Water Reabsorption and the Effect of Diuretics on Urine Formation

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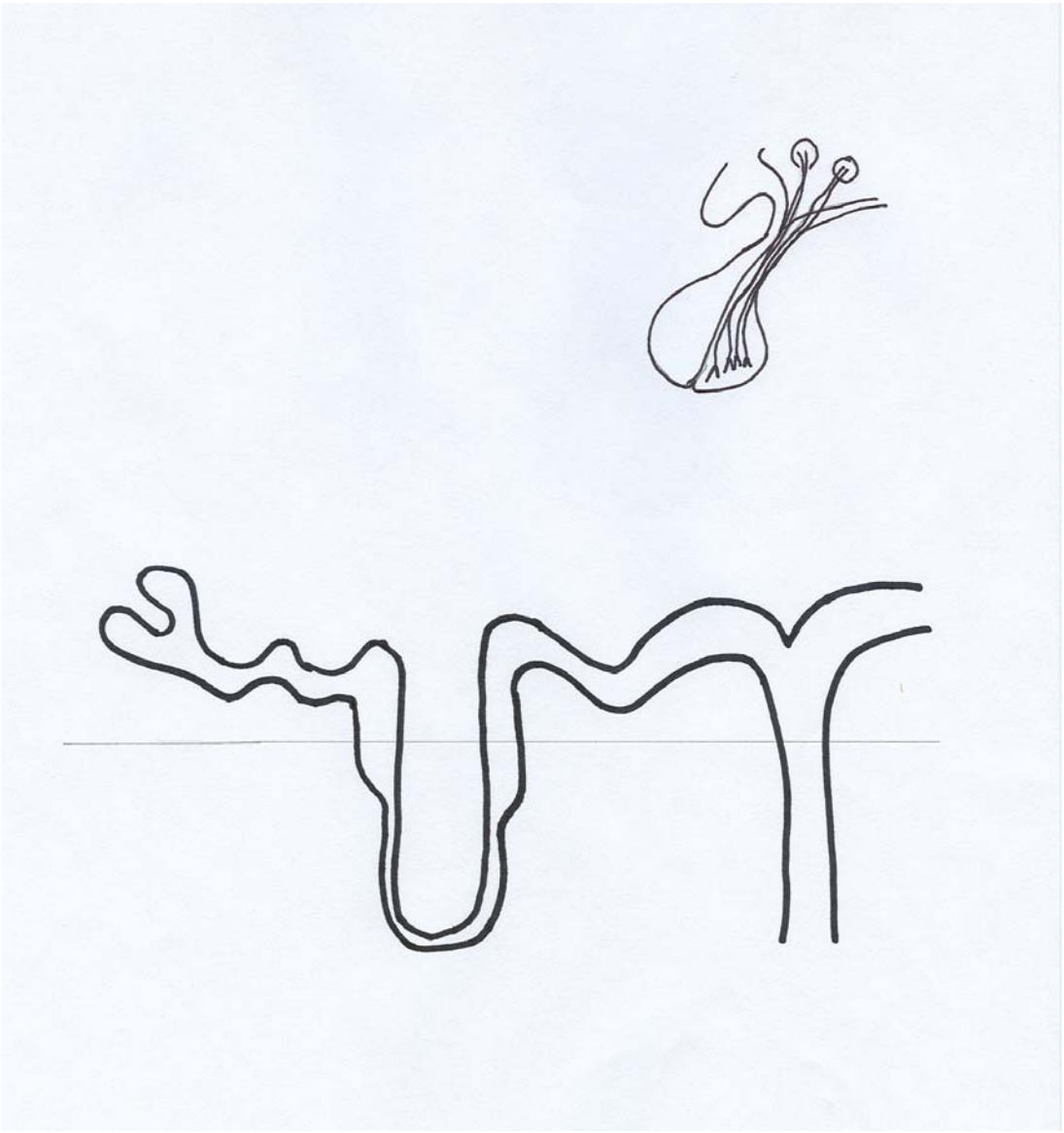
This activity may be done in conjunction with a more traditional urinalysis lab. The idea is to help students understand the regulation of water reabsorption in the kidney and how various chemicals an impact the process.

Objectives:

- Understand the regulation of sodium and water reabsorption in the nephron and collecting ducts.
- Be able to define the term diuretic.
- Understand where and how each type of diuretic affects the reabsorption of water.
- Understand why an individual might be prescribed or exposed to the various types of diuretics.

Equipment:

- Nephron & collecting duct poster board charts (including a schematic of the hypothalamus)
- Na^+ / glucose cotransporters
- Na^+ / Cl^- cotransporters (distal convoluted tubule)
- Na^+ channels
- K^+ channels
- Cl^- channels
- Na^+/K^+ ATPase pumps (basolateral membrane)
- Aquaporins or water channels
- Water molecules
- Aldosterone & aldosterone receptors
- Vasopressin & vasopressin receptors
- Loop diuretics
- Thiazide diuretics
- Potassium sparing diuretics
- Osmotic diuretic (mannitol molecules)
- Vasopressin inhibitors



Notes for use: I have drawn the chart of the nephron and hypothalamus – pituitary on a posterboard and laminated it for longer term use. The transporters, channels, and all other molecules are pre-made for student use. They can be made of heavy cardstock or posterboard and laminated for longer term use. I have made the aldosterone and aldosterone receptors so they will physically fit together. I have also made the aldosterone competitors so they will fit with the aldosterone receptors. The same applies to the vasopressin, vasopressin receptors and vasopressin competitors.

I can certainly see a computer savvy person modifying this into a computer simulation for students to use.

Activity I: Water regulation in the nephron & collecting ducts

Using the poster board chart provided, place the appropriate channels, transporters, and receptors in the appropriate locations on the nephron and collecting ducts. Be sure to place the channels transporters and receptors on the correct membrane, the apical or luminal membrane and the basolateral membrane. Place the aldosterone and vasopressin with their appropriate receptors.

Questions:

1. Which regions of the nephron and collecting ducts reabsorb sodium?

2. What mechanisms are used to reabsorb the sodium in each of these locations?

3. Which regions of the nephron and collecting ducts reabsorb water?

4. What mechanisms are used to reabsorb the water in each of these locations?

5. Why is the movement of water so often linked with the movement of sodium?

6. Identify the locations where water and sodium move independently. Why is the movement of water and sodium independent in these locations?

Activity II: Diuretics and their effects on the nephron and collecting ducts

Diuretics:

- Definition: a drug or other substance that results in diuresis or an increased excretion of water.

- Classes and actions:
  - Osmotic diuretics
    - Acts in the proximal tubule
    - Increase solutes in the glomerular filtrate that are not reabsorbed in the proximal tubule.
    - Increases osmolarity of the glomerular filtrate
    - Mannitol is an example of a solute that is filtered but not reabsorbed.
  - Xanthines
    - Caffeine (a mild diuretic) increases glomerular filtration.
  - Loop diuretics
    - Inhibit the Na^+/K^+ ATPase pumps in the nephron loop.
  - Thiazides
    - Inhibit the Na^+/Cl^- co transporter in the distal convoluted tubule.
    - An additional effect of thiazides is to dilate blood vessels
  - Potassium sparing diuretics
    - Act as a competitor with aldosterone for the aldosterone receptors in the distal tubule and cortical collecting duct.
    - Allow excretion of water without the loss of potassium.
  - Vasopressin inhibitors
    - Vasopressin receptor inhibitors
    - Alcohol: inhibits release of vasopressin
    - Water: reduces the osmolarity of the plasma

Using the completed chart from **Activity I**, place each of the diuretics in the location it has its effect. Be sure to place the diuretic so that it shows the effect the diuretic has on the channels, transporters, and/or receptors.

Questions:

1. How does increasing the osmolarity of the glomerular filtrate result in osmotic diuresis?

2. How does mannitol act as an osmotic diuretic?

3. Why does uncontrolled diabetes mellitus result in osmotic diuresis?

4. Why does increasing glomerular filtration rate increase urine volume?

5. How does a loop diuretic affect sodium and water reabsorption?

6. How does a thiazide diuretic affect sodium and water reabsorption?

7. How does a potassium sparing diuretic affect sodium and water reabsorption?

8. How does the potassium sparing diuretic prevent potassium secretion?

9. How does a vasopressin inhibitor reduce water reabsorption?

10. How does alcohol reduce water reabsorption?

11. How does reduced plasma osmolarity reduce water reabsorption?

Activity III:

Some basic medical uses for diuretics:

- Hypertension
- Congestive heart failure
- Edema

Some diuretic side effects:

- Frequent urination
- Dizziness and weakness
- Hyponatremia

Questions:

1. Explain how a diuretic can be beneficial for treating hypertension.

2. Explain how a diuretic can be beneficial for treating congestive heart failure. Hint, think about systolic ventricular dysfunction and the effect of afterload.

3. Explain how a diuretic can be beneficial for treating edema.

4. Explain why a diuretic may be the cause frequent urination.

5. Explain why a diuretic may be the cause frequent dizziness and weakness.

6. Explain why a diuretic may be the cause hyponatremia.

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