Materials Needed

- ☐ Beads (1 large red, 1 large white, 2 large purple, 2 medium green, 6 small orange, 6 small yellow, 15 small blue, 15 small black, and 15 small brown)
- ☐ Pipe cleaner or string
- ☐ Two petri dishes
- ☐ Laminated simplified nephron diagram poster (or posterboard/ whiteboard on which to draw the simplified nephron diagram)
- ☐ Water-soluble markers (black, brown, red, blue, orange, purple, yellow, and green)

Instructions

1. For the four parts of this activity you will use the image of a simplified nephron in **Figure 31-5** to help you visualize the movements of substances into and out of the nephron. Complete the following instructions to label the laminated poster:
   a. Use a black marker to label the following structures: the glomerular capsule (write "GC"), the proximal tubule ("PT"), the nephron loop ("NL"), the distal tubule ("DT"), and the collecting duct ("CD").
   b. Draw a brown dotted line through the nephron to separate those parts of the nephron that are in the cortex from those that are in the medulla. Label the cortex and medulla.
   c. Label the glomerulus ("G"), afferent arteriole ("AA"), efferent arteriole ("EA"), peritubular capillary ("PC"), and vasa recta ("VR") in red. Remember that peritubular capillaries actually arise from efferent arterioles of cortical nephrons, whereas the vasa recta arises from efferent arterioles of juxtamedullary nephrons. These nephrons are so near each other that each is supplied by both peritubular capillaries and the vasa recta.

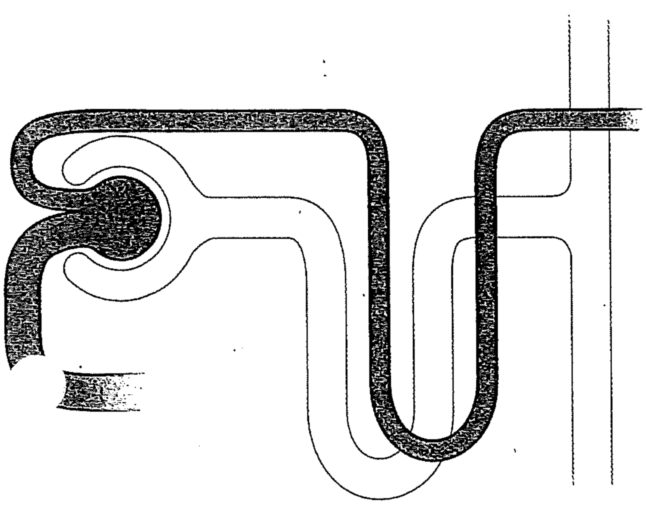


Figure 31-5 A simplified schematic view of a nephron and its blood supply for the laminated poster used in Activity 2.

   d. Draw a green box around the renal corpuscle.
   Which process occurs here?
   ____
   e. Draw an orange box around the renal tubule.
   Which processes occur here?
   ____
   ____
   f. Draw small black and brown circles in the medullary interstitium to represent sodium ions (Na^+) and chloride ions (Cl^-), respectively. Indicate the presence of an interstitial concentration gradient by increasing the number of "ions" you draw as you move from the cortex to the medulla.
   What is the function of the interstitial concentration gradient in the medullary region?
   ____
   ____
   ____
   g. Finally, label the inside of one half of a petri dish "blood" and another half "filtrate." The different beads represent different substances.
   - 1 large red bead = red blood cell
   - 1 large white bead = white blood cell
   - 2 large purple beads = plasma proteins
   - 1 medium green bead = creatinine
   - 1 medium green bead = penicillin
   - 6 small orange beads = organic nutrients
   - 6 small yellow beads = urea molecules
   - 15 small blue beads = water molecules
   - 15 small black beads = sodium ions
   - 15 small brown beads = chloride ions

Part A. Glomerular Filtration in the Renal Corpuscle

1. In this part of the activity, you will demonstrate the movement of substances from the blood of the glomerulus into the glomerular space of the glomerular capsule.
   a. Using a piece of pipe cleaner or string, connect a plasma protein and a penicillin to indicate that the two are typically bound together.
   b. Fill the petri dish containing "blood" with the following substances: 1 red blood cell, 1 white blood cell, 1 creatinine, 1 penicillin bound to a plasma protein, 1 plasma protein, 6 organic nutrients, 6 urea molecules, 15 water molecules, 15 sodium ions, and 15 chloride ions.
   c. Move the dish representing "blood" and various solutes into the afferent arteriole.
   d. Move the "blood" dish containing solutes into the renal corpuscle.

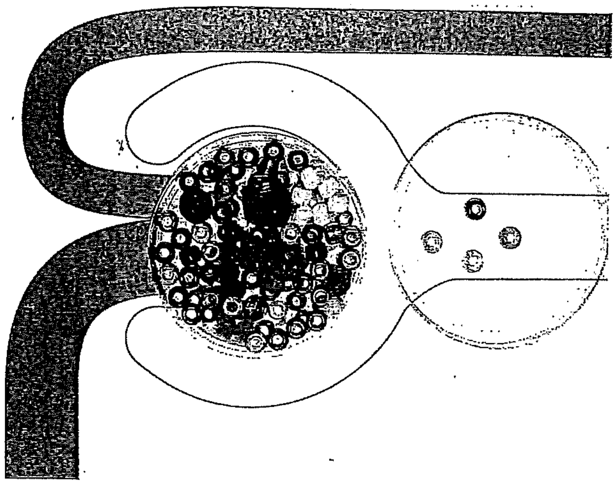


Figure 31-6 Demonstrating glomerular filtration.

e. Demonstrate glomerular filtration: For substances that are freely filtered, move all the corresponding beads into the "filtrate" dish in the glomerular space, as shown in **Figure 31-6.**

Which substances are freely filtered? Why?

For substances that are not in the filtrate under normal circumstances, leave the corresponding beads in the "blood" dish within the glomerulus.

Which substances are not filtered at all? Why?

In what ways is the renal corpuscle structurally adapted for the function of filtration?

Part B. Tubular Reabsorption into the Peritubular Capillary

1. In this part of the activity you will move the "blood" from the glomerulus into the efferent arteriole and then into the peritubular capillaries surrounding the proximal tubule. You will move the "filtrate" from the glomerular capsule into the proximal tubule.
   a. For substances that are maximally reabsorbed (99–100%) in the PT, move all the corresponding beads into the "blood" within the peritubular capillary.

      Which substances are maximally reabsorbed?

   b. For the substances that are 60–80% reabsorbed in the PT, move nine corresponding beads into the "blood" within the peritubular capillary.

      Which substances are 60–80% reabsorbed?

   c. For the substance that is 50% reabsorbed in the PT, move three corresponding beads into the "blood" within the peritubular capillary.

      Which substance is 50% reabsorbed?

   d. For the substance that is not reabsorbed, leave the corresponding bead in the "filtrate."

      Which substance is not reabsorbed?

      Why is the amount of solute that the renal tubule can absorb limited? Why would you expect to find glucose in the urine of a person with diabetes?

Part C. Tubular Secretion from the Peritubular Capillary

1. In this part of the activity you will demonstrate tubular secretion from the peritubular capillary into the renal tubule.
   a. Detach the penicillin from the plasma protein and move it into the "filtrate" in the renal tubule.

      Why was penicillin not filtered at the renal corpuscle?

      What is creatinine? Is creatinine secreted by the nephron?

      Why is it sometimes used to estimate the glomerular filtration rate (GFR)?

   b. Move the three urea beads back into the "filtrate" in the renal tubule.

      What is urea, and where is it produced?

iove two beads representing ions back into the "filtrate" in the renal tubule.

Name three types of ions that are secreted into the renal tubule.

How does the filtrate in the renal tubule differ from the urine that will eventually leave the collecting duct and drain into the renal pelvis?

t D. Water Conservation

In this part of the activity you will first demonstrate the role of the countercurrent multiplier (nephron loop).

a. Move the "filtrate" in the proximal tubule down the descending nephron loop.

b. As the "filtrate" travels down the descending limb, move two water beads out of the nephron loop and into the interstitium, as shown in **Figure 31-7**.

What is the driving force that pulls water out of the ·ph

Why don't sodium ions and chloride ions move into the descending limb?

c. As the "filtrate" travels up the ascending limb, move four sodium beads and four chloride beads out of the nephron loop and into the interstitium.

Why do these ions leave the nephron?

Why doesn't water move back into the ascending limb?

Why is the nephron loop called the countercurrent multiplier?

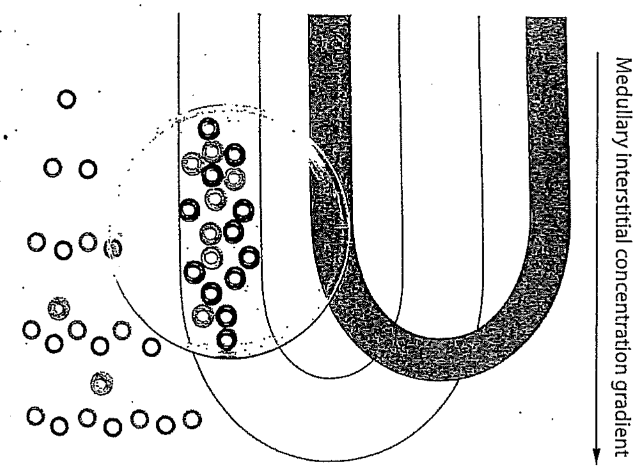


Figure 31-7 Demonstrating the countercurrent multiplier.

2. Next you will demonstrate the role of the countercurrent exchanger (vasa recta).

   a. Move the "blood" from the peritubular capillary down the descending limb of the vasa recta.

   Describe the permeability characteristics of the vasa recta.

   b. As the "blood" moves down the descending limb, demonstrate the movement of the appropriate beads from the "blood" to the interstitial fluid.

   c. As the "blood" moves up the ascending limb, demonstrate the movement of the appropriate beads from the "blood" to the interstitial fluid.

   Why is it necessary for the vasa recta to extend deep into the medullary region?

   Why is the vasa recta called the countercurrent exchanger?

   What would be the physiological consequence if the vasa recta was not part of a countercurrent mechanism?

3. Now you will demonstrate the role of the collecting duct.
   a. Move the "filtrate" from the nephron loop into the distal tubule and then into the collecting duct.
   b. As the "filtrate" moves down the collecting duct, move two water beads into the interstitial fluid of the medullary region.
   The movement of water out of the collecting duct happens only when which hormone is present?

   ____

   c. Move the "filtrate" toward the end of the collecting duct.
   What happens to some of the urea at this point?

   ____

   ____

   d. Demonstrate the movement of urea by moving two yellow beads from the "filtrate" in the collecting duct into the interstitium.
   Why is this important?

   ____

   ____

   List the contents of the urine that leaves the collecting ducts.

   ____

   ____

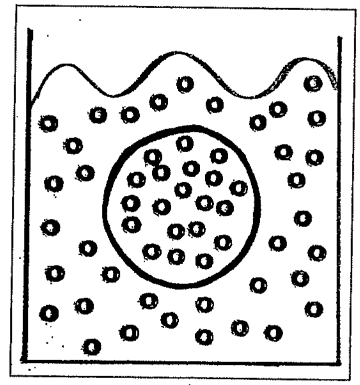
   Describe the path of urine from the collecting ducts to the urethra.

   ____

   ____

Lab BOOST>>>

Understanding Tonicity



Tonicity can be a very confusing concept. To better understand the role that tonicity plays in urine concentration, use a piece of paper, pencil, blue beads (water = solvent) and red beads (ions = solute) to visually represent what happens when a cell is placed into a hypertonic environment. Remember that tonicity is a relative term used to compare the concentration of two different solutions. If Solution A is hypertonic to Solution B, then Solution A has a higher solute concentration than Solution B. On a sheet of paper, draw a large circle (3 inches in diameter) inside a beaker. "Fill" the cell with 18 water beads and 2 ion beads. Because the cell has a total of 20 beads and 2 of these beads are ions, the cell has a 1/10 or 10% solute concentration. Now "fill" the beaker with 18 water beads and 18 ion beads. The solution in the beaker has an 18/36 or 50% solute concentration. The cell membrane is impermeable to the solute; therefore, water will move by osmosis from an area of high concentration to an area of low concentration through the cell membrane. Move 10 water beads from the cell into the hypertonic solution. In the same way, water leaves the nephron loop and enters the interstitial fluid, thus allowing the kidney to reabsorb water as the urine is concentrated.

ACTIVITY 3

Using the Results of a Urinalysis to Make Clinical Connections

Learning Outcomes

1. Perform a urinalysis on urine samples and draw conclusions based on the results.

Materials Needed

- ☐ Six test tubes
- ☐ Test tube rack
- ☐ 10-ml graduated cylinder
- ☐ Wax pencil
- ☐ Student urine sample or simulated "normal" urine sample
- ☐ Simulated unknown urine samples
- ☐ Urinalysis strips
- ☐ Safety glasses and disposable gloves

Instructions

In this activity you will perform a urinalysis on a normal urine sample and on several unknown urine samples. When you have completed the urinalysis, you will use your results to match each unknown sample to a "patient." *Note:* If you are using student urine samples, follow the directions given by your instructor for obtaining these samples.

1. Put on safety glasses and gloves.
2. Obtain a test tube rack and six test tubes.
3. Use a wax pencil to label the test tubes A, B, C, D, E, and F.
4. Pour 5 ml of student urine sample (or simulated "normal" urine) "A" into test tube A.
5. Pour 5 ml each of unknown simulated urine "B" through "F" into test tubes B through F.
6. Note the color (pale yellow, medium yellow, dark yellow, or other—provide description), transparency (clear, slightly cloudy, or cloudy), and odor (characteristic or other—provide description) of each sample A–F. Record your data in the table on the next page.