

## Chapter 7

### Excretory system

#### 7.1 The organs that process and remove wastes

Several organs in the body are involved either in the processing of wastes or in the excretion of those wastes

- Lungs
  - Involved in the excretion of the carbon dioxide that is produced by all body cells during cellular respiration
- Liver
  - Processes many substances so that they can be excreted
- Sweat glands in the skin
  - Secrete sweat, which is largely water, for cooling
- Alimentary canal
  - passes out bile pigments, which enter the small intestine with the bile
- Kidneys
  - Principal excretory organs, responsible for maintaining the constant concentration of materials in the body fluids

#### 7.2 The liver and skin

##### Liver

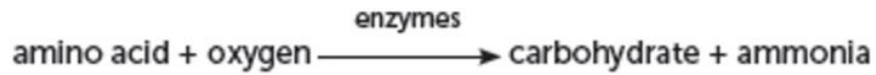
- Located in the upper abdominal cavity.
- Large organ with a host of different functions, one of which is the preparation of materials for excretion
- Liver plays an important role in processing chemicals into a safer form
  - Example: It converts ammonia produced from proteins into the safer form of urea by a process called **deamination**

##### Liver also

- Bile production
- Breaks down RBC'S - live for 120 days, broken up and reused, then a pigment - bile + then faeces / urine
- Glycogen formation
- ~500 functions

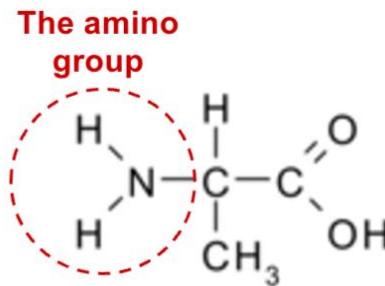
##### Deamination

- Uses enzymes to remove the amino group (NH<sub>2</sub>) from the amino acids.
- Once the amino group has been removed, it is converted by the liver cells to ammonia (NH<sub>3</sub>) and then finally to urea
- The urea is eliminated from the body in the urine
- Remaining part of the amino acid (mainly carbon and hydrogen), is converted into a carbohydrate that can be readily broken down by the cells to release energy, carbon dioxide and water



### Deamination

- Is the **stripping of nitrogen** from **amino acids** and **nitrogen bases (RNA)**
- **Nitrogen occurs in the amino (NH<sub>2</sub>) part of an amino acid**
- a **nitrogen** is **toxic to the human body** and **must be removed**



Alanine

- Occurs in **liver**

### Outline chemistry deamination

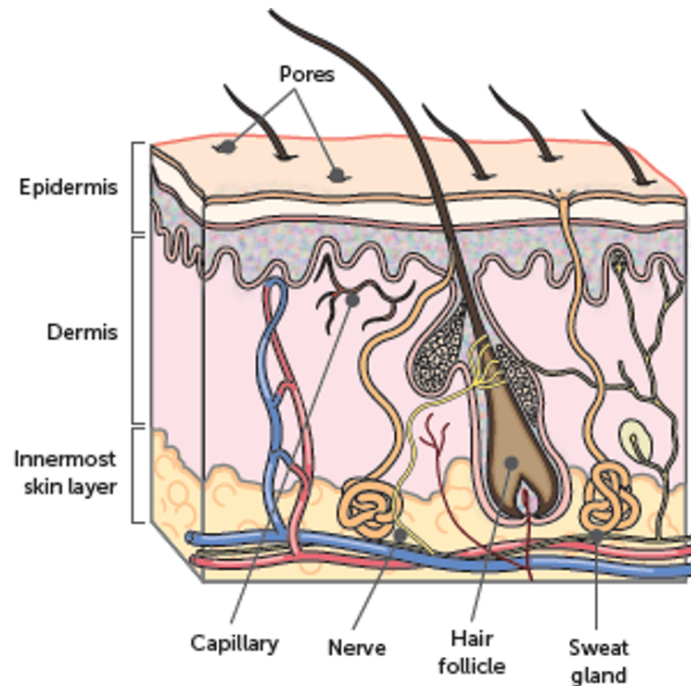
- **Amino acid** → **ammonia** + organic compounds (used for respiration)
- **Ammonia** (very toxic) + CO<sub>2</sub> → **urea** (H<sub>2</sub>NCONH<sub>2</sub>)

### Nitrogen wastes

Nitrogen compound	Source	Amount	Relative Toxicity
Urea	Amino Acids	21 g/day	Moderate
Creatinine	Muscle metabolism	1.8 g/day	High
Uric acid	RNA	480 mg/day	Weak

## Skin

- Main functions of the skin are to provide a protective covering over the surface of the body and to regulate body temperature, but it also has an important role in excretion
- Sweat glands secrete ~500mL of water per day.
  - Dissolved in the water are sodium chloride, lactic acid and urea
    - these are being secreted from the body
- Sweat glands are located in the lower layers of the skin.
- A duct carries the sweat to a hair follicle or to the skin surface where it opens at a pore.
- Cells surrounding the glands are able to contract and squeeze the sweat to the skin surface

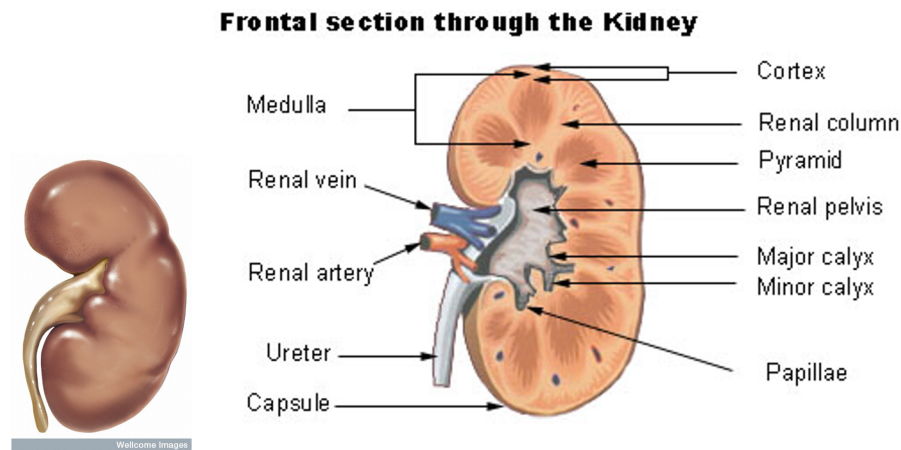


The structure of skin, including sweat glands

## 7.3 The kidneys

### Function of kidneys

- To rid the body of wastes, especially nitrogenous wastes such as urea
- To regulate the balance of fluid, salt and pH
- They achieve these outcomes by filtering the blood as it passes through the kidneys
- Waste substances are removed by the process of **filtration** and **tubular secretion**
- Useful substances are returned to the body by the process of **selective reabsorption**



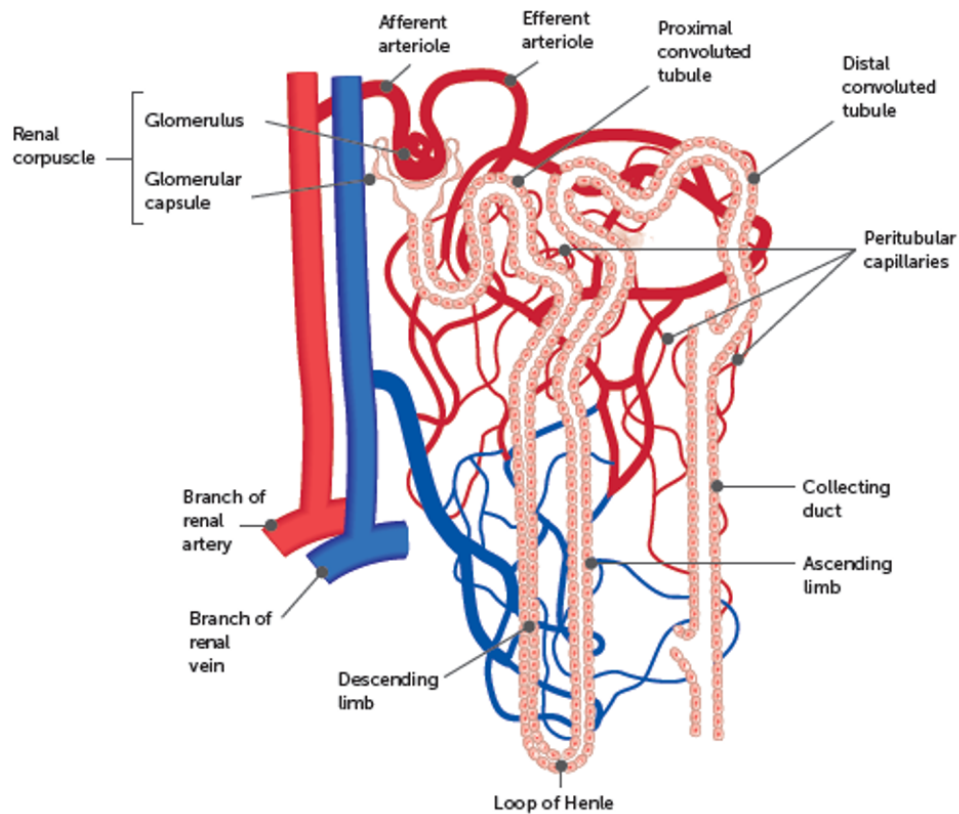
### The kidney - external

#### Nephrons

- Functional unit of kidneys
- A nephron consists of a **Bowman's capsule**, a **renal tubule** and their associated blood supply
- Each kidney contains approx. one million nephrons

#### Structure of nephrons

- Composed of a large number of microscopic structures called nephrons and collecting ducts
- Functional unit of the kidney where urine is formed
- About 1.2 million nephrons in each human kidney, and each is surrounded by a complex network of blood capillaries
- Responsible for removing wastes from the blood and regulating blood composition
- Blood enters kidney through renal arteries
- Blood enters the nephron through the afferent arteriole
- Filtered in the glomerulus, a network of capillaries, and then exits via the efferent arteriole



### Production of urine

- Formation of urine by the nephrons of the kidneys involves three major processes
  - Glomerular filtration
  - Selective reabsorption
  - Secretion by the tubules

### Glomerular filtration

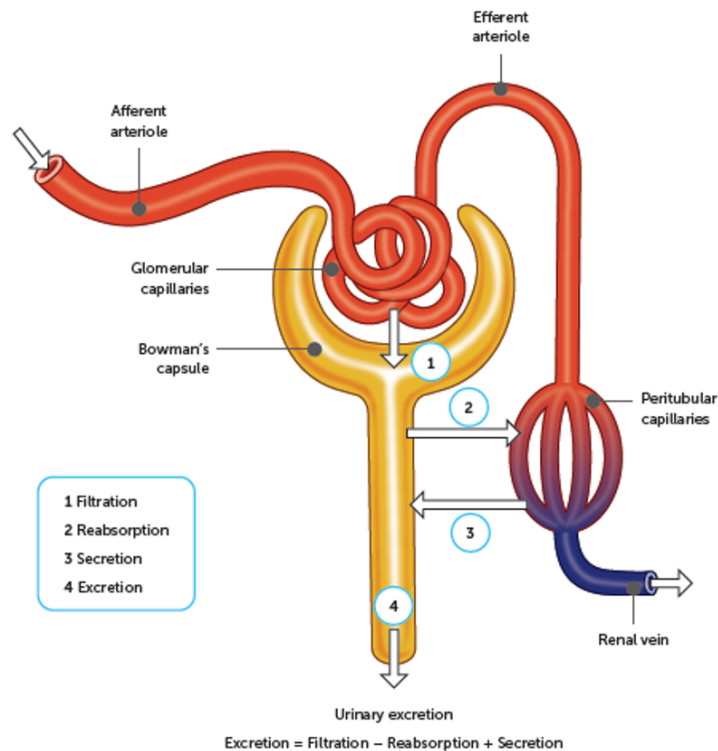
- Takes place in the renal corpuscle when fluid is forced out of the blood and is collected by the glomerular capsule

### Selective absorption

- Many components of the plasma that are filtered from the capillaries of the glomerulus are of use to the body
- Therefore some **selective reabsorption** of the filtrate must take place, returning them to the blood in the peritubular capillaries.
- Processes carried out by cells that line the renal tubule

### Tubular secretion

- Adds materials to the filtrate from the blood, such as potassium, hydrogen ions and creatinine.
- This process maintains blood pH and urine pH



- Water and other substances not reabsorbed drain from the collecting ducts into the renal pelvis.
- From the pelvis, the urine drains into the ureters and is pushed to the urinary bladder where it is stored.
- The two ureters, one from each kidney, extend to the urinary bladder.
- The urethra carries urine from the bladder to the exterior of the body.

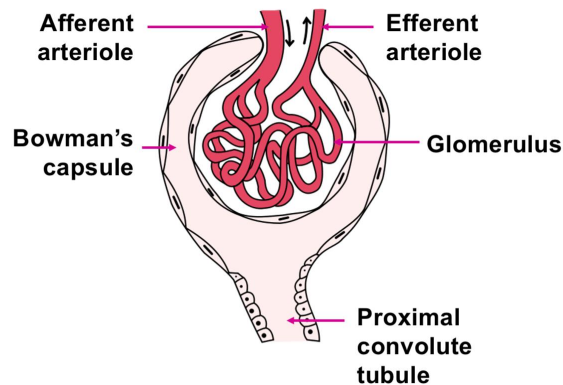
### Summary of the functioning of the kidney

REGION OF NEPHRON	ACTIVITIES TAKING PLACE
Renal corpuscle	Filtration of blood from capillaries of glomerulus
	Formation of filtrate in the glomerular capsule
Proximal convoluted tubule and loop of Henle	Passive reabsorption of potassium, chloride and bicarbonate ions
	Active reabsorption of glucose and sodium
	Passive reabsorption of water by osmosis
Distal convoluted tubule	Active reabsorption of sodium ions
	Active reabsorption of water, depending on the body's water needs
	Secretion of hydrogen and potassium ions, creatinine and certain drugs such as penicillin
Collecting duct	Active reabsorption of water, depending on the body's water needs

### The renal corpuscle

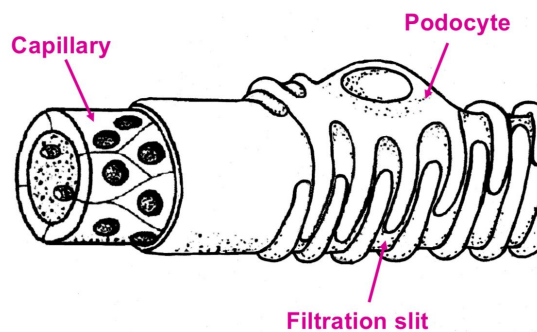
- Filtration takes place in the renal corpuscle
- Consists of the Bowman's capsule and a mass of blood capillaries - the **Glomerulus**

## The renal corpuscle



### Podocytes

- Lining the Bowman's capsule are specialised cells
- These cells have finger-like extensions that wrap around the capillaries of the glomerulus
- The spaces between the "fingers" are **filtration slits**



### Filtration

Process	Structure	Substance	Active or passive
Filtration	Renal corpuscle	<b>Filtrate</b>	
		Water	Passive (mass flow)
		Urea, Glucose, Amino acids, Vitamins, Salts (mainly sodium & chlorine)	Passive

### The proximal tubule

- **Microvilli** line the proximal tubule and create a **brush border**, which greatly increases the surface area for reabsorption

### Reabsorption

Structure	Substance	Active/passive
PCT	Water (60-70%) Salts (60-70%) Glucose (100%) Amino acids (100%) Vitamins (100%)	Passive (osmosis)  All active
Loop of Henle	Water (25%) Na <sup>+</sup> /Cl <sup>-</sup> (25%)	Passive (osmosis) Active
DCT	Water (5%) Na <sup>+</sup> /Cl <sup>-</sup> (5%)	Passive (osmosis) Active
Collecting duct	Water (5%)	Passive (osmosis)

### Tubular secretion

Process	Structure	Substance	Mode
Tubular secretion	PCT & DCT	H <sup>+</sup> NH <sub>4</sub> <sup>+</sup> (ammonium) Creatinine Toxins Drugs Neurotransmitters	Active

### Urine

- Urine is a clear, transparent fluid. It normally has an amber colour
- It is collected in the bladder and eliminated through the urethra
- The average amount of urine voided in 24 hours is about 1200cm<sup>3</sup>

### Composition of urine

- Typically, urine contains:
  - approx. 95-96% water
  - approx 4-5% other solutes (incl. organic molecules such as urea, creatinine and uric acid), ions (mainly sodium & chloride ions) and other metabolic wastes

### Composition of urine (guide only)

COMPONENT	%
Water	96.0
Urea	2.0
Various ions	1.5
Other	0.5



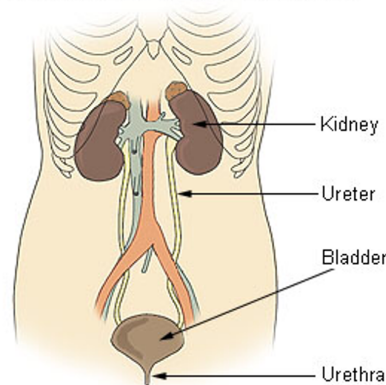
### Not the only excretion

- lungs
- skin
- liver
- has to be part of the cells and then removed as waste
- faeces/digestion isn't excretion

### Structure of urinary system

- Major structural components of the **urinary system** are:
  - Kidneys x2
  - Urinary bladder x1
  - Ureters x2
  - Urethra x1

**Components of the Urinary System**



## 7.4 Effects of lifestyle on excretion

### Kidney stones

- Formed from solid crystals that build up inside the kidneys
- Usually form when urine becomes too concentrated
- Small crystals may pass unnoticed, or crystals may combine to form stones
- Large stones can get stuck in the ureter, bladder or urethra, causing intense pain, and may need to be broken up with sound waves or physically removed during surgery

### Kidney failure

- When the kidneys lose their ability to excrete waste and to control the level of fluid in the body
- 1 in 3 adult Australians is at risk of developing kidney disease.
- Most kidney diseases affect the glomeruli, reducing their ability to filter the blood.
- Protein and sometimes RBC may leave the blood at the glomerulus and will then be present in the urine.
- If excessive proteins are lost in the urine, blood protein levels fall and fluid accumulates in the tissues, causing swelling of the hands, feet, face or other areas

### Kidney failure factors

- Diabetes, high blood pressure or kidney disease slowly destroy the nephrons in the kidneys.
- Eventually, the only way to maintain life is by dialysis or a kidney transplant

**Kidney failure lifestyle**

- To maintain healthy kidneys
  - maintain a healthy diet and weight
  - abstain from smoking
  - drink water instead of sugary drinks
  - drink alcohol in moderation
  - do not use performance-enhancing drugs

**Liver disease**

- When the liver is not able to function effectively, it is unable to process toxins ready for elimination
- Can be caused by infection, autoimmune problems, genetic disorders, cancer, and lifestyle factors such as excessive alcohol consumption and a fatty diet

**Liver disease symptoms**

- yellow tinge to the skin (jaundice)
- abdominal pain and swelling
- swelling in feet and legs
- nausea or vomiting
- fatigue
- dark urine
- faeces are pale or dark coloured