Artificial Kidney Department

Lec 1
General Aspect about the Kidney Function

Introduction

- Kidneys are paired vital organs responsible for maintaining body homeostasis.
- Functions include excretion of waste products, regulation of fluid and electrolytes, acid-base balance, and hormone production.
- Disorders of kidney function significantly affect systemic health.

Gross Anatomy of the Kidney

- Located retroperitoneally on either side of the vertebral column.
- Surrounded by three layers: renal capsule, perirenal fat, renal fascia.
- Structures: cortex, medulla (pyramids), renal pelvis leading to ureter.

Gross Anatomy of the Kidneys

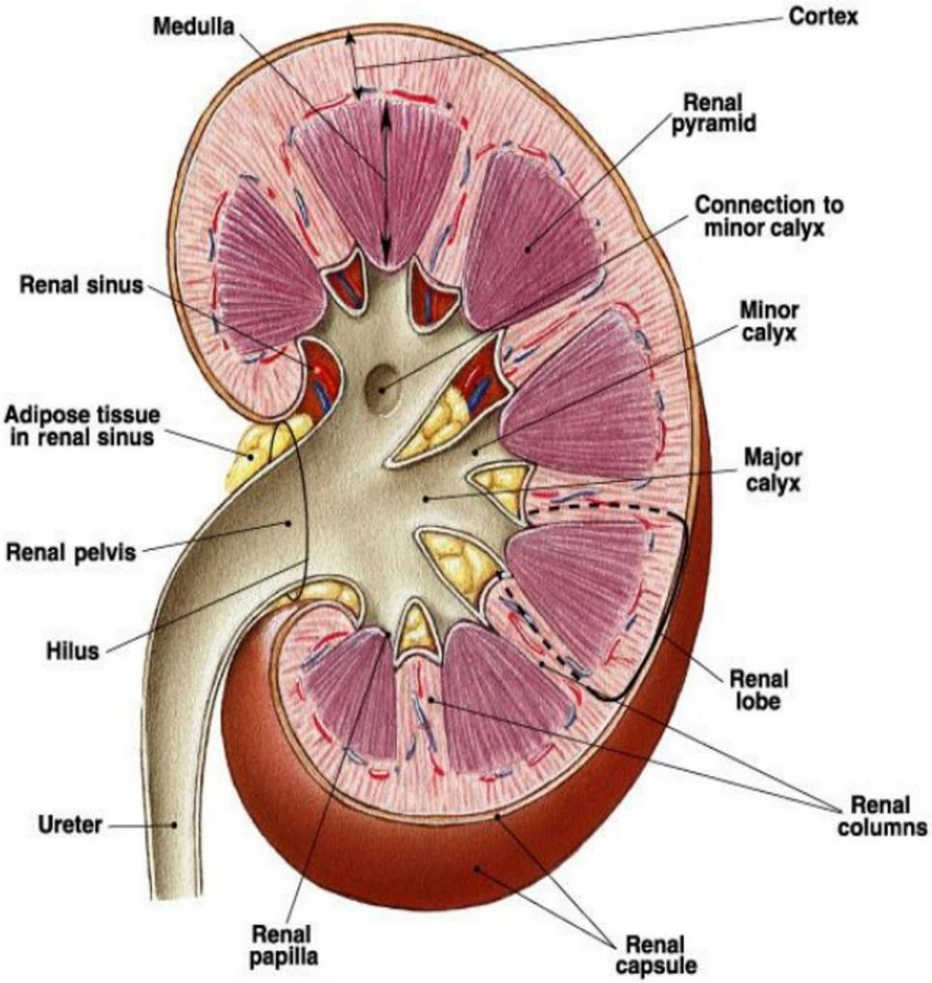


Figure from: Martini, *Anatomy & Physiology*, Prentice Hall, 2001

Renal capsule is tough, fibrous capsule (tunica fibrosa)

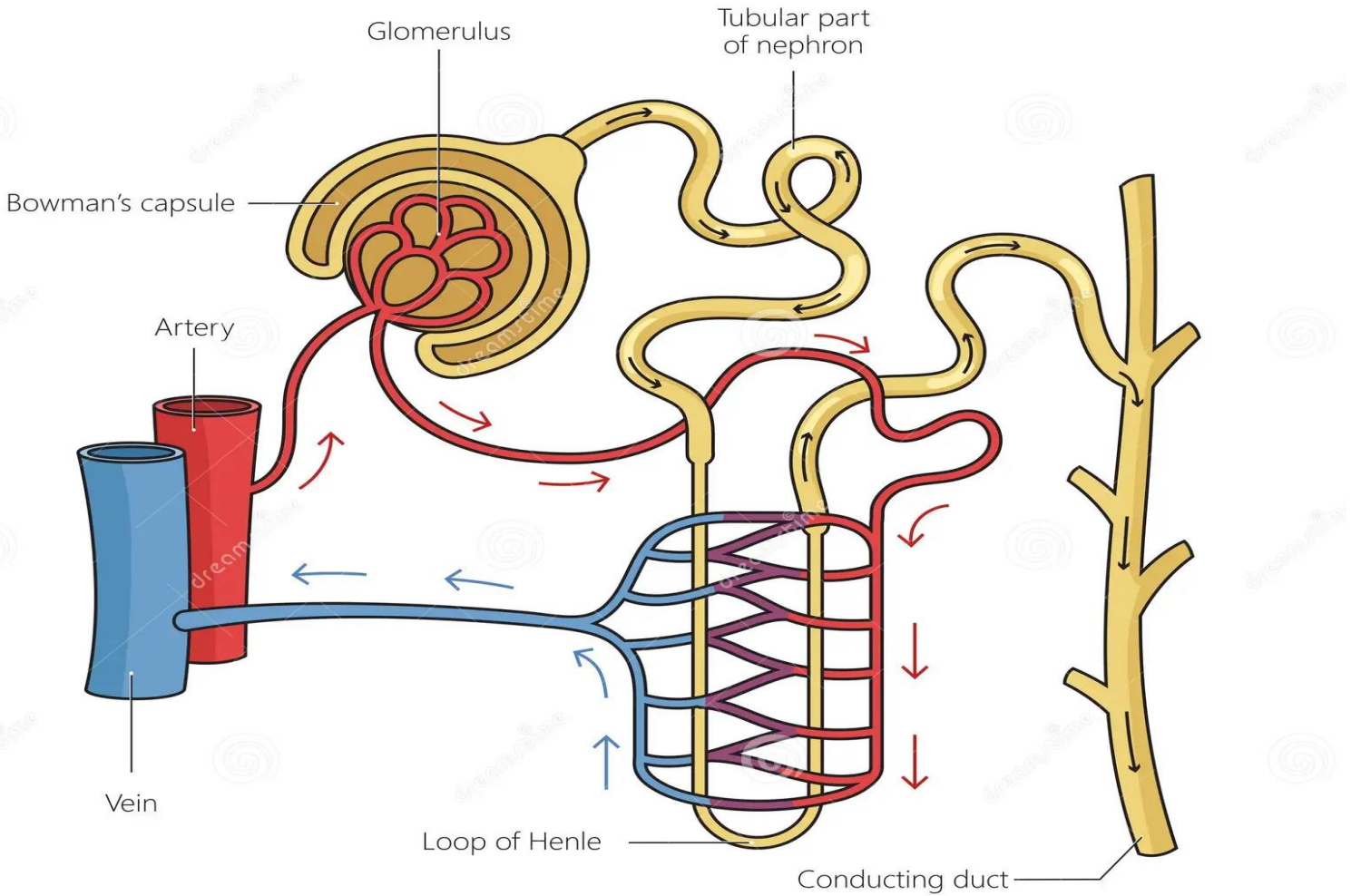
Hilus is entry point for renal artery, vein, and nerve (mostly sympathetic fibers)

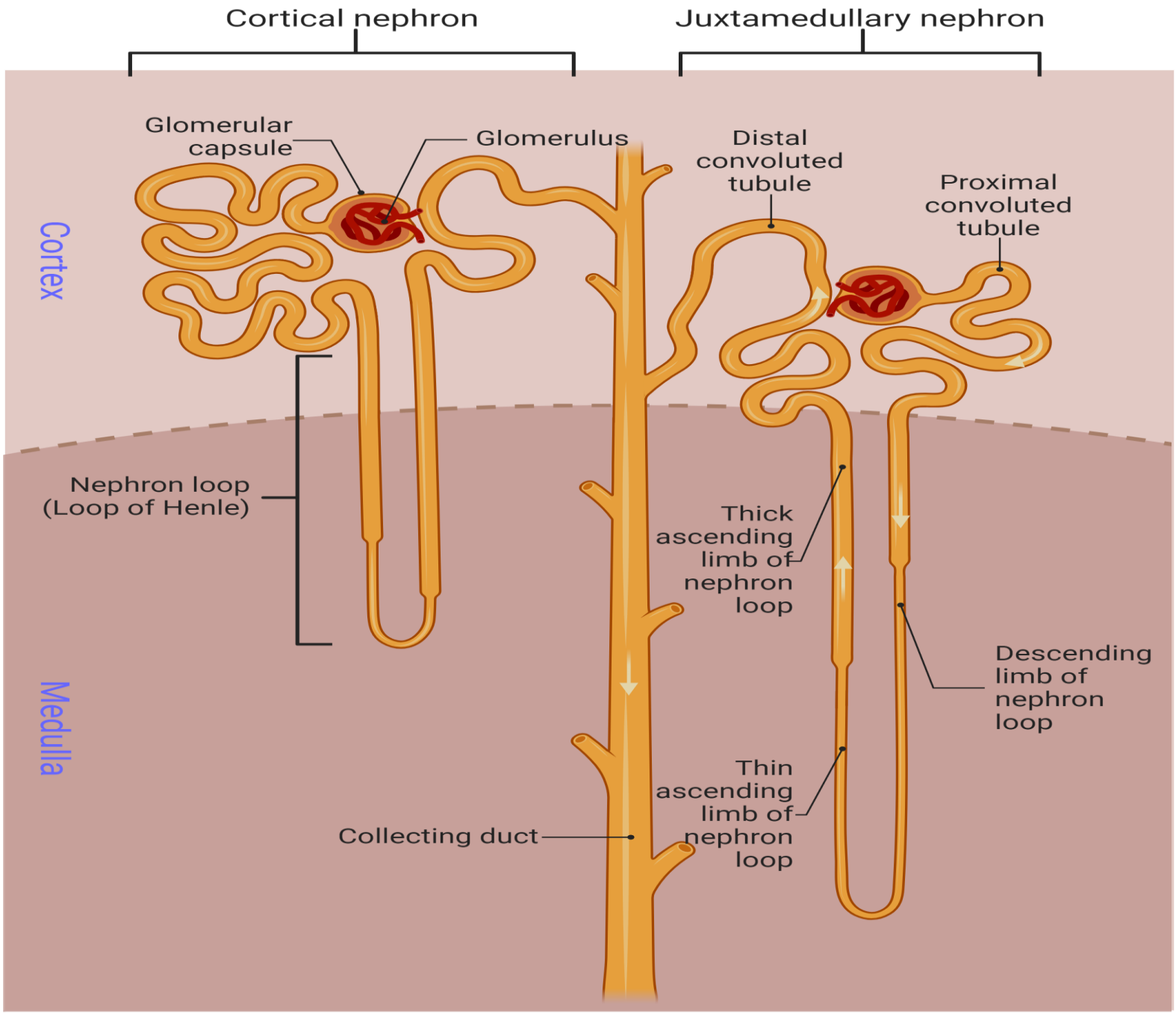
Bases of renal pyramids face the cortex, apices face the renal pelvis and end at renal papillae

Microscopic Anatomy

- Nephron is the structural and functional unit (~1 million per kidney).
- Two main types: cortical (85%) and juxtamedullary (15%).
- Nephron includes glomerulus, tubules, loop of Henle, distal tubule, and collecting duct.

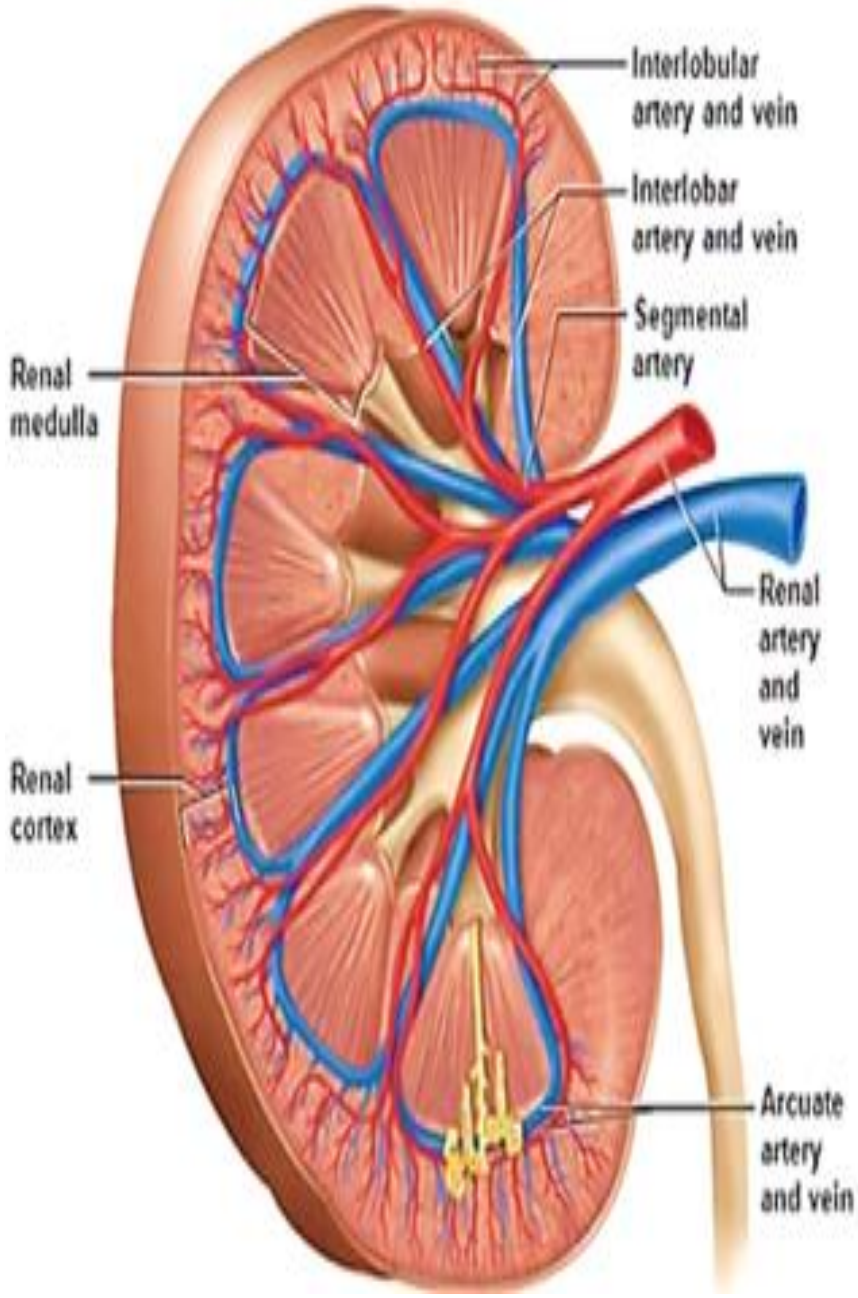
Nephron Structure

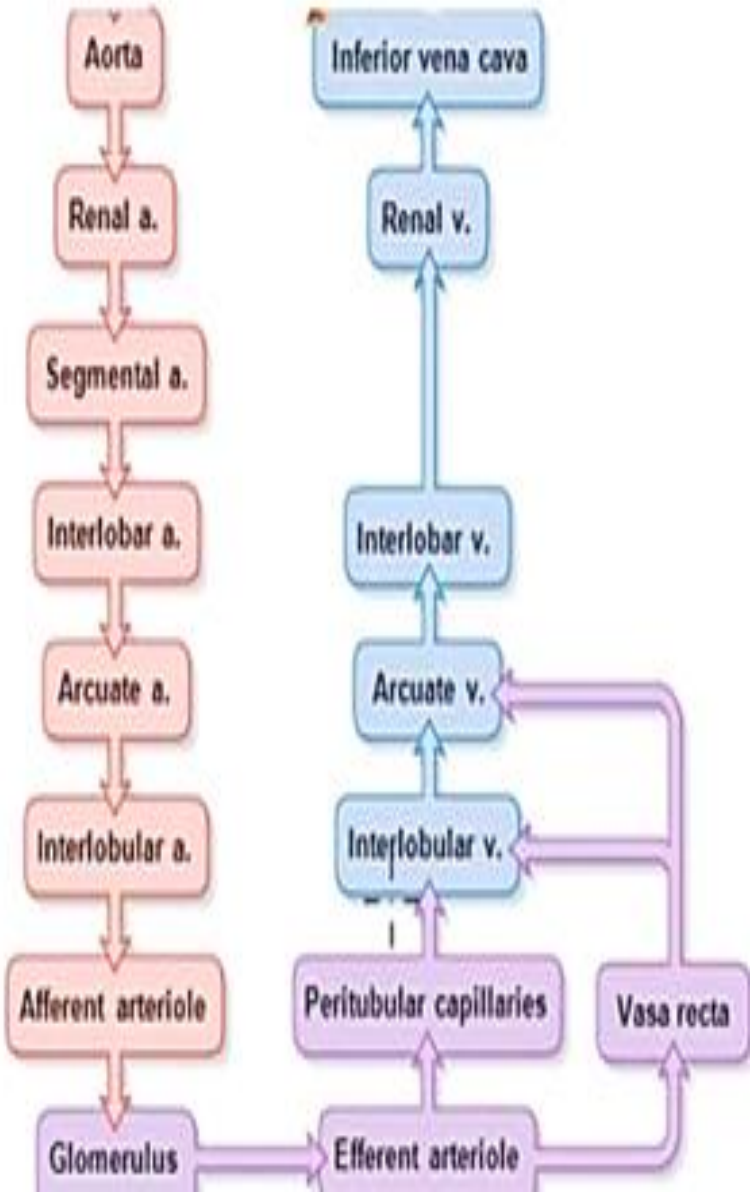




Blood Supply to the Kidney

- Renal artery from abdominal aorta → segmental → interlobar → arcuate → interlobular arteries.
- Afferent arteriole supplies glomerulus; efferent arteriole forms peritubular capillaries and vasa recta.
- Renal vein drains into inferior vena cava.


Interlobular artery and vein
Interlobar artery and vein
Segmental artery
Renal medulla
Renal artery and vein
Renal cortex
Arcuate artery and vein


Aorta
Renal a.
Segmental a.
Interlobar a.
Arcuate a.
Interlobular a.
Afferent arteriole
Glomerulus
Inferior vena cava
Renal v.
Interlobar v.
Arcuate v.
Interlobular v.
Peritubular capillaries
Efferent arteriole
Vasa recta

Glomerulus and Bowman's Capsule

- Glomerulus: tuft of capillaries specialized for filtration.
- Filtration barrier: endothelial cells, basement membrane, podocytes.
- Bowman's capsule collects ultrafiltrate → proximal tubule.

Glomerular Filtration

- Driven by hydrostatic pressure (blood pressure).
- Normal GFR ~125 mL/min (180 L/day).
- Selective process: water and small solutes pass, proteins and cells retained.
- GFR regulated by autoregulation and systemic factors.

Proximal Convoluted Tubule

- Reabsorbs ~65% of filtered Na+, Cl-, water.
- Nearly all glucose and amino acids reabsorbed.
- Secretes H+, ammonia, certain drugs.
- Key role in acid-base balance.

Loop of Henle

- Descending limb: permeable to water, impermeable to solutes.
- Ascending limb: impermeable to water, actively reabsorbs Na+/K+/Cl-.
- Establishes counter-current multiplier system to concentrate urine.

Distal Convoluted Tubule

- Reabsorbs Na+, Cl-; regulated by hormones.
- Parathyroid hormone stimulates Ca2+ reabsorption.
- Important in fine-tuning electrolyte balance.

Collecting Duct

- Final site for adjustment of urine composition.
- ADH increases water reabsorption via aquaporins.
- Aldosterone promotes Na+ reabsorption and K+ secretion.
- Intercalated cells regulate acid-base status.

Tubular Reabsorption

- Selective reuptake of valuable solutes and water.
- Involves active and passive transport.
- 99% of filtered fluid reabsorbed; only 1-2 L urine excreted daily.

Tubular Secretion

- Transfer of solutes from blood into tubular fluid.
- Important for K+, H+, drugs, toxins.
- Helps maintain electrolyte and pH balance.

Water Homeostasis

- Controlled by ADH (vasopressin) acting on collecting duct.
- Dehydration → ↑ADH → concentrated urine.
- Overhydration → ↓ADH → dilute urine.

Electrolyte Balance

- Na+ balance maintained by RAAS and aldosterone.
- K+ balance: secretion in distal tubule and collecting duct.
- Ca2+ regulated by PTH and calcitriol.

Acid-Base Regulation

- Kidneys excrete hydrogen ions (H+) and reabsorb bicarbonate (HCO3-).
- Phosphate and ammonia act as urinary buffers.
- Chronic kidney disease causes metabolic acidosis due to impaired acid excretion.

Endocrine Functions

- Erythropoietin: stimulates RBC production in response to hypoxia.
- Renin: regulates blood pressure via RAAS cascade.
- Calcitriol (1,25-dihydroxy vitamin D): increases intestinal calcium absorption.

Renin-Angiotensin-Aldosterone System (RAAS)

- Renin released from juxtaglomerular cells when BP or Na+ decreases.
- Renin converts angiotensinogen → angiotensin I.
- ACE converts angiotensin I → angiotensin II (vasoconstrictor).
- Angiotensin II stimulates aldosterone release from adrenal cortex.

Measurement of Kidney Function

- Serum creatinine: byproduct of muscle metabolism, rises with dysfunction.
- Blood urea nitrogen (BUN): less specific than creatinine.
- eGFR: estimated from serum creatinine, age, sex, race.
- Clearance tests: inulin clearance = gold standard for GFR.

Urine Analysis

- Physical: volume, color, clarity, specific gravity.
- Chemical: protein, glucose, ketones, blood.
- Microscopic: cells, crystals, casts.
- Provides insight into renal and systemic disorders.

Finally:

- Kidneys maintain body homeostasis via filtration, reabsorption, secretion, and hormone production.
- Disorders of kidney function have systemic consequences.
- Understanding physiology is essential for managing renal diseases.
- Artificial kidneys and transplantation remain crucial therapies.

Thank you