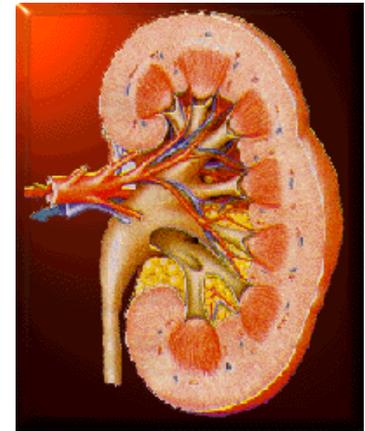


# The Urinary System

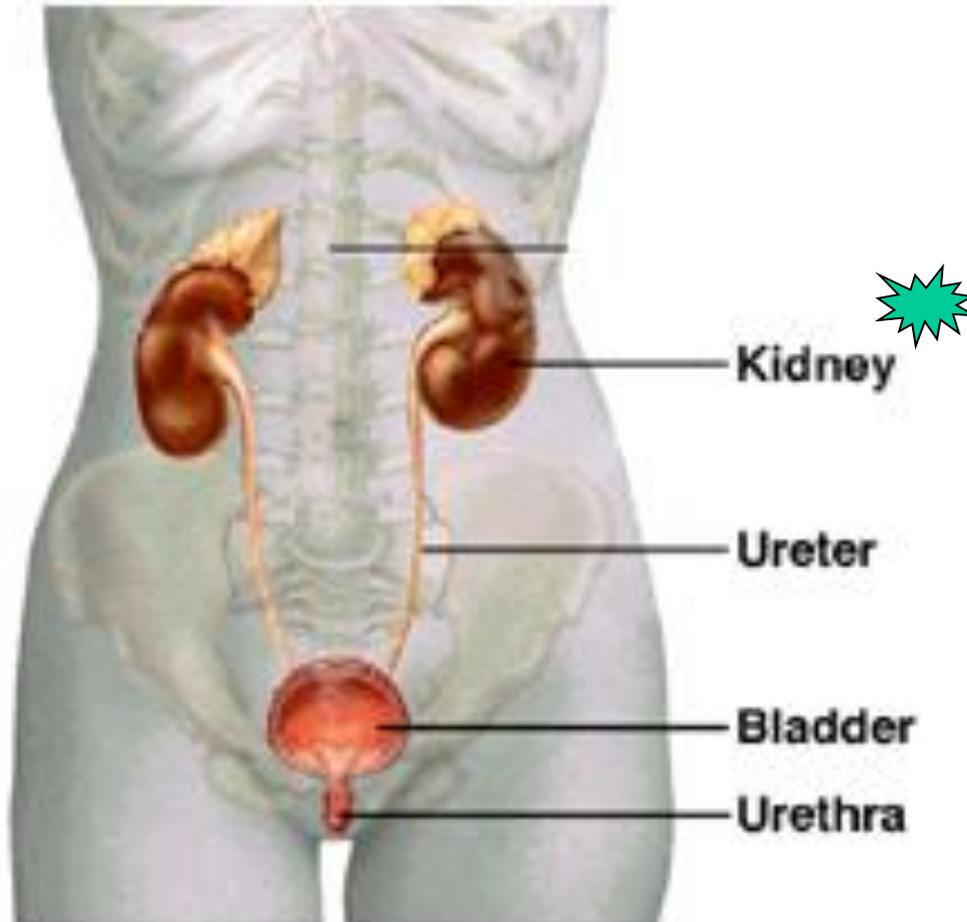


# Function



1. Remove nitrogenous wastes
2. Maintain electrolyte, acid-base, and fluid balance of blood
3. Homeostatic organ
4. Acts as blood filter
5. Release hormones: calcitriol & erythropoietin

# Composition of the Urinary System



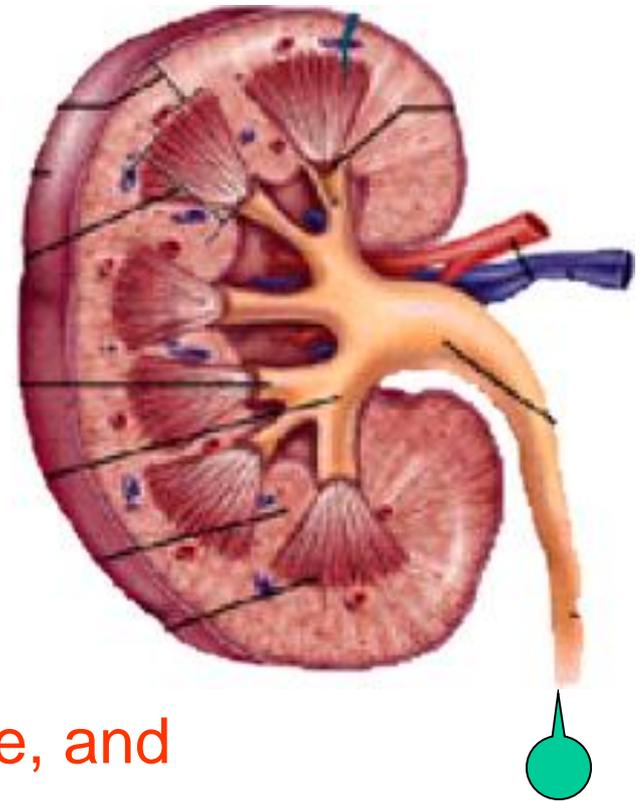
# Functions of the Kidneys

1) filter blood plasma, separate wastes, return useful materials to the blood, and eliminate the wastes.

Toxic ***nitrogenous wastes***

- ammonia, urea, uric acid, creatine, and creatinine

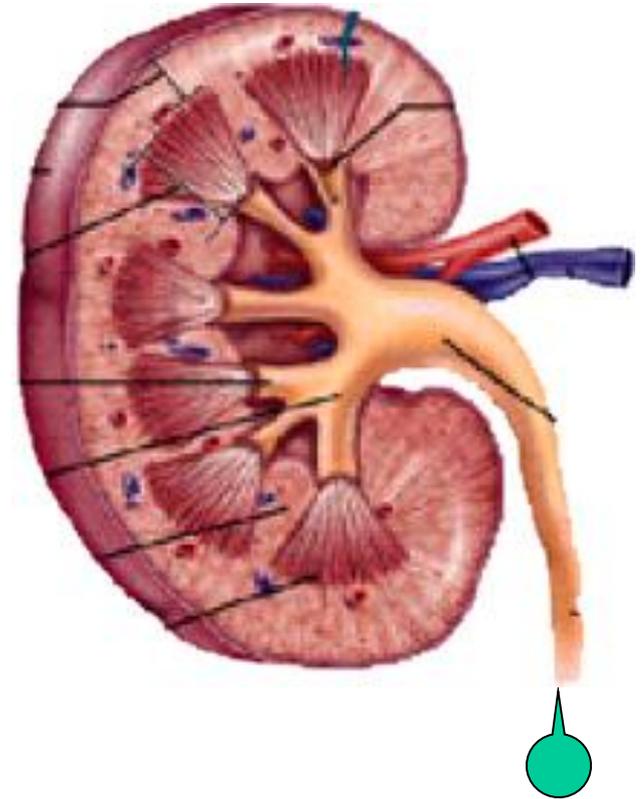
- cause diarrhea, vomiting, and cardiac arrhythmia, convulsions, coma, and death.



# Functions of the Kidneys

1) filter blood plasma, separate wastes, return useful materials to the blood, and eliminate the wastes.

2) regulate blood volume and osmolarity.



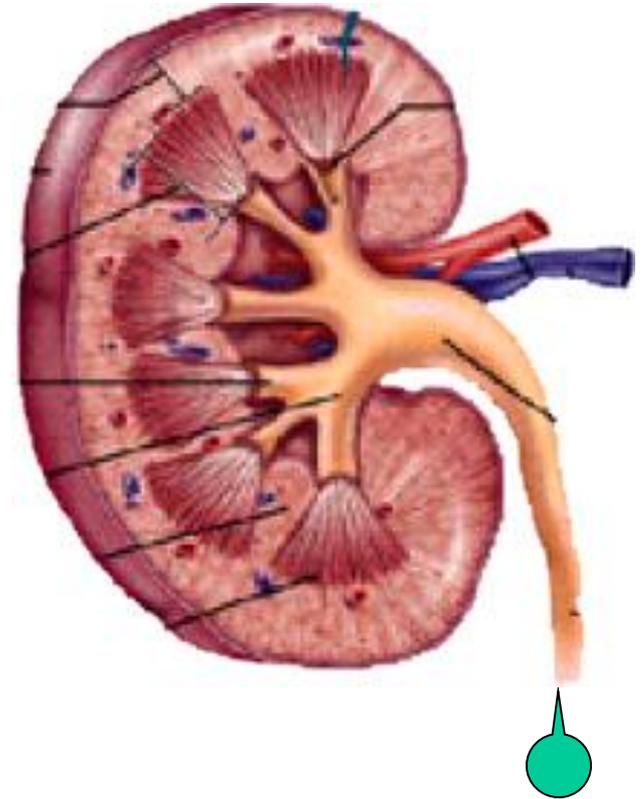
# Functions of the Kidneys

## 3) produce hormones

1. renin
2. erythropoietin
3. calcitrol

## 4) regulate acid-base balance of the body fluids.

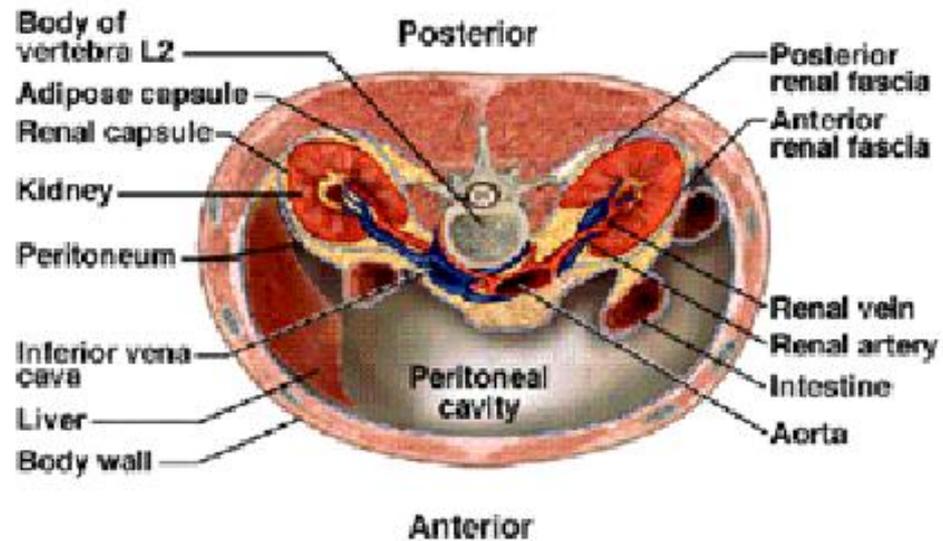
## 5) detoxify superoxides, free radicals, and drugs.



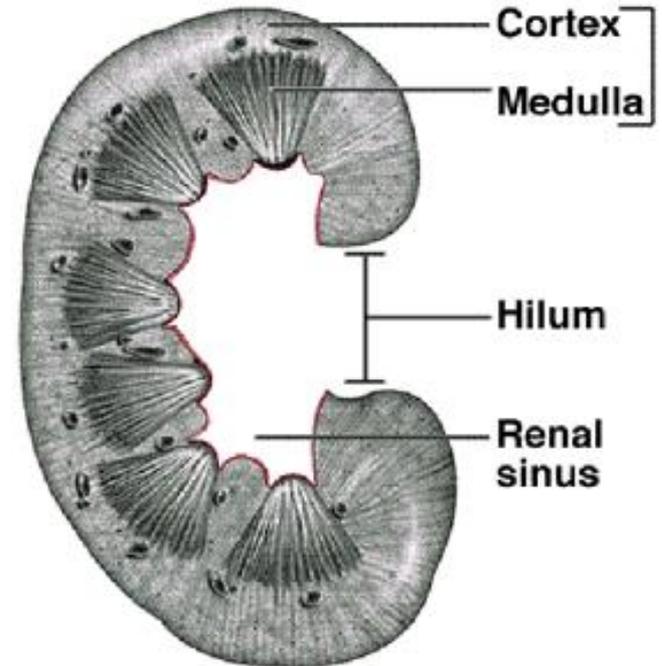
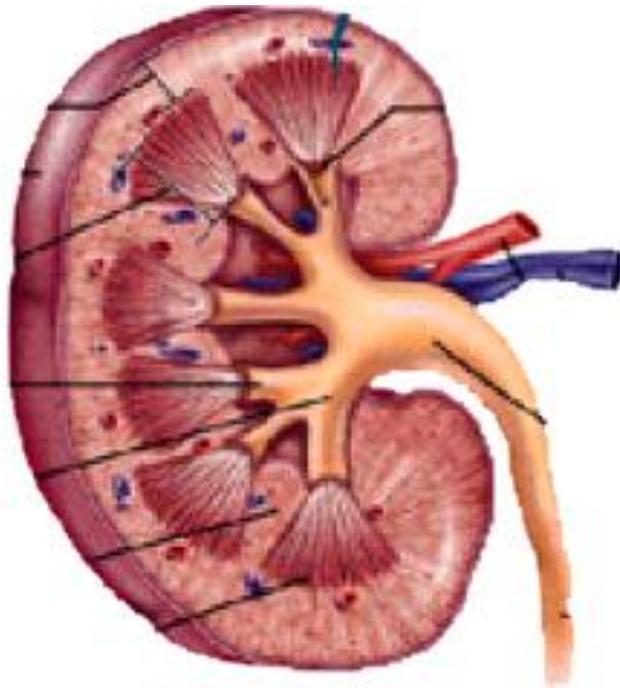
# Kidney Functions

- Filter 200 liters of blood daily, allowing toxins, metabolic wastes, and excess ions to leave the body in urine
- Regulate volume and chemical makeup of the blood
- Maintain the proper balance between water and salts, and acids and bases

- The kidneys lie along the posterior abdominal wall

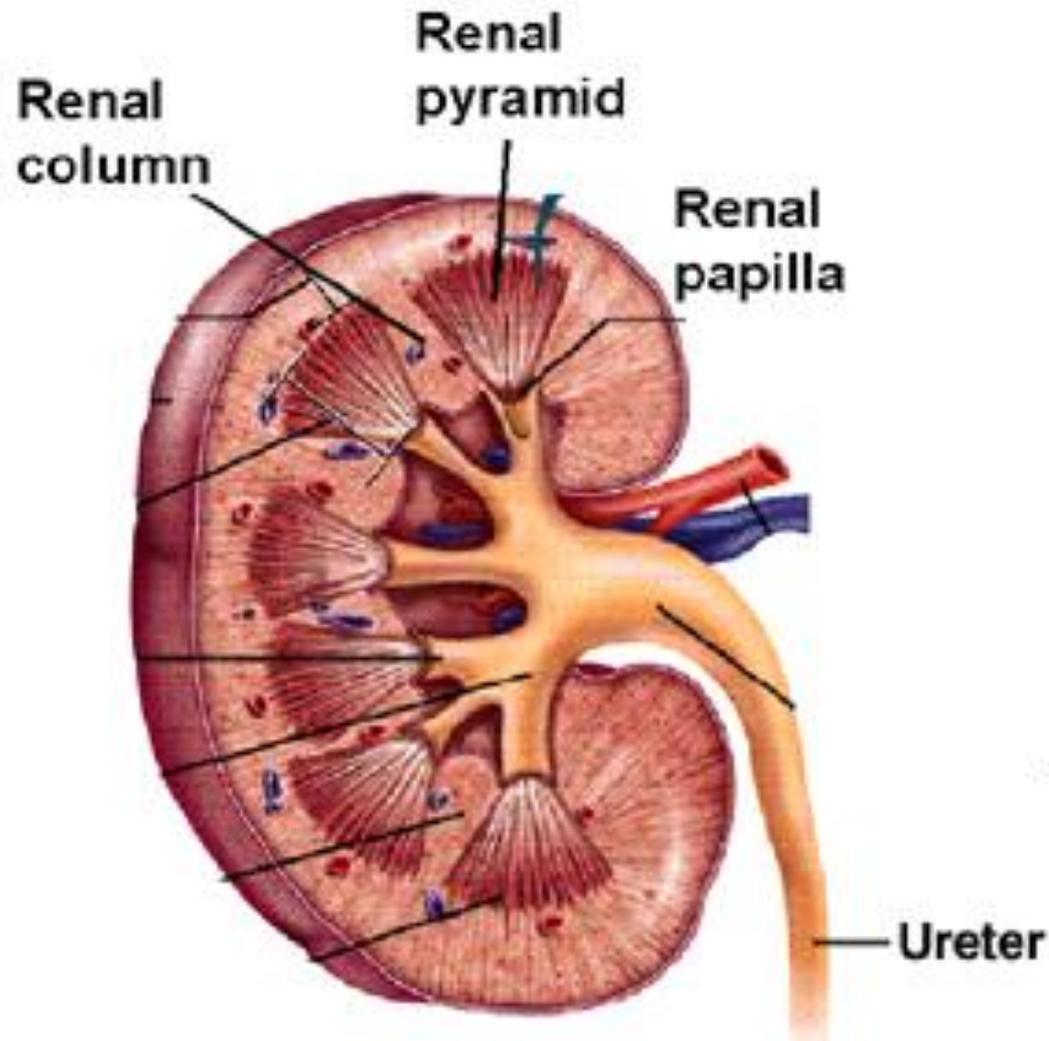


- The medial surface of the kidney is concave with a ***hilum*** carrying renal nerves and blood vessels.

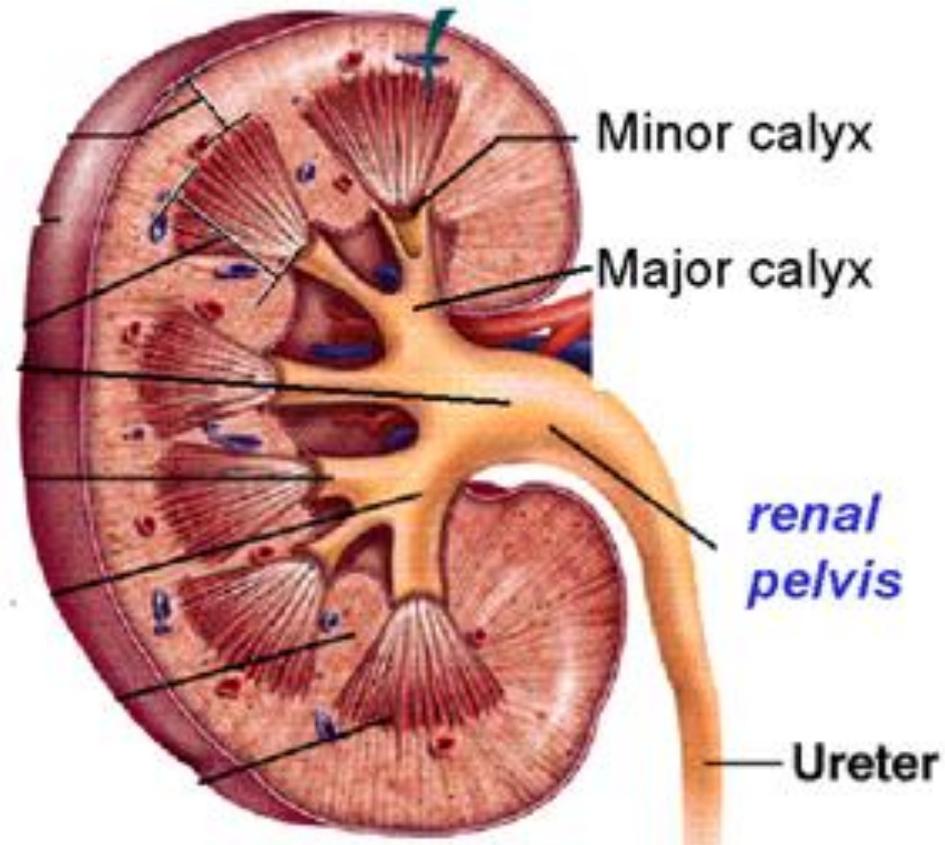


The renal parenchyma is divided into an outer ***cortex*** and inner ***medulla***.

Extensions of the cortex (*renal columns*) project toward the sinus, dividing the medulla into 6-10 *renal pyramids*. Each pyramid is conical with a blunt point called the *papilla* facing the sinus.



The papilla is nestled into a cup called a *minor calyx*, which collects its urine. Two or three minor calyces merge to form a *major calyx*. The major calyces merge to form the *renal pelvis*.



# The Nephron

- The kidney contains 1.2 million **nephrons**, which are the functional units of the kidney.

- A nephron consists of :

**i. blood vessels**

*afferent arteriole*

*glomerulus*

*efferent arteriole*

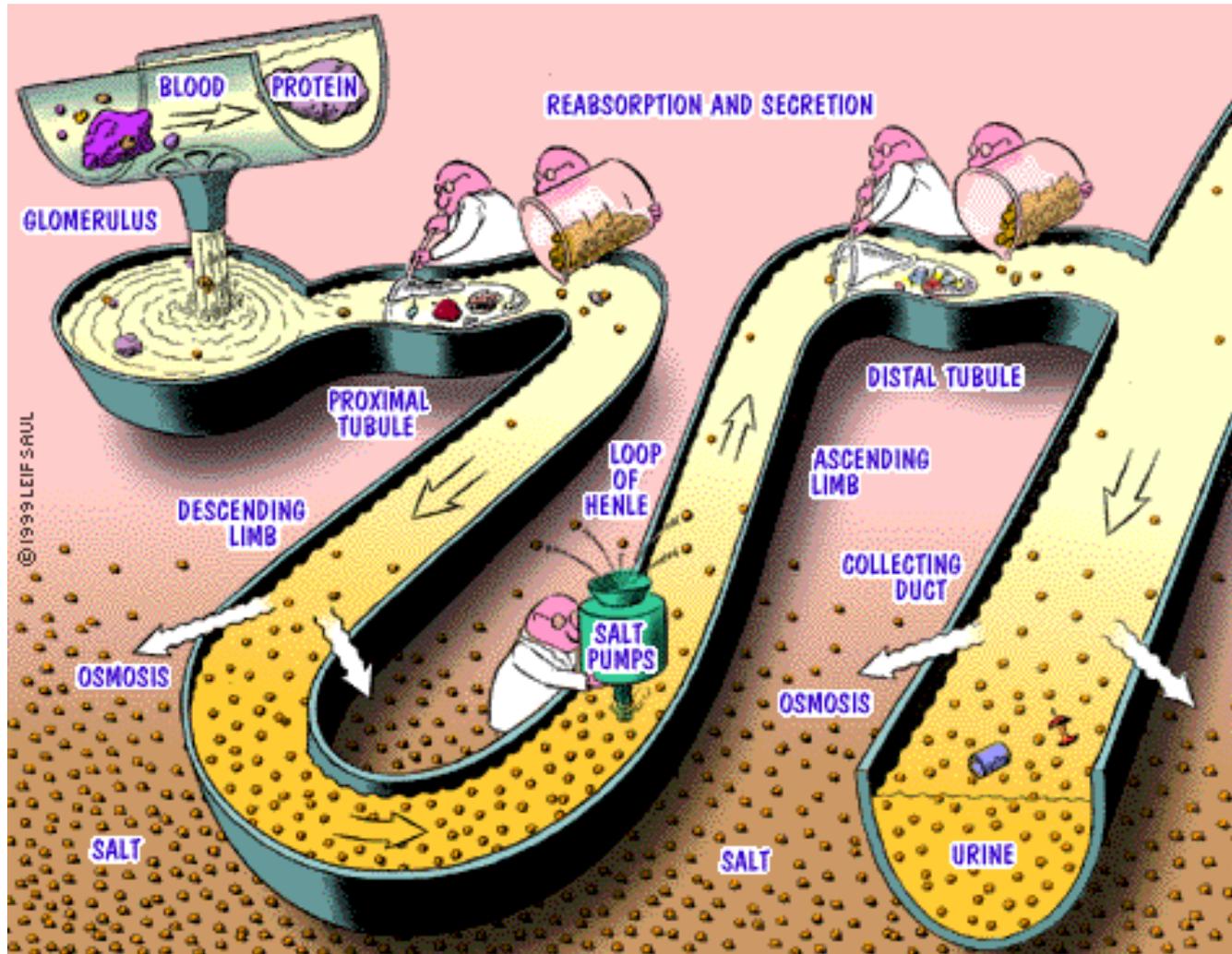
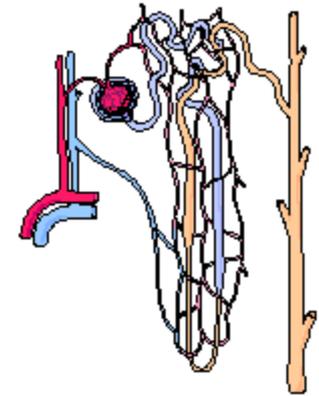
**ii. renal tubules**

*proximal convoluted tubule*

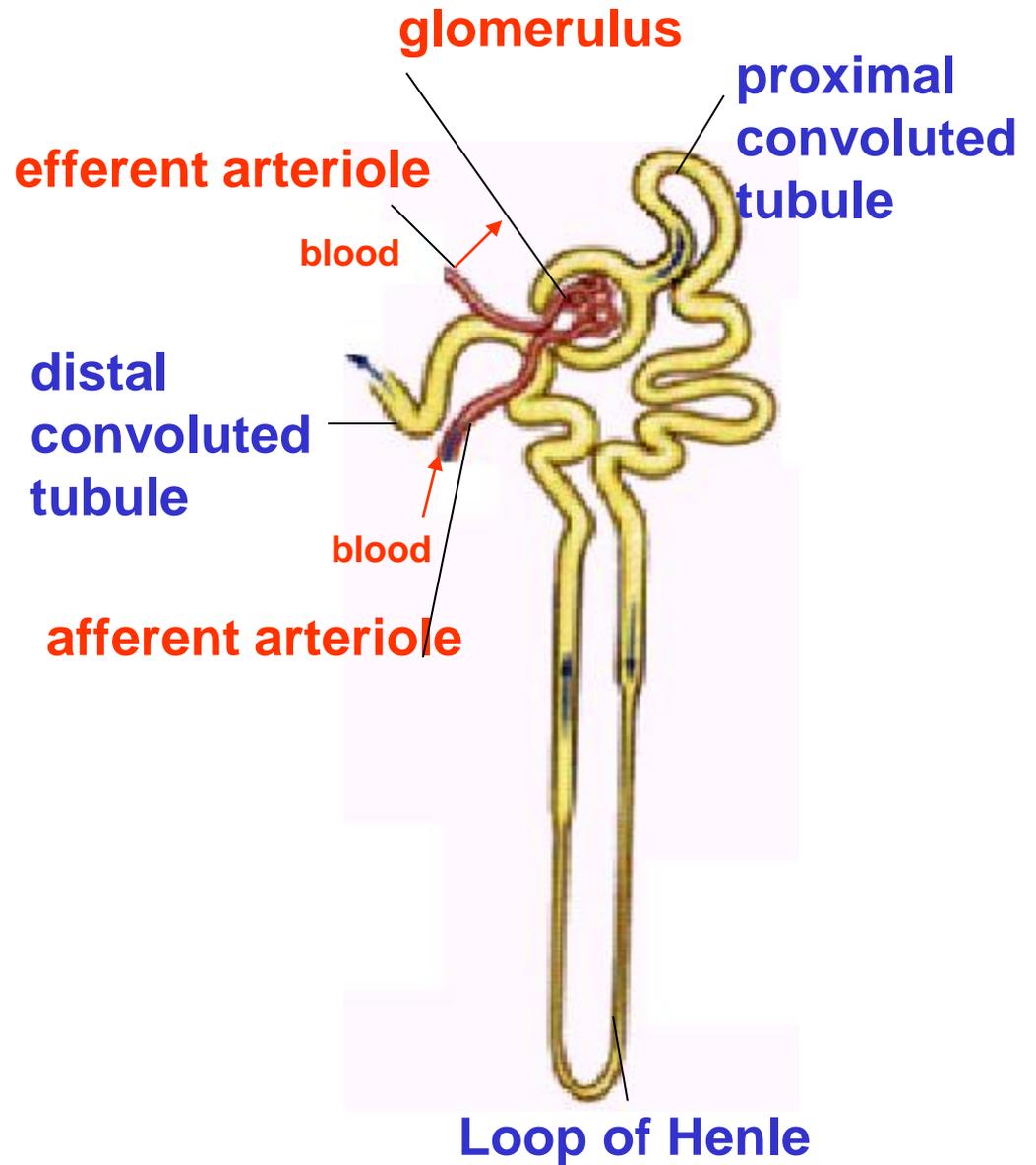
*loop of Henle*

*distal convoluted tubule*

# Nephron

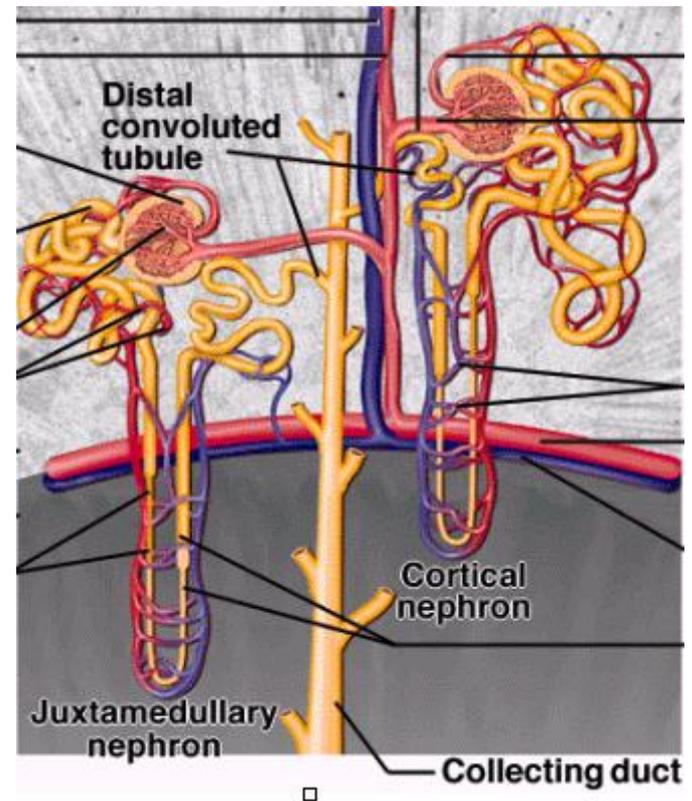
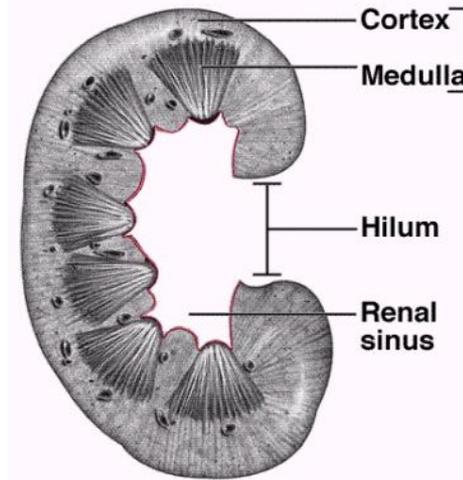


# The Nephron

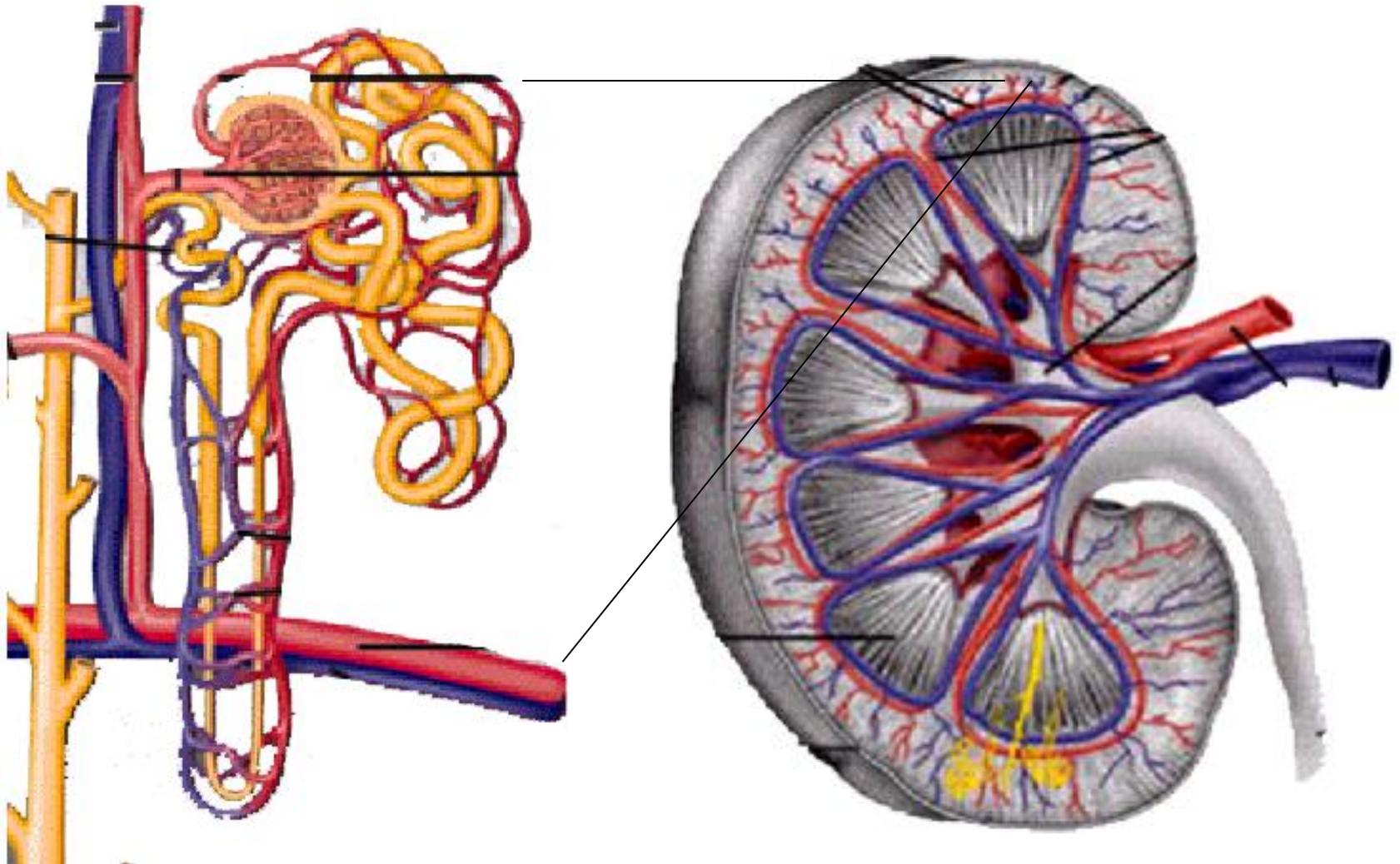


# The Nephron

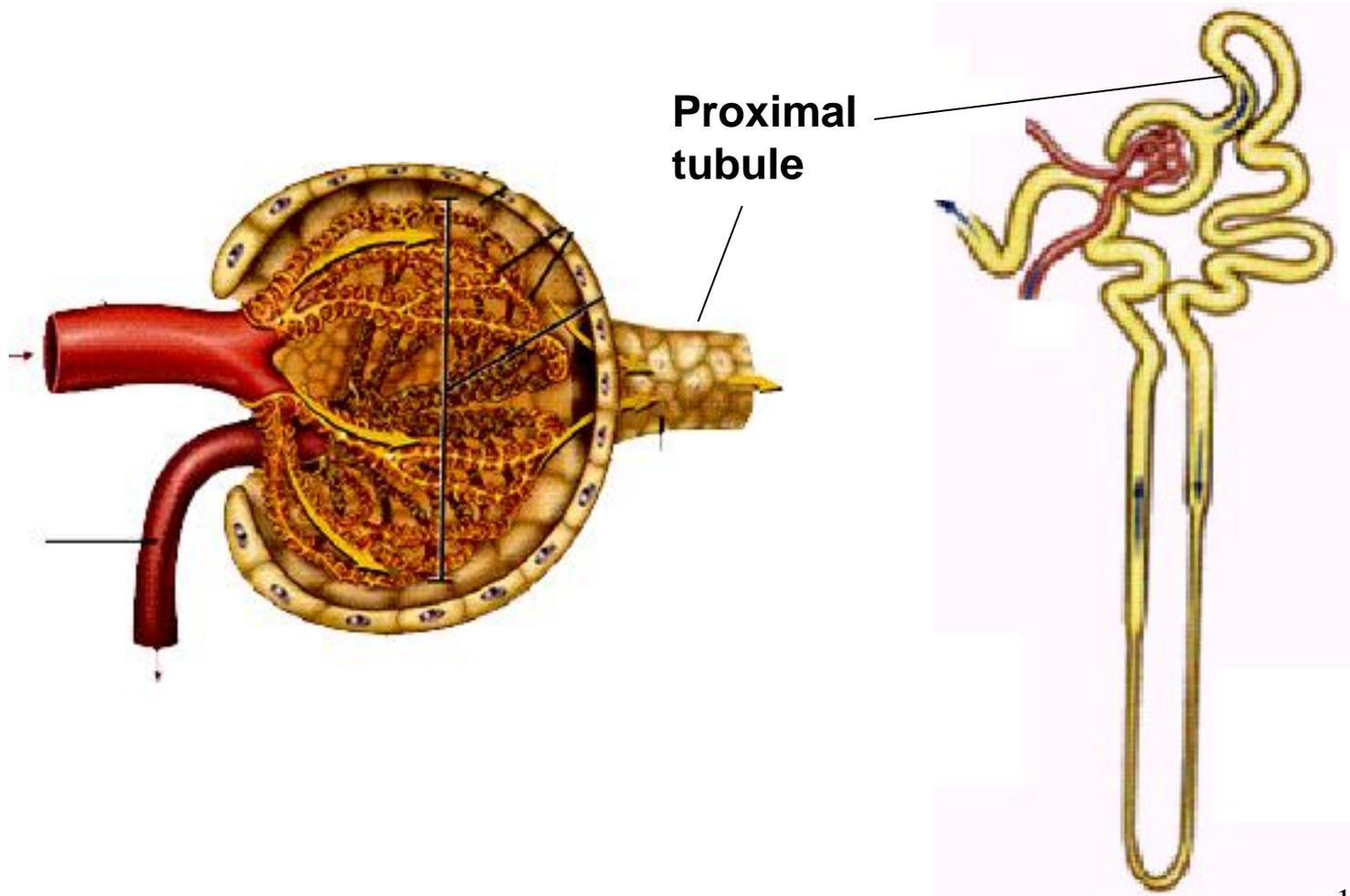
- Most components of the nephron are within the cortex.



**Nephrons are connected to renal artery/vein and ureter.**



The glomerulus is enclosed in a two-layered glomerular (Bowman's) capsule.



# Urine

**Water- 95%**

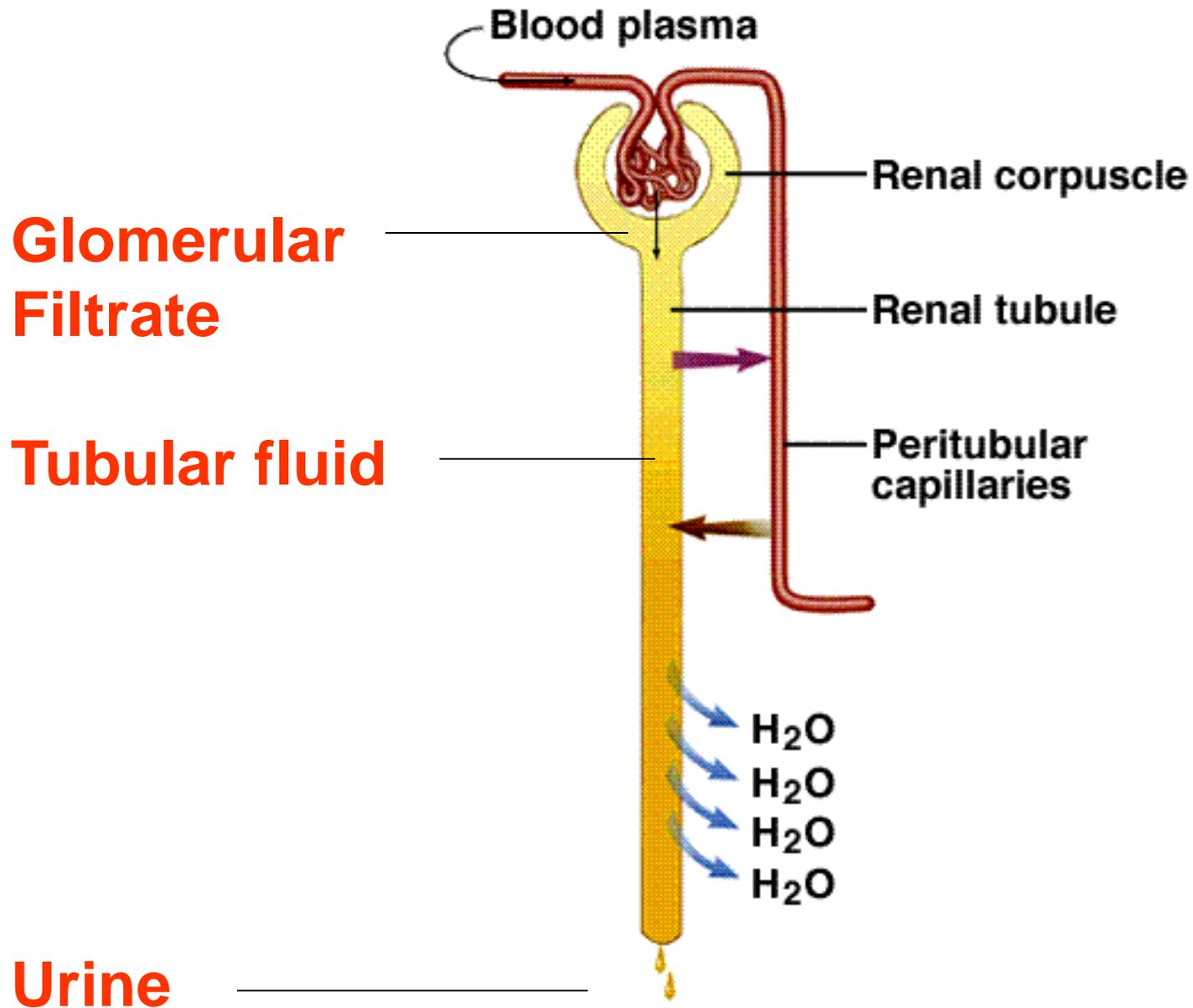
**Nitrogenous waste:**

- urea
- uric acid
- creatinine

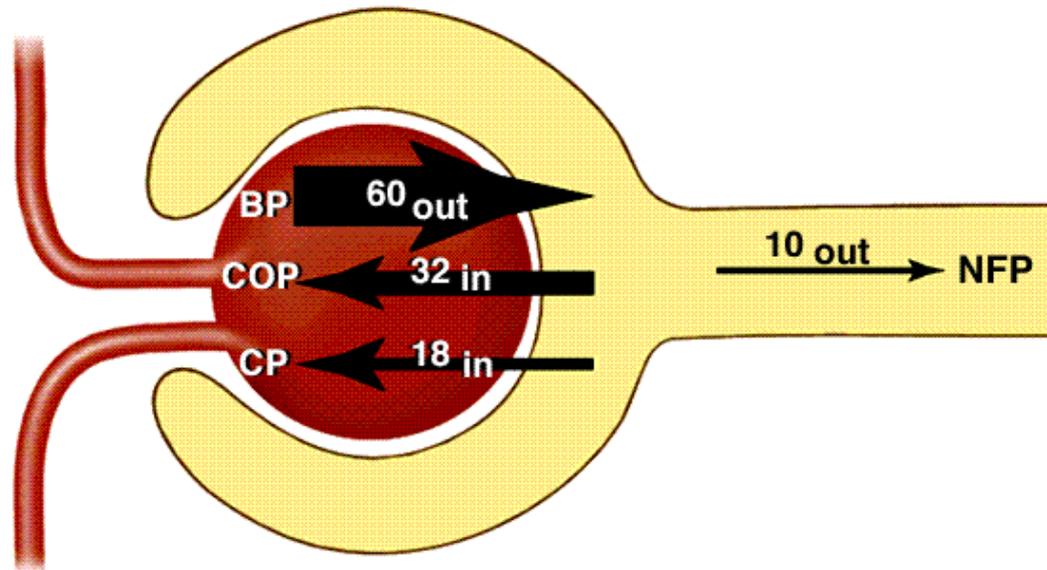
**Ions:**

- sodium
- potassium
- sulfate
- phosphate

From the original 1800 g NaCl, only 10 g appears in the urine

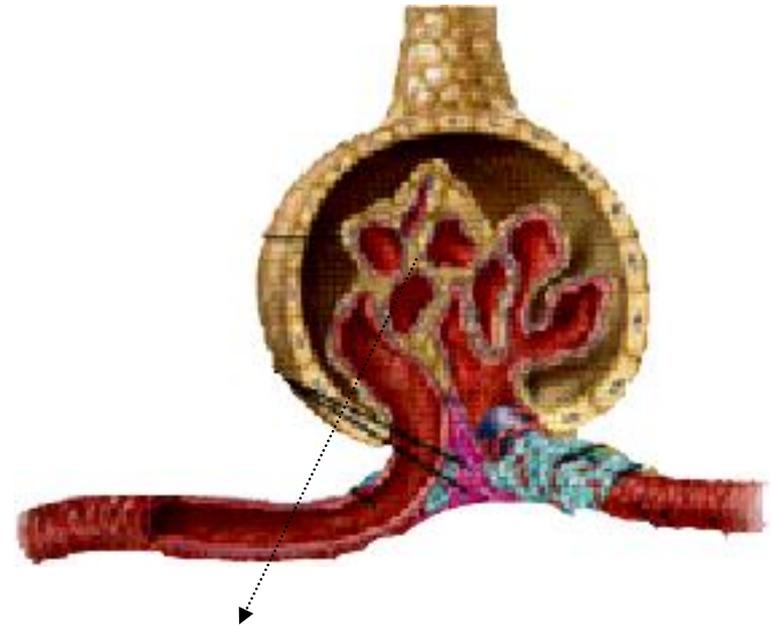


# 1) Glomerular Filtration



# The Filtration Membrane

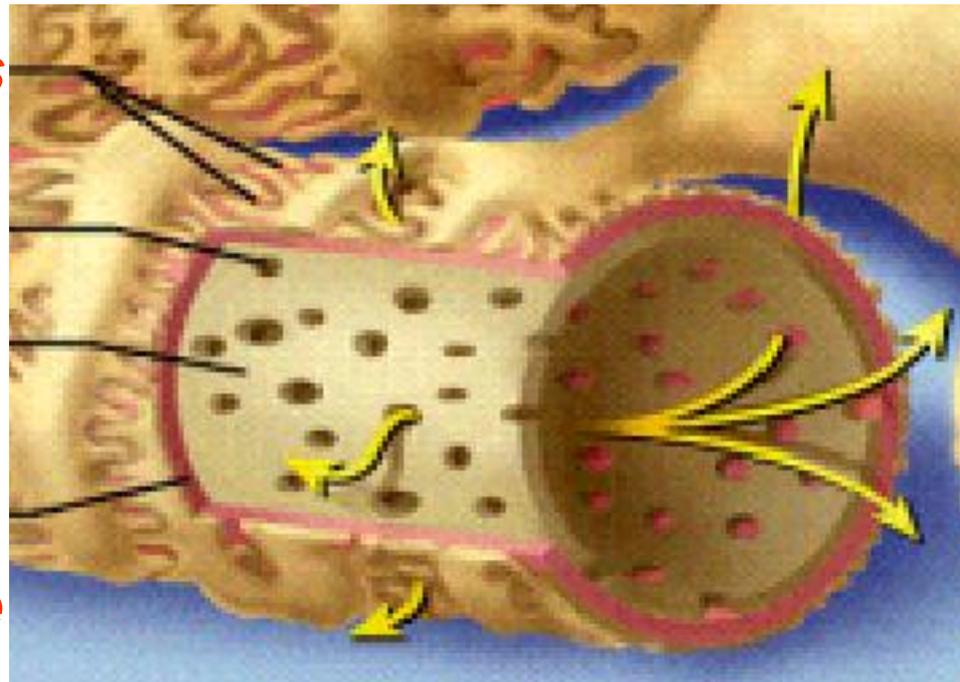
From the plasma to the capsular space, fluid passes through three barriers.



*foot processes*

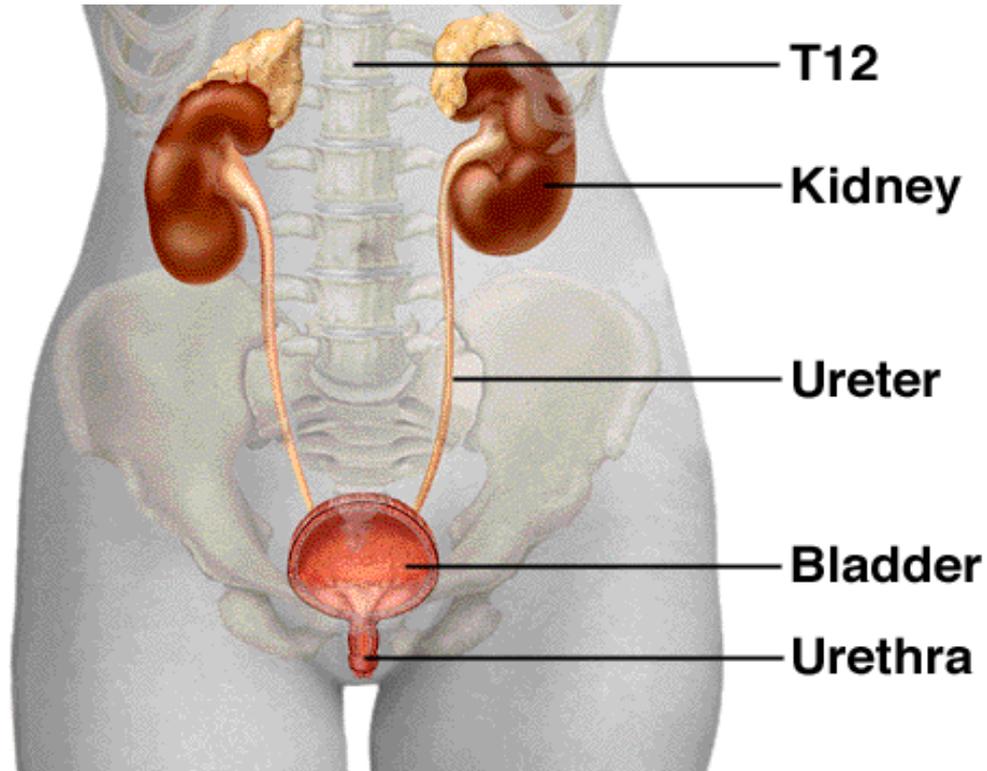
*fenestrated epithelium*

*basement membrane*

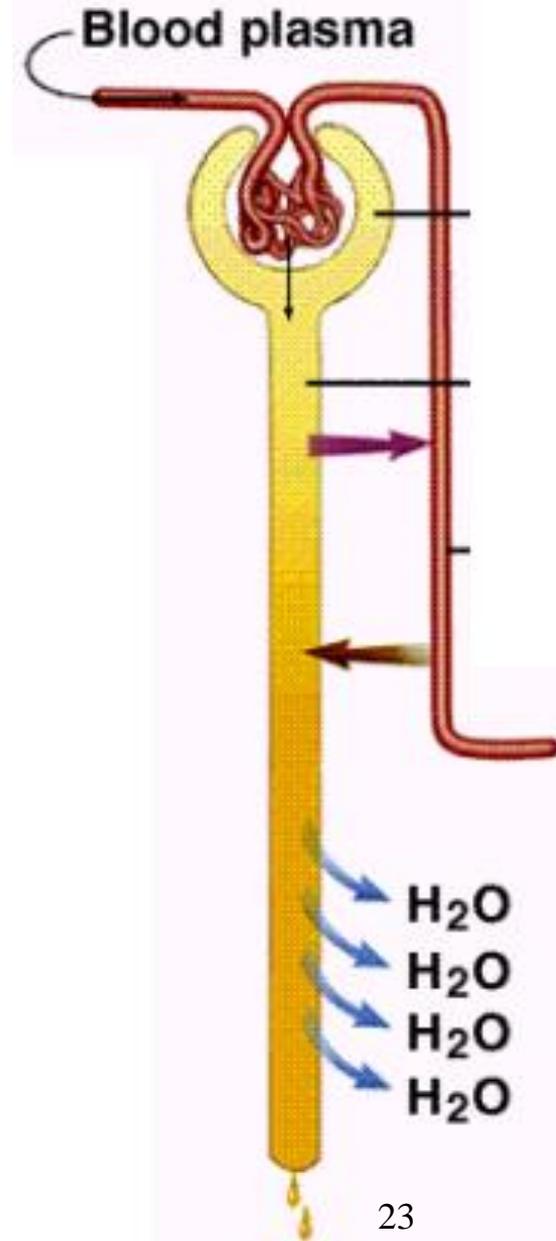


**Blood cells**  
**Plasma proteins**

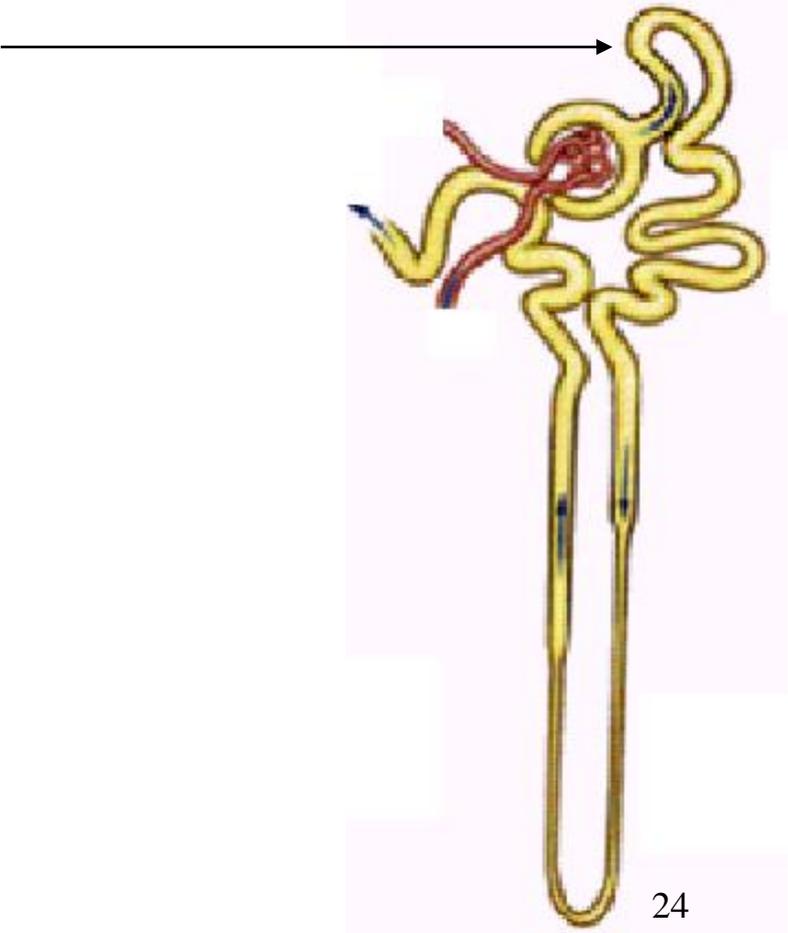
in urine



About **99%** of Water and other useful small molecules in the filtrate are normally reabsorbed back into plasma by renal tubules.

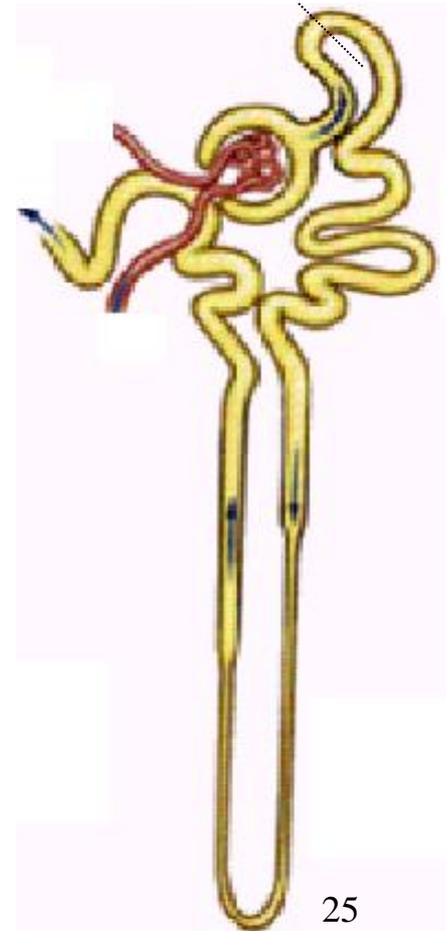
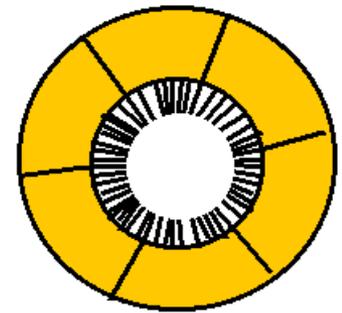


# Reabsorption in Proximal Convoluted Tubules



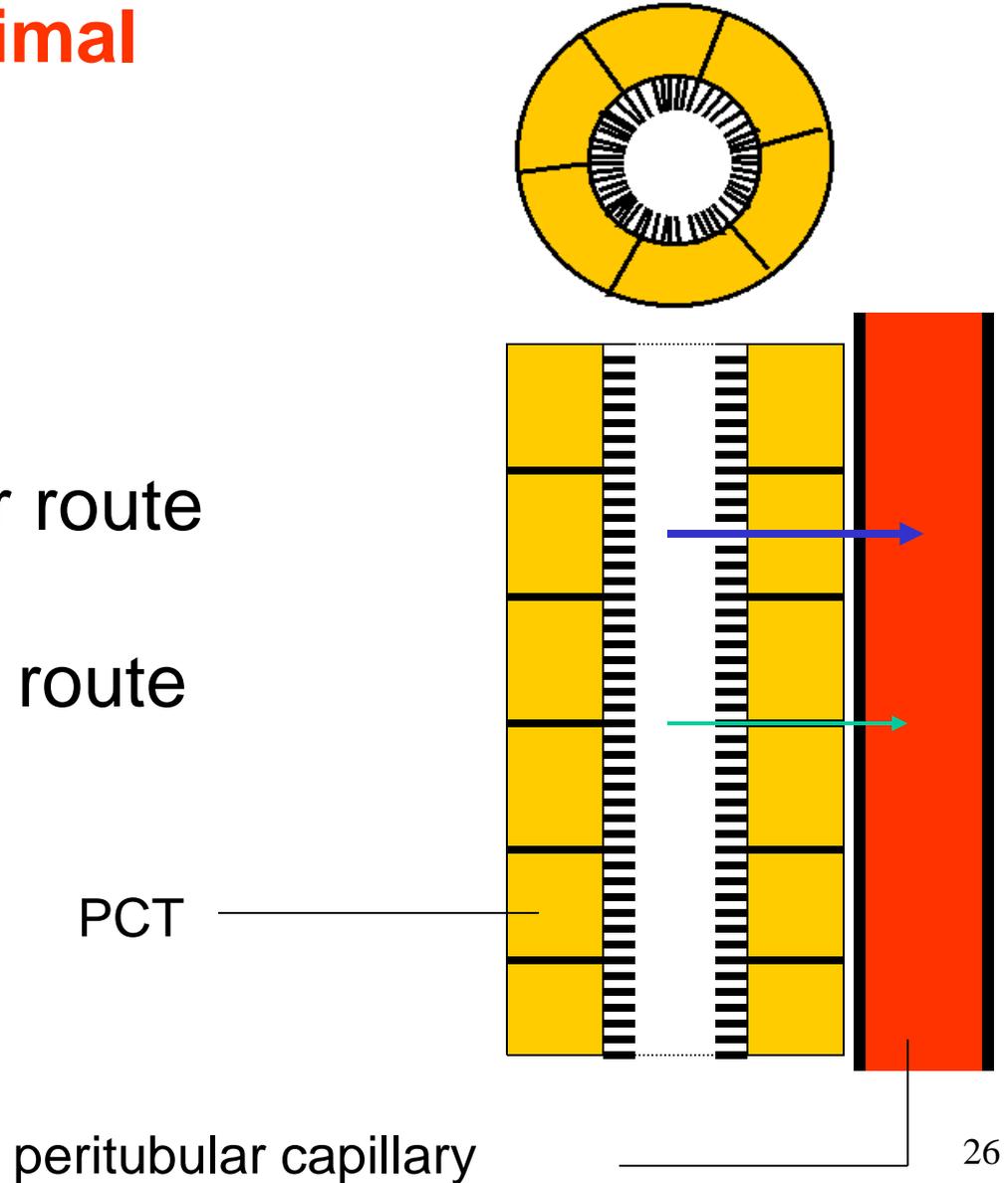
- The proximal convoluted tubule (PCT) is formed by one layer of epithelial cells with long apical microvilli.

- PCT reabsorbs about **65%** of the glomerular filtrate and return it to the blood.



# Routes of Proximal Tubular Reabsorption

- 1) transcellular route
- 2) paracellular route



# Mechanisms of Proximal Tubular Reabsorption

- 1) Solvent drag
- 2) Active transport of sodium.
- 3) Secondary active transport of glucose, amino acids, and other nutrients.
- 4) Secondary water reabsorption via osmosis
- 5) Secondary ion reabsorption via electrostatic attraction
- 6) Endocytosis of large solutes

# Urine Properties

## Composition and Properties of Urine

Fresh urine is *clear*, containing *no blood cells* and *little proteins*. If cloudy, it could indicate the presence of bacteria, semen, blood, or menstrual fluid.

# Urine Volume

An average adult produces **1-2 L** of urine per day.

a. Excessive urine output is called ***polyuria***.

b. Scanty urine output is ***oliguria***. An output of less than **400 mL/day** is insufficient to excrete toxic wastes.

# Diabetes

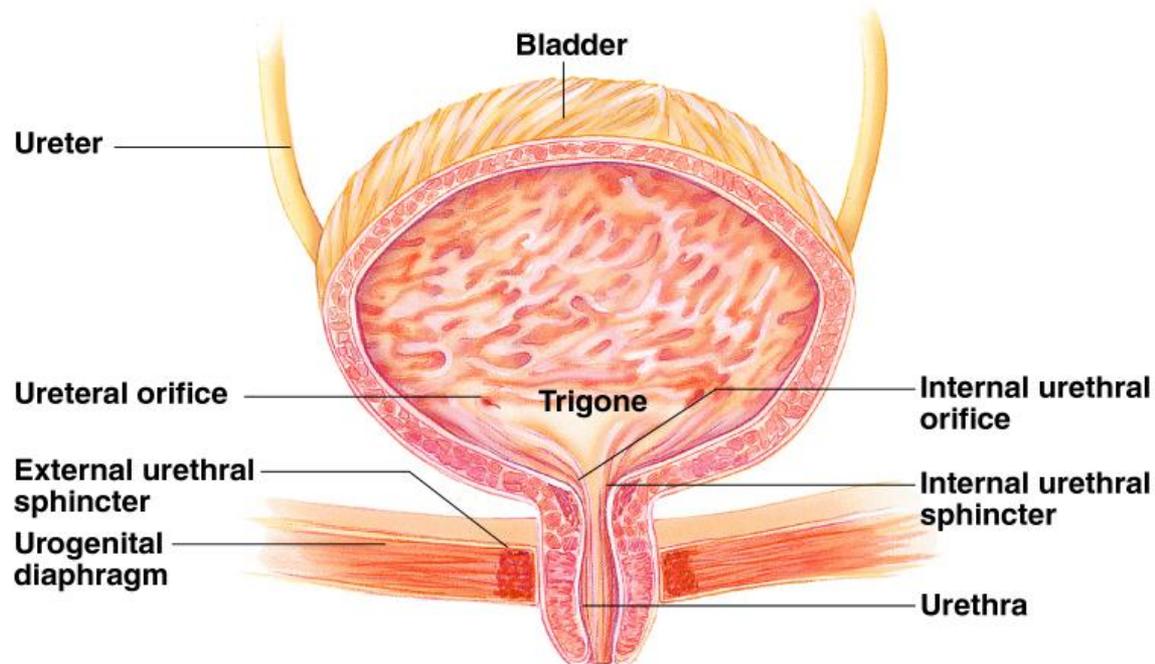
- is chronic polyuria resulting from various metabolic disorders, including ***Diabetes mellitus*** and ***Diabetes insipidus***

# Ureters

- Slender tubes attaching the kidney to the bladder
  - Continuous with the renal pelvis
  - Enter the posterior aspect of the bladder
- Runs behind the peritoneum
- Peristalsis aids gravity in urine transport

# Urinary Bladder

- Smooth, collapsible, muscular sac
- Temporarily stores urine



# Urinary Bladder

- Trigone – three openings
  - Two from the ureters
  - One to the urethrea

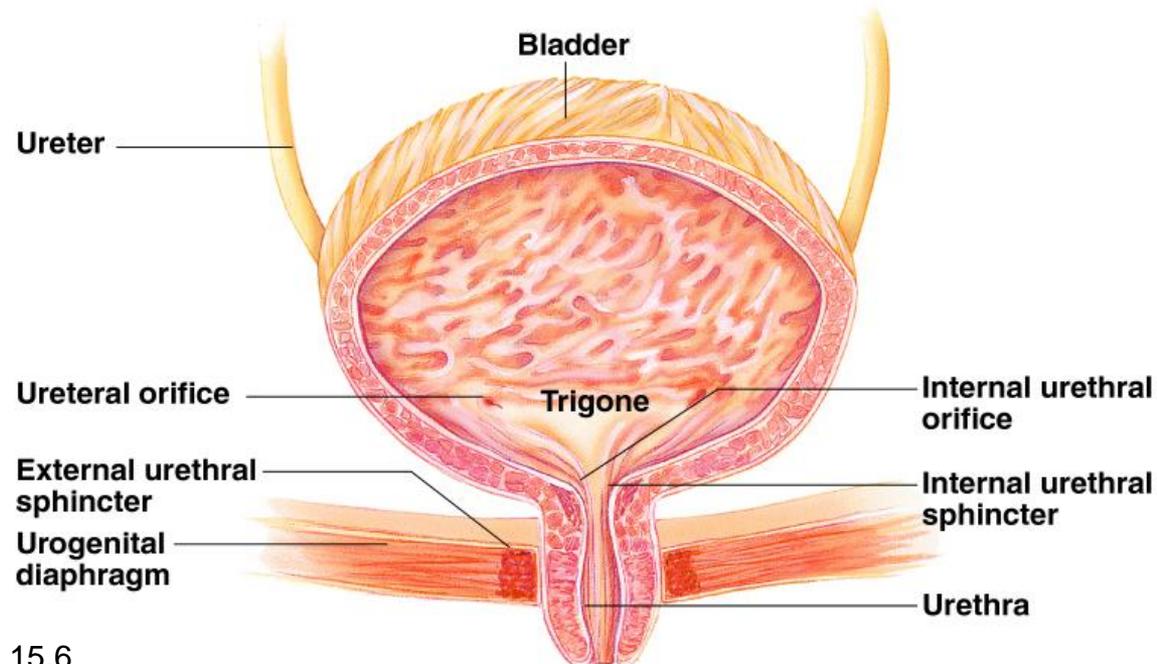


Figure 15.6

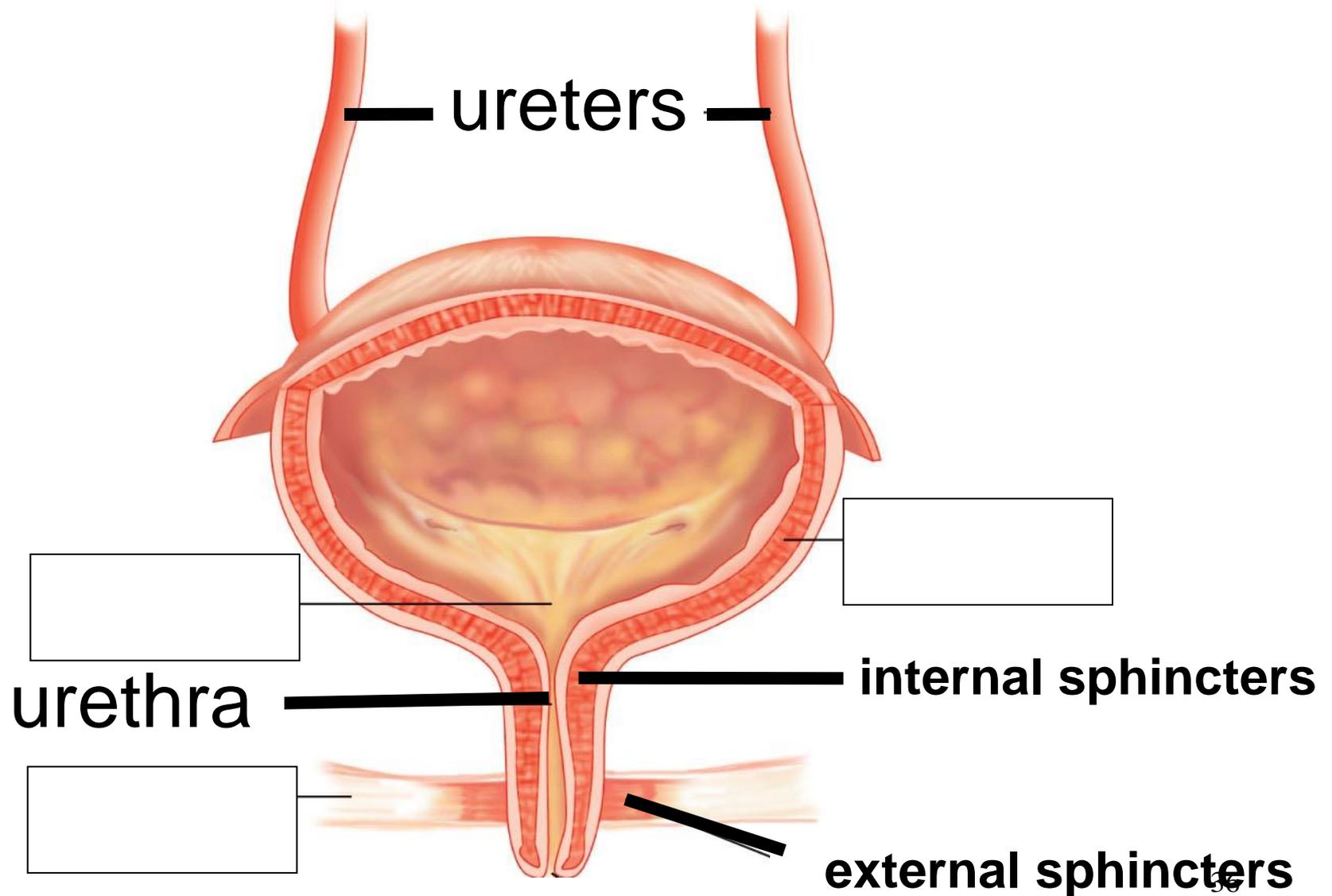
# Urinary Bladder Wall

- Three layers of smooth muscle (detrusor muscle)
- Mucosa made of transitional epithelium
- Walls are thick and folded in an empty bladder
- Bladder can expand significantly without increasing internal pressure

# Urethra

- Thin-walled tube that carries urine from the bladder to the outside of the body by peristalsis
- Release of urine is controlled by two sphincters
  - Internal urethral sphincter (involuntary)
  - External urethral sphincter (voluntary)

# Urinary Bladder



# Urethra

thin walled tube - conveys urine from bladder to external environment.

Similar structure to ureter

Sphincters: internal urethral [involuntary] & external urethral [voluntary]

- Male Urethra
  - 20 cm long [7-8 in]
  - Transports both urine & semen
- Eternal urethral orifice opens at tip of penis
- Female Urethra
  - 3-4 cm long [1.5 in]
  - External urethral orifice opens just anterior to the vaginal opening

### Bladder and Sphincter Muscles

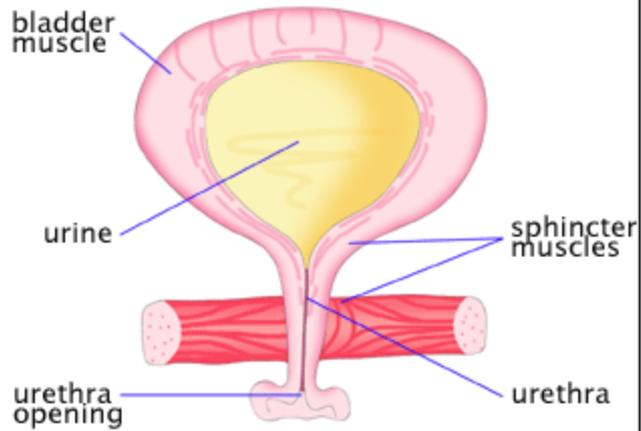
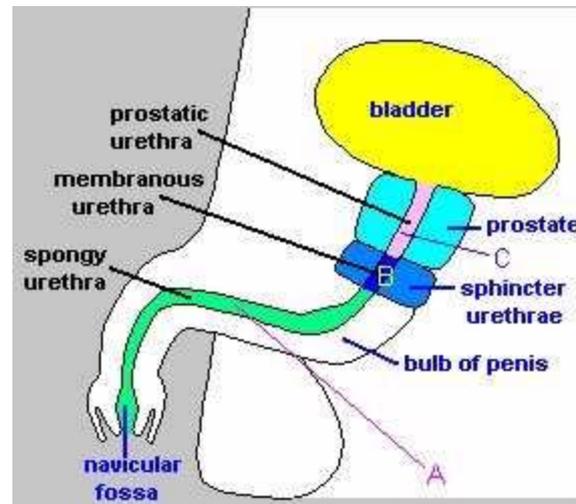
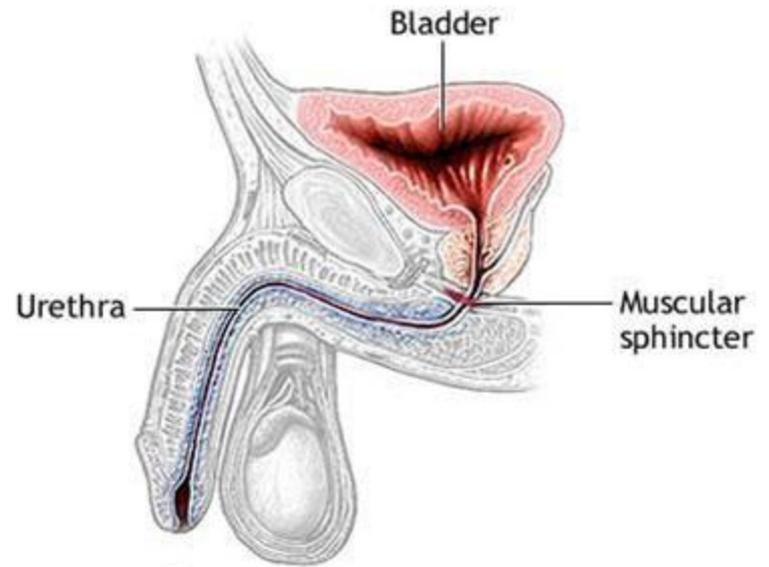


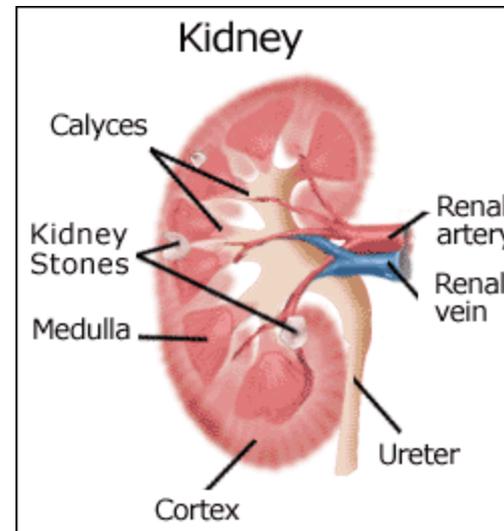
Image Source: National Kidney and Urological Diseases Information Clearinghouse.



# Kidney Stones

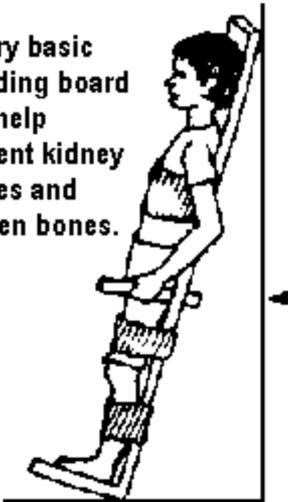
Kidney stones affect more than a million Americans each year. Twelve to 24 million Americans will develop stones in their lifetime and the incidence rate has increased dramatically over the last 20 years with approximately 350,000 new stone cases reported each year.

In the United States, 7 to 10 of every 1,000 hospital admissions are due to kidney stones.



Kidney stones are solid masses of mineral salt deposits that are normally filtered through the kidney and voided in urine. Urine naturally contains substances that dissolve the waste materials that form these solids or *calculi*. However, when the amounts of these salts are excessive, the urine may be unable to dissolve them all, leaving crystals that accumulate in the kidney and gradually increase in size.

A very basic standing board can help prevent kidney stones and broken bones.

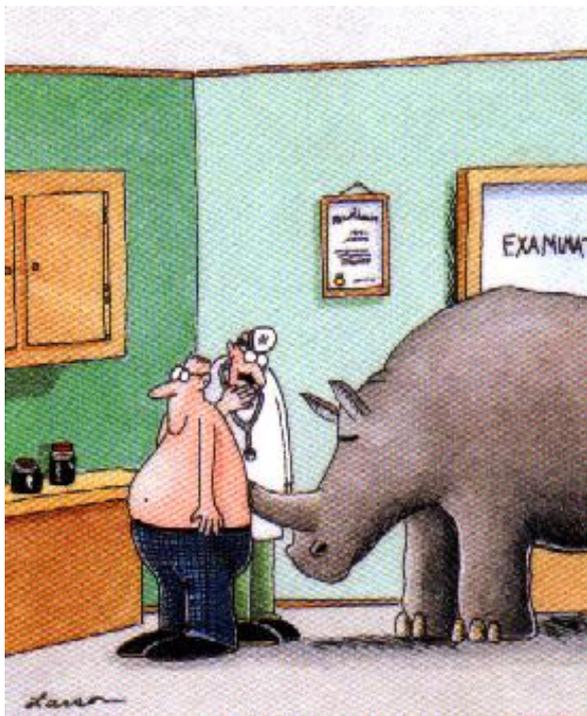


The stones can be as small as a grain of sand or as large as a golf ball. The size, shape, and location of the stone can cause many different symptoms.

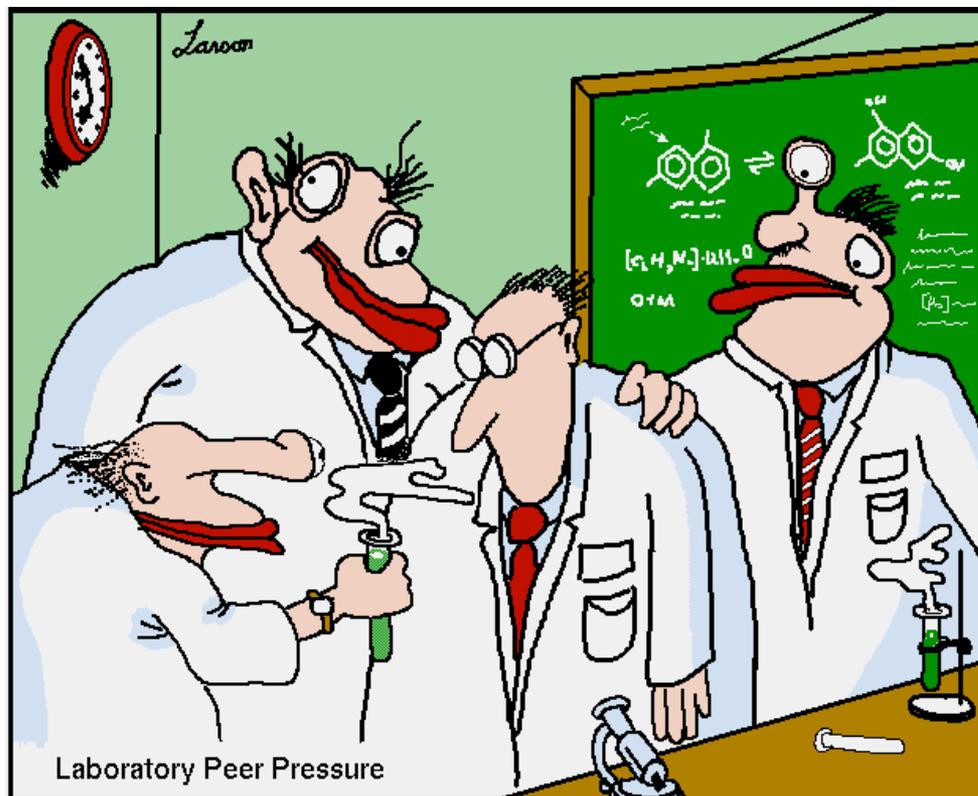
"Renal colic causes a severe cramping pain felt in the back and the side, and sometimes in the lower abdomen."



Most renal calculi are so small they are passed through the urinary tract without any symptoms. Larger calculi can obstruct the renal ducts, or become lodged in the ureters. These larger obstructions cause sharp, severe pain in the sides and back as they move through the urinary tract. In medical parlance, this condition is called *renal colic*.



Well, I guess you don't have kidney stones after all.

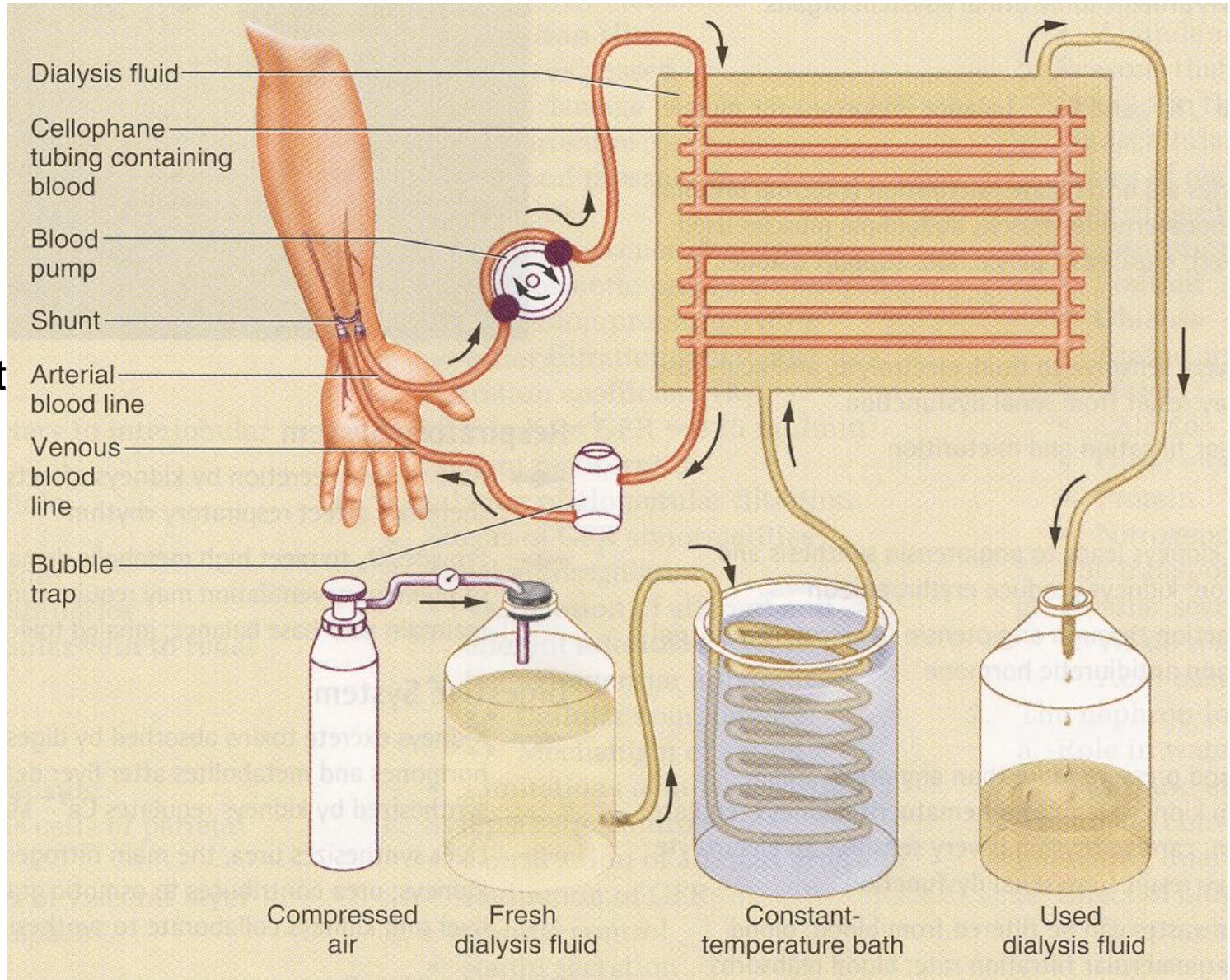


Laboratory Peer Pressure

# 1) Dialysis machine

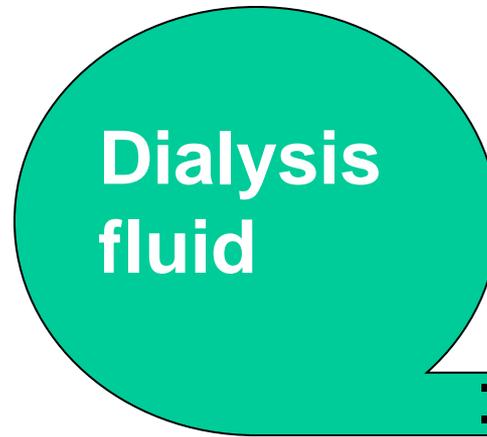
- efficient

- inconvenient

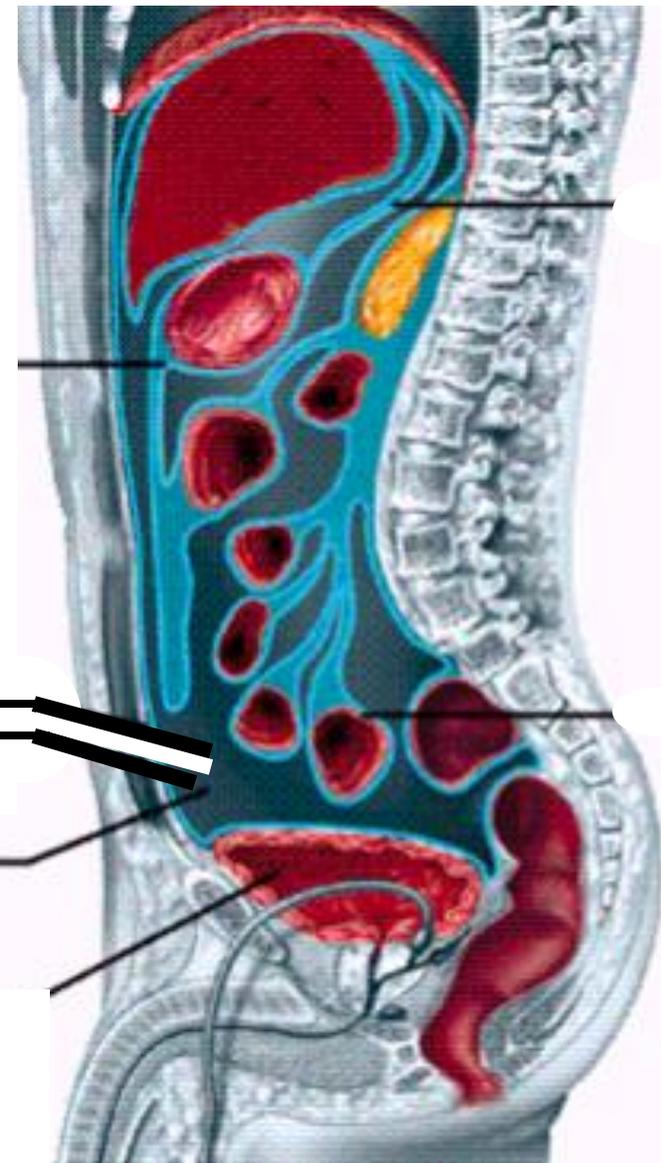


## 2) **Continuous ambulatory peritoneal dialysis (CAPD)**

- The peritoneal membrane is a natural dialysis membrane
- convenient
- less efficient

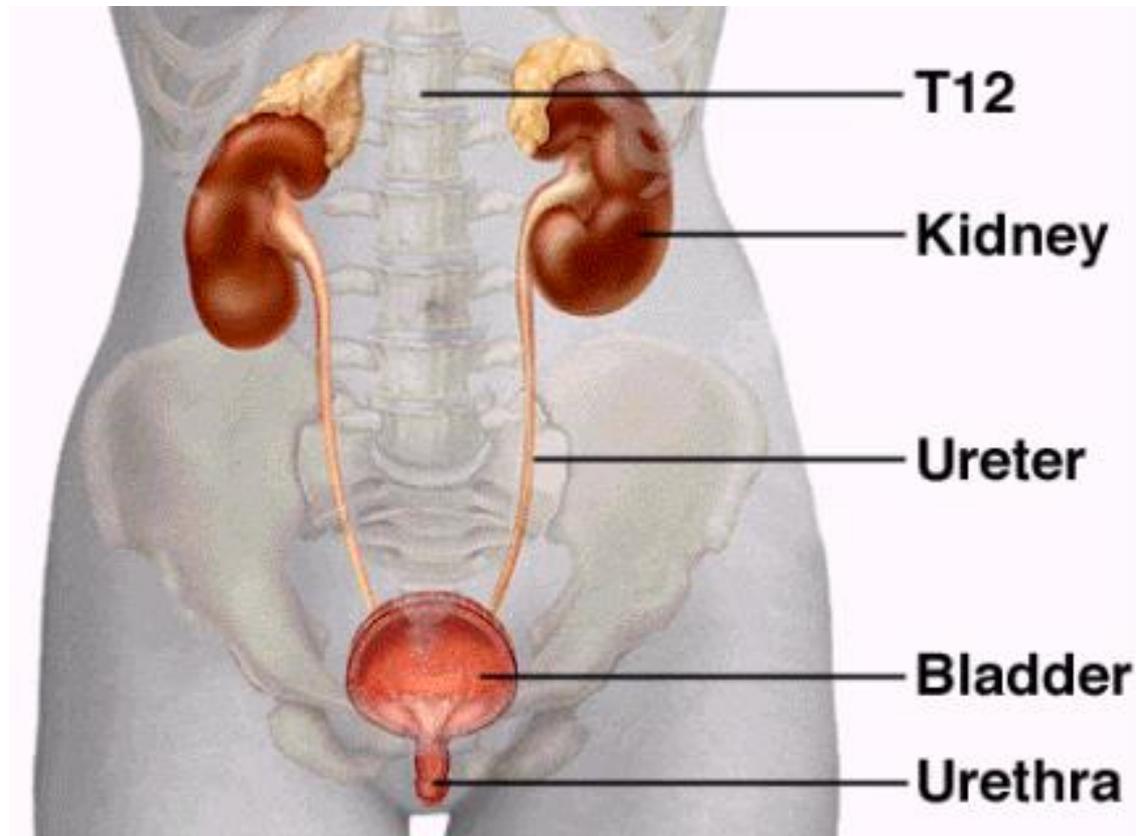


**Peritoneal cavity**



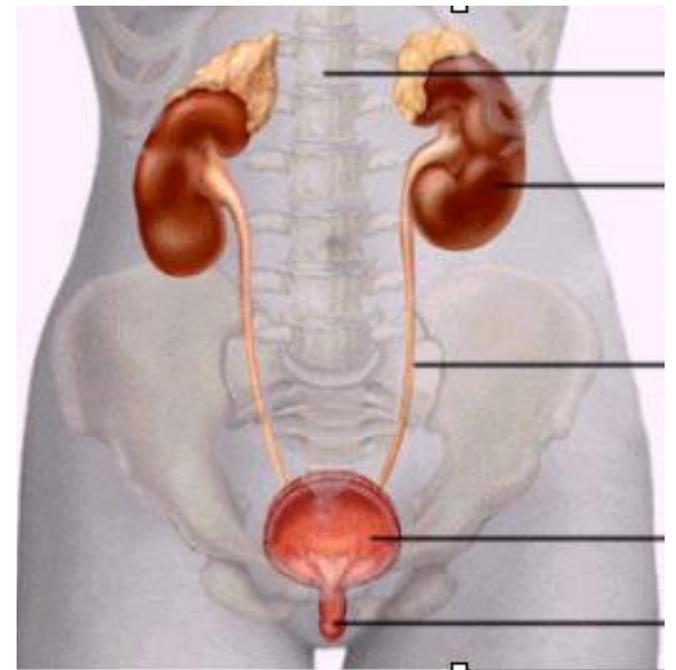
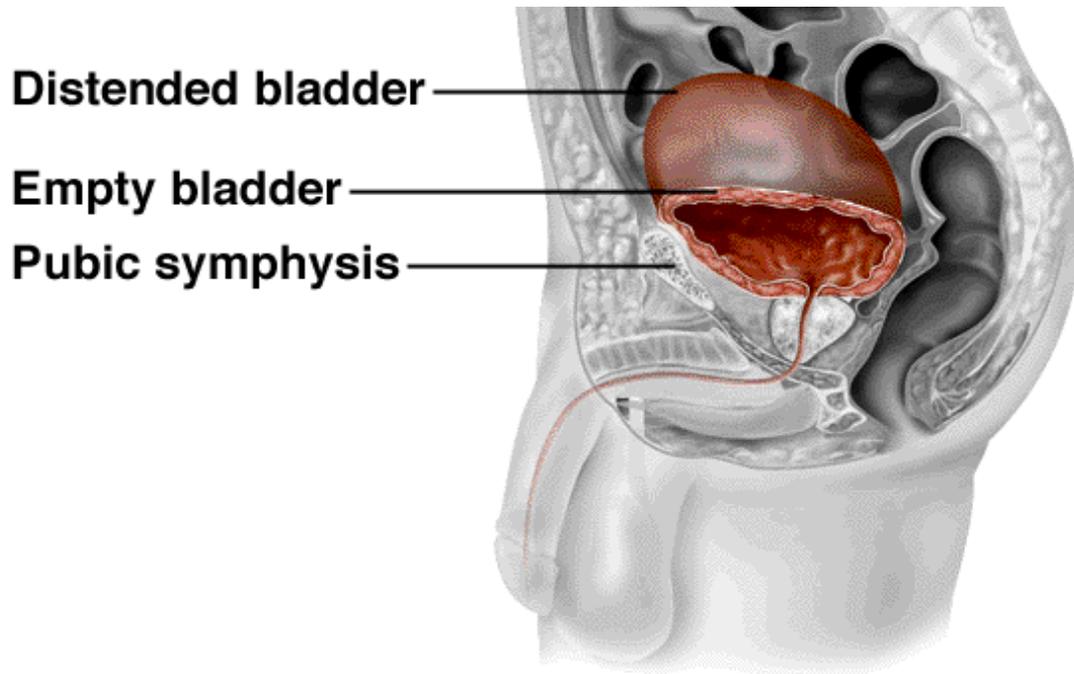
# The Ureters

The ureters are muscular tubes leading from the renal pelvis to the lower bladder.

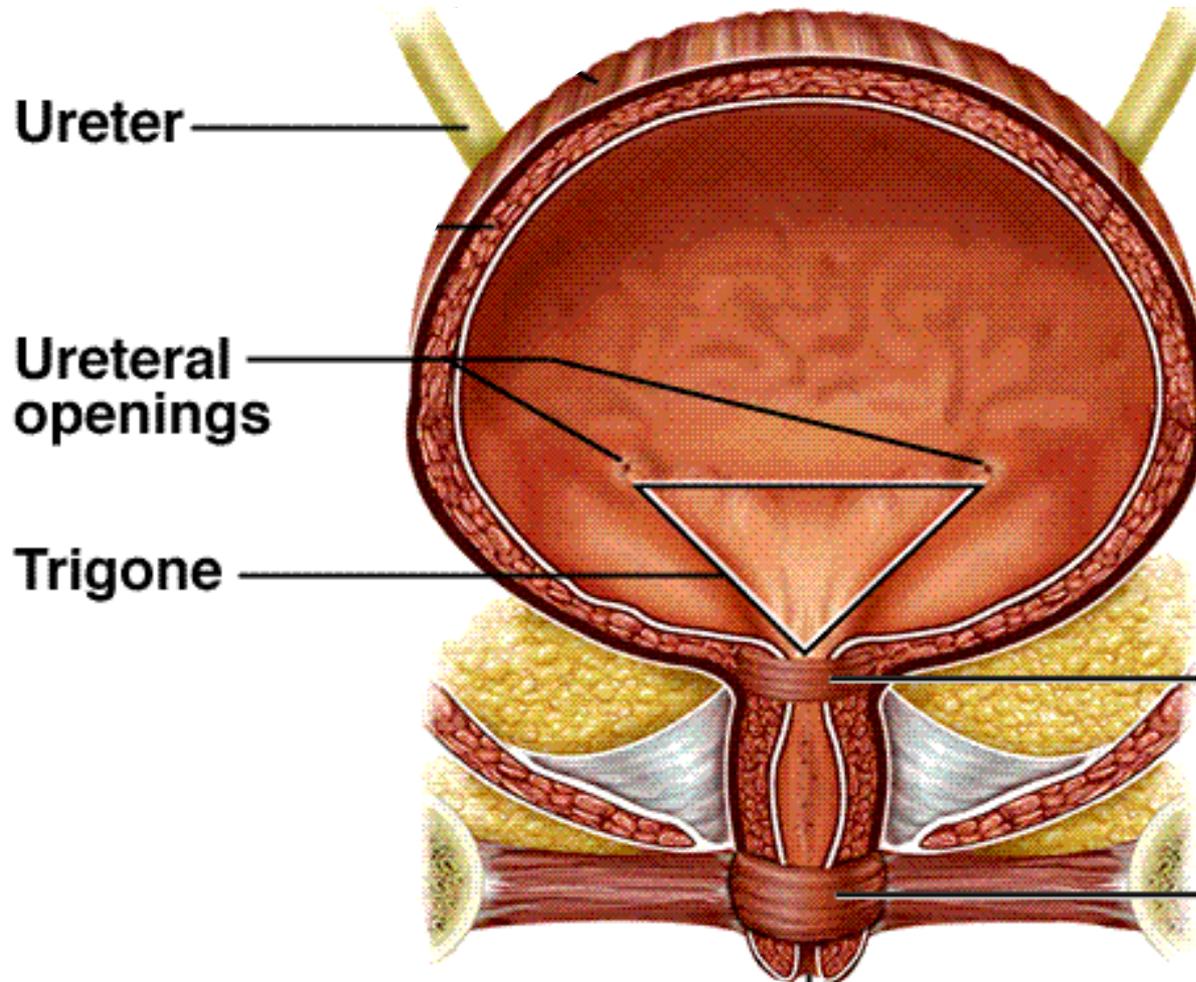


# The Urinary Bladder

- is a muscular sac on the floor of the pelvic cavity.
- is highly distensible and expands superiorly.



The openings of the **two ureters** and the **urethra** mark a triangular area called the **trigone** on the bladder floor.



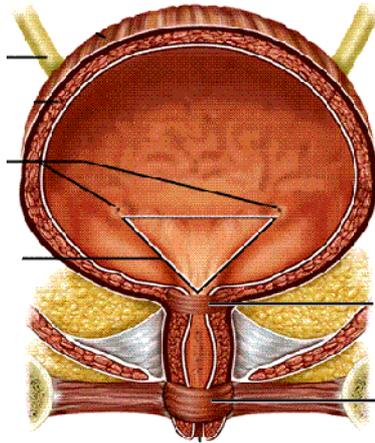
## The Urethra

- conveys urine from the urinary bladder to the outside of the body.

### Females

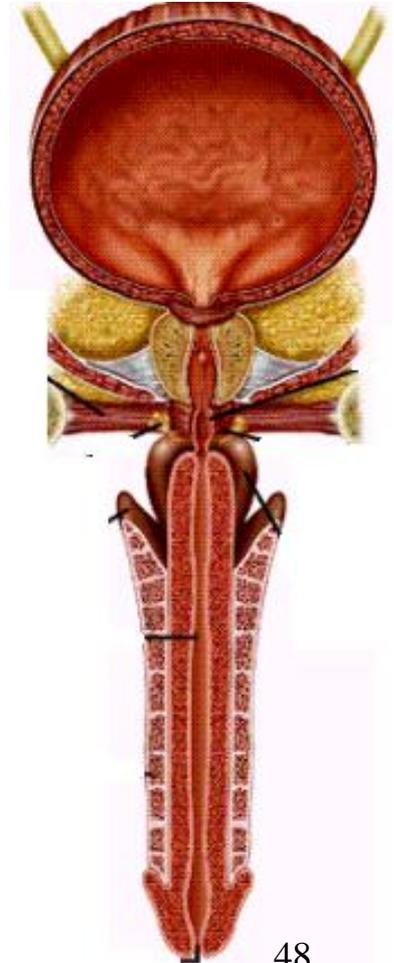
3-4 cm

greater risk of  
urinary tract  
infections



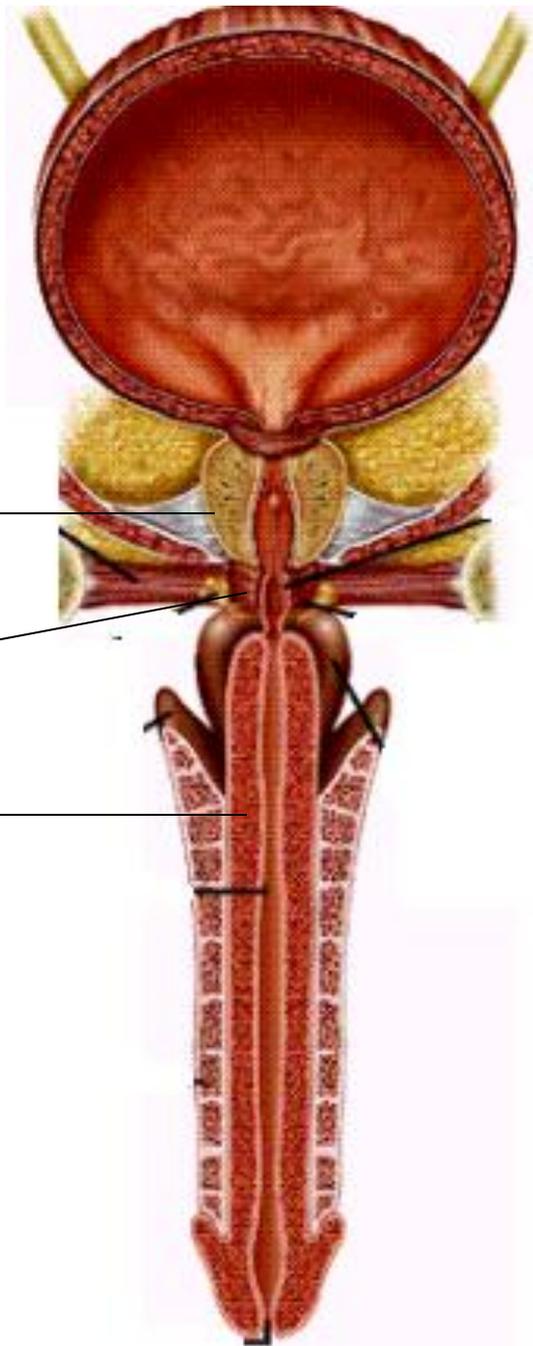
### male

~18 cm



The male urethra has three regions:

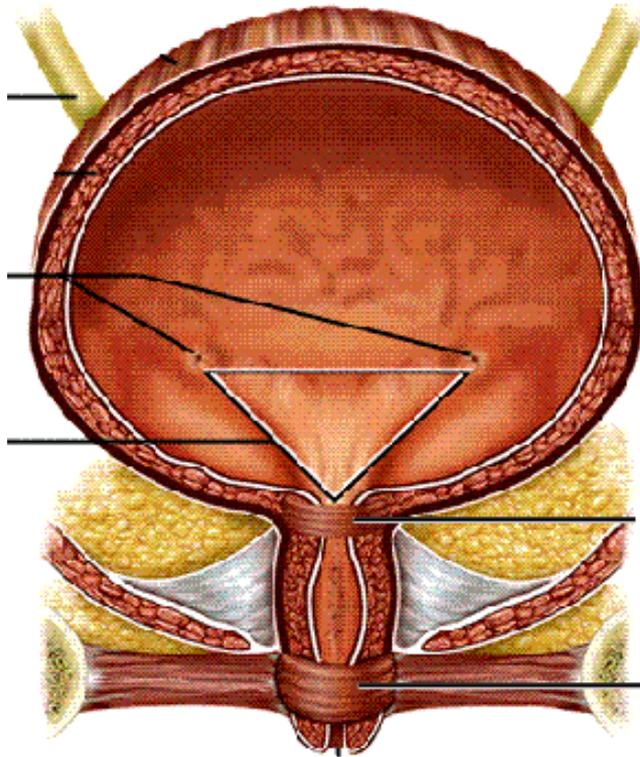
- 1) prostatic urethra
- 2) membranous urethra
- 3) penile urethra.



Difficulty in voiding urine  
with enlarged prostate

In both sexes:

- internal urethral sphincter- under involuntary control.
- external urethral sphincter - under voluntary control



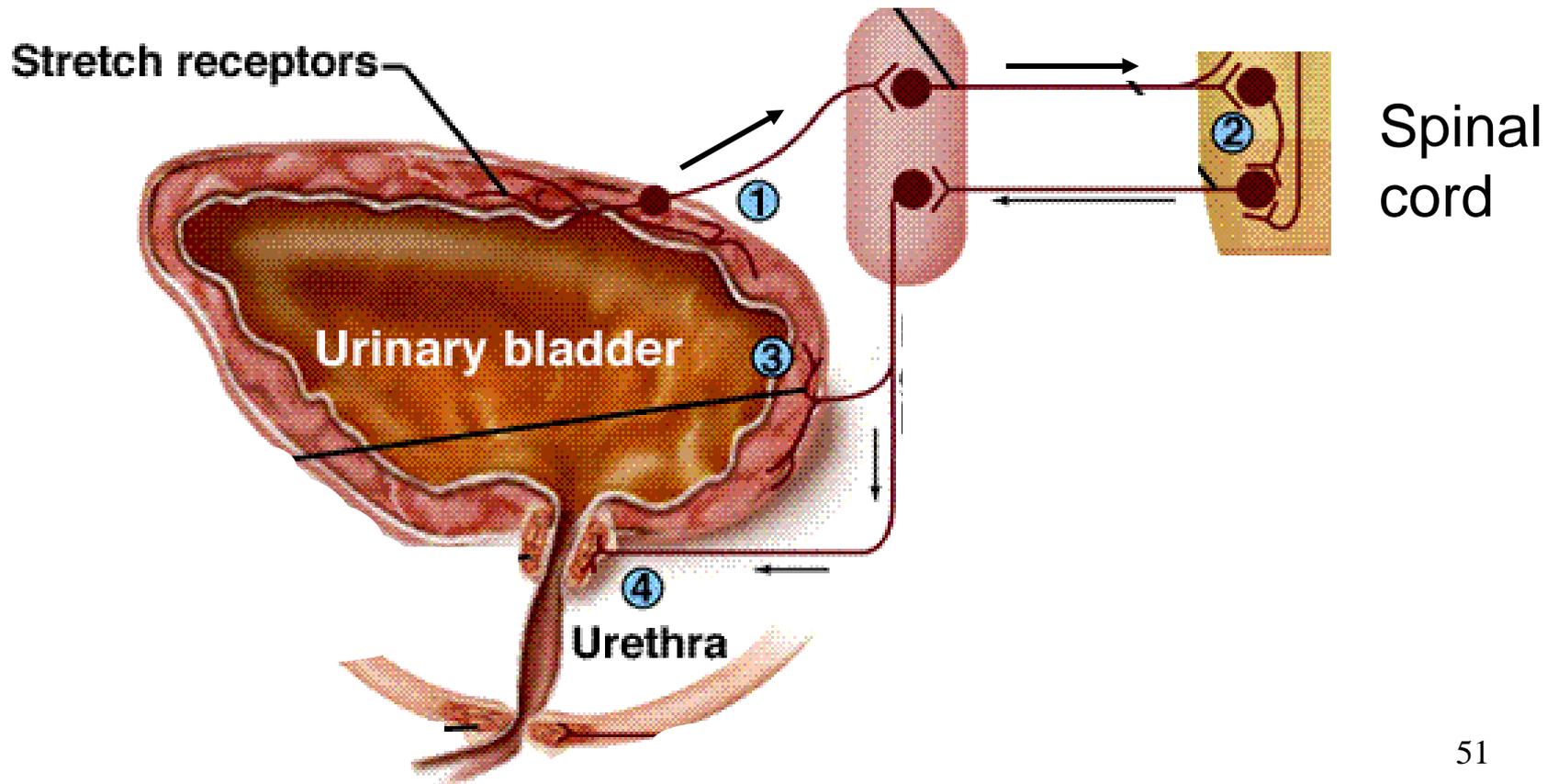
internal urethral sphincter

external urethral sphincter

# Voiding Urine in infants

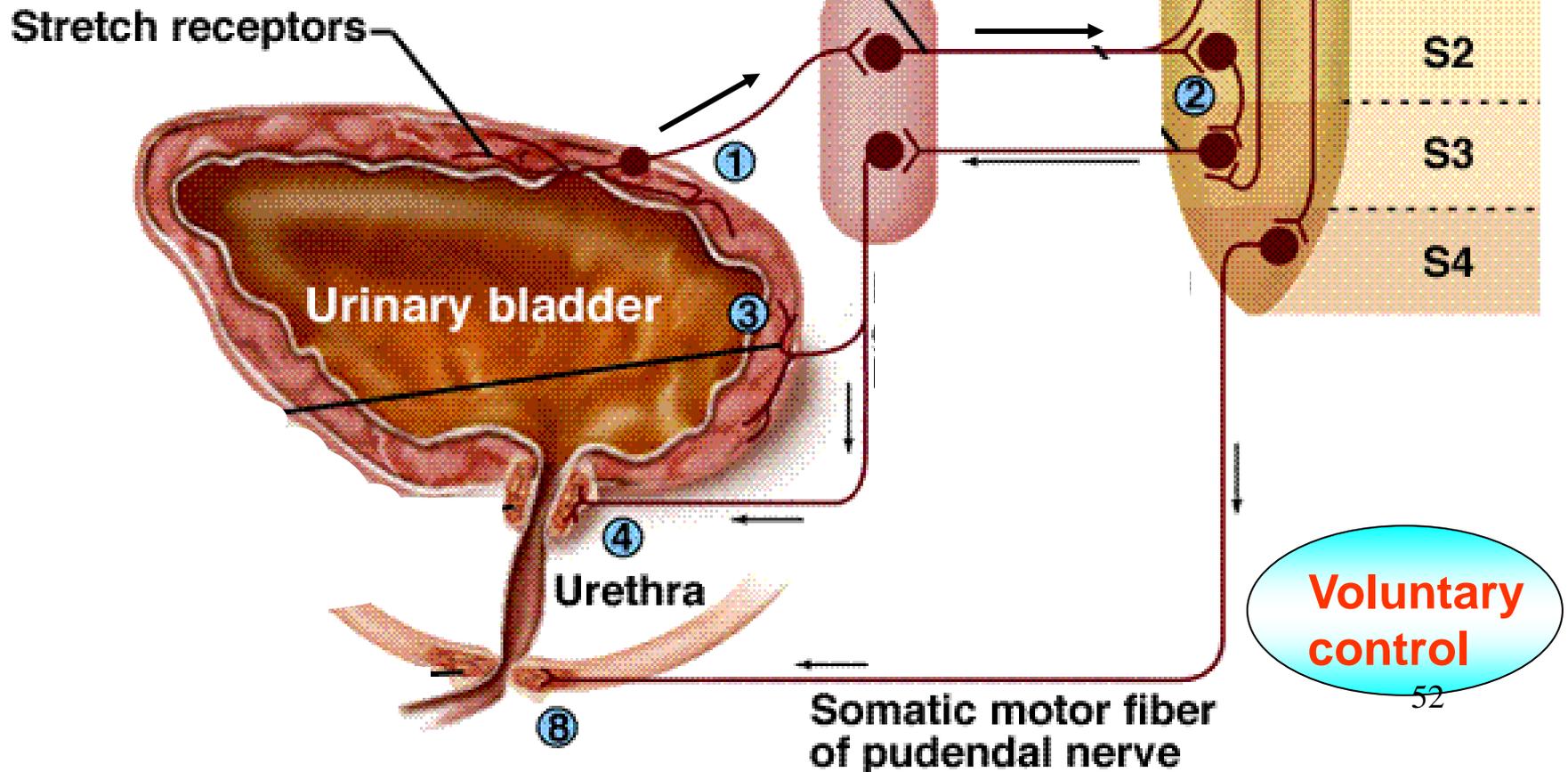
## *micturition reflex*

When the bladder contains about 200 ml of urine, stretch receptors in the wall send impulses to the spinal cord. Parasympathetic signals return to stimulate contraction of the bladder and relaxation of the internal urethral sphincter.



## Voiding Urine in adults

Once voluntary control has developed, emptying of the bladder is controlled predominantly by a micturition center in the pons. This center receives signals from stretch receptors and integrates this information with cortical input concerning the appropriateness of urinating at the moment. It sends back impulses to stimulate relaxation of the external sphincter.

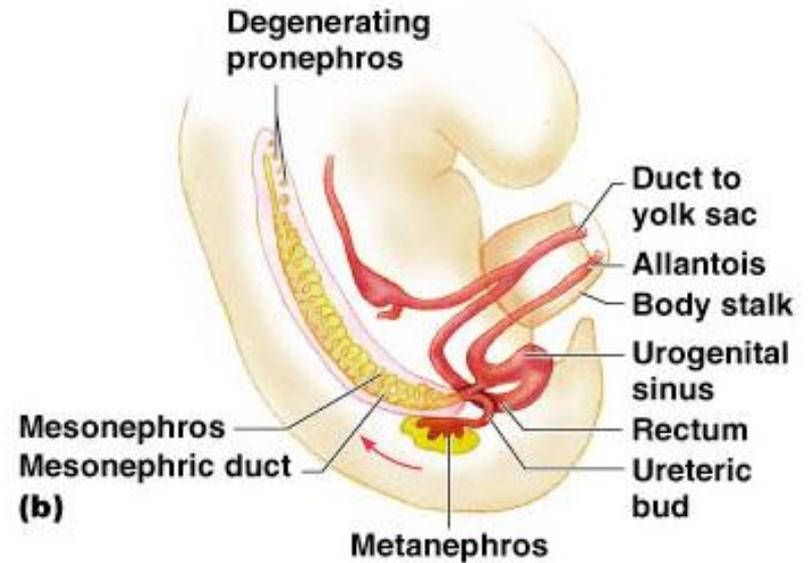
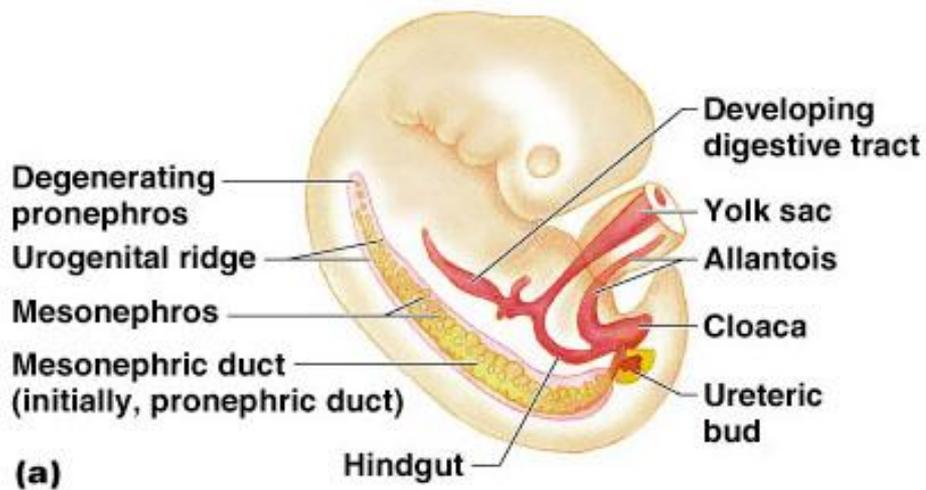


# Developmental Aspects

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- Three sets of embryonic kidneys develop, with only the last set persisting
- The pronephros never functions but its pronephric duct persists and connects to the cloaca
- The mesonephros claims this duct and it becomes the mesonephric duct
- The final metanephros develop by the fifth week and develop into adult kidneys

# Developmental Aspects



# Developmental Aspects

