The Urinary System

- Kidneys, ureters, urinary bladder & urethra
- Urine flows from each kidney, down its ureter to the bladder and to the outside via the urethra
- Filter the blood and return most of water and solutes to the bloodstream
Overview of Kidney Functions

- Regulation of blood ionic composition
  - Na+, K+, Ca+2, Cl- and phosphate ions
- Regulation of blood pH, osmolarity & glucose
- Regulation of blood volume
  - conserving or eliminating water
- Regulation of blood pressure
- Release of erythropoietin & calcitriol
- Excretion of wastes & foreign substances
Internal Anatomy of the Kidneys

• Parenchyma of kidney
  – renal cortex = superficial layer of kidney
  – renal medulla
    • inner portion consisting of 8-18 cone-shaped renal pyramids separated by renal columns
    • renal papilla point toward center of kidney

• Drainage system fills renal sinus cavity
  – cuplike structure (minor calyces) collect urine from the papillary ducts of the papilla
  – minor & major calyces empty into the renal pelvis which empties into the ureter
Internal Anatomy of Kidney

- Nephron
- Renal hilus
- Path of urine drainage:
  - Papillary duct in renal pyramid
  - Minor calyx
  - Major calyx
  - Renal pelvis
- Renal artery
- Renal vein
- Renal cortex
- Renal medulla
- Renal column
- Renal pyramid in renal medulla
- Renal sinus
- Renal papilla
- Fat in renal sinus
- Renal capsule
- Ureter
- Urinary bladder
Human Kidney

(b) Frontal section of right kidney
Blood & Nerve Supply of Kidney

• Abundantly supplied with blood vessels
  – receive 25% of resting cardiac output via renal arteries

• Functions of different capillary beds
  – glomerular capillaries where filtration of blood occurs
  – peritubular capillaries that carry away reabsorbed substances from filtrate (renal cortex)
  – vasa recta supplies nutrients to medulla

• Sympathetic vasomotor nerves regulate blood flow by altering arterioles
Blood Vessels around the Nephron

- Glomerular capillaries are formed between the afferent & efferent arterioles
- Efferent arterioles give rise to the peritubular capillaries and vasa recta
Blood Supply to the Nephron

- Afferent arteriole
- Glomerulus
- Efferent arteriole
- Peritubular capillaries
- Vasa recta
The Nephron

- Kidney has over 1 million nephrons composed of a corpuscle and tubule
  - Renal corpuscle = site of plasma filtration
    - glomerulus is capillaries where filtration occurs
    - glomerular (Bowman’s) capsule is double-walled epithelial cup that collects filtrate
  - Renal tubule
    - proximal convoluted tubule
    - loop of Henle dips down into medulla
    - distal convoluted tubule
  - Collecting ducts and papillary ducts drain urine to the renal pelvis and ureter
80-85% of nephrons are cortical nephrons

Renal corpuscles are in outer cortex and loops of Henle lie mainly in cortex
15-20% of nephrons are juxtamedullary nephrons

Renal corpuscles close to medulla and long loops of Henle extend into deepest medulla enabling excretion of dilute or concentrated urine
Structure of Renal Corpuscle

- Bowman’s capsule surrounds capsular space
  - podocytes cover capillaries to form visceral layer
  - simple squamous cells form parietal layer of capsule
- Glomerular capillaries arise from afferent arteriole & form a ball before emptying into efferent arteriole
- Mesangial cells are contractile cells that help regulate glomerular filtration
Juxtaglomerular Apparatus

- Structure where afferent arteriole makes contact with ascending limb of loop of Henle
  - macula densa is thickened part of ascending limb
  - juxtaglomerular cells are modified muscle cells in arteriole
  - Functions to help regulate blood pressure within kidneys
Histology of Renal Corpuscle

(b) Renal corpuscle
Number of Nephrons

• Remains constant from birth
  – any increase in size of kidney is size increase of individual nephrons

• If injured, no replacement occurs

• Dysfunction is not evident until function declines by 25% of normal (other nephrons handle the extra work)

• Removal of one kidney causes enlargement of the remaining until it can filter at 80% of normal rate of 2 kidneys
Overview of Renal Physiology

- Glomerular filtration of plasma
- Tubular reabsorption
- Tubular secretion
Anatomy of Ureters

- 10 to 12 in long
- Varies in diameter from 1-10 mm
- Extends from renal pelvis to bladder
- Retroperitoneal
- Enters posterior wall of bladder
- Physiological valve only
  - bladder wall compresses ureteral openings as it expands during filling
  - flow results from peristalsis, gravity & hydrostatic pressure
Location of Urinary Bladder

- Posterior to pubic symphysis
- In females is anterior to vagina & inferior to uterus
- In males lies anterior to rectum
Anatomy of Urinary Bladder

- Hollow, distensible muscular organ with capacity of 700 - 800 mL
- Trigone is smooth flat area bordered by 2 ureteral openings and one urethral opening
Micturition Reflex

• Micturition or urination (voiding)
• Stretch receptors signal spinal cord and brain
  – when volume exceeds 200-400 mL
• Impulses sent to micturition center in sacral spinal cord (S2 and S3) & reflex is triggered
  – parasympathetic fibers cause detrusor muscle to contract, external & internal sphincter muscles to relax
• Filling causes a sensation of fullness that initiates a desire to urinate before the reflex actually occurs
  – conscious control of external sphincter
  – cerebral cortex can initiate micturition or delay its occurrence for a limited period of time
Anatomy of the Urethra

• Females
  – length of 1.5 in., orifice between clitoris & vagina
  – histology
    • transitional changing to nonkeratinized stratified squamous epithelium, lamina propria with elastic fibers & circular smooth muscle

• Males
  – tube passes through prostate, UG diaphragm & penis
  – 3 regions of urethra
    • prostatic urethra, membranous urethra & spongy urethra
    • circular smooth muscle forms internal urethral sphincter & UG diaphragm forms external urethral sphincter
Urinary Incontinence

• Lack of voluntary control over micturition
  – normal in 2 or 3 year olds because neurons to sphincter muscle is not developed

• Stress incontinence in adults
  – caused by increases in abdominal pressure that result in leaking of urine from the bladder
    • coughing, sneezing, laughing, exercising, walking
  – injury to the nerves, loss of bladder flexibility, or damage to the sphincter