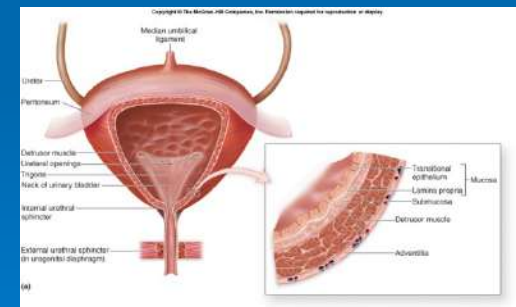
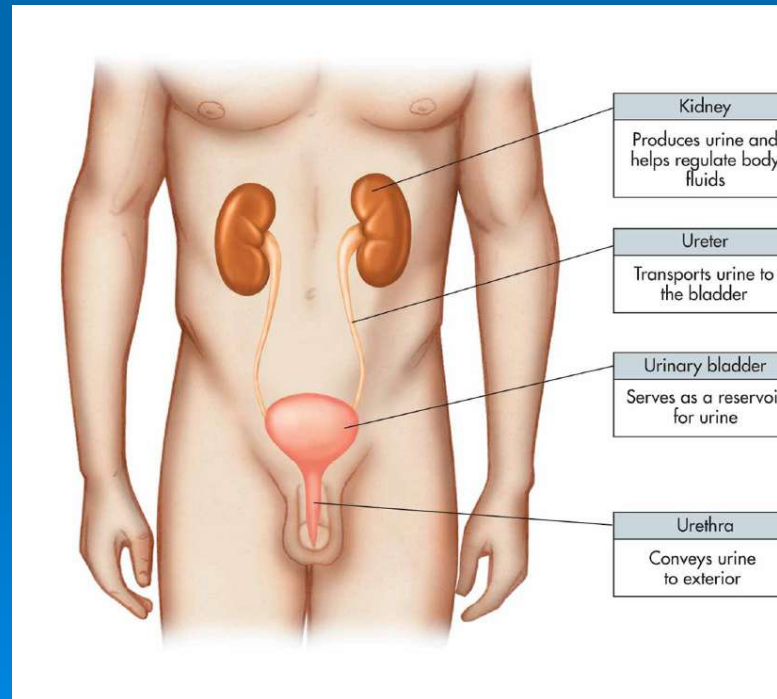
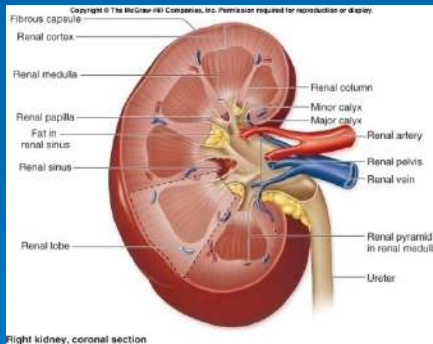


# Anatomy, Physiology & Disease

## Chapter 16

### The **Urinary** System: Filtration and Fluid Balance



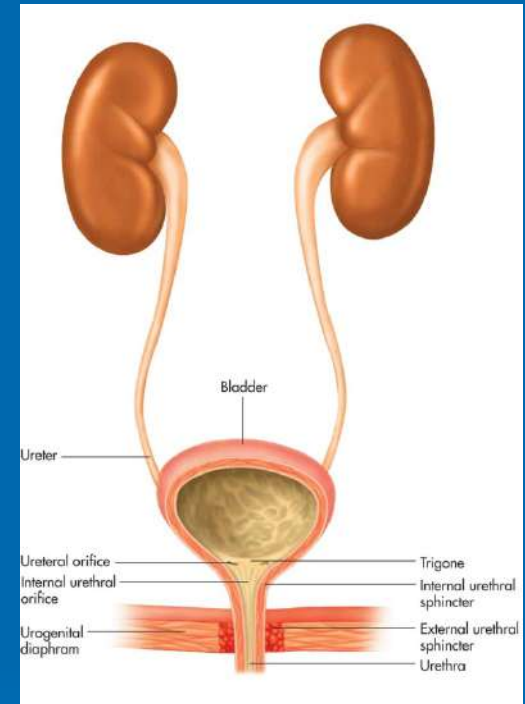
# *Introduction*

- **Kidneys act as purification plant**, cleaning blood of waste materials.
- **Kidneys control electrolyte** (Na, K, Cl, Co<sub>2</sub>)
- **& fluid balances** for body.
- **Kidneys filter blood, reabsorb & secrete ions, & produce urine.**
- **Without this important function** you would survive only a **few days.**



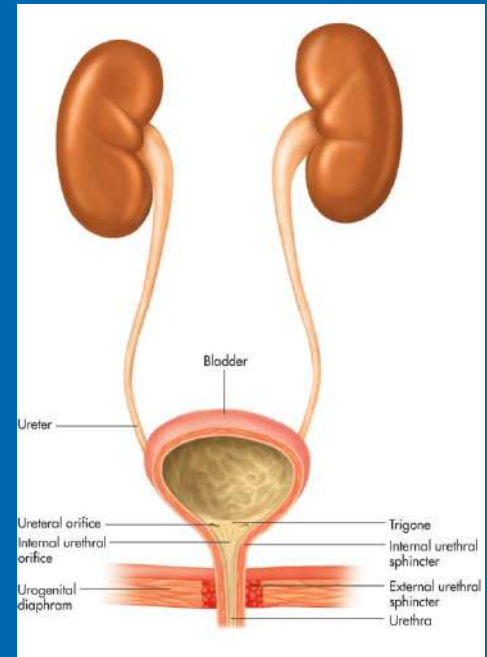
# Urinary System Overview

- **Two kidneys**, bean shaped organs located in **superior dorsal** abdominal cavity that **filter blood & make urine**, & accessory structures.
- **Ureter** a tube that carries urine from each kidney to a **single urinary bladder**, located in **inferior ventral** pelvic cavity.
- **Bladder**: expandable sac that holds urine.



# Urinary System Overview con't

- **Urethra**: a tube that **transports** urine from bladder to the Meatus.
- **Function of urinary system** is to **make urine**, thus controlling body's **fluid & electrolyte balance & eliminating waste products**.
- **To make urine**, 3 processes are necessary:
  - **Filtration** — purification
  - **Reabsorption** — of water
  - **Secretion** — of excess water

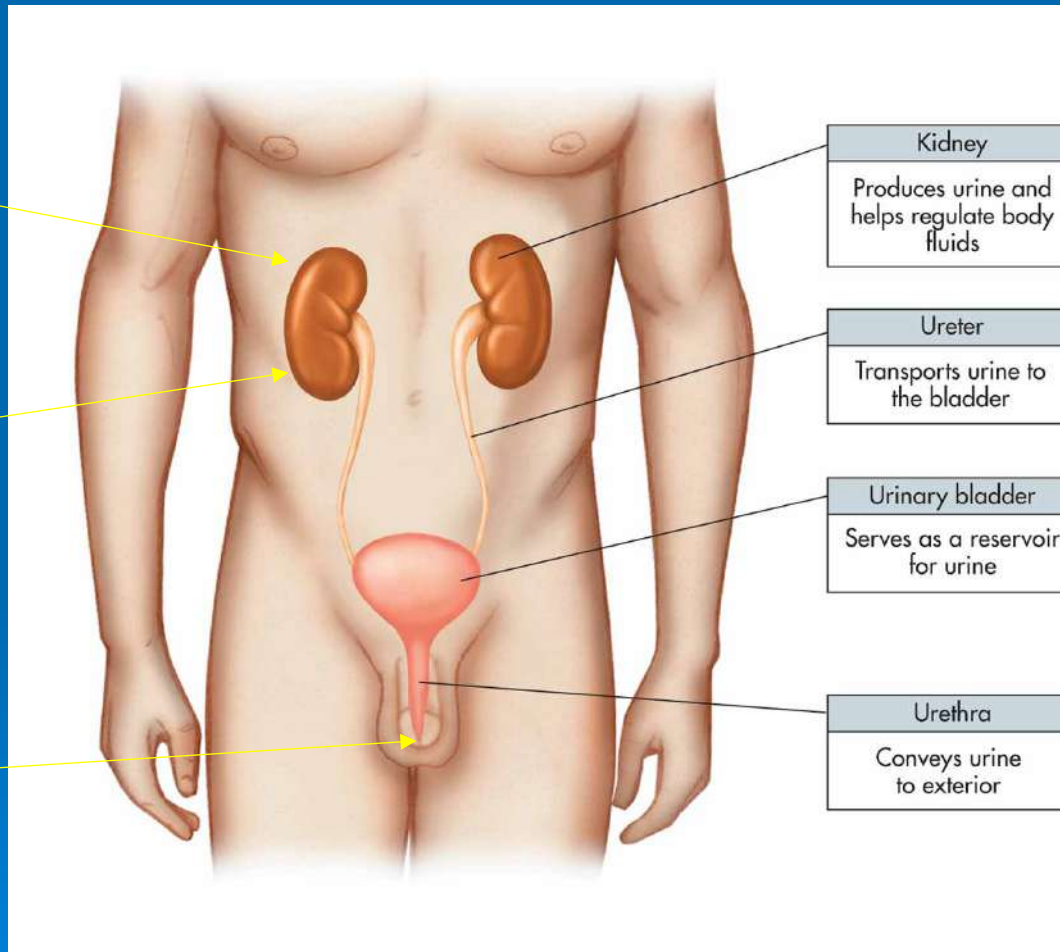


# The Urinary System

Upper Pole

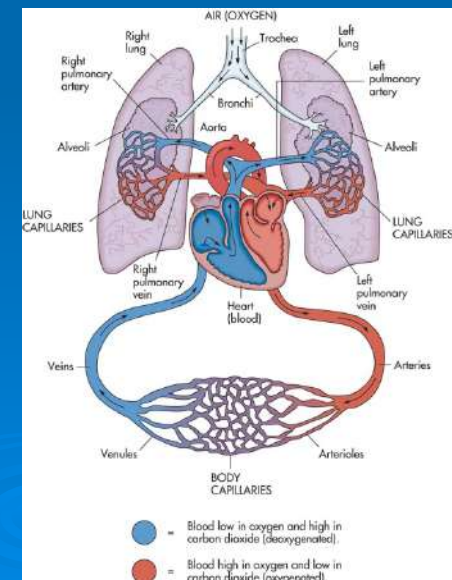
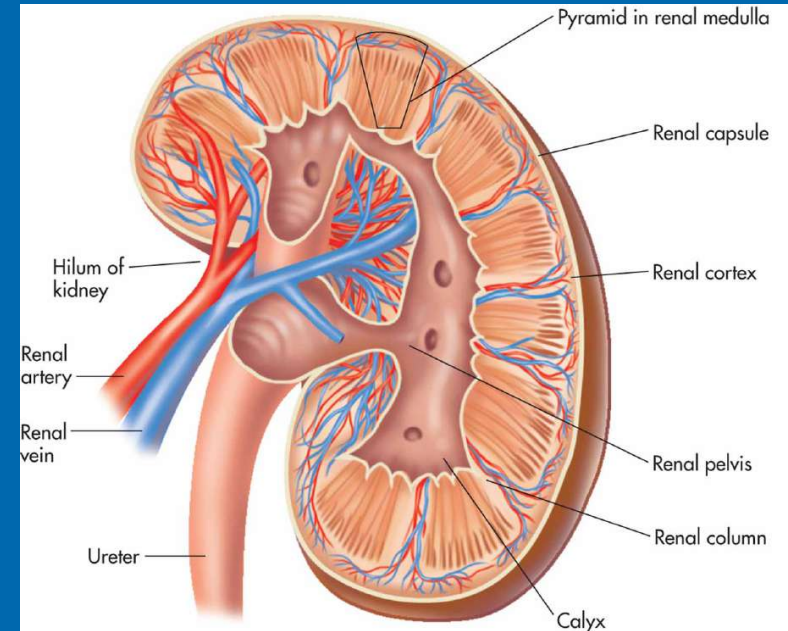
Lower Pole

Meatus



# External Anatomy of the Kidney

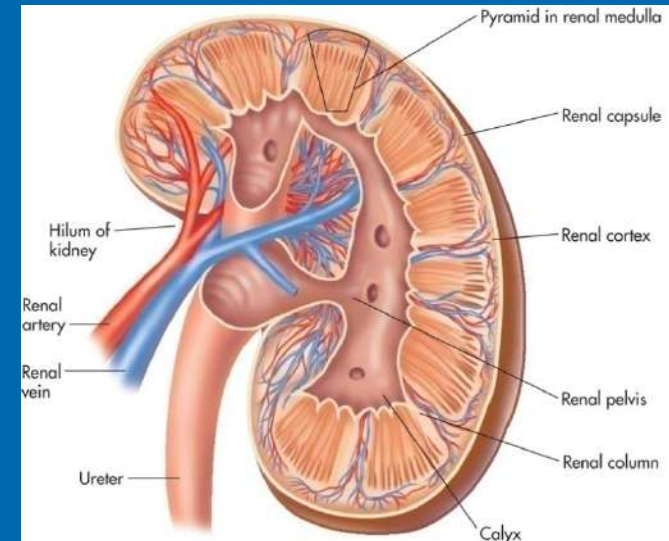
- **Renal Capsule:** Kidney covered by fibrous layer of **connective tissue**.
- **Renal Hilum:** Gives kidney its **shape**.
- **@ Hilum renal arteries** bring blood to kidneys to be filtered and **renal veins** take filtered blood away from kidney.
- **Ureter** also attached at hilum to transport urine from kidney to bladder



# Internal Anatomy of the Kidney

Kidney divided into 3 layers:

- **Renal cortex:** outer layer, grainy in appearance, has little obvious structure to naked eye; **where blood filtration occurs.**
- **Renal medulla:** middle layer: **Transports urine** to the renal pelvis via “**pyramids.**”
- **Renal pelvis:** inner layer. **Collects urine.**



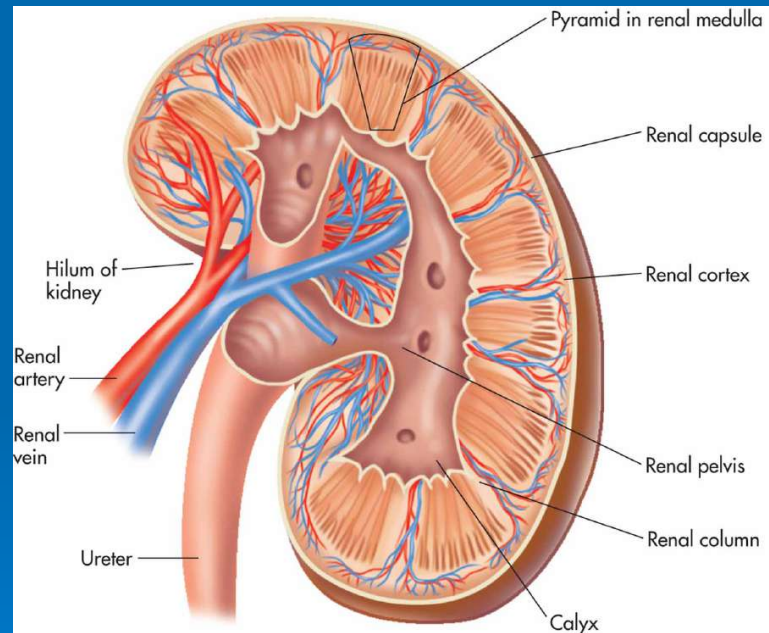
## Path of Urine Production

1. Renal Cortex
2. Renal Medulla
3. Renal Pelvis



# Renal Cortex

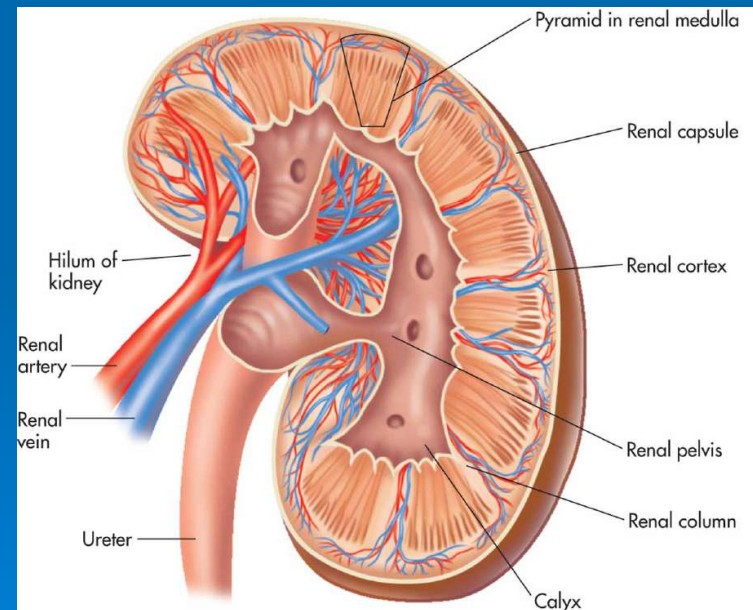
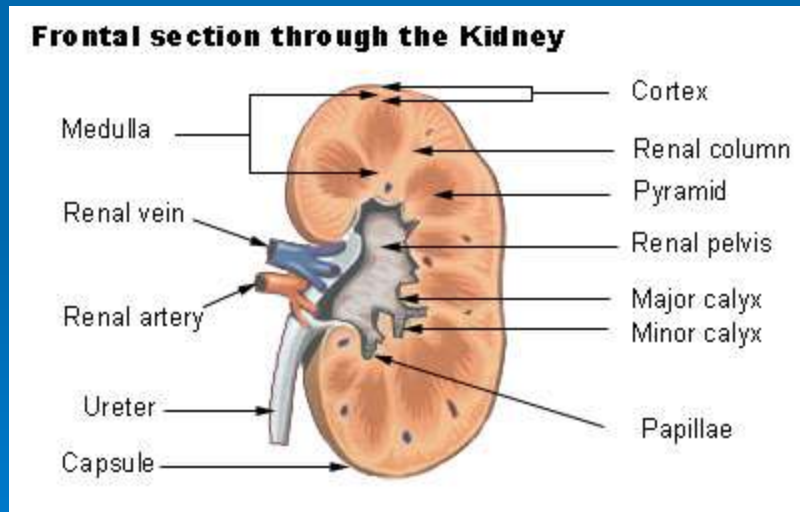
- **Outer layer:** grainy in appearance, has little obvious structure to naked eye; where blood **filtration** occurs.





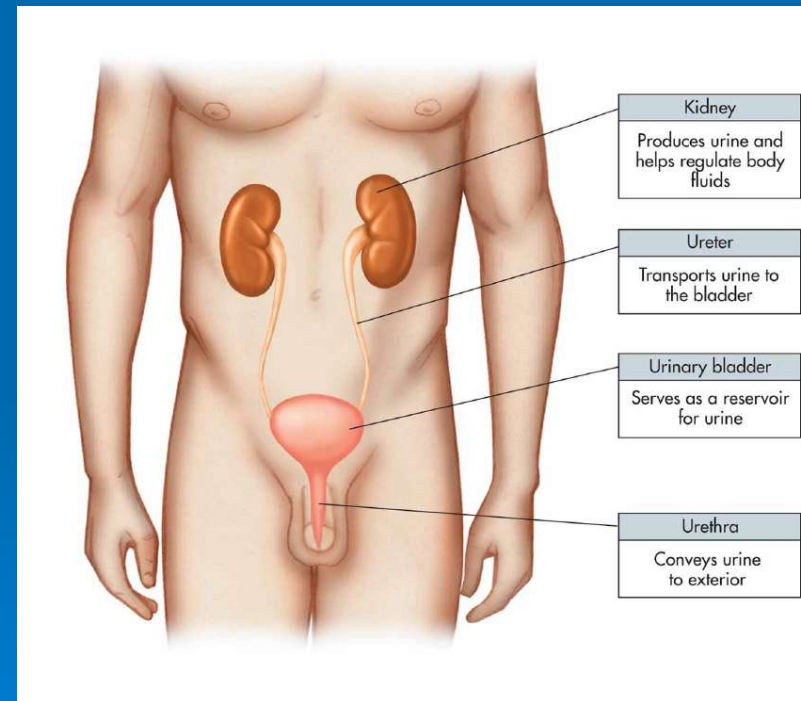
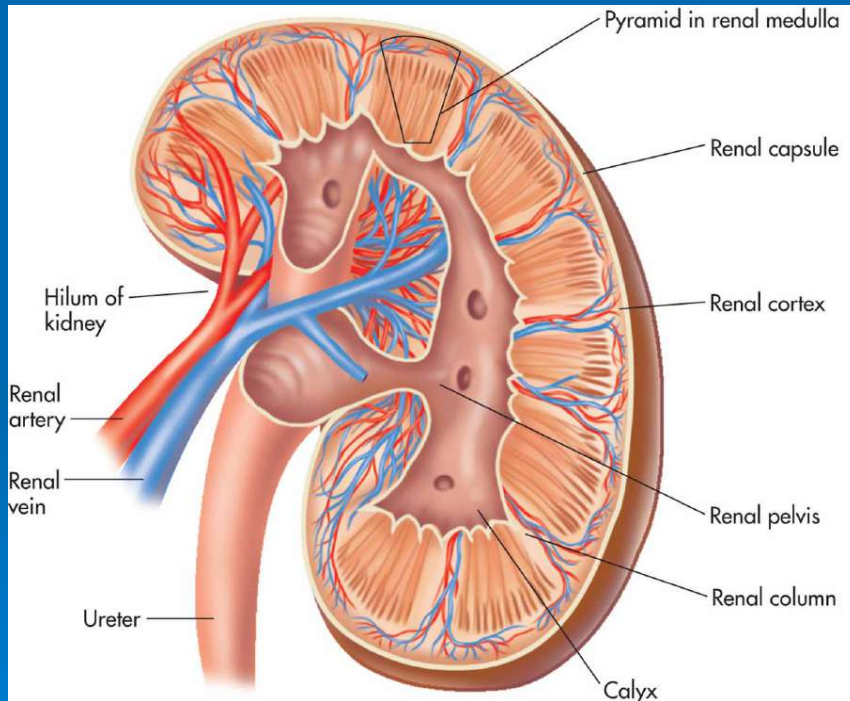
# Renal Medulla

- middle layer: **Transports urine** to the renal pelvis via **7-18 “pyramids,”** or collecting tubes.
- **pyramids composed of** collecting tubules for urine that is formed in kidney.



# Renal Pelvis

- Inner layer: **Collects**, then **empties** urine into **proximal Ureter** on way to bladder.

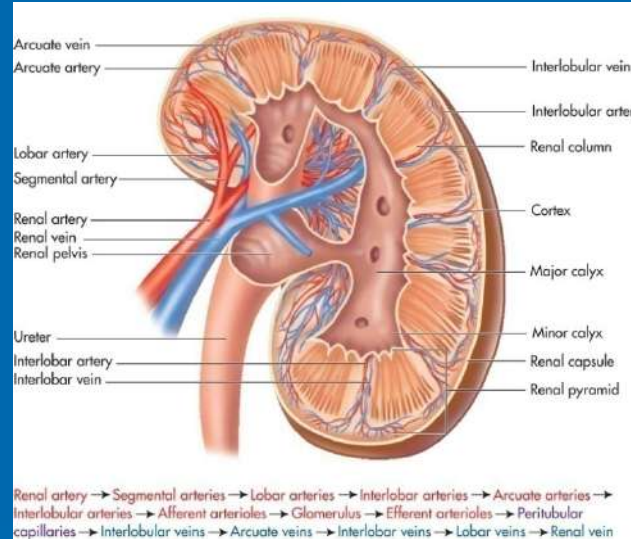


# Vasculature of the Kidney

**Healthy blood supply to kidney is essential**

## Arterial System

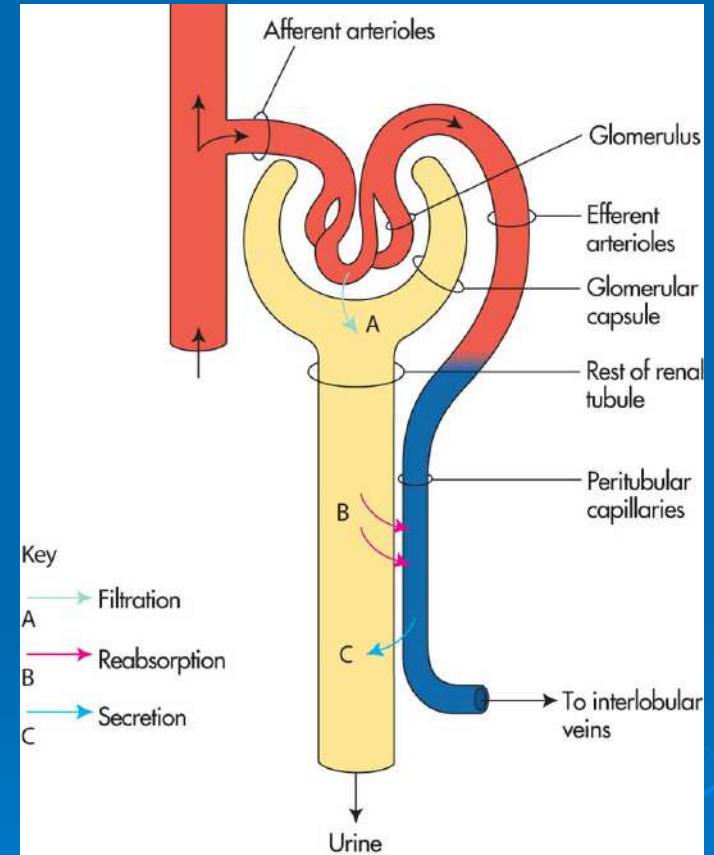
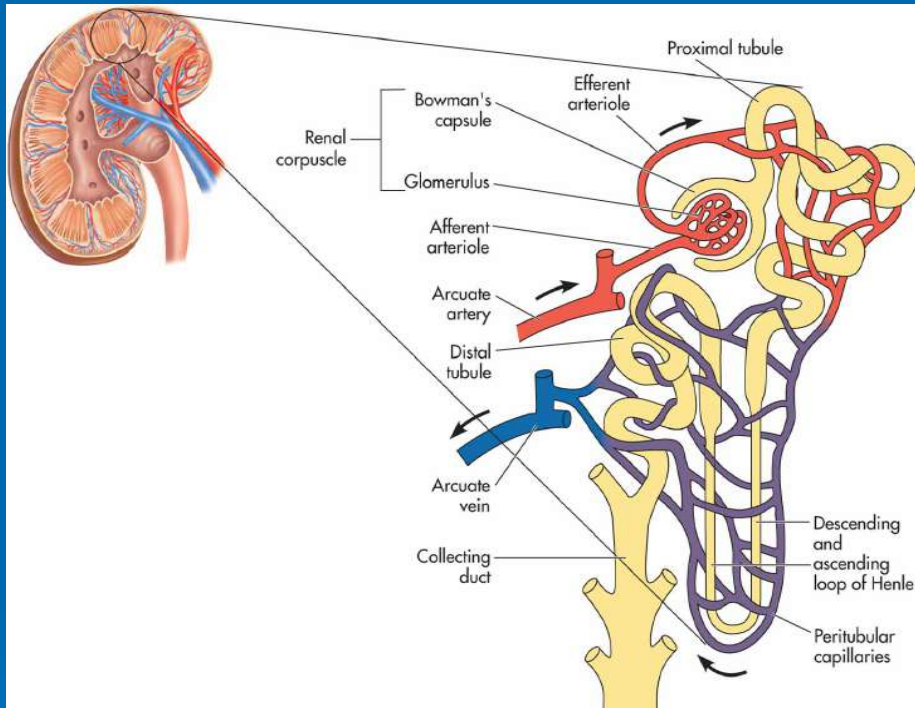
- Renal
- Segmental
- Lobar
- Interlobular
- Arcuate
- Interlobular
- Afferent arterioles
- Glomerulus
- Efferent arterioles



## Venous System

- Renal
- Lobar
- Interlobular
- Arcuate
- Interlobular
- Peritubular capillaries

# The Nephron

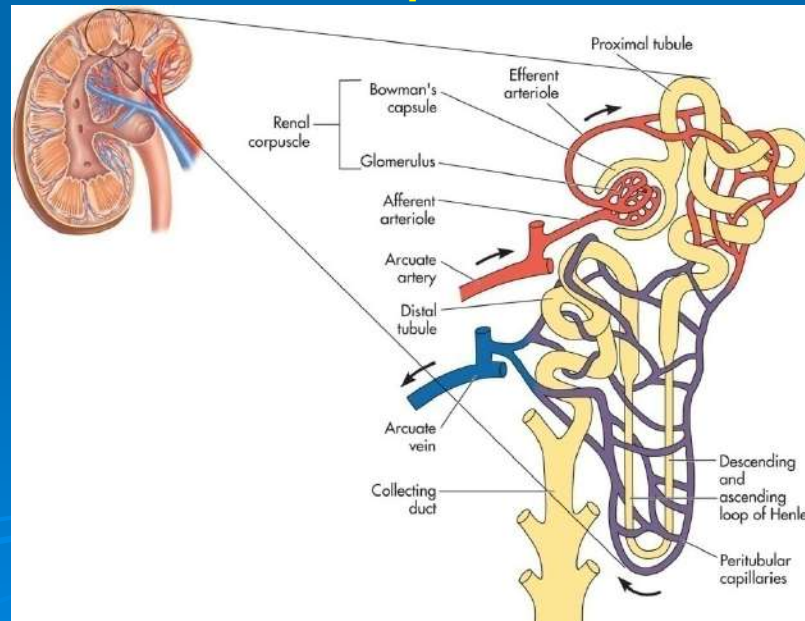


Schematic view of the three stages of urine production: (A) filtration; (B) reabsorption; and (C) secretion.



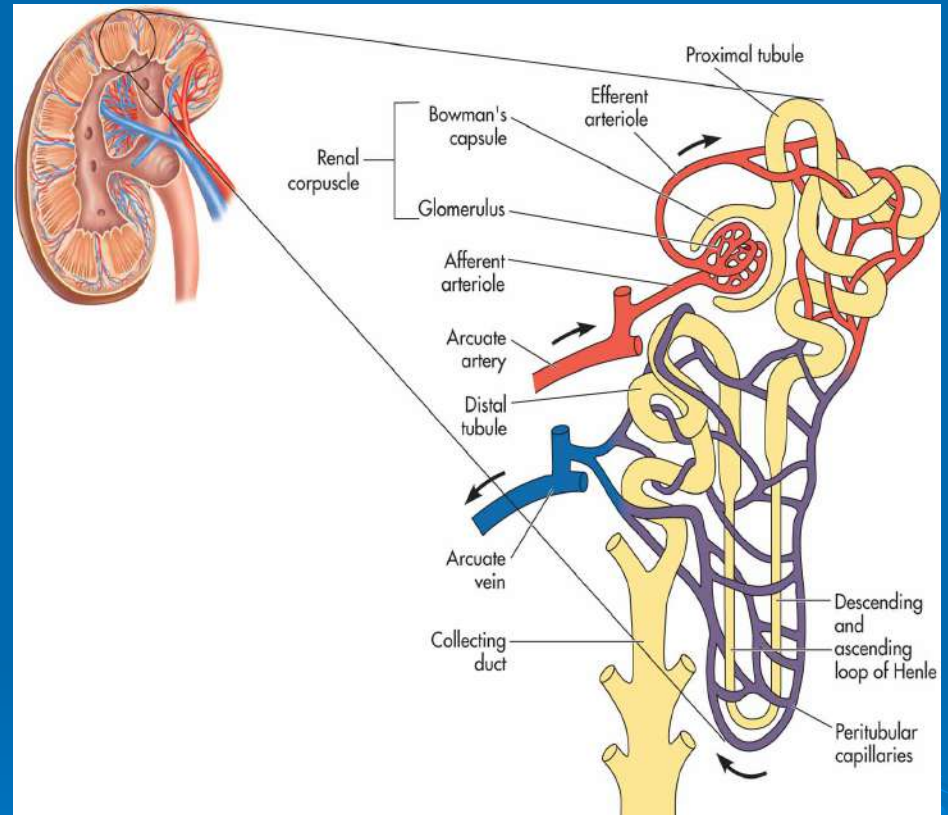
# The Nephron

- **Functional unit of kidney:** consisting of millions of **microscopic** funnels and tubules.
- **Divided into 2 parts:**
  - Renal Corpuscle:** a filter
  - Renal Tubule:** where **reabsorption & secretion** take place.



# The Nephron con't

- Blood enters renal corpuscle via **glomerulus**, ball of capillaries.
- Surrounding **glomerulus** is double-layered membrane called **Bowman's capsule**, the filter.



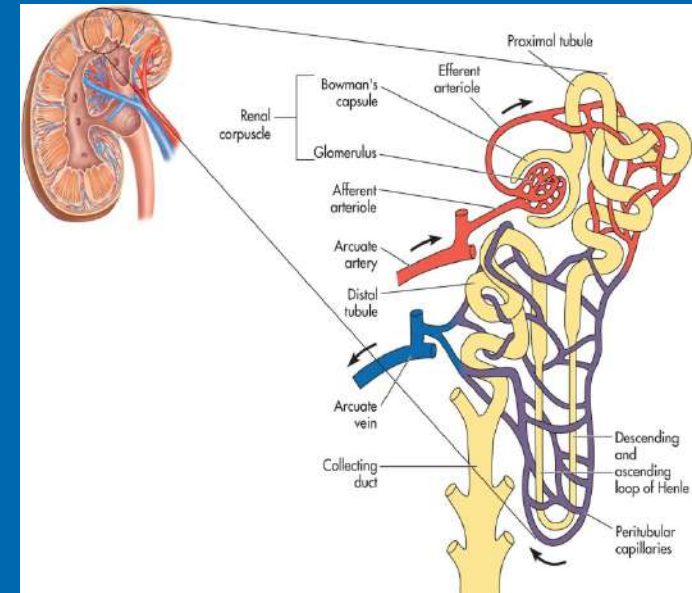
# The Nephron con't

➤ **Blood flows** into **glomerulus** & everything BUT blood cells & few large molecules, mainly protein, pushed from capillaries across filter & into glomerular (**Bowman's**) capsule. Fluid now called "filtrate."

➤ **Protein urea**: protein in UA (filtrate)

or

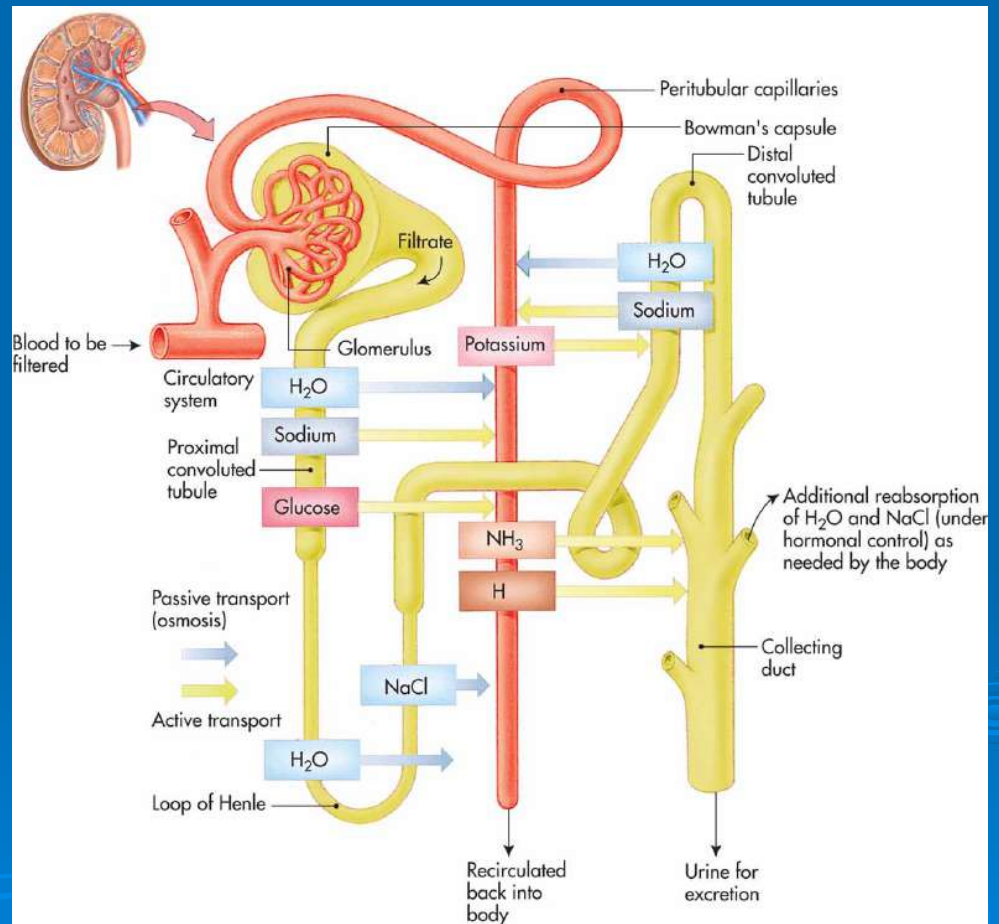
**Hematuria**: blood in UA indicates renal problems!



# The Nephron con't

## Renal Tubules

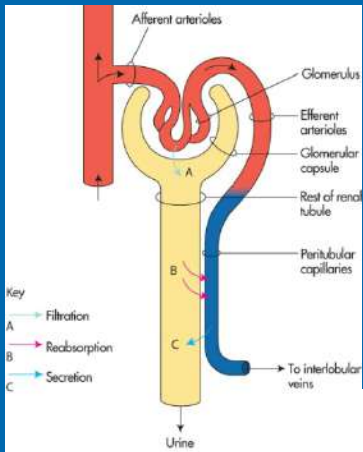
- Proximal loop
- Loop of Henle
- Distal loop



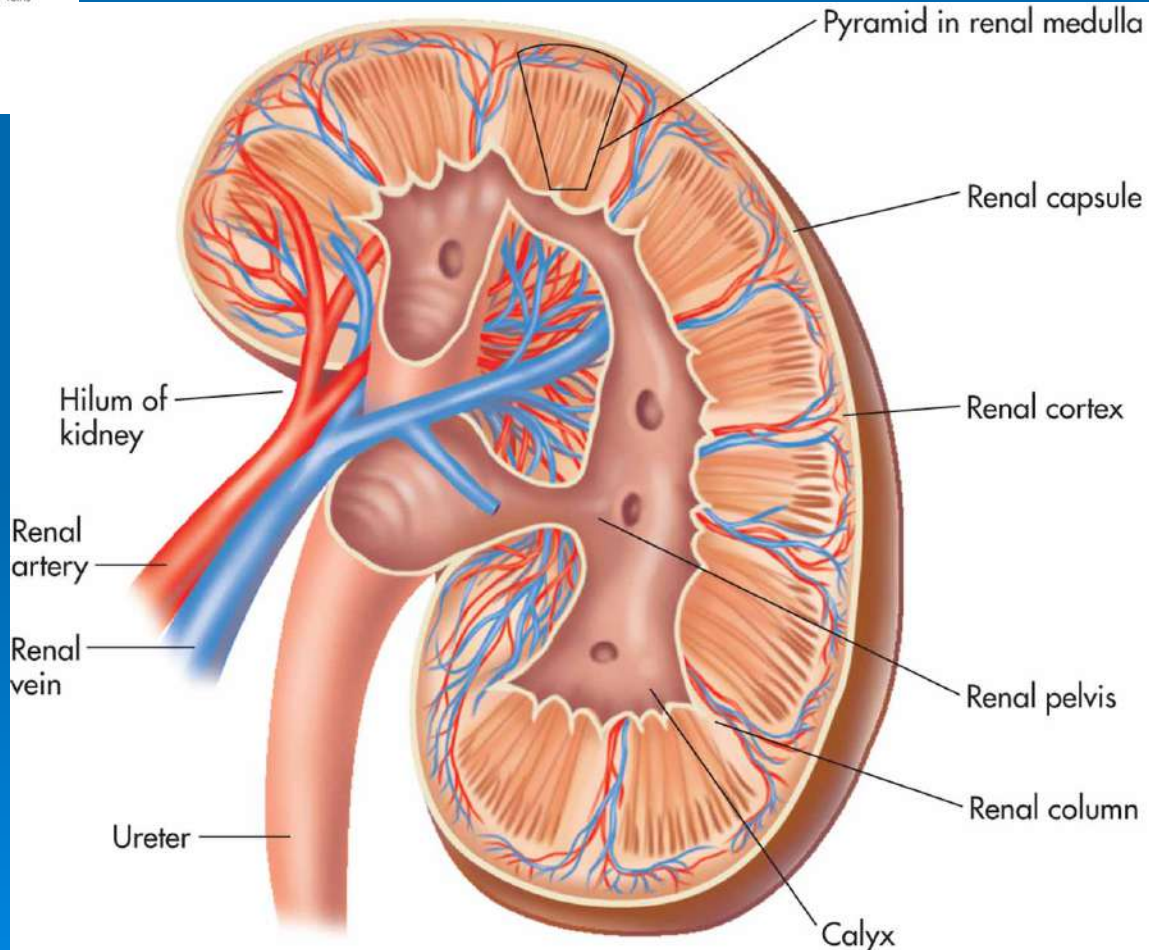
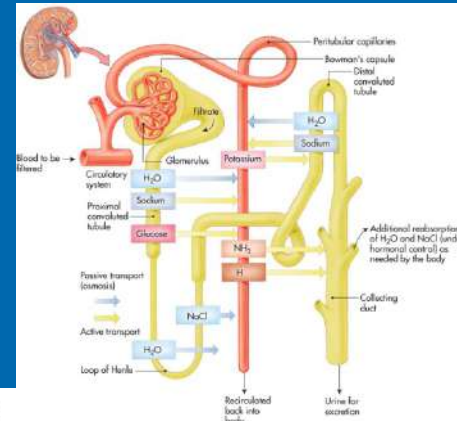
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# Path of Urine Production



Schematic view of the three stages of urine production: (A) filtration; (B) reabsorption; and (C) secretion.

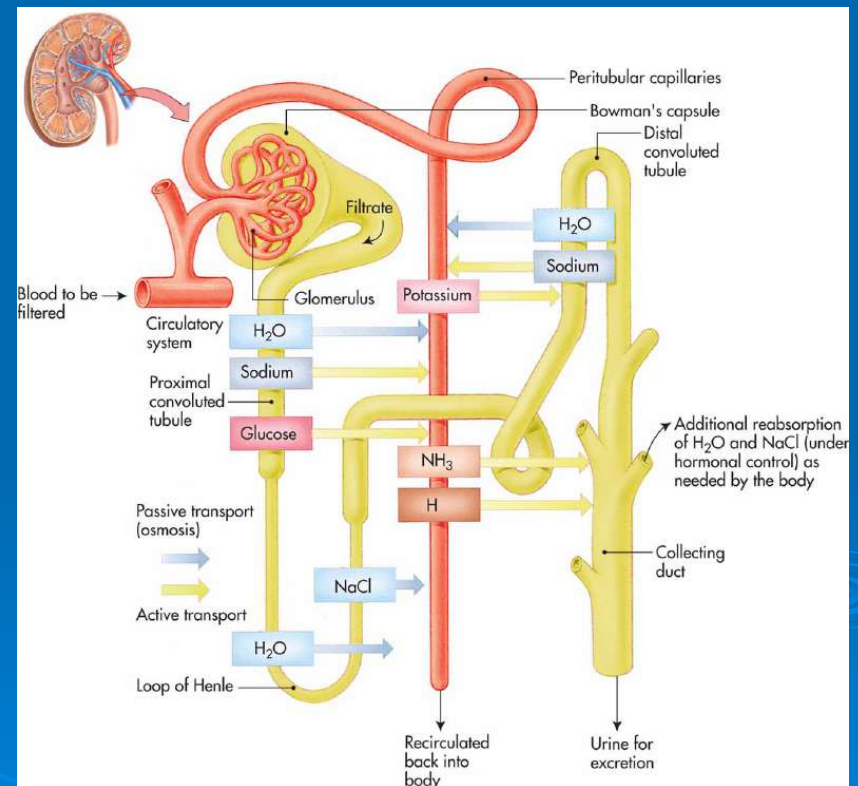


# How **Urine** is Formed

**3 processes** must occur in Nephron:

1. **Glomerular Filtration**: fluid & molecules pass from glomerular capillaries **into** glomerular (**Bowman's**) capsule.

**Filtrate** flows into renal tubule.

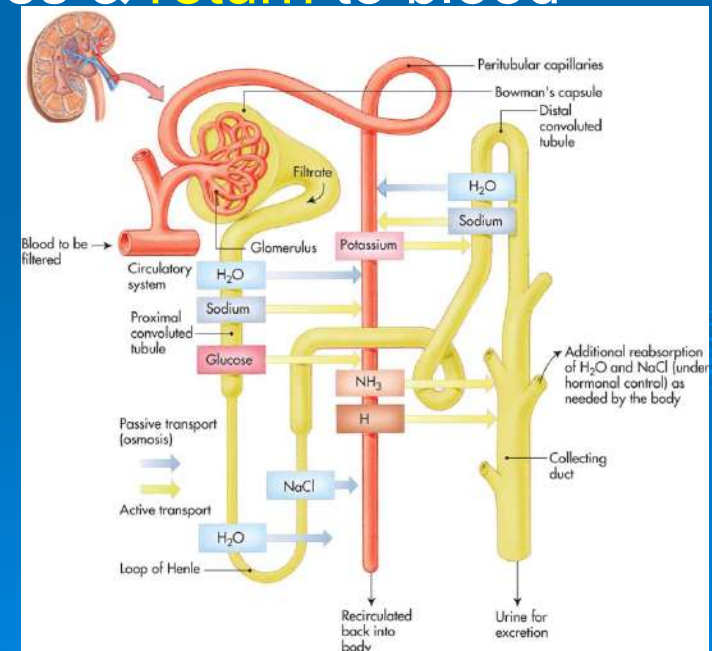


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# How **Urine** is Formed

**3 processes** must occur in Nephron:

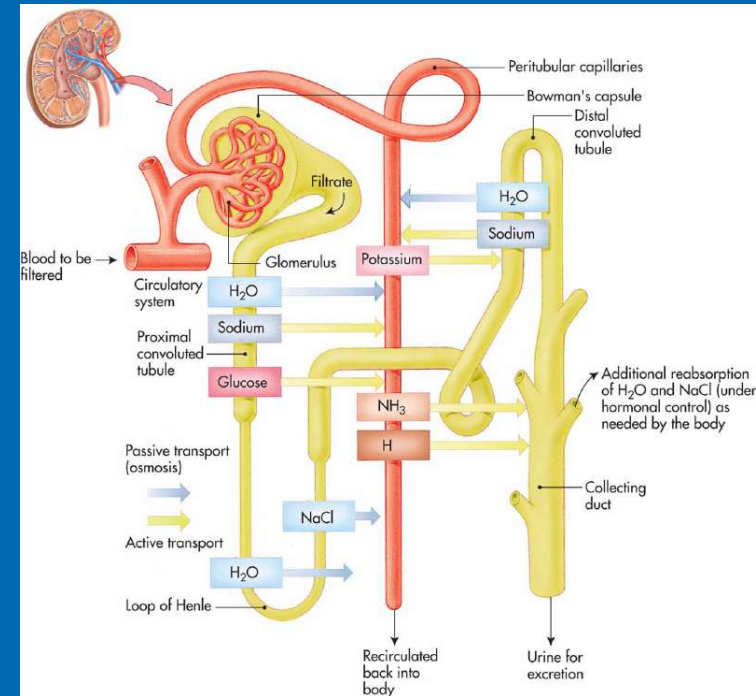
1. **Glomerular Filtration**: fluid & molecules pass from glomerular capillaries **into** glomerular (**Bowman's**) capsule. **Filtrate** flows into renal tubule.
2. **Tubular Reabsorption**: substances reabsorbed pass from renal tubule **into** peritubular capillaries & **return** to blood stream.



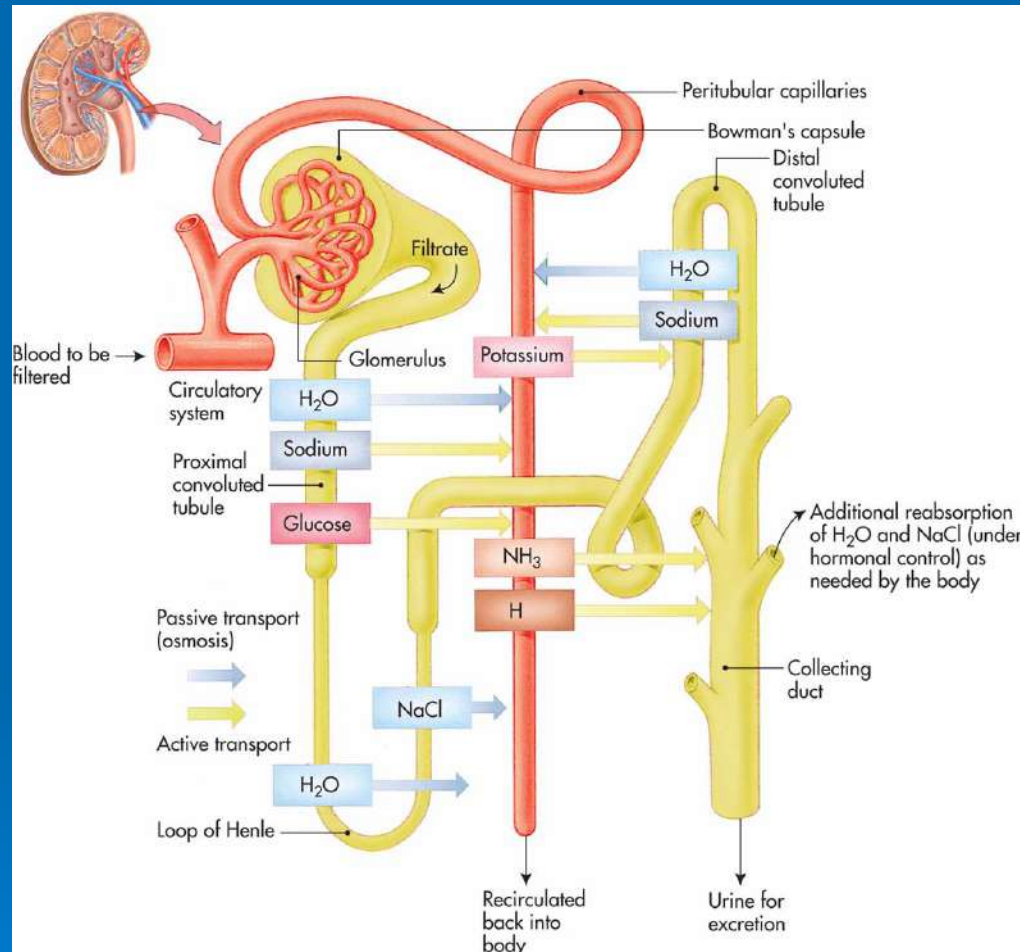
# How **Urine** is Formed

3 processes must occur in Nephron:

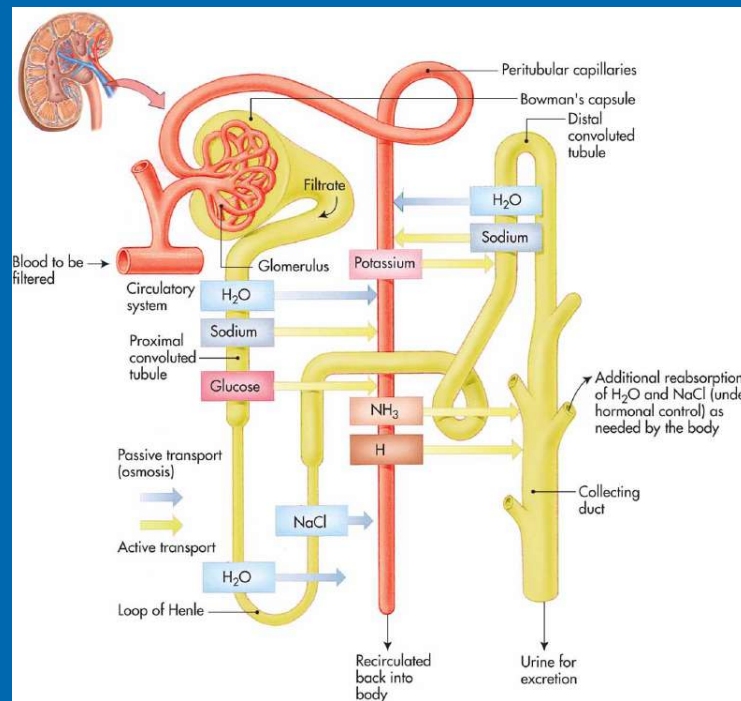
1. **Glomerular Filtration**: fluid & molecules pass from glomerular capillaries **into** glomerular (**Bowman's**) capsule. **Filtrate** flows into renal tubule.
2. **Tubular Reabsorption**: substances reabsorbed pass from renal tubule **into** peritubular capillaries & **return** to blood stream.
3. **Tubular Secretion**: substances that are secreted pass through peritubular capillaries **into** renal tubule & eventually leave body as **urine**, no longer filtrate...



# How Urine is Formed Summary



# Reabsorbed VS Secretion



**TABLE 16-2 Individual Tubule Functions**

TUBULE	SUBSTANCES REABSORBED OR SECRETED
Proximal tubule	Potassium, chloride, sodium (80% of sodium is normally reabsorbed in the proximal tubule), magnesium, bicarbonate, phosphate, amino acids, glucose, fructose, galactose, lactate, citric acid, water, hydrogen (H <sup>+</sup> ), neurotransmitters, bile, uric acid, drugs, toxins, ammonia, urea
Descending loop	Water (90% of the water is normally reabsorbed in the descending loop), urea
Ascending loop	Sodium, potassium, chloride, urea
Distal tubule	Sodium, potassium, chloride, hydrogen (H <sup>+</sup> ), water
Collecting duct	Sodium, potassium, chloride, water, urea

# Pathology Connection: Kidney Stones (Renal Calculi)

## Etiology:

Calcium, phosphorus, & uric acid crystals, & nephritis.

## S/S:

Hematuria, flank/abd/pelvic pain. Urgency, fever, N/V.

Mild to extreme pain 10/10!

## D/X:

History/Exam, UA, Ultrasound or CT, KUB, IVP



Agony



Pain



Misery

# Normal KUB & IVP



**KUB**



**IVP**



# Abnormal IVP



**NFRK**



# Abnormal IVP



# Abnormal IVP



**RRC**

**RUPJC**



# Abnormal IVP



L

# Abnormal IVP



# Normal IVP



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Pathology Connection:  
RX for **Kidney Stones** (**Renal Calculi**) con't

Depends on size & location of stone

**Pain/Nausea medications**, fluids, strain UA

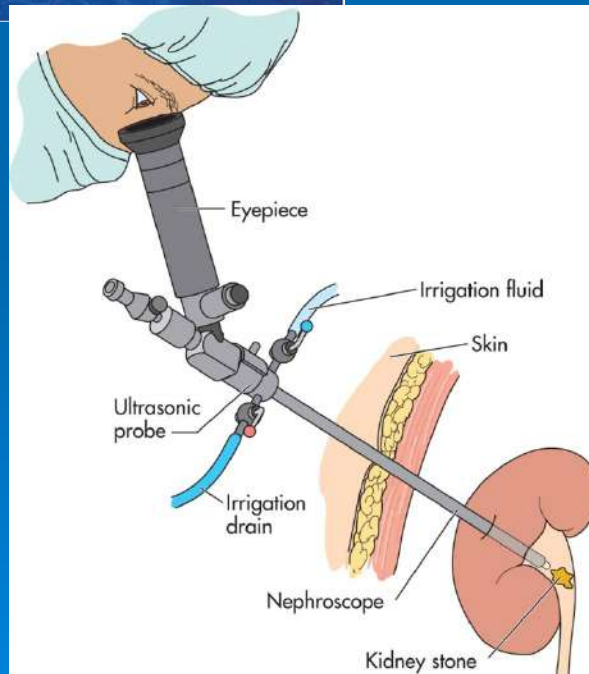
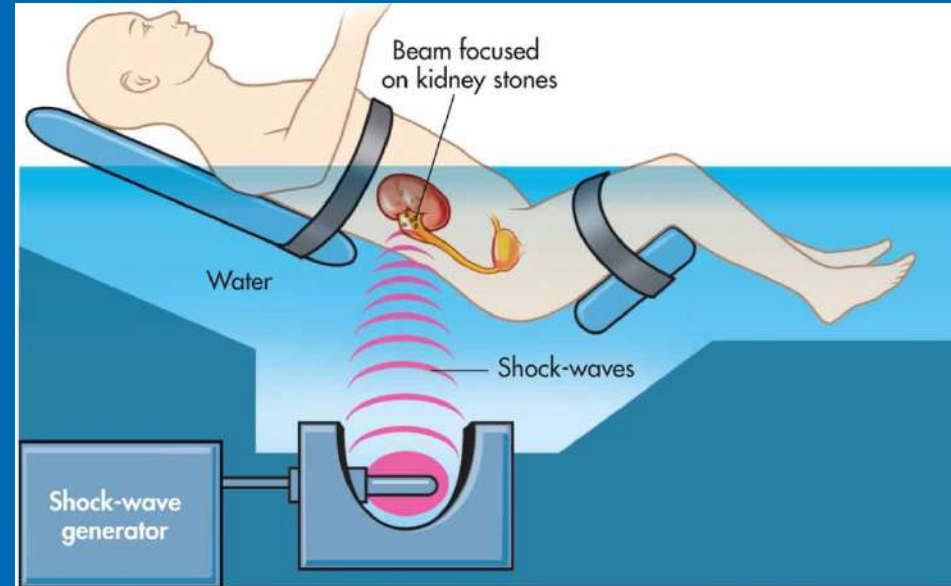
**Extracoporal Lithotripsy**: shock waves to break up stone into smaller stones.

**Ureteroscopy**: fiberoptic endoscope threaded up urethra, through bladder, & into ureter; attached instrument shatters stone & captures pieces.

**Percutaneous Nephro/ureterolithotomy**: Surgical removal of stone



# Extracorporeal Lithotripsy





# Common Disorders of the Urinary System

## Urinary Tract (Bladder) Infection (UTI)

**Etiology:** fecal bacteria into urinary tract

**S/S:** freq, dysuria, hematuria, turbid urine, & urine with unusual odor, fever, hypogastric or LBP.

**Dx:** UA, C&S, Pt. History

**Rx:** Antibiotics, increase fluids

Prognosis: Excellent

Pts. Most @ Risk: Women, elderly, hospitalized with or without catheters, men with BPH.



# Common Disorders of the Urinary System

## Polycystic Kidney Disease

**Etiology:** Genetic

**S/S:** enlarged, cystic kidneys, hypertension, UTI, dilute urine, liver cysts, pain, hematuria, aneurysm

**Dx:** CT, MRI, Genetic tests

**Rx:** various meds and or Renal Transplant

**Prognosis:** No cure without transplant



Contrast-enhanced abdominal computed tomography showing kidneys (arrows) containing numerous cystic masses. [Reproduced with permission from Fred, H.L. and Siddique, I. (1995) New Eng. J. Med. 333, 31.]



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# Common Disorders of the Urinary System

## Ischemic Nephropathy

**Etiology:** decrease blood flow to kidneys

**S/S:** kidney failure, uremia, hypertension or hypotension, oliguria, increase serum creatinine & urea.

**Dx:** UA, BUN & Creatinine

**Rx:** treat underlying cause & symptoms, possible renal transplantation.

**Prognosis:** Poor without treating cause or transplantation.

# Common Disorders of the Urinary System

## Diabetic Nephropathy

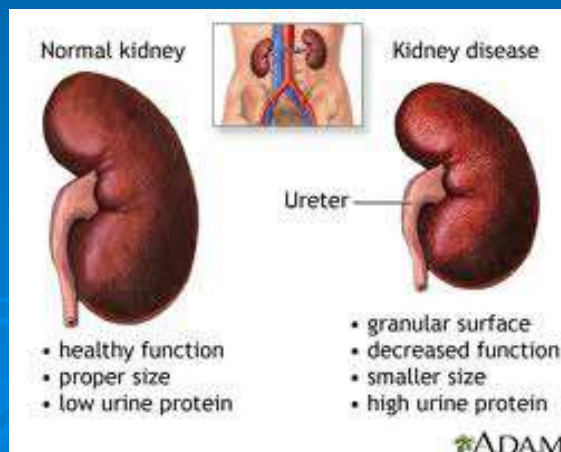
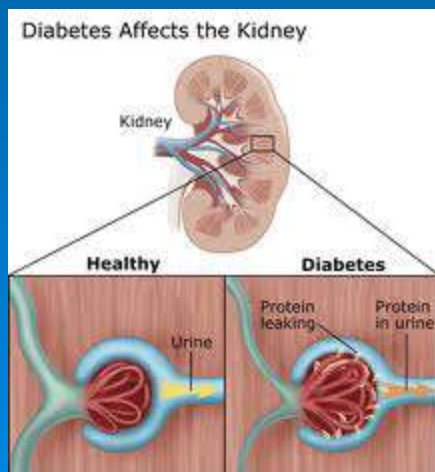
**Etiology:** Diabetes Mellitus (type I or II)

**S/S: early stages:** increased glomerular filtration, protein in urine, **later:** uremia, HTN.

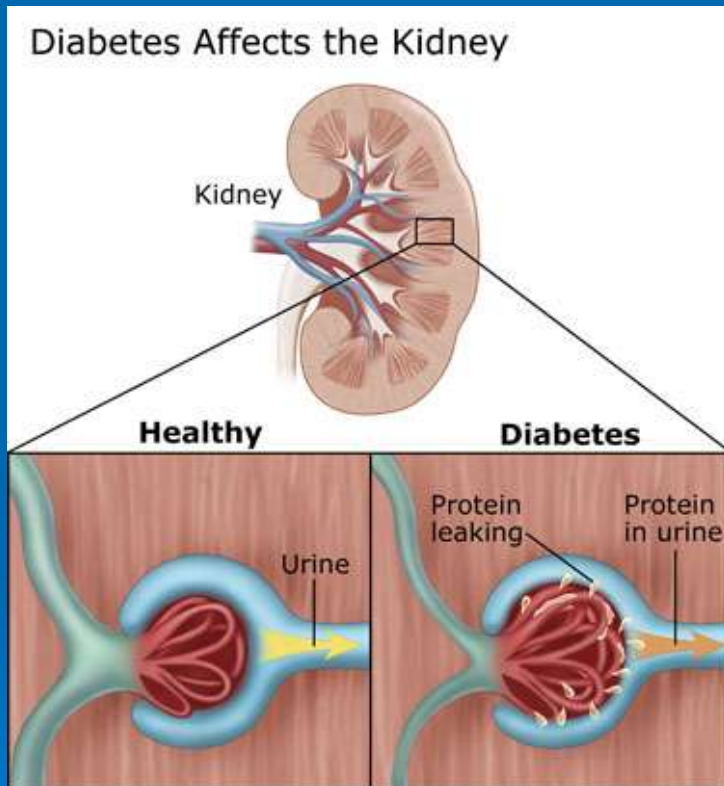
**Dx:** BUN, Creatinine, UA, 24 hour UA

**Rx:** tight glycemic control, blood anti-HTN Meds, lipid control, diet, kidney replacement

**Prognosis:** Poor without RX & Pt. life-style changes



# Diabetic Nephropathy



# Common Disorders of the Urinary System

## Drug Induced Nephropathy

**Etiology:** drugs toxic to kidney tissue, especially contrast dye & NSAIDs.

**S/S: early stages:** increased glomerular filtration, protein in urine, **later:** uremia, hypertension

**Dx:** BUN, Creatinine, UA, 24 hour UA

**Rx:** : stop drugs, no contrast dyes for patients with known risk factors, keep patients well hydrated before contrast dye use.

**Prognosis:** Poor without treating cause or transplantation.

# Common Disorders of the Urinary System

## Glomerulonephritis

**Etiology:** : inflammation & scarring of glomerulus

**S/S: early stages:** increased glomerular filtration, protein in urine, **later:** uremia, hypertension

**Dx:** BUN, Creatinine, UA, 24 hour UA

**Rx:** treating underlying cause may decrease progression.

**Prognosis:** Poor if cause not found, transplantation

# Common Disorders of the Urinary System

## Uremia

**Etiology:** build up of organic waste products in blood due to renal insufficiency.

**S/S:** elevated BUN & Creatinine, fatigue, neuropathy, seizures, lack of appetite, decreased smell & taste, mental confusion, insulin resistance, itching, inflammation, clotting problems.

**Dx:** BUN, Creatinine, UA, 24 hour UA

**Rx:** dialysis or renal transplantation

**Prognosis:** poor without dialysis or transplantation



# Common Disorders of the Urinary System

**Diabetes Insipidus** (Dull-lacking flavor)

**Etiology:** ADH deficiency

1. **Central** (Brain)
2. **Nephrogenic** (Kidneys)

**S/S:** polyuria, dilute urine, thirst, dehydration, low K+, lethargy, muscle pain, irritability.

**Dx:** UA, 24 UA, BUN, Creatinine, CT head & abdomen

**Rx:** Thiazide or Amiloride “**Loop**” Diuretics or surgery.

**Prognosis:** Varies

# Common Disorders of the Urinary System

## Renal Failure

**Etiology:** acute or chronic decrease in glomerular filtration rate.

**S/S:** decrease urine output, uremia, edema, loss of appetite, fatigue, hiccups, nausea, mental confusion, clotting disorder, seizures, coma.

**Dx:** UA, BUN & Creatinine, CT, IVP.

**Rx:** BP meds, glucose & protein control, treatment of underlying condition, prevention CVD, peritoneal or hemodialysis, transplantation.

**Prognosis:** Good with transplantation

# Common Disorders of the Urinary System

## Overactive Bladder (Incontinence)

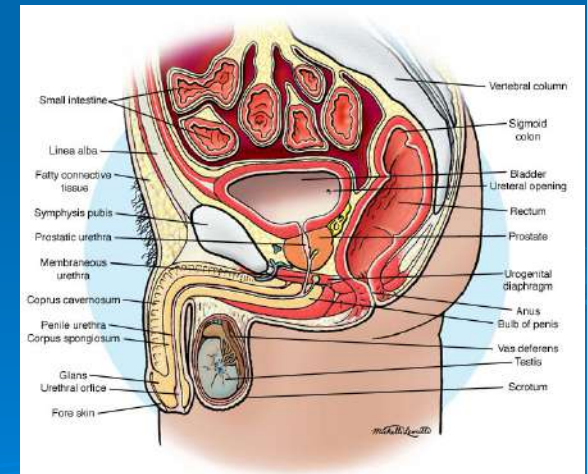
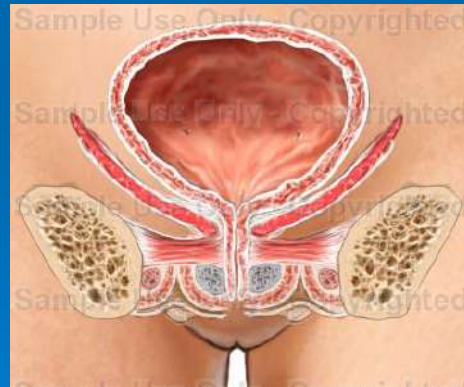
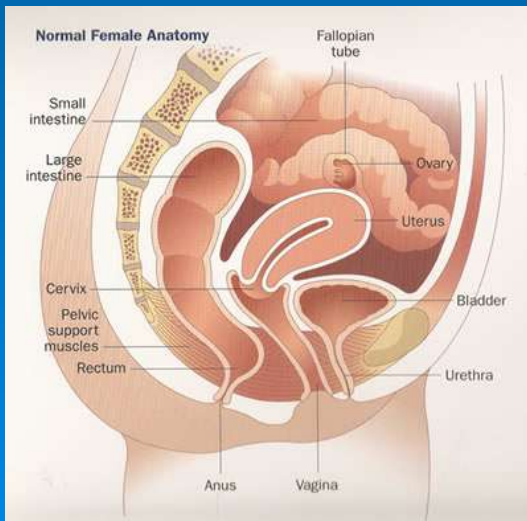
**Etiology:** Unkn. Possible life-style choices

**S/S:** urgency, inability to control urine flow

**Dx:** Pt. Hx, UA, bladder studies

**Rx:** Bladder training, sympathetic drugs

**Prognosis:** Good



# Common Disorders of the Urinary System

## Bladder Cancer

**Etiology:** Malignant tumor fm tobacco, radiation

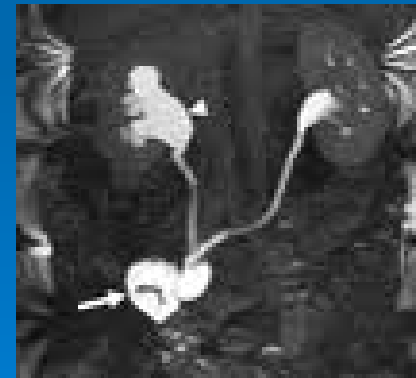
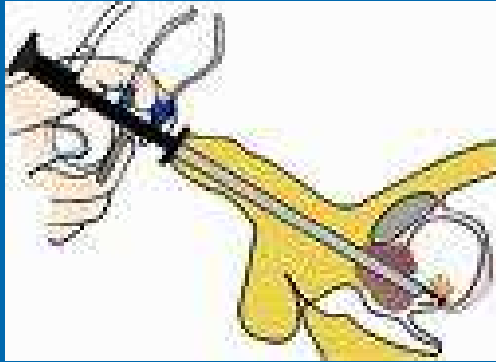
**S/S:** Hematuria, UTI's, dysuria

**Dx:** UA, cytology, cystoscopy, CT

**Rx:** 1. Transurethral Resection BT (**TUR-BT**)  
2. Chemotherapy 3. Radiation

**Prognosis:** Very good if Dx early, poor if stage 3-4.

# Bladder Cancer



# Staging Cancer

## The TNM System

- **T**: describes the **size** & whether it has invaded nearby tissues.
- **N**: describes regional **lymph nodes involved**
- **M**: describes distant **metastasis**

# Staging Cancer

- **0**: no cancer found
- **1**: **In-situ** (Latin “**in the place**”) in the layer of cells in which they developed.
- **2**: **Localized**: Cancer **limited** to the organ in which they developed.
- **3**: **Regional**: Cancer spread to **nearby** lymph nodes or organs.
- **4**: **Distant**: Cancer spread to **distant** lymph nodes or organs.

# Hemolytic Uremic Syndrome

- **Etiology:** bacterial infection with certain strains of E. coli, toxins damage kidneys
  - **S/S:** fever, abdominal pain, pallor, fatigue, bruising, decreased urination, swelling
  - **Dx:** blood tests, history
- Tx:** blood transfusion, kidney dialysis