Biology 20 – Human Systems – The Excretory System – Lesson 2 – Urine Formation

http://www.nelson.com/ABbio20-30/teacher/protect/otr/Bio2030OTR/attachments/i_AnimationSimulation/kidney_anatomy_v2.html

- Urine formation occurs in the **nephrons**

- It involves 3 parts:
  - Filtration
  - Reabsorption
  - Secretion

Filtration

- The gomerulus acts like a high-pressure filter

- **H_2O** and dissolved solutes pass through the walls of the glomerulus into the Bowman's capsule

- **Proteins**, **blood cells** and **platelets** are too large to pass out of the glomerulus and stay in the blood

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Table 2 Comparison of Solutes

Solute	Glomerulus	Bowman's capsule
water	yes	yes
sodium chloride	yes	yes
glucose	yes	yes
amino acids	yes	yes
hydrogen ions	yes	yes
urea	yes	yes
plasma proteins	yes	no
erythrocytes	yes	no
platelets	yes	no

Reabsorption

- Every minute, 120mL of fluid enters the nephrons of the kidneys
  - If all of this formed urine, you would produce 120mL of urine/min and have to drink 1L of water every 10min to replace the lost fluid
  - Fortunately, only 1 mL of urine is produced from the 120 mL that enters the nephrons

- Reabsorption occurs by both active and passive transport

- **Sodium** ions (Na^+) are actively transported out of the nephron, back into the blood
  - Negative ions (Cl^-, HCO_3^-) follow by attraction
  - Water follows because of osmotic force
  - There are many mitochondria in the cells of the nephron to provide energy

- As water leaves the nephron, the remaining urine becomes more **concentrated**

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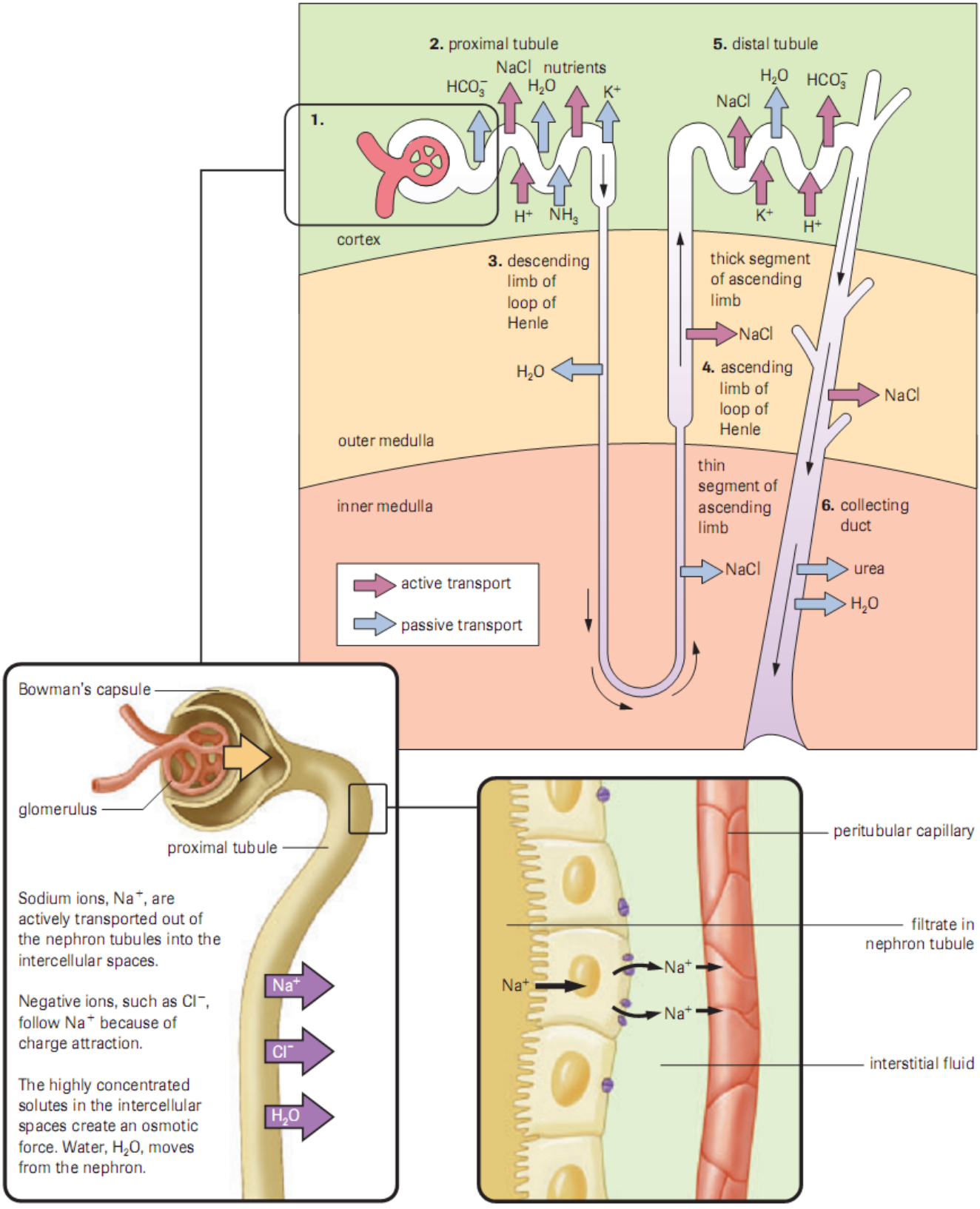

Figure 4

Tubular Secretion

- Secretion is the movement of substance from the **blood** into the **nephron**
- Ammonia, excess H^+ ions, and potassium ions (K^+) move into the blood
- Occurs by **active transport**

Table 3 Urine Formation

Site	Description of process	Substances transported
1. glomerulus and Bowman's capsule	• Filtration of water and dissolved solutes occurs as blood is forced through walls of glomerulus into Bowman's capsule by fluid pressure in capillaries.	• sodium ions (Na^+), chloride ions (Cl^-), water (H_2O), hydrogen ions (H^+), glucose, amino acids, vitamins, minerals, urea, uric acid
2. proximal tubule	• Selective reabsorption of nutrients from filtrate back into blood occurs by active and passive transport. • Within proximal tubule, pH is controlled by secretion of hydrogen ions (H^+) and reabsorption of bicarbonate ions (HCO_3^-).	• bicarbonate ions (HCO_3^-), salt (NaCl), water (H_2O), potassium ions (K^+), hydrogen ions (H^+), ammonia (NH_3), glucose, amino acids, vitamins, urea
3. descending limb of loop of Henle	• The descending limb of loop of Henle is permeable to water, resulting in loss of water from the filtrate by osmosis. • Salt (NaCl) becomes concentrated in the filtrate as descending limb penetrates inner medulla of kidney.	• water (H_2O)
4. ascending limb of loop of Henle	• A thin segment of ascending limb of loop of Henle is permeable to salt, resulting in the diffusion of salt out of ascending limb. • Salt continues to pass from filtrate to interstitial fluid in the thick segment of ascending limb.	• salt (NaCl)
5. distal tubule	• Secretion of substances from blood into nephron occurs by active transport. Distal tubule helps regulate potassium (K^+) and salt (NaCl) concentration of body fluids. • As in the proximal tubule, pH is controlled by tubular secretion of hydrogen ions (H^+) and reabsorption of bicarbonate ions (HCO_3^-).	• salt (NaCl), potassium ions (K^+), water (H_2O), hydrogen ions (H^+), bicarbonate ions (HCO_3^-), uric acid, ammonia (NH_3)
6. collecting duct	• Urine formation	• water (H_2O), salt (NaCl), urea, uric acid, minerals

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Regulation of Urine Production:

- Kidneys help regulate salt balance, blood volume, and blood pH

Maintaining Blood Volume:

- blood volume too low – low blood pressure
- blood volume too high – high blood pressure

Aldosterone

- Hormone released from adrenal cortex of kidney when BP is too low
    - aldosterone increases Na^+ reabsorption, water is then also reabsorbed

Antidiuretic hormone (ADH)

- diuresis means increased amount of urine; antidiuresis means decreased amount of urine
- osmoreceptors in hypothalamus detect changes in osmotic (water) pressure
- if water is being lost (leaving tissues) the hypothalamus shrinks sending a signal to the pituitary gland to release ADH
- 85% of water is reabsorbed in the proximal tubule and loop of nephron
- when ADH is present, the distal convoluted tubule and collecting ducts reabsorb more water (therefore less urine)
- if no ADH the other 15% of water is lost
- if you don't drink much water, ADH is released, more water absorbed to dilute solutes in blood, less urine

Diuretics are agents that increase urine output

- Alcohol increases urine by preventing release of ADH; less water is reabsorbed; more urine
    - Leads to dehydration (hangover)
- Caffeine increases urine by increasing glomerular filtration rate and reducing Na^+ reabsorption
- Diuretic drugs that reduce blood pressure also inhibit reabsorption of Na^+, decreasing blood volume

Maintaining Blood pH: pH of blood is ideally around 7.4

- if acidic; excess hydrogen ions are excreted; sodium and bicarbonate ions are reabsorbed ($NaHCO_3$ is a base)
- if basic; more hydrogen ions are reabsorbed; fewer sodium and bicarbonate ions reabsorbed