Renal diseases

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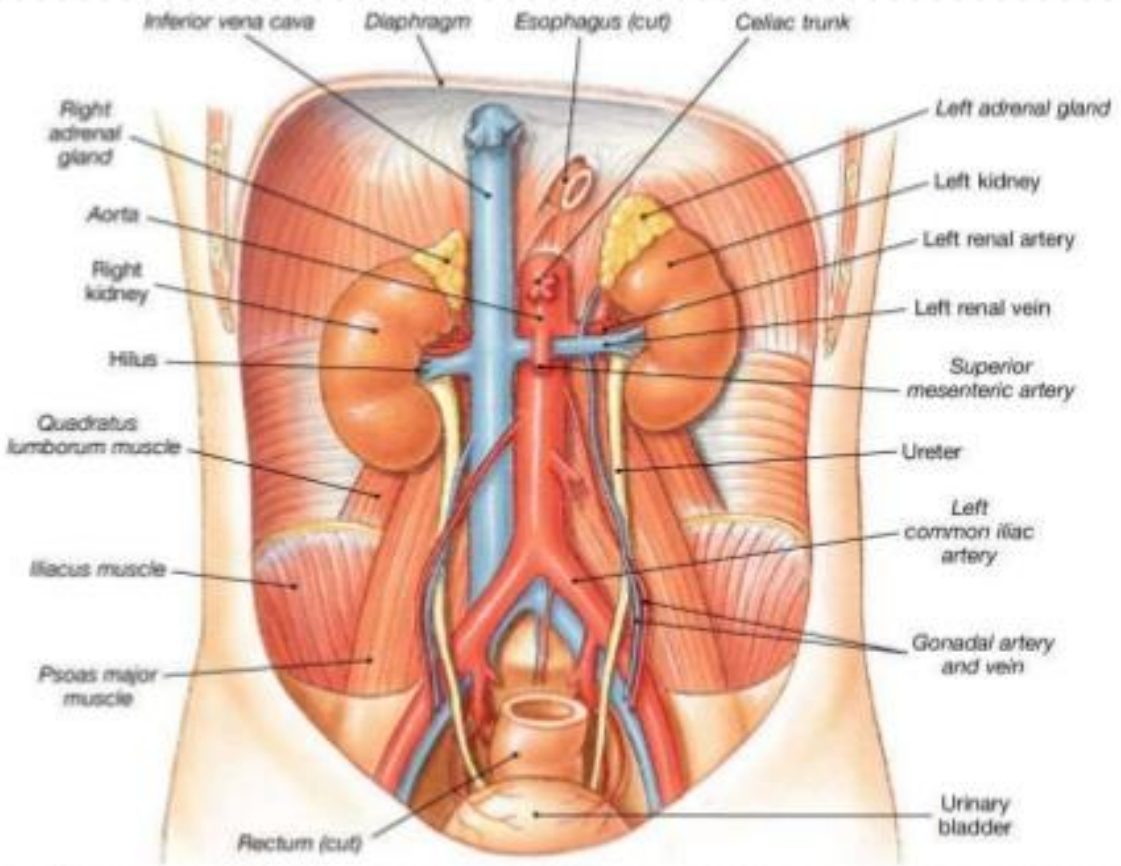
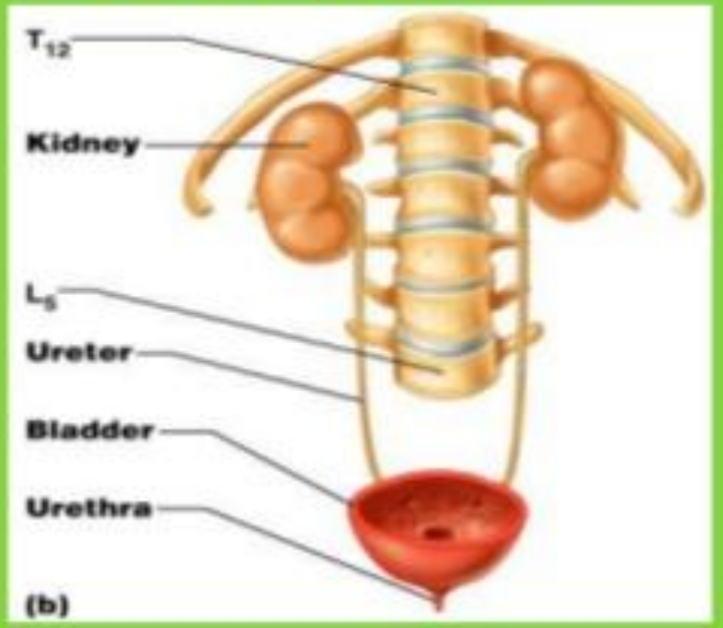
INTRODUCTION – THE KIDNEY

- A retroperitoneal organ
- T11-L3
- Normal size: 11-15cm in adults.
- Right kidney usually shorter than the left (upper limit of variation in length between right & left 1.5 cm)



Location and External Anatomy of Kidneys

- Located **retroperitoneally**
- Lateral to …… vertebrae ?
- T12 to L 3
- Average kidney
  - 12 cm tall, 6 cm wide, 3 cm thick
- **Hilus**
  - On concave surface
  - Vessels and nerves enter and exit
- Renal capsule surrounds the kidney

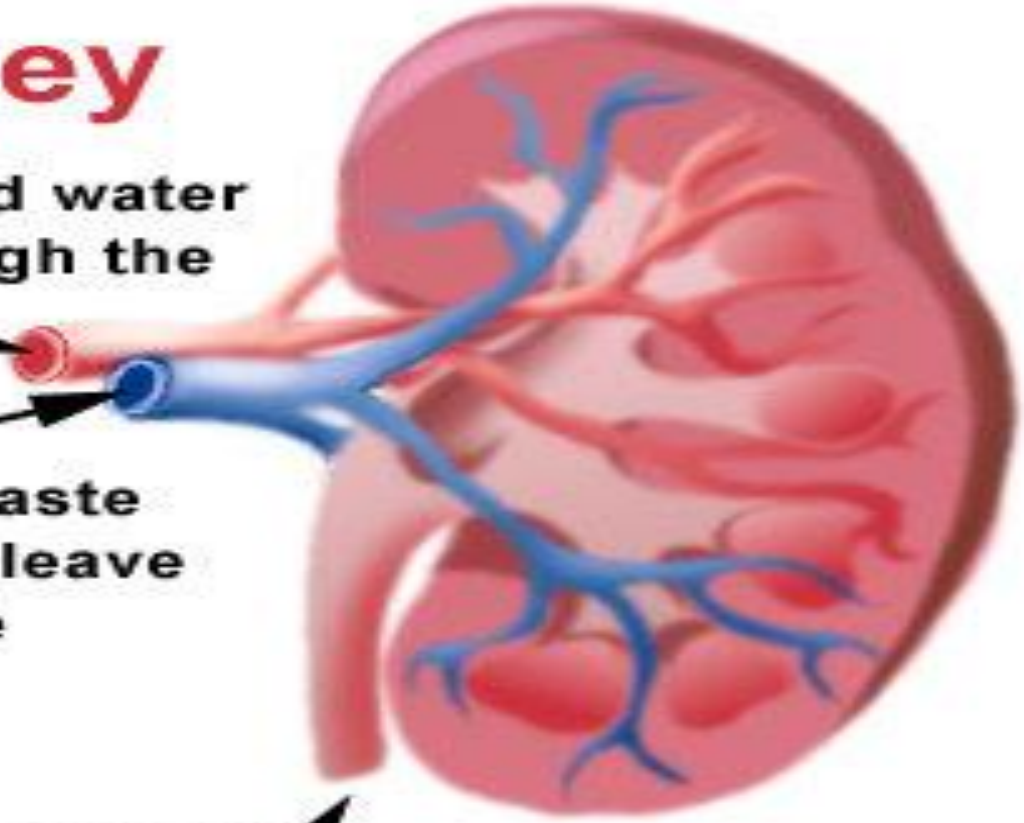


FUNCTIONAL ANATOMY

- **The renal parenchyma comprises an outer cortex and an inner medulla.**

- **The functional unit of the kidney is the nephron of which each contains approximately one million.**

A Kidney



Blood, waste and water enter here through the Renal Artery

Blood without waste or excess water leave here through the Renal Vein

Excess water and Toxic Waste in the form of Urine leaves here via the Ureter

FUNCTIONAL ANATOMY

- ***Each nephron*** **is made up of a glomerulus, proximal tubule, loop of Henle, distal tubule and collecting duct.**
- **The renal capsule and ureters are innervated via T10-12 and L1 nerve roots, and**
- **renal pain is felt over the corresponding dermatomes**

Have loops of Henle that descend into the renal medulla-15%

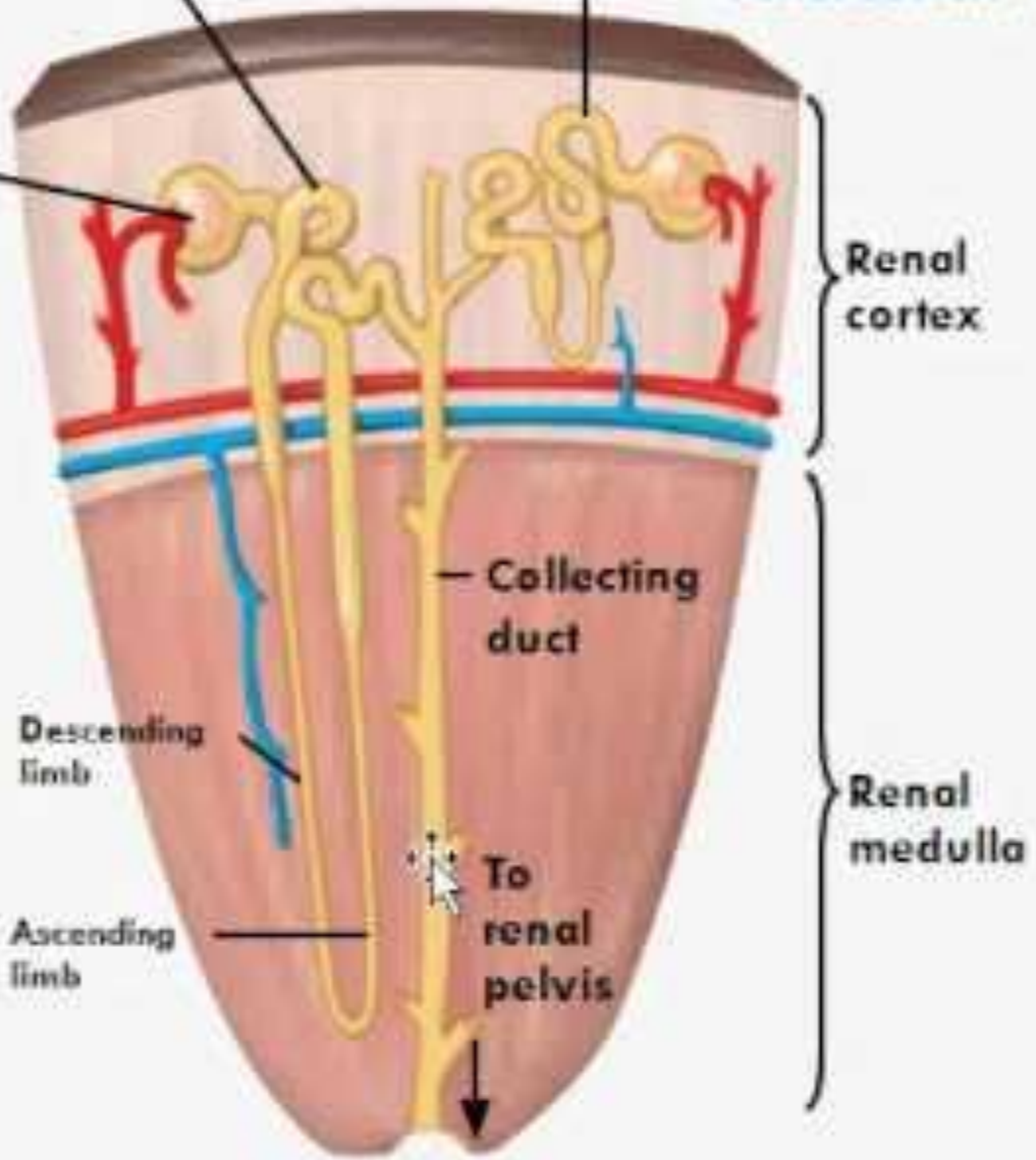
Juxtamedullary nephron

Cortical nephron

Confined to the renal cortex- 85%

Glomerulus

Nephron consists of a single long tubule & a ball of capillaries called the **glomerulus**

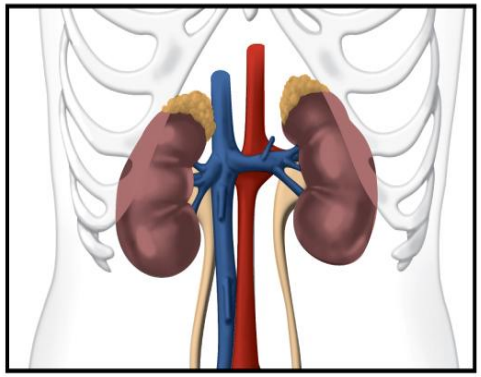


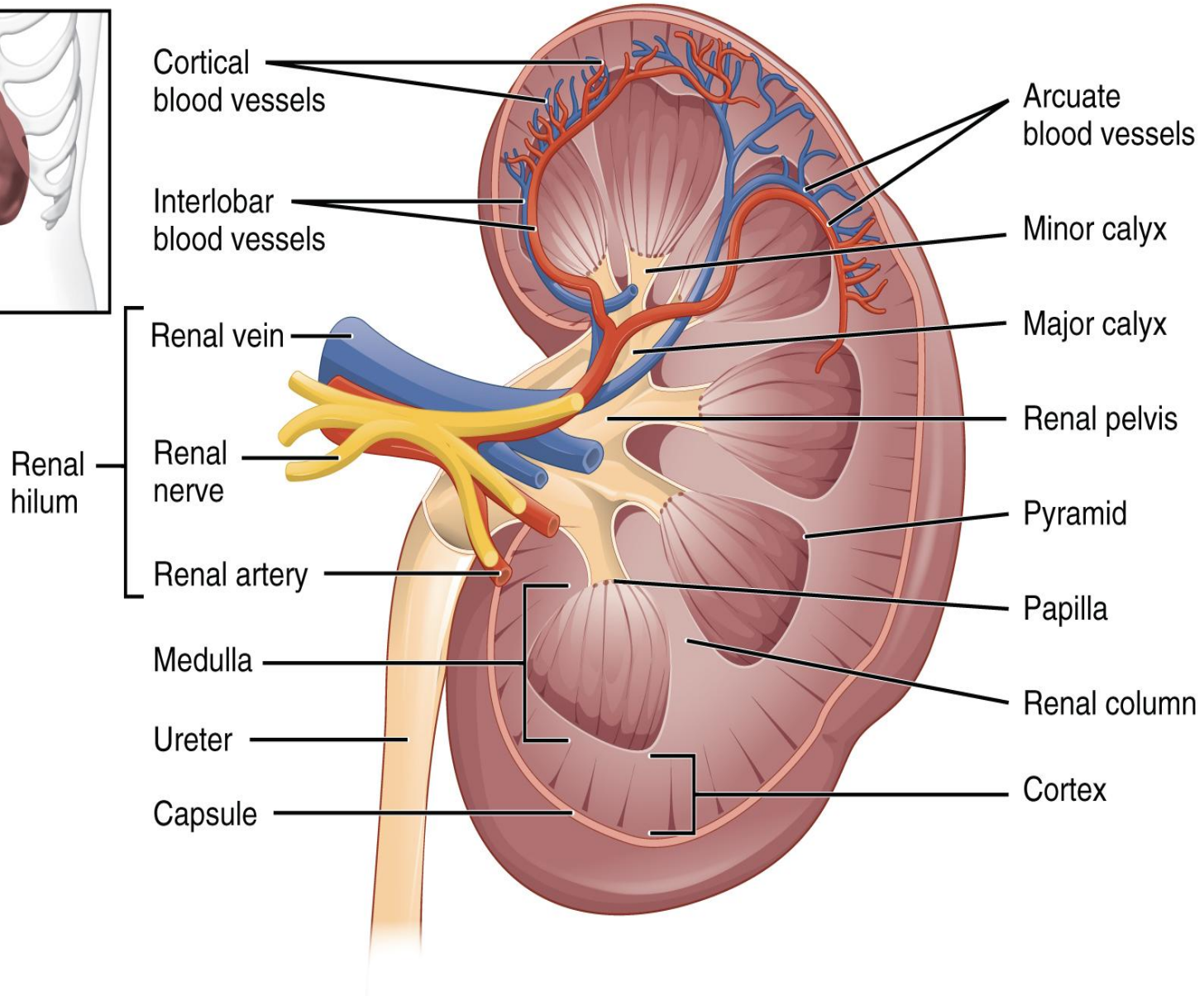
FUNCTIONAL ANATOMY

- Arterial blood is supplied to the kidneys via the renal arteries, which branch off the abdominal aorta, and venous blood is conveyed to the inferior vena cava via the renal veins.

- Approximately 25% of humans possess dual or multiple renal arteries on one or both sides.

- The *renal artery* undergoes a series of divisions within the kidney forming successively the *interlobar arteries*, which run radially to the corticomedullary junction,




Cortical blood vessels
Interlobar blood vessels
Renal hilum
Renal vein
Renal nerve
Renal artery
Medulla
Ureter
Capsule
Arcuate blood vessels
Minor calyx
Major calyx
Renal pelvis
Pyramid
Papilla
Renal column
Cortex

FUNCTIONAL ANATOMY

- *Afferent glomerular arterioles* arise from the interlobular arteries to supply the glomerular capillary bed, which drains into *efferent glomerular arterioles*.
- Efferent arterioles from the outer cortical glomeruli drain into a peritubular capillary network within the renal cortex and thence into increasingly large and more proximal branches of the renal vein.

FUNCTIONAL ANATOMY

- The *glomerulus* comprises four main cell types:
- (1) endothelial cells which are fenestrated with 500–1000 Å pores;
- (2) visceral epithelial cells (podocytes) which support the delicate glomerular basement membrane by means of an extensive trabecular network (foot processes);
- (3) parietal epithelial cells which cover the Bowman's capsule;
- (4) mesangial cells

FUNCTIONAL ANATOMY

- The *juxtaglomerular apparatus* comprises the macula densa,
- the extraglomerular mesangium and the terminal portion of the afferent glomerular arteriole (which contains renin-producing granular cells) together with the proximal portion of the efferent arteriole.

RENAL FUNCTION

- **PHYSIOLOGY**
- An essential feature of renal function is that a large volume of blood – 25% of cardiac output or approximately 1300 mL per minute – passes through the two million glomeruli.
- The *ultrafiltration rate* (glomerular filtration rate; GFR) is approximately 120–130 mL/min per 1.73 m2 surface area in adults.
- This means that, each day, ultrafiltration of 170–180 L of water and unbound small-molecular-weight constituents of blood occurs.
- .

What a Kidney Does

WATER. Ensures that there's not too much or too little water in the body.

BLOOD PRESSURE. Makes sure that pressure isn't too high or too low.

WASTES. Gets rid of urea, uric acid, toxins, and other wastes via urine.

BONES. Activates vitamin D, which helps the body absorb calcium.

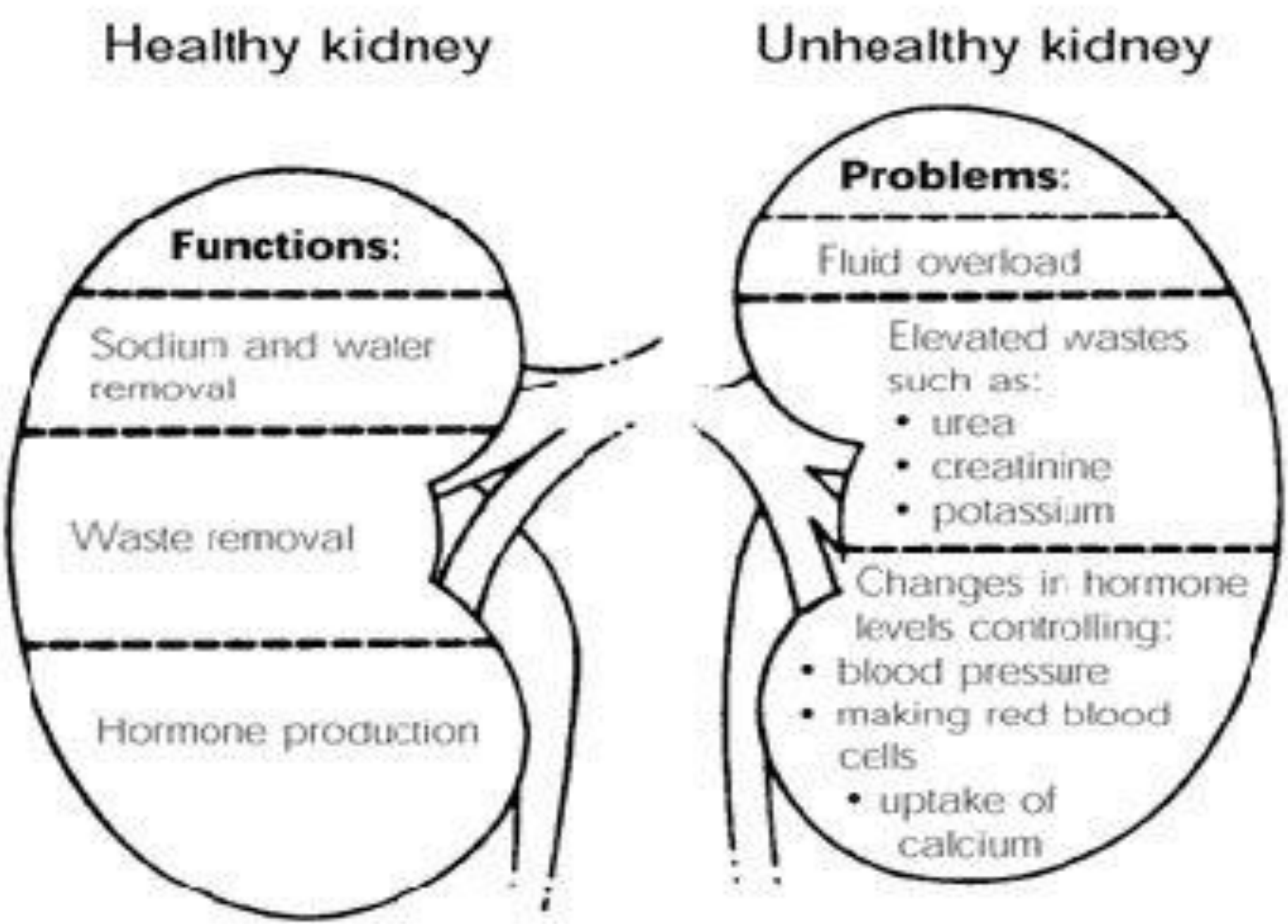
ACID-BASE BALANCE. Makes sure that the body isn't too acidic or too alkaline.

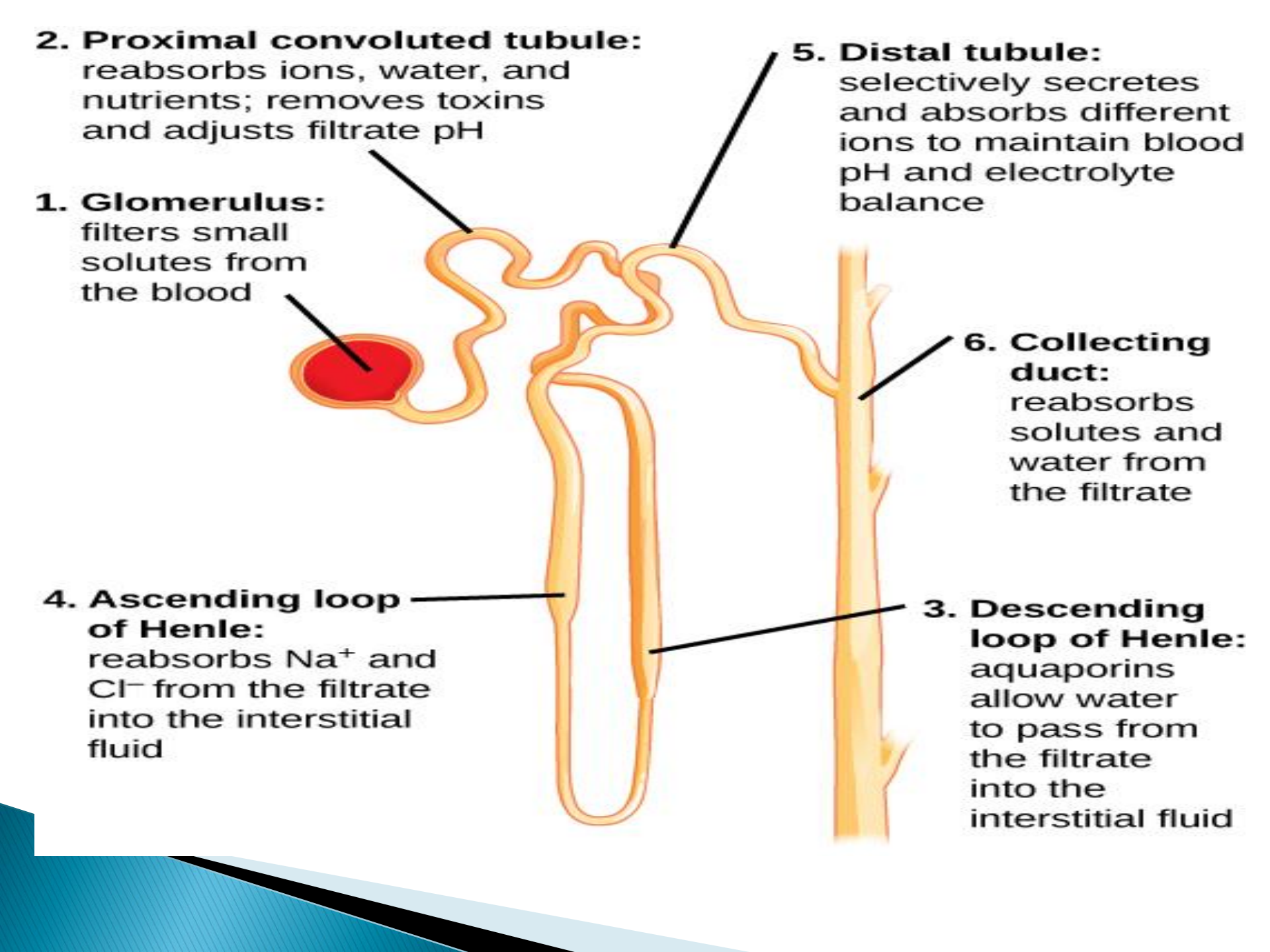
HEART. Maintains a balance of electrolytes (like potassium, sodium, and calcium), which is critical for heart rhythm.

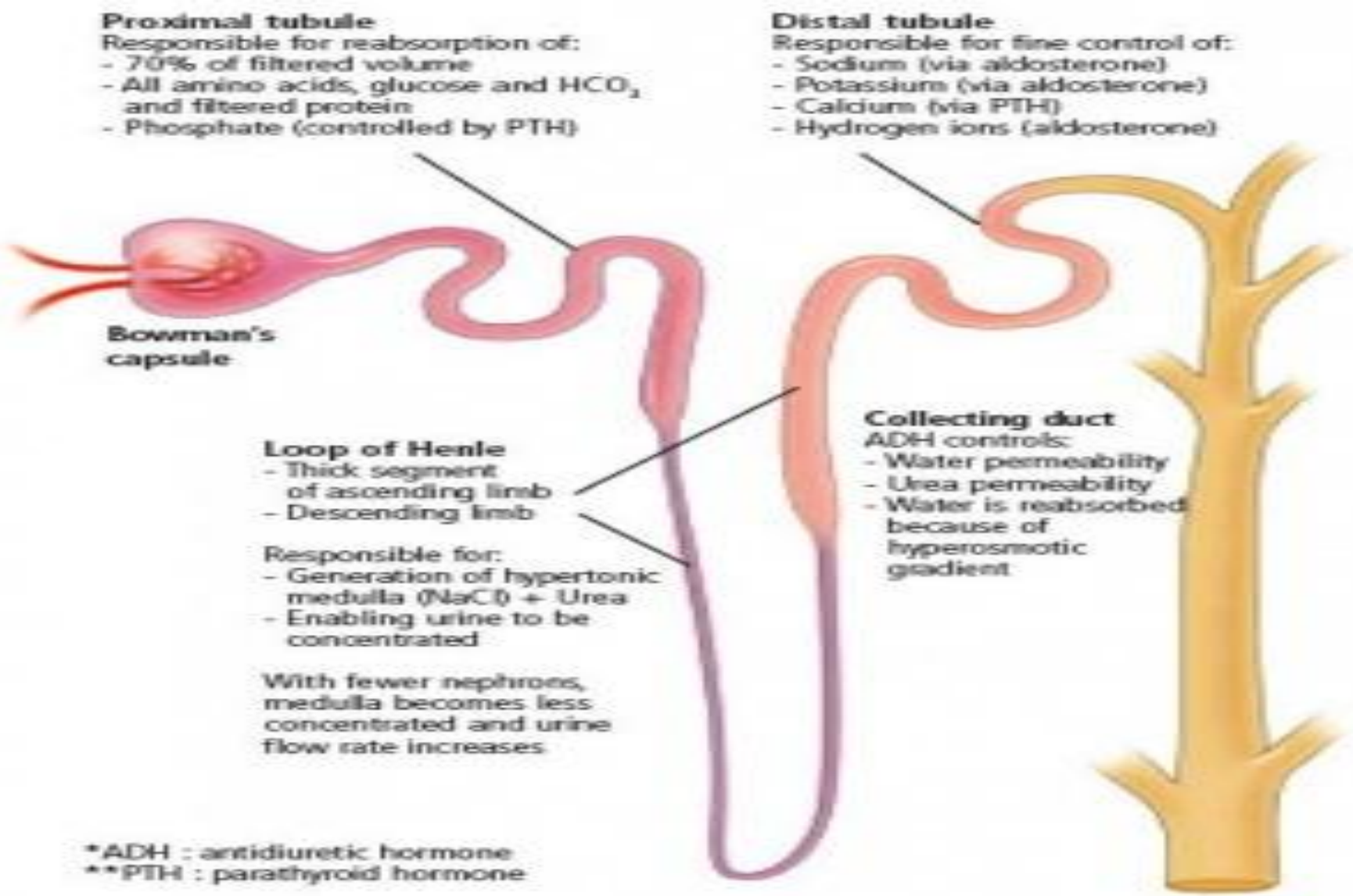
BLOOD. Releases erythropoietin, which tells bone marrow to make red blood cells.

FUNCTIONS OF THE KIDNEY

- **1- Execratory function:**
  - a. metabolites
  - b. drugs
  - c. toxins
- **2- Homeostatic function:**
  - a. Maintenance of water balance.
  - b. Maintenance of electrolyte balance.
  - c. Maintenance of acid-base balance.
- **3- Endocrine (hormonal) secretory function:**
  - a) Renin by the juxtaglomerular cells (JG)
  - b) Erythropoietin hormone by endothelial cells of peritubular capillaries of renal cortex
  - c) Prostaglandins.
- **4- Endocrine (hormonal) metabolic function:**
  - The kidney converts vitamin D3 → active 1,25-dihydroxycholecalciferol by alpha one hydroxylase enzyme in cells of PCT under effect of PTH.


Healthy kidney
Unhealthy kidney
Functions:
Sodium and water removal
Waste removal
Hormone production
Problems:
Fluid overload
Elevated wastes such as:
• urea
• creatinine
• potassium
Changes in hormone levels controlling:
• blood pressure
• making red blood cells
• uptake of calcium


2. Proximal convoluted tubule: reabsorbs ions, water, and nutrients; removes toxins and adjusts filtrate pH
5. Distal tubule: selectively secretes and absorbs different ions to maintain blood pH and electrolyte balance
1. Glomerulus: filters small solutes from the blood
6. Collecting duct: reabsorbs solutes and water from the filtrate
4. Ascending loop of Henle: reabsorbs Na^+ and Cl^- from the filtrate into the interstitial fluid
3. Descending loop of Henle: aquaporins allow water to pass from the filtrate into the interstitial fluid



Each nephron consists of a glomerulus (the filter), a proximal tubule, loop of Henle, distal and cortical collecting tubule and a collecting duct.

PHYSIOLOGY

- selective reabsorption of water, essential electrolytes and other blood constituents, such as glucose and amino acids, from the filtrate in transit along the nephron
- Thus, 60–80% of filtered water and sodium are reabsorbed in the proximal tubule along with virtually all the potassium, bicarbonate, glucose and amino acids

PHYSIOLOGY

- Additional water and sodium chloride are reabsorbed more distally, and fine tuning of salt and water balance is achieved in the distal tubules and collecting ducts under the influence of aldosterone and antidiuretic hormone (ADH).
- The final urine volume is thus 1–2 L daily.
- Calcium, phosphate and magnesium are also selectively reabsorbed in proportion to the need to maintain a normal electrolyte composition of body fluids.

Glomerular filtration rate (GFR)

- In health, the GFR remains remarkably constant owing to intrarenal regulatory mechanisms.
- In disease, with a reduction in intrarenal blood flow, damage to or loss of glomeruli, or obstruction to the free flow of ultrafiltrate along the tubule, the GFR will fall and the ability to eliminate waste material and to regulate the volume and composition of body fluid will decline.
- This will be manifest as a rise in the plasma urea or creatinine and in a reduction in measured GFR.

TUBULAR FUNCTION

- The major function of the tubule is the selective reabsorption or excretion of water and various cations and anions to keep the volume and electrolyte composition of body fluid normal.
- The active reabsorption from the glomerular filtrate of compounds such as glucose and amino acids also takes place.
- Within the normal range of blood concentrations these substances are completely reabsorbed by the proximal tubule.

ENDOCRINE FUNCTION

- **Renin-angiotensin system**
- The juxtaglomerular apparatus is made up of specialized arteriolar smooth muscle cells that are sited on the afferent glomerular arteriole as it enters the glomerulus.
- These cells synthesize prorenin, which is cleaved into the active proteolytic enzyme renin.
- Active renin is then stored in and released from secretary granules.
- Renin converts angiotensinogen in blood to angiotensin I.

ENDOCRINE FUNCTIONS...

- Kidneys have primary endocrine function since they produce hormones
- In addition, the kidneys are site of degradation for hormones such as insulin and aldosterone.
- In their primary endocrine function, the kidneys produce erythropoietin, renin and prostaglandin.
- **Erythropoietin** is secreted in response to a lowered oxygen content in the blood. It acts on bone marrow, stimulating the production of red blood cells.

Renin-angiotensin system

- Angiotensin-converting enzyme (ACE), which is located in the lung, luminal border of endothelial cells, glomeruli and other organs, converts angiotensin I to angiotensin II.
- Renin release is controlled by:
- pressure changes in the afferent arteriole
- sympathetic tone
- chloride and osmotic concentration in the distal tubule via the macula densa
- local prostaglandin and nitric oxide release.

Renin–angiotensin system

- Angiotensin II has two major systemic effects: systemic vasoconstriction and sodium and water retention.
- Both of these actions will tend to reverse the hypovolaemia or hypotension that is usually responsible for the stimulation of renin release.
- Angiotensin II promotes renal NaCl and water absorption by direct stimulation of Na+ reabsorption in the early proximal tubule and by increased adrenal aldosterone secretion which enhances Na+ transport in the collecting duct.

Erythropoietin

- Erythropoietin is the major stimulus for erythropoiesis.
- It is a glycoprotein produced principally by fibroblast-like cells in the renal interstitium.
- Under hypoxic conditions both the alpha and beta subunits of hypoxia inducible factor 1 (HIF-1) are expressed, leading to subsequent erythropoietin gene transcription.

Erythropoietin

- Loss of renal substance, with decreased erythropoietin production, results in a normochromic, normocytic anaemia.
- Conversely, erythropoietin secretion may be increased, with resultant polycythaemia, in patients with polycystic renal disease, benign renal cysts or renal cell carcinoma.
- Recombinant human erythropoietin has been biosynthesized and is available for clinical use, particularly in patients with renal failure.