III. **Cortical labyrinths (pars convoluta):** area between medullary rays, containing renal corpuscles, convoluted tubules, and collecting tubules.

IV. **Uriniferous tubule:** nephron and its connecting tubule, that will connect to collecting duct, in the medullary ray.

**Medulla – Contains:**

I. **Straight tubules** (of nephron): continue from cortex into the medulla.

II. **Collecting ducts:** continue from cortex into the medulla.

III. **Vasa recta:** capillary network accompanying tubules and ducts from cortex into medulla. Runs in parallel with various tubules. Present only in juxta-medullary nephron. The vessels represent the vascular part of the **countercurrent exchange system** that regulates the concentration of urine.

IV. **Tubules in the medulla:**
   a. **Form Pyramids** – 8-18 conical structures (base-cortex & apices-renal sinus). Each pyramid is divided into **outer medulla** (divided into **inner stripe** and **outer stripe** – to locate specific parts of nephron) adjacent to cortex and inner medulla.
   b. **Renal columns (of Bertin)** – cap of cortical tissue over pyramids that extend “spills” peripherally around lateral portion of the pyramid. regarded as part of medulla.
   c. **Papilla** – apical portion of the pyramid. projects into **minor calyx** (extension of renal pelvis). **area cribrosa** – Tip of papilla, perforated by openings of collecting ducts.
   d. **2-3 Minor calyx become major calyces** that empty into renal pelvis.
4) **Distal straight Tubule:**
- **thick ascending limb** – Part of ascending limb of loop of Henle, in medullary rays of medulla and cortex.
- **cell characteristics:** large cuboidal, apical nucleus – forms bulge into lumen. Basolateral folds that contain many mitochondria and few not developed microvilli.
- **function:** transports ions from tubular lumen to interstitium. Electroneutral transporter enters ions from lumen to cell. Then they leave the cell to interstitium – Na⁺ by active transport, K⁺ and Cl⁻ by diffusion. K channel enable K ions to leak back to tubule lumen > lumen is more positive > positive ions as Ca and Mg are pushed to be reabsorbed in interstation. *no water movement.*
- **Uromodulin** – also *Tamm-Horsfall protein.* Protein produced by epithelial cells of thick ascending limb. It influences NaCl reabsorption and urine concentration ability.
  **Blue text** – Uromodulin 1) modulates cell adhesion and signaling by cytokines. 2) Inhibits the aggregation of Ca oxalate crystals – **prevent kidney stones.** 3) defend from urinary infection. Found in urine in case of inflammatory kidney diseases.

5) **Distal convoluted tubule:**
- **Location:** Cortical labyrinth, 1/3 of proximal convoluted tubule length, 5 mm. Pass between *macula densa* and connecting tubule.
- **Cell characteristics:** similar to cells of distal straight tubules, but taller and have no developed brush borders.
- It was previously believed that Aldosterone acts on distal convoluted tubule, but new researches show that it acts on collecting tubules.
- Cells of this tubule have highest Na/K ATPase activity to interstitium → increase ion transport → most ions reabsorb to body.
- The tubule is impermeable to water.
- **function:**
  a) regulate Ca reabsorption by signal of parathyroid hormone.
  b) reabsorption of ions:
  - Na⁺ reabsorption – instead of K that is secreted into tubule.
  - urine acidification – by bicarbonate reabsorption and H secretion.
  - Cl⁻ Reabsorption – by Na/Cl transporters.
  - Ammonium Secretion – due to bicarbonate generation.

6) **Connecting tubule:**
- Transition between distal convoluted tubule and cortical collecting duct.
- **Pathway:** 1) in sub-capsular nephron it joins directly to cortical collecting duct. 2) in mid-cortical and juxtamedullary nephrons few connecting tubules merge > form arched connecting tubule > connect cortical connecting duct.
- **Cell Characteristics:** simple epithelium, changes from Distal Convoluted Tubule epithelium to collecting duct epithelium, and may include the 2 kinds.
- **Function:** K secretion by principal cells. Secretion is regulated by mineralocorticoids from adrenal cortex.
b) **Urothelial permeability barrier** –
  - Uroplakin proteins (UPIa 1-3) – cover the luminal surface of transitional epithelium and form urothelial plaques that make this layer **impermeable** to small molecules. These proteins make the outer leaflet of membrane lipid bilayer twice as thick as the inner leaflet > form asymmetrical appearance named **asymmetric unit membrane (AUM)**.
  - Hinge regions – separates parts of urothelial plaques. contain all other non-plaque proteins.
  - Tight junctions Aid in formation of permeability barrier. **Blue text:** uropathogenic *Escherichia coli* bacteria cause 85% of urinary tract infections. It binds and colonize transitional epithelium by FimH adhesins that interact with uroplakins proteins.
  - Permeability barrier is maintained despite dynamic changes of stretching.

2. lamina propria: – with Dense collagen fibers, many cells and lymphocytes.

**NO muscularis mucosa, NO submucosa.**

B) **Muscularis layer:**
  - In the tubular portions – ureters and urethra – usually 2 layers of smooth muscle (see in the lamina propria:
    a) Longitudinal layer – inner layer that has loose spiral pattern.
    b) Circular layer – outer layer that has tight spiral pattern. (opposite to that of the muscularis externa of the intestinal tract).
  - Smooth muscle is **mixed** with CT to form parallel bundles.
  - Peristaltic contractions move urine from minor calyces through ureter to the bladder.

1) **Ureter:**
  - **Function:** conducts urine from the renal pelvis to the urinary bladder.
  - **Shape:** 24-34 cm long. Travels obliquely on the bladder and distal part enters it. Usually the ureter is embedded in the retroperitoneal adipose tissue.
  - **Epithelium:** Transitional epithelium = **urothelium**.
  - **smooth muscle layer:** 2 main layers and 2 additional layers.
    a) inner longitudinal layer,
    b) middle circular layer,
    c) outer longitudinal layer – present only at distal end of ureter, where it passes through bladder wall and becomes part of it.
  - **Adventitia layer:** contain adipose tissue, vessels, nerves.
  - As the bladder distends or its smooth muscles contract → the openings of the ureters are compressed to **prevent urine** reflux into ureters and **prevent spread of infections** to kidney. Infections in bladder are common mostly in female.