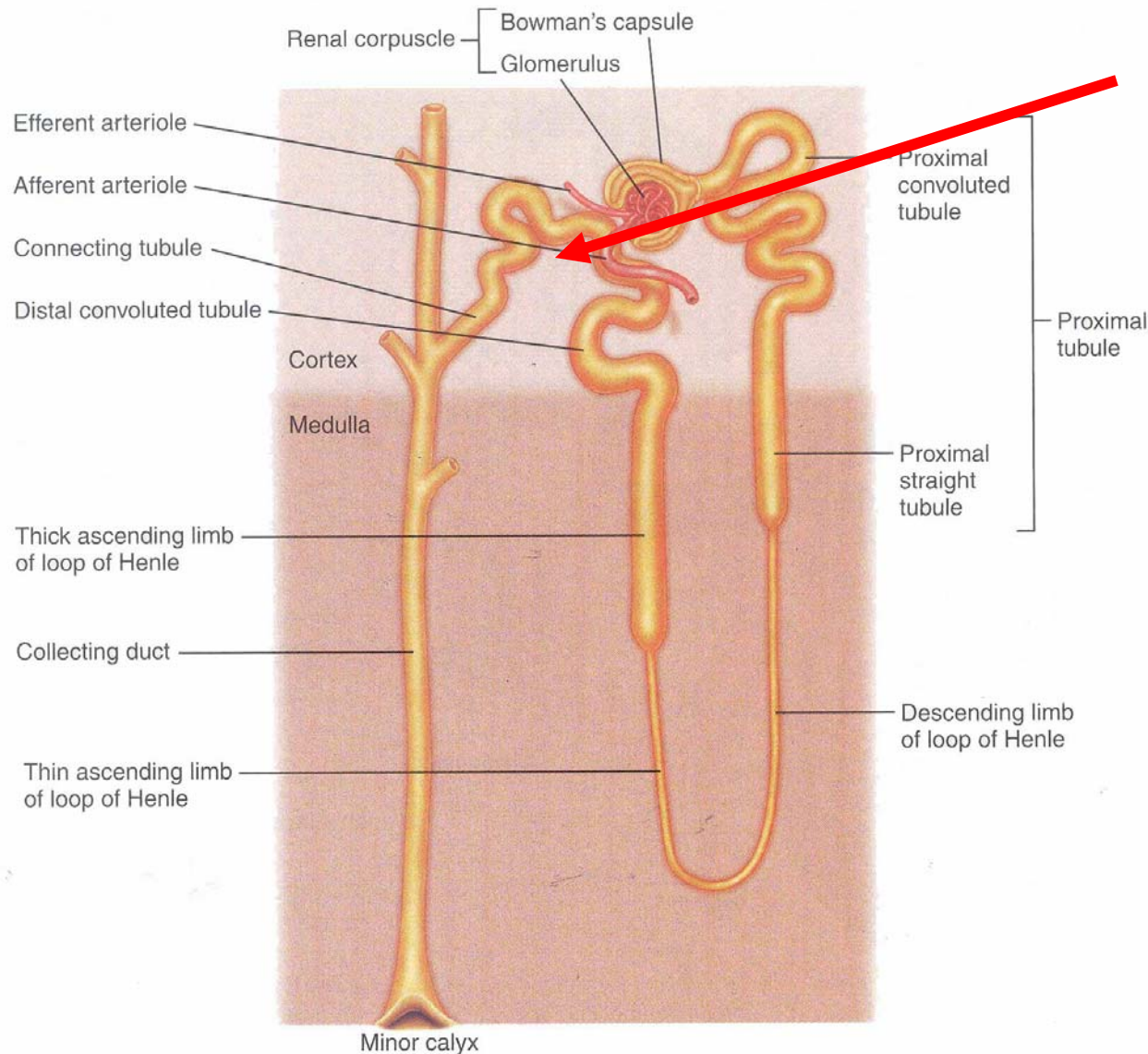
Further concentrates urine.

Also means that salt concentration will be highest near bend in the loop.

DESCENDING LOOP OF HENLE: No active transport of salt out of the descending loop of Henle.

ASCENDING LOOP OF HENLE: Chlorine ions actively transported out of loop *into the interstitial space*. Oppositely charged sodium ions follow. However, *water does not move out of the ascending loop*.

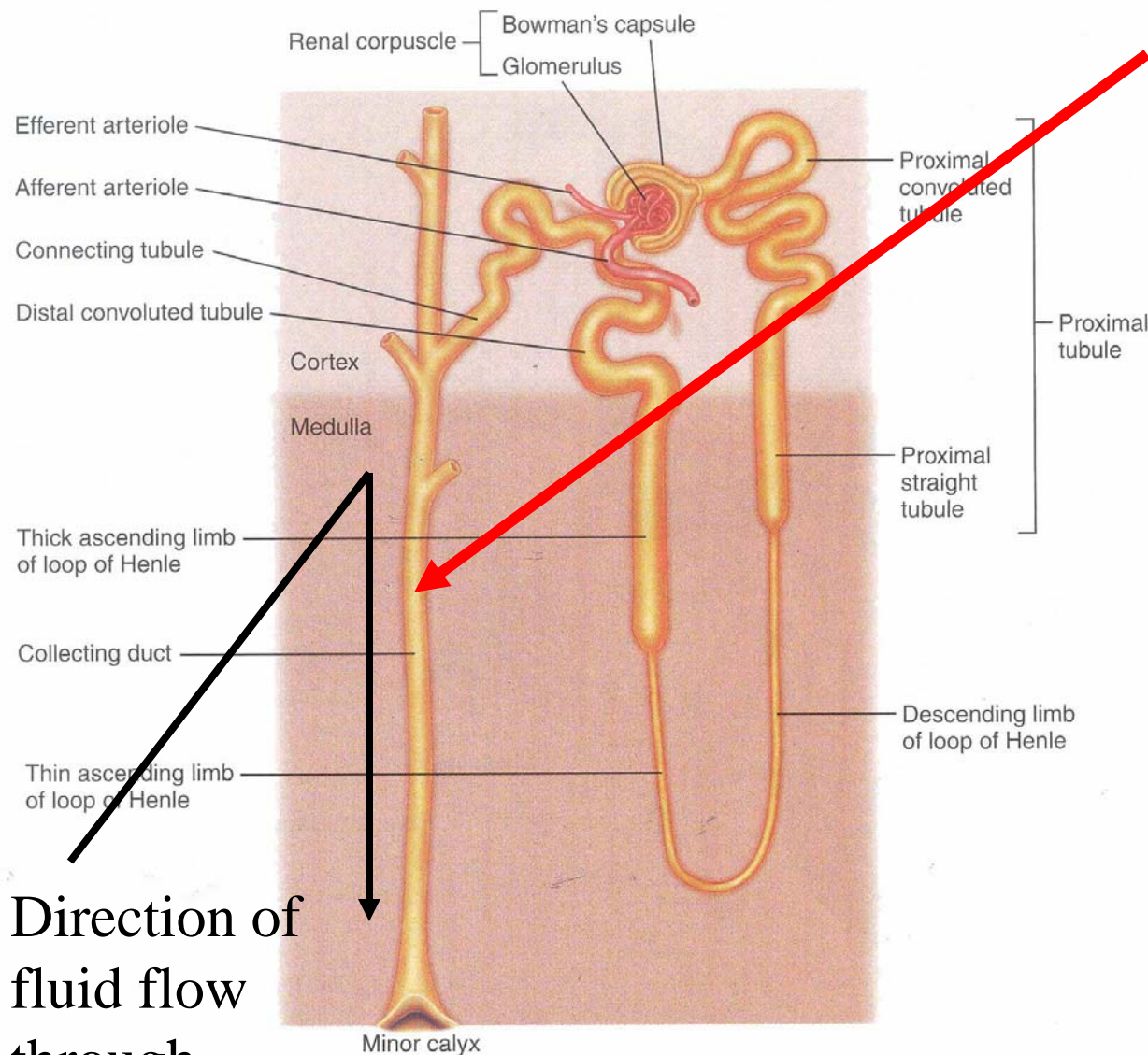
A concentration gradient IN THE INTERSTITIAL SPACE has been set up by the chlorine (plus sodium) transport.



Distal Convolved Tubule:

In addition to sodium-chloride, potassium, ammonia, and carbonate removed from filtrate here. These are retained as needed by the body.

At this point, nephron has used materials IN the glomerular filtrate to set up a concentration gradient in the interstitial space of the kidney.



Direction of
fluid flow
through
collecting
tubule.

By process of osmosis, water wants to move from region of higher water concentration to lower. This pulls water from filtrate, leaving behind a more concentrated “urine”.

Collecting Duct:

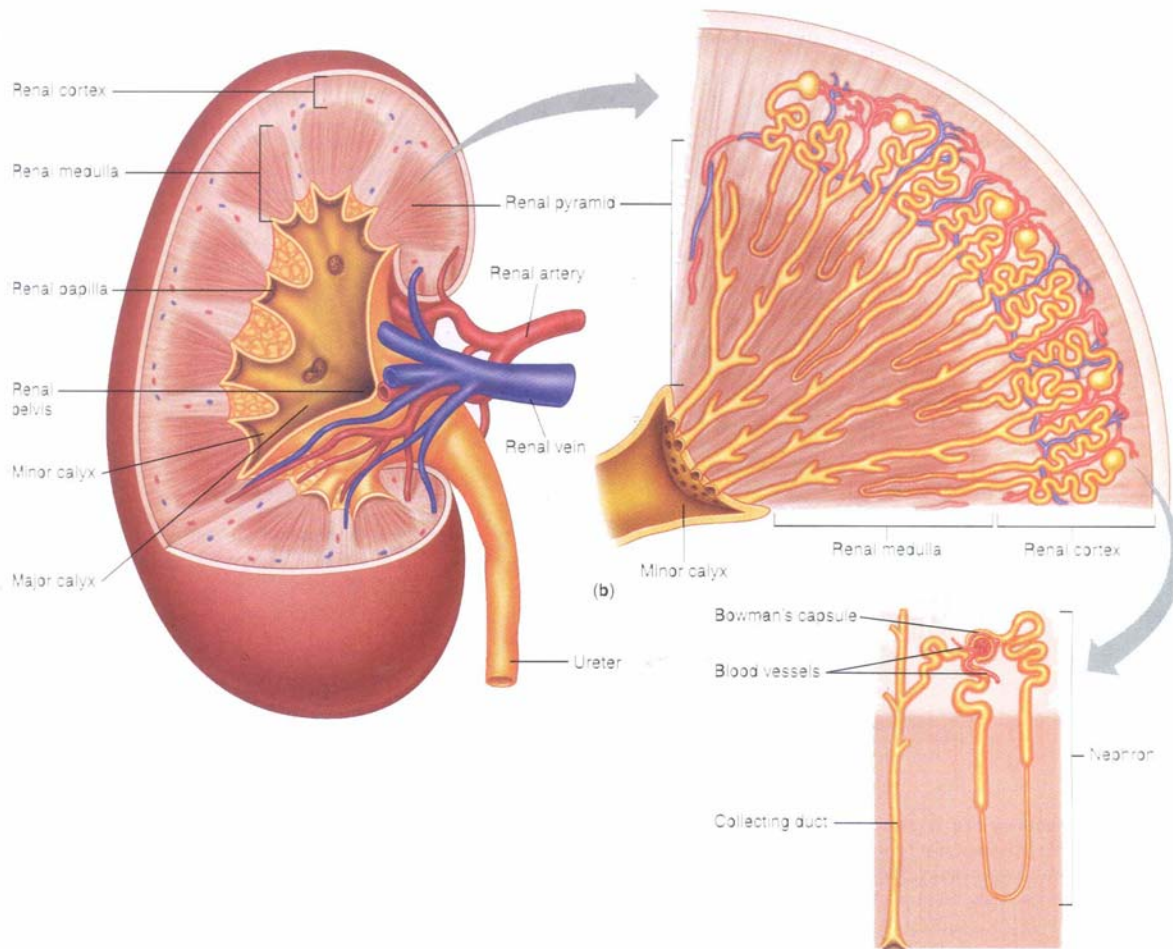
Receives many proximal convoluted tubules.

Collecting duct now passes through the concentration gradient set up by many adjacent nephrons.

So, as glomerular filtrate passes down collecting tubule, it moves through higher and higher concentration of salts that were set up by loops of Henle.

By setting up a countercurrent system, a salt concentration gradient is set up in the interstitial space (highest concentration near curve of loop of Henle).

As fluid in collecting tubules reacts to concentration gradient, water is pulled out, concentrating filtrate as urine.



**GROSS ANATOMY
DEFINE BY
MICROSCOPIC
STRUCTURE:**

CORTEX – part that contains the convoluted tubules and proximal part of Loop of Henle, and proximal part of collecting tubules.

MEDULLA -- contains distal part of Loop of Henle, and distal part of collecting tubules. Where most of the active transport takes place.

URINE PRODUCTION: HORMONAL CONTROL

In regards to urine production, the most important hormone is ANTIDIURETIC HORMONE, or **ADH**.

ADH makes the collecting duct **MORE** permeable to water. Thus, secretion of ADH causes the **retention** of water in the body, and more concentrated urine. (ADH is usually secreted in response to environmental situations that require the retention of water.)

A **diuretic** will have opposite effect: decreases permeability of collecting tubule, so you lose lots of water (copious, dilute urine). Examples of diuretics: caffeine, alcohol (beer particularly due to the hops), capsaicin (the active ingredient in hot peppers), others.