Histology1

Urinary System

Components

- Paired kidneys
- Paired uretersحالبان
- Bladder مثانة
- Urethra إحليل

Kidney Functions

- Regulates water, electrolytes, and extracellular fluid volume
- Eliminates waste products (notably urea), toxins, and drugs
- Maintains acid-base balance
- Hormonal/metabolic roles: secretes **renin** (regulates blood pressure), **erythropoietin** (stimulates erythrocyte production), and **activates vitamin D** (regulates calcium balance)

Kidney Structure

Stroma

- Capsule
- Trabeculae
- Reticular stroma

Parenchyma

- Uriniferous tubules (functional units الوحدة الأساسية الوظيفية)

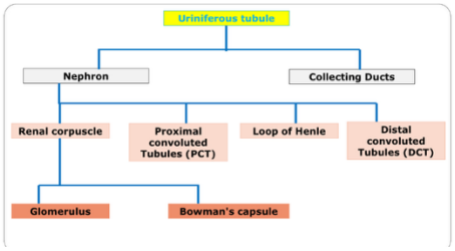
General Organization

- **Cortex**: outer shell, extends as columns between medullary pyramids
- **Medulla**: composed of medullary pyramids, apex (papilla) projects into calyces
- **Lobe**: medullary pyramid + associated cortex

- **Lobule**: central medullary ray + surrounding cortex (contains collecting duct and all nephrons draining into it)

Uriniferous Tubule & Nephron

❖ Uriniferous Tubule



- **Functional unit**: nephron + collecting ducts
- ~1.3 million nephrons/kidney
- Several nephrons drain into one collecting duct

❖ Nephron Structure وحدة الترشيح الأساسية

- Renal corpuscle (glomerulus + Bowman's capsule)
- Proximal convoluted tubule (PCT)
- Loop of Henle
- Distal convoluted tubule (DCT)

❖ Nephron Types

- **Cortical**: most numerous, superficial cortex, short loops of Henle
- **Juxtamedullary**: near cortex-medulla junction, long loops of Henle

Age & Adaptation:

- **Nephron** number **decreases** with age, accelerated by hypertension
- After unilateral nephrectomy, remaining kidney hypertrophies and increases filtration rate

Renal Corpuscle

Structure

- Oval/round, in cortex

- **Glomerulus**: tuft of ~50 capillary loops (fenestrated endothelium, thick basement membrane)
- **Bowman's capsule**: double-layered (outer parietal/simple squamous, inner visceral/podocytes)
- Two poles: **urinary** (to PCT), **vascular** (afferent/efferent arterioles)

It has two layers:

- Outer (parietal) layer: Called capsular epithelium,Lined by simple squamous epithelium
- Inner (visceral) layer: Called glomerular epithelium,Lined by modified epithelium (podocytes)

Podocytes

- Modified, stellate cells with primary and secondary processes (pedicels)
- Filtration slits between pedicels, closed by slit diaphragms (composed of nephrin and other proteins)

• Play an important role in filtration

• Concerned with the renewal of glomerular capillaries BM

Mesangial Cells

- Intraglomerular and extraglomerular
- Functions: phagocytosis, structural support, immune defense, repair,regulate capillary flow via contraction

Blood-Renal (Filtration) Barrier

❖ **Components**

1. Fenestrated capillary endothelium (blocks RBCs), but anything less than RBCs diameter can pass
2. Thick, fused glomerular basement membrane (3 three layers(by EM): lamina rara externa" lucent area, lamina rara interna" lucent area, dense intermediate zone)
3. Filtration slits with slit diaphragms (restrict proteins >70 kDa), Smaller proteins that are filtered from plasma are **degenerated**, and the amino acids reabsorbed

هذه الأغشية تشبه (tight junctions)، لكنها معدَّلة خصيصًا لتأدية وظيفة الترشيح. تتكوّن من بروتينات مهمة مثل: **Nephrin**(البروتين الرئيسي)، بروتينات أخرى glycoproteins, and proteoglycans تمنح الشحنة السالب

❖ **Function**

- Permits passage of water, ions, small molecules
- Blocks large proteins
- Disorders (e.g., diabetes, glomerulonephritis) increase permeability, causing proteinuria

- **Renal Tubules**

Region	Epithelium/Features	Location	Function (summary)
PCT	Simple cuboidal, many mitochondria, long microvilli	Cortex	Reabsorption (nutrients, proteins, water, ions)
Loop of Henle	Thick: cuboidal, no microvilli; Thin: squamous	Medulla/rays	Thick: active ion reabsorption; Thin: passive Na+, Cl–
DCT	Simple cuboidal, short microvilli, empty lumens	Cortex	Electrolyte reabsorption
Collecting Ducts	Principal: cuboidal/columnar, pale; Intercalated: dark	Medulla/rays	Water/electrolyte reabsorption, acid-base balance

- Intercalated cells: Few and scattered; slightly darker staining

Loop of Henle

• Present between the proximal and distal convoluted tubules

❖ A U-shaped structure with;

• A thick descending limb

• A thin descending limb

• A thin ascending limb

• A thick ascending limb (TAL) with simple cuboidal epithelium

• The thin parts are lined by simple squamous epithelia

• The nuclei of the cells lining the thin limbs bulge into the lumen of the tubule, these limbs resemble capillaries in cross section

Collecting Ductsآخر جزء قبل خروج البول من الكلية

- Transport filtrate to minor calyx

○ Two cell types:

- Principal (light) cells: cuboidal-columnar, reabsorb Na+, secrete K+, respond to aldosterone/ADH

- Intercalated (dark) cells: maintain acid-base balance (secrete H+ or HCO_3^-)
  - Cortical ducts: cuboidal, in medullary rays
  - Medullary ducts: columnar, larger, in medulla
  - Papillary ducts (ducts of Bellini): at pyramid apex

The collecting ducts are distinguished from proximal and distal tubules b prominent of the cell boundaries

It has two types of cells

1- Principal (light) cells

•Cuboidal, then increase in tall distally to become columnar

• Central round nuclei

• Light cytoplasm

- Basal infoldings

• Short microvilli

• Reabsorb Na+, secrete K

• Respond to aldosterone and ADH.

2- Dark (intercalated) cells

• Rich in organelles

• Well developed microvilli

• No basal infoldings

• Maintain acid-base balance by secreting

either **H+** (from type A or a intercalated cells)

or **HCO3 -** (from type B or *B* intercalated cells).

Juxtaglomerular Complex

Location

- Between afferent arteriole and DCT of same nephron

Components

- Macula densa: DCT cells, sense Na+ concentration
- Juxtaglomerular (JG) cells: modified smooth muscle, secrete renin,

They are modified smooth muscle cells of the afferent arteriole, small numbers are present in the efferent arteriole.

- Extraglomerular mesangial (**Lacis**) cells: between arterioles and macula densa

Functions

- Secretes erythropoietin and renin
- Regulates glomerular filtration rate and blood pressure

Urine Formation

- **Filtration**: Blood plasma filtered through glomerulus
- **Reabsorption**: Essential molecules/ions/water reabsorbed into blood
- **Secretion**: Additional substances (H+, creatinine, drugs, urea) secreted into tubule.
- Blood and glucose are normally absent from urine

Urinary Passages

➢ **Urothelium** (Transitional Epithelium)

- Three layers: **basal** (small cells), **intermediate** (cuboidal/columnar), **superficial** (umbrella cells)
- Umbrella cells: protect against hypertonic urine, contain **uroplakins** forming plaques, provide osmotic barrier

➢ **Ureter** من الكلية للمثانة

- **Mucosa**: transitional epithelium, lamina propria
- **Muscularis**: inner longitudinal, outer circular smooth muscle (sometimes third layer near bladder)
- **Adventitia**: connective tissue, nerves, vessels

➢ **Urinary Bladder** المثانة

- **Mucosa**: transitional epithelium, lamina propria
- **Muscularis**: three smooth muscle layers (detrusor muscle: inner longitudinal, middle circular, outer longitudinal)
- **Adventitia/serosa**: connective tissue, mesothelium on superior surface
- Mucosa is folded when empty, smooth & thinner when full

➢ **Urethra :** الاحليل

Male:

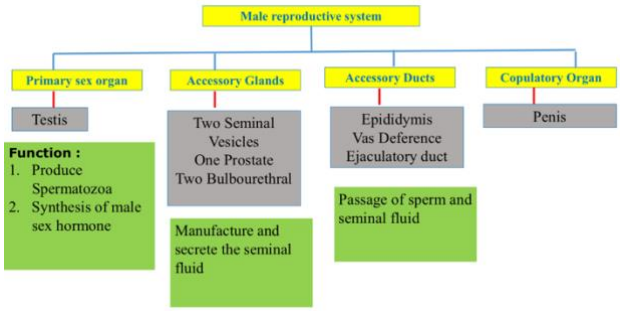
- **Prostatic**: through prostate, lined by urothelium
- **Membranous**: through external sphincter, lined by stratified/pseudostratified columnar
- **Spongy**: in penis, stratified/pseudostratified columnar, distal stratified squamous

Female:

- Short (3–5 cm), from bladder to vestibule
- Lined by transitional epithelium proximally, stratified squamous distally
- Lamina propria: highly vascularized
- Passes through urogenital diaphragm (external sphincter of striated muscle)

Histo2

Histology of the Male Genital System



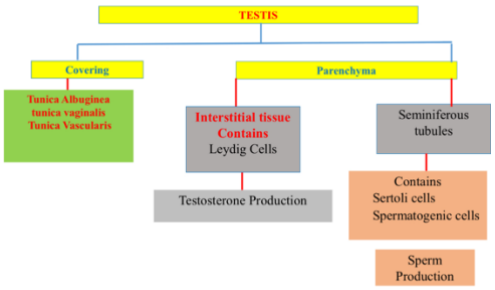
Components :

- Primary Sex Organ: Paired **testes**
- Secondary Sex Organs:
  - **Genital Ducts**: ١Epididymis, ٢Vas Deferens, ٣Ejaculatory Duct
  - **Accessory Glands**: ١Seminal Vesicles (paired), ٢Prostate (single), ٣Bulbourethral Glands (paired)
  - Copulatory Organ: **Penis**

Functions:

- Production of spermatozoa
- Synthesis of male sex hormones (testosterone)
- Manufacture and secretion of seminal fluid
- Passage of sperm and seminal fluid

Testis:



- Location: Scrotum, outside body cavity
- Shape: Ovoid,egg-shaped
- Coverings: Tunica vaginalis (visceral & parietal), tunica albuginea (dense connective tissue), tunica vascularis
- Internal Structure:
  - **Mediastinum testis**: Thickening of tunica albuginea at posterior
  - **Septa**: Divide testis into lobules (each with 1-4 seminiferous tubules)
  - **Interstitial Tissue**: Contains **Leydig cells** (testosterone production)

Seminiferous Tubules

- Lining: Stratified seminiferous epithelium on basement membrane
- Cell Types:
  - **Sertoli Cells**: Support, phagocytosis, secretion (ABP, inhibin, anti-Müllerian hormone), nutrition, blood-testis barrier formation
  - **Spermatogenic Cells**: Spermatogonia → Primary spermatocytes → Secondary spermatocytes → Spermatids → Spermatozoa
  - Other Cells: **Myoid cells** (peristalsis)supporting spermatogenesis, fibroblasts

Spermatogenesis (Stages):

- **Spermatogonia**: Diploid, on basal lamina, **type A** (reserve/pale), They have a spherical nuclei/ type **B** (differentiate)larger nuclei, At puberty under effect of FSH they undergo mitotic activity and gives Primary spermatocytes

- **Primary Spermatocytes**: Largest, 46 chromosomes, first meiotic division
- **Secondary Spermatocytes**: 23 chromosomes, short-lived, second meiotic division
- **Spermatids**: 23 chromosomes, differentiate into **spermatozoa**

Spermatozoa Structure:

- **Head**: Nucleus, acrosomal cap (lysosomes)
- **Neck**: Centrioles, connecting piece
- **Middle** Piece: Mitochondrial sheath, fibrous sheath, axoneme (9+2 microtubules)
- **Tail**: Principal piece (longest) Axoneme (9 +2),, end piece (shortest) Axoneme (9 +2).

Sertoli Cells

- Origin: Mesodermal
- Features: Tall columnar, complex cell margins, euchromatic nucleus
- Functions: Support, phagocytosis, secretion (testicular fluid, ABP, inhibin, anti-Müllerian hormone), nutrition, blood-testis barrier

- Resistant to heat, x-irradiation, infection and malnutrition
- The most numerous cells in the epithelium before puberty and reduced (make up to 10 % of the cell population) after puberty because of the increase in germ cells
- Have plasma membrane receptors for follicular stimulating hormone (FSH)

• Sertoli cells are bound to each other and to the germ cells by several types of cell-cell junctions
• **Sertoli-basal lamina junctions:**
• Hemidesmosomes
• **Sertoli-germ cell junctions:**
• Desmosome
• **Sertoli-Sertoli junctions:**
• Gap junctions
• Tight junctions

Functions of Sertoli cells

1. **Supporting cells.**
   Sertoli cells surround and physically support the developing germ cells.
2. **Phagocytic cells.**
   - Sertoli cells phagocytize and digest the residual bodies released in the last stage of spermiogenesis,.
3. **Secretory cells.**
   - **The testicular fluid** carry non motile sperm to epididymis
   - **Androgen-binding protein (ANP)** which concentrates testosterone to a level required for spermiogenesis, is promoted by follicle-stimulating hormone (FSH)
   - **Inhibin** which inhibits the secretion of **FSH** (recently, inhibin injections are used as male contraceptive as it inhibits spermatogenesis).
   - **Anti-mullerian hormone** that causes regression of the embryonic müllerian ducts
4. **Nutrition** They supply the spermatogenic cells with nutrition taken from near by capillaries, as the spermatogenic cells are isolated from blood supply by the testis barrier.
5. **Formation of blood-testis barrier**

Blood-Testis Barrier:

- Formed by: Tight junctions between Sertoli cells
- Compartments: **Basal** (spermatogonia), **adluminal** (primary/secondary spermatocytes, spermatids)
- Functions: Controls passage of materials, protects against immune response, prevents autoimmune reactions

Interstitial (Leydig) Cells

- Location: Between seminiferous tubules
- Features: Large, polygonal, acidophilic cytoplasm, lipid droplets
- Function: Secrete testosterone (stimulated **by LH**)
- Activity: Active during embryogenesis (placental gonadotropin), regress until puberty

Genital Ducts

❖ **Intratesticular Ducts**:

- Straight Tubules (Tubuli Recti)
- Rete Testis
- Efferent Ductules

❖ **Excretory Genital Ducts:**

- **Epididymis**: Highly coiled duct (6m), pseudostratified columnar epithelium with stereocilia, smooth muscle, site for sperm maturation/storage, phagocytosis, fluid reabsorption

Mucosa : This duct is lined by pseudostratified columnar epithelium composed of rounded basal cells & columnar cells.
•The cells have long branched microvilli called "stereocilia"
•**Musculosa :** A circular smooth muscle layer
•**Adventitia :** A connective tissue layer

- **Vas Deferens**: Thick muscular wall (3 layers), pseudostratified columnar epithelium with stereocilia, rich in elastic fibers, sympathetic innervation

Mucosa is irregular. It is lined by a pseudostratified columnar epithelium cells with stereocilia.
The lamina propria is unusually rich in elastic fibres.
Musculosa is well developed (up to 1.5 mm thick) and consists of a thick circular layer of smooth muscle between thinner inner and outer longitudinal layers.
It is innervated with sympathetic innervation
Adventitia : A connective tissue layer

- **Ejaculatory Ducts: Union** of vas deferens ampulla **&** seminal vesicle, **opens** into prostatic urethra, lined by simple/pseudostratified columnar epithelium, **no** muscle

Accessory Glands

❖ **HSeminal Vesicles:**

- Each seminal vesicle consists of one coiling tube (about 15cm long).
- **Mucosa** shows thin, branched, anastomosing folds. The epithelium is variable appearing columnar or pseudostratified columnar secretory epithelium .
- **Muscularis** consists of inner circular and outer longitudinal layers of smooth muscle.
- **Adventitia :** A thin fibroelastic connective tissue layer
- **Functions** The secretion of the seminal vesicles is thick, yellowish, alkaline fluid rich in protein, fructose and vitamin C, these are of importance for nutrition and production of energy for sperms.

❖ **Prostate:**

- Structure: 30-50 compound tubuloalveolar glands, **stroma** (fibromuscular), **parenchyma** (3 gland types: periurethral, submucosal, main prostatic)
- Epithelium: Simple columnar(acini,duct)/pseudostratified columnar or simple or squamous (glandular epithelium) .
- Secretion: Thin, milky, alkaline, rich in acid phosphatase
- Clinical Notes: **Prostate enlargement** (benign, carcinoma), **prostatic concretions** (corpora amylacea) تكلسات ،مرتبطة بالعمر

❖ **Bulbourethral Glands:**

- paired glands contributing to seminal fluid

Penis

- Structure: ١ Three erectile tissues (**2 corpora cavernosa**, **1 corpus spongiosum**), ٢tunica albuginea (dense fibroelastic), ٣thin skin covering
- Erectile Tissue: Supplied by helicine arteries, contains cavernous blood spaces *separated by* connective tissue and smooth muscle trabeculae

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