**Urinary system** (chapter 17) **Page 1**

Urinary system (excretory system)

The organ system that cleans the blood (removes urea and other

nitrogen-containing wastes) and balances the blood (adjusts the blood’s solutes (ions, pH, nutrients, water content) to their proper

concentrations)

• The kidney filters (takes the liquid part) of the blood into tubules

called nephrons. The nephrons reabsorb (transport) only the proper amounts of solutes and water back into the blood

√ Wastes and excess solutes and excess water are not

reabsorbed back into the blood (The kidney forms the urine

out of them)

• The other excretory system organs (ureters, bladder, urethra) store

urine and channel it out of the body

Figs 17.1 and 17.12

Major blood components:

• Water

• Blood cells (RBC, WBC, platelets)

• Proteins (albumin, antibodies, clotting factors, etc.)

• Ions (Na+, Cl-, K+, H+, HCO3-, Ca2+, etc.)

• Nutrients (glucose, amino acids, fatty acids, vitamins, etc.)

• Nitrogen-containing wastes (Urea, uric acid, etc.)

√ The nitrogen-containing wastes are made by the liver from NH3 (ammonia), a cellular waste product

Fig 13.1; table 13.1

**Urinary system** **Page 2**

Kidneys

A pair of organs (located near the lowest ribs) that clean and balance

the blood and form the urine.

• Cortex = The outermost region of the kidney; where most of the

nephrons are located

√ In the cortex, the nephrons filter, clean, and adjust the blood

• Medulla = The middle region of kidney; it contains renal pyramids

and renal columns

√ Renal pyramids = Medulla regions where urine (formed in the

cortex) passes through the medulla on its way to the renal pelvis

√ Renal columns = Medulla regions where arteries and veins pass through medulla (carrying blood to and from cortex)

• Renal pelvis = A cavity in the innermost part of kidney that collects

urine from the renal pyramids and drains it into the ureters

Figs 17.2

**Urinary system** **Page 3**

Structures connected to kidney:

• Renal artery = Blood vessel that brings blood to be cleaned/balanced

to kidney

• Renal vein = Blood vessel that carries cleaned/balanced blood away

from kidney

• Ureter = Tube that carries urine from kidney to bladder

• Adrenal gland = An endocrine gland that sits superiorly on each

kidney

√ An entirely separate organ from kidney

Figs 11.18 and 17.4

**Urinary system** **Page 4**

Nephrons

Tubular structures in the renal cortex that filter the blood, reabsorb solutes and water, and form the urine. Only the balanced amounts of water and solutes are reabsorbed back into the blood. Wastes (like urea) and excess water/solutes are not reabsorbed (they form the urine)

• The glomerular capsule (Bowman’s capsule) = The enlarged end of the nephron that encloses a glomerulus and together they filter the smaller blood molecules into the nephron

• The proximal convoluted tubule = The nephron region where the

most reabsorption of solutes and water from filtrate occurs

√ This region of the nephron can reabsorb water and all solute

types (except urea)

• The nephron loop (Loop of Henle) = The nephron region that loops

down toward the medulla then up again into the cortex

√ The nephron loop specializes in NaCl and water reabsorption

• The distal convoluted tubule = The final nephron region

√ This region of the nephron can reabsorb water and all solute

types (except urea)

Figs 17.5 and 17.12

Filtration

The selective passage of molecules through a porous membrane based on the size of the molecules. Filtration is powered by blood pressure.

• The glomerular capsule and the glomerulus together form the renal

corpuscle (the filter of the nephron)

•Blood cells and blood proteins are too large to enter the nephron. All

other blood solutes are small enough to filter into the nephron. These

include water, ions, nutrients (such as glucose, amino acids, and

vitamins), and nitrogen containing wastes (such as urea)

• Filtrate = The liquid that passes from the blood into the nephron

Fig 17.10; table 17.5

**Urinary system** **Page 5**

Collecting ducts

Tubes that collect filtrate from the ends of nephrons and transport the filtrate through the medulla to the renal pelvis

• The final reabsorption of water and NaCl from the filtrate takes

place in the collecting duct

• Each collecting duct receives filtrate from many nephrons

• The renal pyramids of the medulla are clusters of collecting ducts

• Urine = The filtrate that exits the collecting duct into the renal pelvis

Figs 17.2, and 17.5

Capillaries associated with the nephron:

• Glomerulus = A ball of capillaries at the end of each afferent

arteriole in the cortex.

√ Smaller molecules of the blood are filtered from the

glomerulus into the nephron

√ The blood that does not filter into the nephron exits the

glomerulus via an efferent arteriole

• Peritubular capillary bed = A capillary bed that surrounds all regions

of the nephron

√ The blood that enters the peritubular capillary bed has low

amounts of water and solutes (because these entered the

nephron at the glomerulus)

√ The peritubular capillary bed receives balanced amounts of

the solutes and water back from the nephron by reabsorption

√ The blood at the end of the peritubular capillary bed is

cleaned and balanced. It drains into venules, which cross the

medulla and exit the kidney by the renal vein

Figs 17.5, 17.8, 17.9, 17.10, 17.12

**Urinary system** **Page 6**

Ureters

Tubes that carry urine from the renal pelvis to the urinary bladder

• Urine is moved by peristalsis of the ureter’s smooth muscles

Figs 17.1 and 17.4

Urinary bladder

A hollow expandable organ that holds urine until urination

• The bladder walls are smooth muscle with an internal epithelial lining

Fig 17.1

Urethra

The tube that carries urine from the bladder to outside the body

• Two sphincters control exit of urine from the body

√ Internal urethral sphincter = An involuntary smooth muscle

sphincter at the exit of the bladder

√ External urethral sphincter = A voluntary skeletal muscle

sphincter (located inferiorly to the internal urethral sphincter)

• The urethra exits the body near the vagina in women, and from the

end of the penis in men

Fig 17.1

**Urinary system** **Page 7**

Urination (micturition)

The emptying of urine in the bladder

• When the volume of urine in bladder reaches about 200 ml, an

involuntary reflex is triggered that contracts the bladder smooth

muscles

√ This forces urine passed the internal urethral sphincter

√ Voluntary contraction of the external urethral sphincter is

now required to prevent urination

√ This causes the first urge to urinate

• We voluntarily open the external urethral sphincter when convenient

to urinate

Fig 17.1

Urinary disorders:

• Urinary retention = The inability to start urination

√ A common side effect of anesthetics

√ Also common in elderly males due to enlarged prostate gland

(located near junction of bladder and urethra)

• Incontinence = The inability to prevent urination due to inability to

control external urethral sphincter

√ Normal in children under two and in some seniors

Fig 17.1

**Urinary system** **Page 8**

Urinalysis

Analysis of urine as a medical diagnostic tool

**Urinary system** **Page 9**

Balance of substances in the blood

Maintaining the proper concentration of each substance in the blood

• Balance of blood substances is needed for the proper functioning of

the body

- Example: The nervous system does not function properly if

Na+ and K+ are not at their proper concentrations

• Balance is maintained by matching the amount of the substance that

enters the blood (by eating and drinking, for example) with the amount that is taken out of the blood (in urine, feces, perspiration, and vomit, for example)

√ Of all the organs, the kidney has the most precise control of removal of substances from the blood, so the kidney is the major organ for maintaining balance of blood substances

• Major aspects of the blood that are balanced by the kidney:

√ Water balance

√ Sodium and potassium balance

√ Blood pressure

√ H+ balance (pH)

**Urinary system** **Page 10**

Water balance

Maintaining the proper concentration of water in the blood

• Water is gained from beverages and foods; Water is lost in urine, feces, perspiration, and evaporation from the skin and the lungs

• Kidney water balancing is regulated by the pituitary hormone ADH (antidiuretic hormone)

• Below normal water concentration in the blood (dehydration)

= High osmolarity of the blood's solutes = More ADH secreted

• Above normal water concentration in the blood (overhydration)

= Low osmolarity of the blood's solutes = Less ADH secreted

• If there were no ADH, the nephron would reabsorb no water from the filtrate, so large amounts of water would leave the body in the urine

• ADH causes the nephrons to reabsorb water from the filtrate

into the blood.

√ High ADH = More water reabsorbed from the filtrate and

less water exits body in urine; this adds water to the blood

√ Low ADH = Less water reabsorbed from the filtrate and

more water exits body in urine; this removes water from the

blood

√ If a person is dehydrated (too little water in the blood, so high

blood osmolarity), the pituitary secretes more ADH. Higher

ADH leads to an increase in blood water concentration

√ If a person is overhydrated (too much water in the blood, high blood osmolarity), the pituitary secretes less ADH. Lower

ADH leads to a decrease in blood water concentration

Fig 17.20; table 17.3

**Urinary system** **Page 11**

Sodium (Na+) and potassium (K+) balance

Maintaining the proper concentration of sodium and potassium ions in

the blood

• Sodium and potassium are gained from beverages and foods; They

are lost in urine, feces, and perspiration

• Sodium and potassium balance are regulated by the adrenal hormone

aldosterone

• If there were no aldosterone, the nephron would retain potassium in the blood but remove large amounts sodium from the blood into the urine

• Aldosterone causes the nephrons to reabsorb sodium from the

filtrate to the blood and simultaneously to secrete potassium from the

blood into the filtrate

√ More aldosterone = More sodium retained by the body and

more potassium exits body in urine

√ Less aldosterone = More potassium retained by the body and

more sodium exits body in urine

√ When blood Na+ is low or K+ is high, more aldosterone is

released

√ When blood Na+ is high or K+ is low, less aldosterone is

released

Fig 17.28

Secretion

Transport of solutes from the blood in the peritubular capillary bed to the filtrate in the nephron

• Only certain solutes in the blood can be secreted (K+, H+, and certain

poisons)

Fig 17.21; table 17.4

**Urinary system** **Page 12**

Regulation of blood pressure

The body will attempt to reverse a sudden drop in blood pressure (as might occur during hemorrhage or shock) by increasing blood volume and increasing vasoconstriction (constriction of the blood vessels)

The kidney is part of the pathways that increase blood pressure if it is low

• When blood pressure is low, the pituitary gland secretes more ADH, which increases the blood volume by increasing the nephron’s water reabsorption

• When blood pressure is low the following pathway is activated:

– The nephron secretes the protein renin into the blood.

– Renin leads to the activation of angiotensin II in the blood

– Angiotensin II raises blood pressure by causing

vasoconstriction

– Angiotensin II also raises blood pressure by causing the adrenal gland to secrete more aldosterone, which increases the nephrons’ Na+ reabsorption into the blood, which brings water into the blood from the tissues by osmosis, which increases blood pressure by increasing blood volume

Figs 17.27; table 17.6

**Urinary system** **Page 13**

pH (acid-base) balance

[Review acids, bases, buffers, and the pH scale in the Water lecture outline. Also, review the effects of CO2 on the blood’s H+ concentration in the Respiratory system lecture outline]

Blood is normally pH 7.35 – 7.45

• Acidosis (acidic blood) = Blood pH below 7.35

√ Common causes: Ingestion of acids and certain poisons,

excessive diarrhea, diabetes, respiratory diseases

√ Depresses the nervous system; at extremes the signals to

inspiratory muscles can slow or cease entirely, leading to

death

• Alkalosis (basic blood) = Blood pH above 7.45

√ Common causes: Ingestion of bases and certain poisons,

excessive vomiting

√ Over-stimulates the nervous and muscular systems; at

extremes the respiratory muscles can seize, leading to death

Blood pH is regulated by three systems:

• The carbonic acid/bicarbonate ion buffer in the blood

• The breathing rate

• The kidneys

**Urinary system** **Page 14**

Regulation of blood pH by the blood’s carbonic acid/bicarbonate ion buffer

• This buffer is the primary regulator of blood pH

• Bicarbonate ion decreases blood H+ (counteracts acidosis)

• Carbonic acid increases blood H+ (counteracts alkalosis)

Fig 16.40

Regulation of blood pH by the lungs (respiratory compensation)

The respiratory system can change blood pH by changing breathing

rate

• Increased breathing rate decreases blood H+ (counteracts acidosis)

• Decreased breathing rate increases blood H+ (counteracts alkalosis)

Table 16.12

Regulation of blood pH by the kidneys (renal compensation)

The kidneys can change blood pH by changing the amount of

bicarbonate ion and hydrogen ion that are reabsorbed or secreted

• If the blood H+ is high (acidosis), the nephrons secrete H+ out of the

blood and reabsorb HCO3– into the blood

• If the blood H+ is low (alkalosis), the nephrons reabsorb H+ into the

blood and but HCO3– is not reabsorbed into the blood