

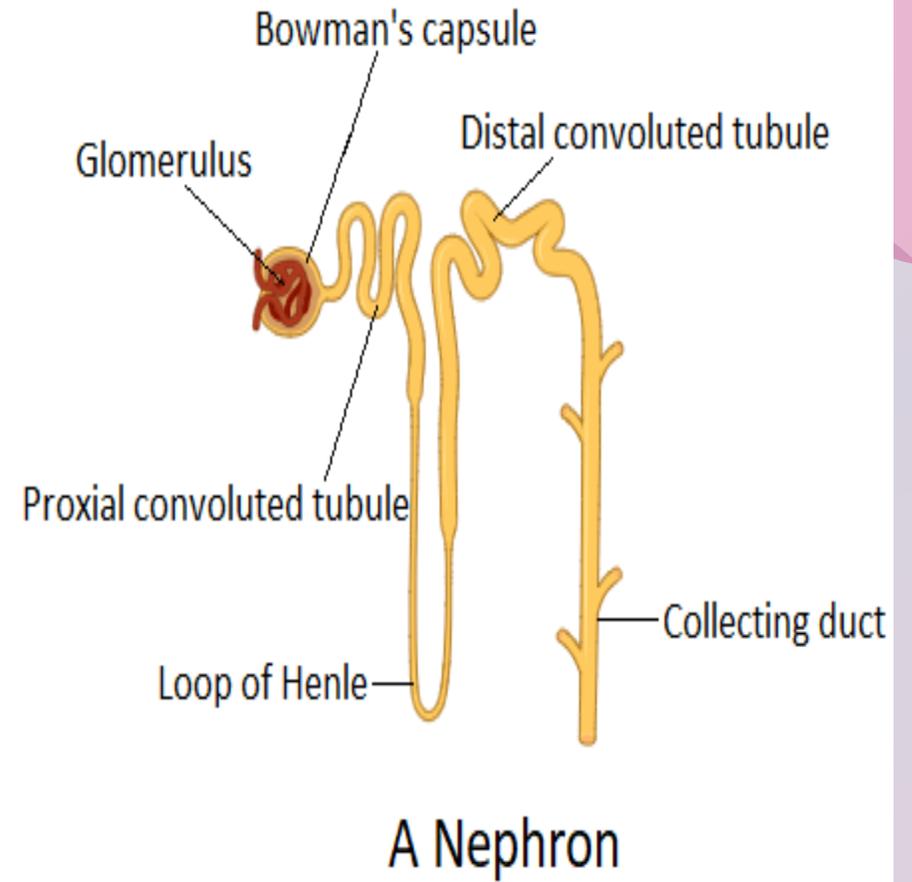
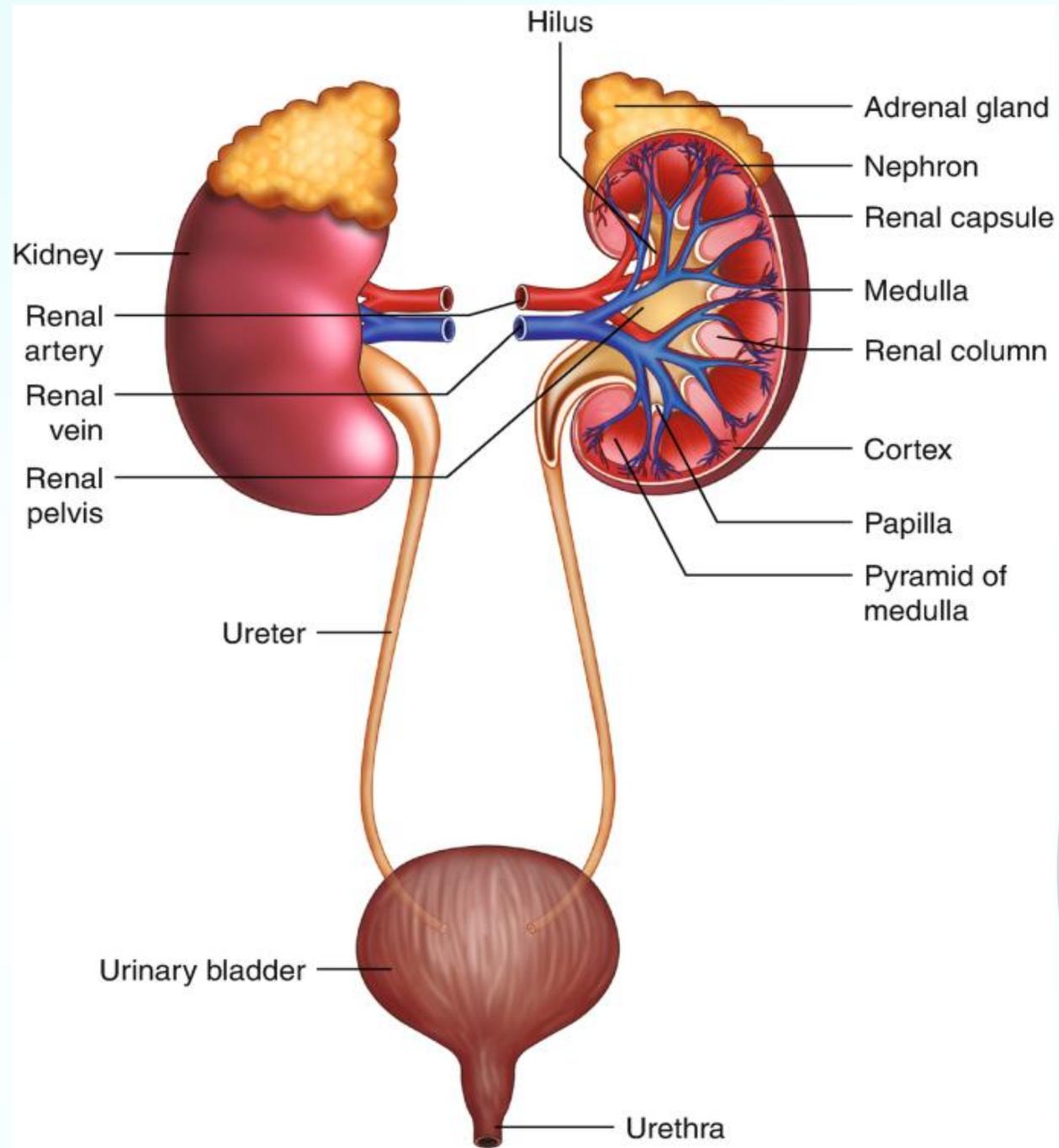


# The Urinary System

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# Introduction

❖ The kidney is a structurally complex organ that has evolved to carry out a number of important functions:

- Excretion of the waste products of metabolism
- Regulation of body water and salt
- Maintenance of acid balance
- Secretion of a variety of hormones and prostaglandins

❖ Diseases of the kidney are as complex as its structure, but their study is facilitated by dividing them into those that affect its four components:

1. Glomeruli
2. Tubules
3. Interstitium
4. Blood vessels

- Due to the large functional reserve capacity of the kidney, early signs of kidney disease are often missed, and much renal damage may occur before renal dysfunction becomes clinically apparent.
- The two most common syndromes associated with glomerular diseases, nephrotic and nephritic

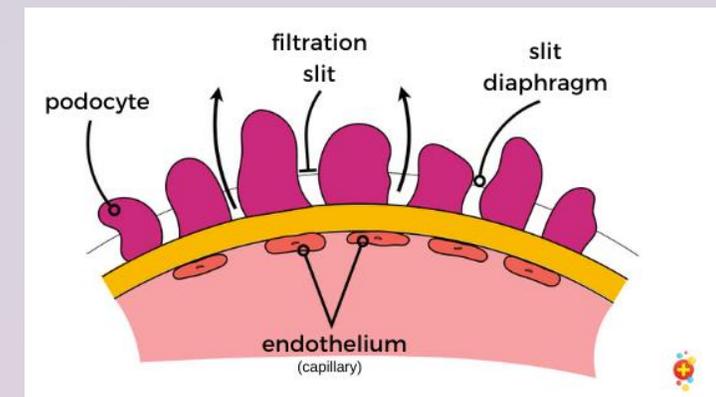
# Important definitions

- ❖ **Azotemia**: refers to an elevation of blood urea nitrogen (BUN) and creatinine levels, and is related largely to a decreased glomerular filtration rate (GFR).
  - Typical feature of both acute and chronic kidney injury.
  - Pre-renal azotemia: is encountered when there is hypoperfusion (decreased) of the kidneys that impairs renal function in the absence of parenchymal damage. In cases of shock, heart failure, or cirrhosis of the liver.
  - Post-renal azotemia: is seen whenever urine flow is obstructed distal to the kidney. Relief of the obstruction is followed by correction of the azotemia.
  - Renal azotemia: in intrinsic defect in the kidney.
- ❖ **Uremia**: Azotemia + clinical signs and symptoms + Biochemical abnormalities
  - Uremic gastroenteritis, peripheral neuropathy, uremic pericarditis.
  - Requires dialysis

# Nephrotic syndrome



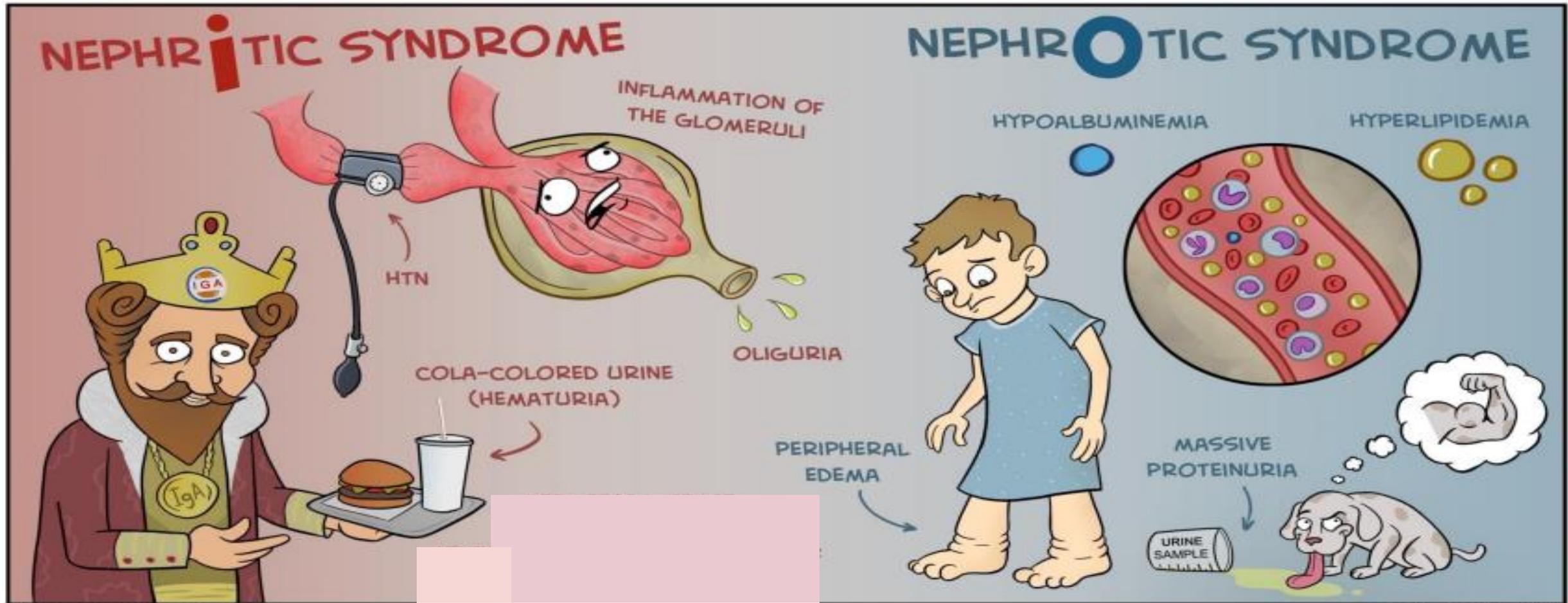
- ❖ **Characterized by the following:**
  - **Proteinuria**, with daily protein loss in the urine of 3.5 g or more in adults (said to be in the “nephrotic range”)
  - **Hypoalbuminemia**, with plasma albumin levels less than 3 g/dL → (low plasma osmotic pressure)
  - **Generalized edema**, the most obvious clinical manifestation
  - **Hyperlipidemia and lipiduria** (lipid in the urine).
- ❖ The nephrotic syndrome has diverse causes that share a common pathophysiology: **a derangement in the capillary walls of the glomeruli that results in increased permeability to plasma proteins.**
- ❖ **Podocyte injury is an underlying mechanism of proteinuria**, and may be the result of nonimmune causes (as in minimal change disease and FSGS) or immune mechanisms (as in membranous nephropathy).



# Nephritic syndrome

- ❖ **Characterized by the following:**
  - **Hematuria** (red cells and red cell casts in urine)
  - **Proteinuria** (usually in the subnephrotic range) with or without edema
  - **Azotemia** (elevation of blood urea nitrogen and creatinine)
  - **Hypertension**
- ❖ The nephritic syndrome usually has an acute onset and is caused by **inflammatory lesions of glomeruli**.
- ❖ The most common cause is immunologically mediated glomerular injury;
- ❖ Acute post infectious glomerulonephritis typically occurs after streptococcal infection in children and young adults but may occur following infection with many other organisms
- ❖ May also be related to **systemic conditions such as lupus erythematosus** where there are excess levels of circulating antibodies or antigen–antibody complexes.

# Nephritic VS Nephrotic



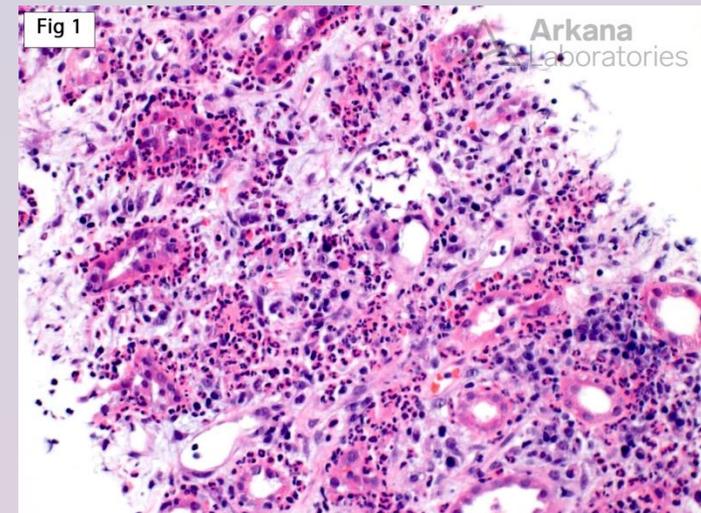
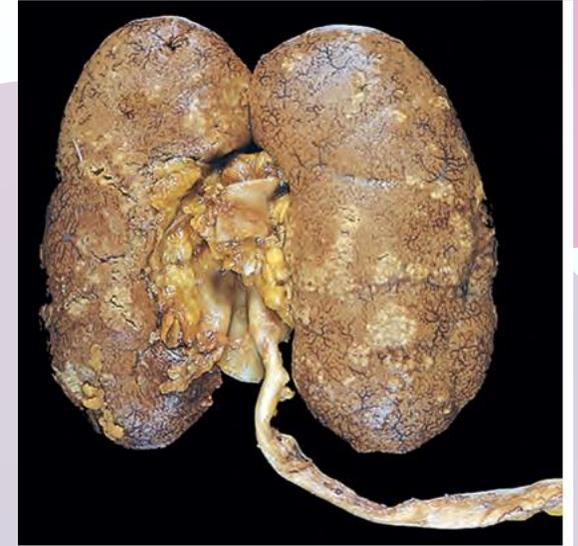
# Renal diseases important terms

- ❖ Rapidly progressive glomerulonephritis (RPGN): results in rapid loss of renal function in a few days or weeks, typically in the setting of nephritic syndrome. If untreated, it leads to death from renal failure within a period of weeks to months.
- ❖ Acute kidney injury: refers to abrupt onset of renal dysfunction characterized by an acute increase in serum creatinine often associated with oliguria or anuria (decreased or no urine flow).
  - It can result from glomerular, interstitial, vascular, or acute tubular injury (ATI)
- ❖ Chronic kidney disease: the presence of a diminished GFR that is persistently less than 60 mL/min/1.73 m<sup>2</sup> for at least 3 months, from any cause, and/or persistent albuminuria. Results from progressive scarring in the kidney of any cause.
  - It is characterized by various metabolic and electrolyte abnormalities such as hyperphosphatemia, dyslipidemia, and metabolic acidosis.
  - However, it is often asymptomatic until the most advanced stages, when symptoms of uremia develop.

# Pyelonephritis

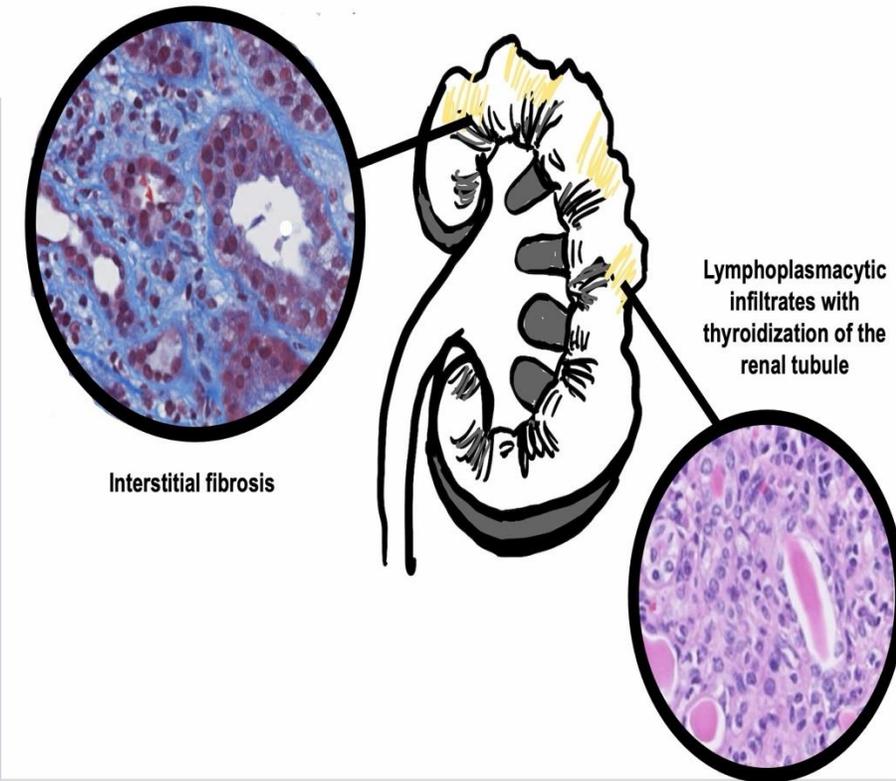
Acute Cystitis → Inflammation of urinary bladder  
Pyelonephritis → Inflammation of the kidney

- ❖ Definition: inflammation affecting the tubules, interstitium, and renal pelvis
- ❖ Two types:
  - 1) **Acute pyelonephritis**:
    - is a bacterial infection caused either by ascending infection (as a result of reflux, obstruction, or other abnormality of the urinary tract), or much less commonly by hematogenous spread of bacteria.
    - **Ascending infection is the most common cause of pyelonephritis**
    - **E. coli is the most common uropathogen isolated from urine or pus cultures**
    - Occurs most frequently in females as well as senior citizens of both sexes
    - Morphology:
      - **it is characterized grossly by abscess in cortex of the kidneys, and microscopically by neutrophils infiltration in tubules and interstitium.**



## 2) Chronic pyelonephritis:

- Definition: Implies recurrent kidney infections, usually associated with urinary obstruction or reflux; results in scarring of the involved kidney, and gradual renal insufficiency.
- Morphology: **scarring** due to chronic injury/ Diffuse, patchy **lymphoplasmacytic tubulointerstitial inflammation** and fibrosis/ Atrophic renal tubules with thyroid type tubular atrophy and intraluminal colloid-like proteinaceous casts (**thyroidization**)
- Common in pediatric population with congenital anomalies
- 
- Slow progression, > 2 decades before consequences of damage are observed



# Renal stones/ calculi

- ❖ May form anywhere in the urinary tract, but most arise in the kidney.
- ❖ Men are affected more often than women, and the peak age at onset is between 20 and 30 years.
- ❖ **Mechanism: the most important determinant is an increased urinary concentration of the stones' constituents, such that it exceeds their solubility (supersaturation).**
- ❖ Familial and hereditary predisposition to stone formation has long been known. Many inborn errors of metabolism, such as cystinuria and primary hyperoxaluria.
- ❖ There are four main types of calculi: (table)
- ❖ **The most common type is calcium oxalate and phosphate stones.**
- ❖ Clinically: Hematuria, urinary obstruction, renal colic (if it passes to the ureter), increased chance of infection.

Stone Type	Percentage of All Stones
<b>Calcium Oxalate and Phosphate</b>	<b>70</b>
Idiopathic hypercalciuria (50%)	
Hypercalciuria and hypercalcemia (10%)	
Hyperoxaluria (5%)	
Enteric (4.5%)	
Primary (0.5%)	
Hyperuricosuria (20%)	
Hypocitraturia	
No known metabolic abnormality (15% to 20%)	
<b>Magnesium Ammonium Phosphate (Struvite)</b>	<b>5-10</b>
<b>Uric Acid</b>	<b>5-10</b>
Associated with hyperuricemia	
Associated with hyperuricosuria	
Idiopathic (50% of uric stones)	
<b>Cystine</b>	<b>1-2</b>
<b>Others or Unknown</b>	<b>±5</b>



# Cystic diseases of the kidney

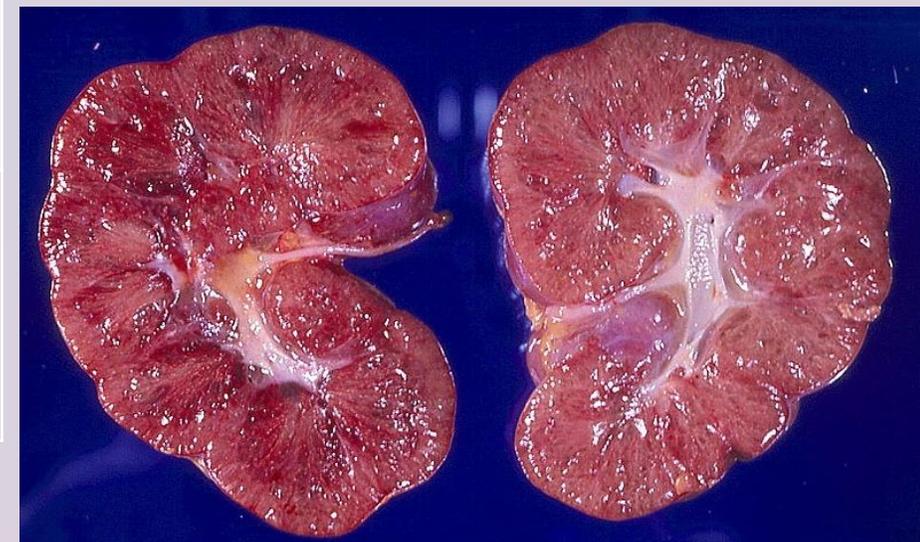
- ❖ **Definition:** Cysts originate from renal tubules, growing and filling with fluid, compressing surrounding tissue.
- ❖ **Morphology in general:** Lined by a single layer of cuboidal or flat renal tubular epithelial cells/ Growing cysts damage blood vessels and compress healthy nephrons, leading to ischemia, inflammation, and fibrosis.
- ❖ **Simple cyst:**
  - ❖ may be single or multiple and usually involve the cortex.
  - ❖ They are commonly 1 to 5 cm but may reach 10 cm or more in size.
  - ❖ They are **translucent, covered by a gray, glistening, smooth membrane, and filled with clear fluid.**
  - ❖ **Simple cysts are common postmortem findings without clinical significance.**



Adult polycystic kidney disease	Childhood polycystic kidney disease
Autosomal dominant	Autosomal recessive
Mutation produces <b>polycystin</b> protein	Mutation produces <b>Fibrocytin</b> protein
Asymptomatic till middle age	Present in infancy with renal insufficiency
Associated with conditions in other organs such as: <b>cysts in liver, berry aneurysm, colonic diverticula</b> , mitral valve prolapse	Associated with <b>multiple liver cysts</b> ,
Grossly: bilateral enlarged kidneys with multiple cysts, containing serous or hemorrhagic fluid.	Grossly: bilateral enlarged kidneys with small cysts in cortex and medulla



**Adult PKD**



**Childhood PKD**

# Renal tumors

## # Renal Cell Carcinoma (RCC):

- **The most common malignant cancer of the kidney**
- The tumors occur most often in older individuals, usually in the sixth and seventh decades of life. More common in males.
- **Tobacco is the most significant risk factor**
- Affecting mostly the upper pole of the kidney.
- A particularly troublesome feature of renal cell carcinoma is its tendency to metastasize widely before giving rise to any local symptoms or signs.

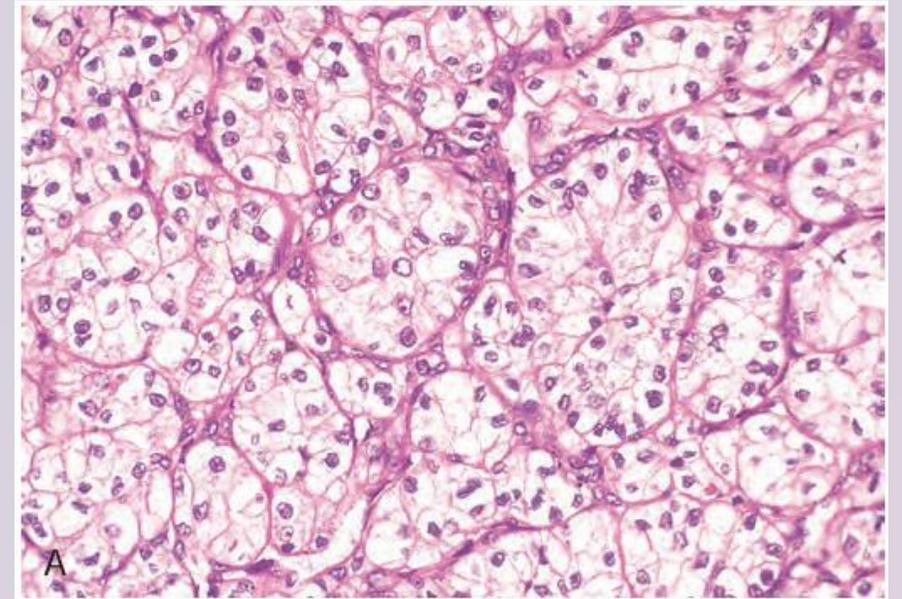
## ❖ Major types of RCC:

### 1) Clear cell carcinoma:

- **the most common type.**
- **Clear cytoplasm**

### 2) Papillary carcinoma:

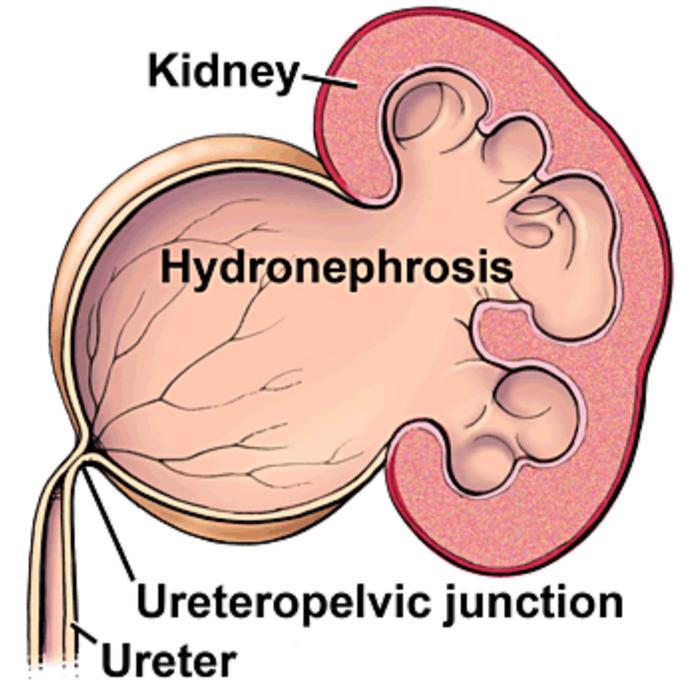
- **Papillary pattern of growth and psammoma bodies.**



# Ureter

## # Congenital anomalies:

- **Ureteropelvic junction (UPJ) obstruction is the most common cause of hydronephrosis in infants and children**
- In adults, UPJ obstruction is more common in women and is most often unilateral.
- Morphology: abnormal organization of smooth muscle bundles or excess stromal deposition of collagen between smooth muscle bundles at the UPJ

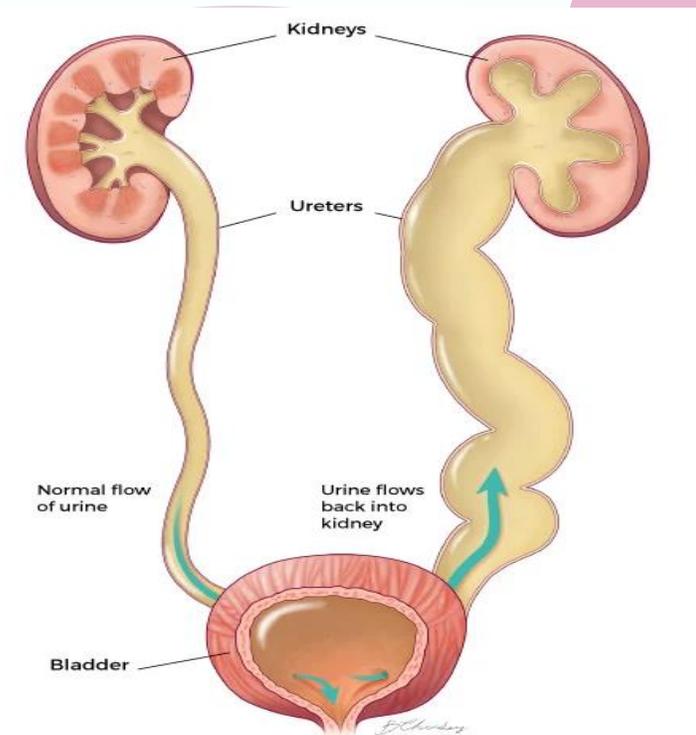


# Urinary Bladder

## # Congenital anomalies:

- ❖ Vesicoureteral reflux is the most common and serious congenital anomaly.
  - Vesicoureteral reflux predisposes to ascending pyelonephritis and loss of renal function.
- ❖ Exstrophy of the bladder is a developmental failure in the anterior wall of the abdomen and the bladder. As a result, the bladder communicates directly with the abdominal surface

## Vesicoureteral reflux



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# Acute and Chronic Cystitis

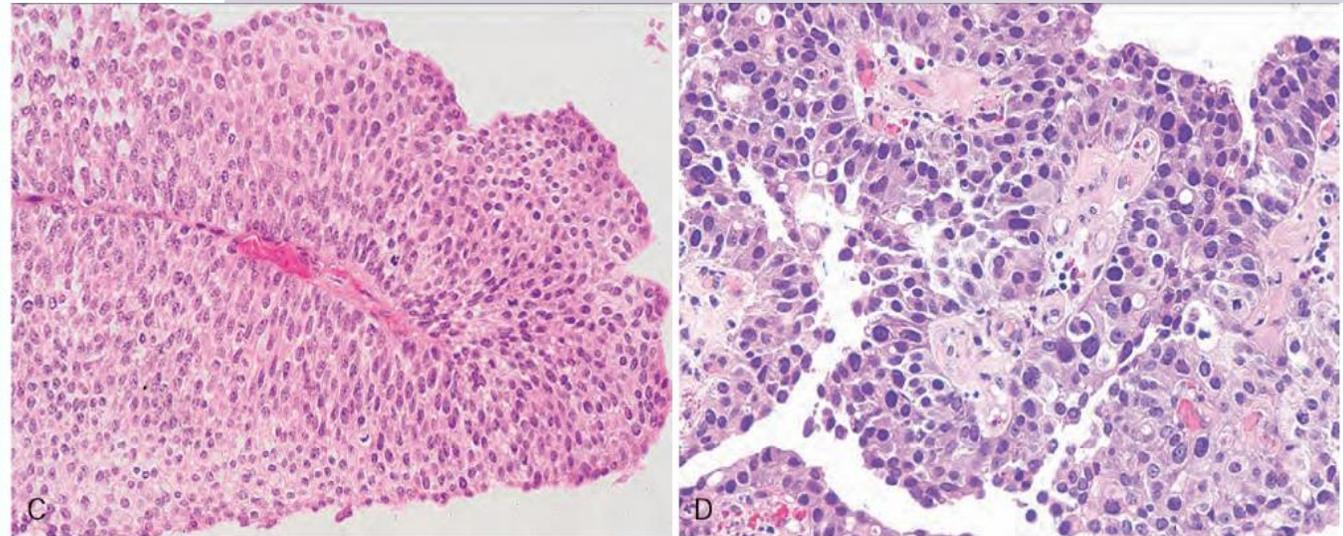
## # Cystitis:

- Inflammation of the urinary bladder.
- Causes:
  - 1) **bacterial: E. coli (the most common pathogen)**, proteus, klebsiella.
  - 2) Fungal: candida albicans, in immunocompromised patients
  - 3) Hemorrhagic cystitis: due to cytotoxic antitumor drugs
  - 4) Radiation cystitis.
- **Clinically:**
  - 1) **Frequency: urination every 15-20 minutes**
  - 2) **Suprapubic pain**
  - 3) **Dysuria: painful or burning sensation during urination.**
  - 4) **Fever**

# Neoplasms of urinary bladder

- ❖ Bladder cancer is the ninth most common cancer type worldwide and is responsible for significant morbidity and mortality.
- ❖ Urothelial neoplasm (Transitional Cell Carcinoma):
  - ❖ The most common type of urinary bladder cancer
  - ❖ Risk factor: Cigarette smoking, Pelvic irradiation for other pelvic cancers
  - ❖ Clinically: painless hematuria (the most common symptom)/ frequency/ dysuria/ hydronephrosis/ pyelonephritis.

**Morphology:** The individual finger-like papillae have a central core of loose fibrovascular tissue, covered by malignant urothelium.



**ANY  
QUESTIONS**

