Kidney Dialysis

Introduction:

Your patient is experiencing kidney failure. Her kidneys are not removing wastes and other undesirable substances from her body. She will need dialysis treatments.

Dialysis treatments use selective (semipermeable) membranes that allow small molecules, like urea, to diffuse out of the blood. The membranes block the diffusion of larger molecules and blood cells so that these will remain in the blood.

One type of dialysis, called hemodialysis, uses a dialysis machine to clean the blood of patients who have problems with their kidneys. **Read the colored sheet titled "Hemodialysis."**

Your Tasks:

- Create a simple miniature model of a kidney dialysis machine.
- Determine which molecules can diffuse through the dialysis membrane.
- Explain what substances should be included in the dialysate to ensure that essential and beneficial small molecules are not lost from the blood.

PART 1: Create a Model Dialysis Machine

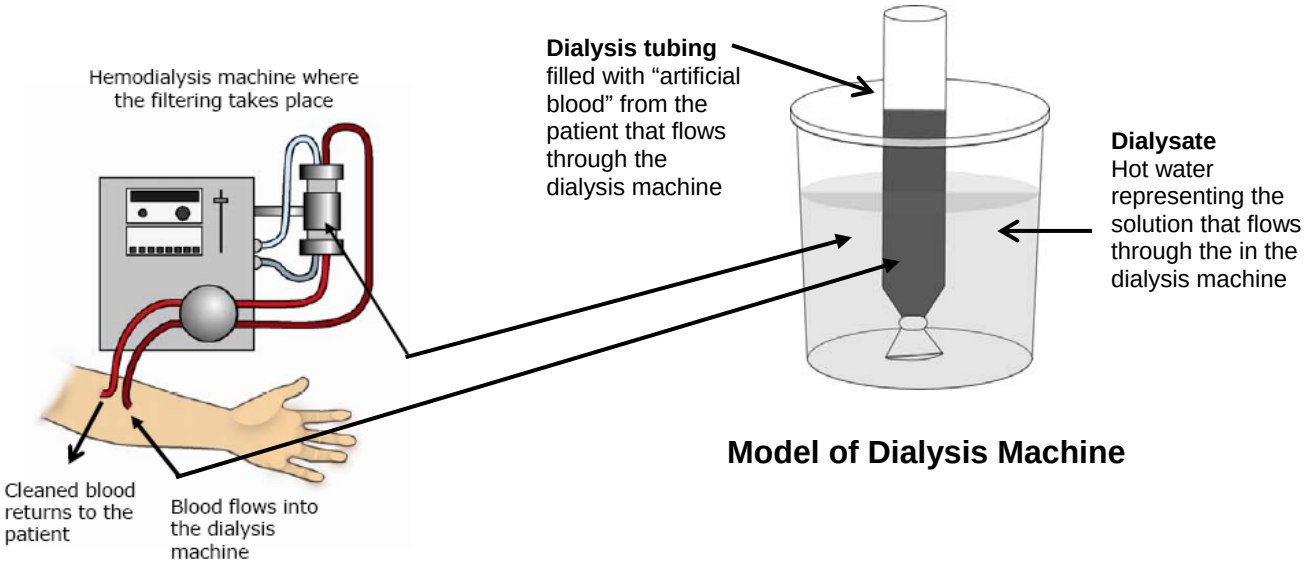
1. Moisten one end of the dialysis tubing by dipping about one-third of its length into tap water. (DO NOT place the entire dialysis tubing into the water, just wet one end of it.)

2. Close the wet end of the dialysis tubing by tying a knot at the end to make a membrane bag as shown in the diagram on the next page. This bag represents the dialysis machine tube through which a patient's blood flows.

3. Prepare "artificial blood" by adding the following ingredients to the large test tube that contains simulated red blood cells (red glitter or red beads):
    - Glucose - one small tube of glucose powder
    - Simulated Urea – one small tube of yellow food color
    - Salt - 1 packet of salt
    - Protein - 1 small tube of protein powder
    - Enough hot tap water to fill the large test tube about half full

4. Screw the lid firmly on the tube of "blood." Wrap a piece of paper towel around the tube, just in case the tube leaks. Gently invert the tube several times to mix the contents. Then immediately use the plastic dropper to transfer the contents into the dialysis tubing bag.

5. Place the dialysis tubing bag into the large cup. Add enough hot water to fill the cup approximately three-quarters full. The hot water represents the liquid in the dialysis machine. This liquid is called **dialysate**.



Model of Dialysis Machine

6. You have now created your own model dialysis machine! Set your model dialysis machine aside for 10 minutes to allow materials to diffuse through the dialysis membrane. While you wait, complete step 7.

7. The substances in the "artificial blood" in the tube are listed in the chart below. Some of these substances will diffuse from the blood, through the semipermeable membrane, and into the dialysate. Complete **Column 1** in the chart below by **predicting** which substances will diffuse through the semipermeable membrane and into the dialysate. You will complete the other columns later in this lab.

	Column 1	Column 2	Column 3
Substances in the blood	Will the substance diffuse through the membrane? **(yes or no)**	Diffused through dialysis membrane into the dialysate **(yes or no)**	Should be added to the dialysate to maintain homeostasis **(yes or no)**
Urea (waste)			
Red Blood Cells			
Proteins			
Glucose			
Salts			

PART 2: Which molecules can pass through the dialysis membrane?

1. Did the yellowish urea wastes diffuse into the dialysate liquid in the cup? Explain how you could determine this. Record the results in Column 2 of the chart on the previous page.

   _____

   _____

2. Did the red blood cells diffuse into the dialysate liquid in the cup? Explain how you could determine this. Record the results in Column 2 of the chart.

   _____

   _____

3. To determine whether protein diffused through the membrane, dip one white protein test strip into the dialysate. If protein is present, the white paper will turn dark red. Record the results of the protein test results in Column 2 of the chart.

4. To determine whether glucose diffused through the membrane, dip one orange glucose test strip into the dialysate. If glucose is present, the orange paper will turn dark blue or green. Record the results of the glucose test results in Column 2 of the chart.

5. To determine whether salt diffused through the membrane, dip one pink salt test strip into the dialysate for 10 seconds. If salt is present, the pink paper will turn a light purple. Record the results of the salt test in Column 2 in the chart on the previous page.

6. Apply your knowledge of diffusion through a membrane to explain why some substances diffused through the membrane and into the dialysate liquid and others substances did not.

   _____

   _____

PART 3: What substances should be included in the dialysate to maintain homeostasis?

Read the information below and then answer the questions that follow:

Maintaining Homeostasis

To maintain **homeostasis** (a state of balance in the body) the concentrations of water and dissolved substances in the body's internal environment (blood and body liquids) must be kept stable - within normal limits that are favorable for cell activities.

Kidneys help maintain homeostasis by regulating the flow of substances into and out of the bloodstream and by removing wastes from the bloodstream. The cell membranes in the kidneys use a process known as active transport to pump essential materials such as glucose and salts back into the bloodstream.

The dialysis membrane cannot carry out active transport like real kidneys do because it is not a living organ. To maintain homeostasis, the dialysate (liquid) in a real dialysis machine must have the same concentrations of solutes such as glucose and salts as those in normal blood plasma. Therefore:

- If the patient's blood contains excess concentrations of any solutes, these solutes will diffuse into the dialysate.
- If the patient's blood plasma lacks the ideal concentration of any solutes, these solutes will diffuse into the patient's blood.
- Because the dialysate liquid does not contain any waste products such as urea, the wastes diffuse into the dialysate.

Use the information in the box above and the diagram below to answer the following questions

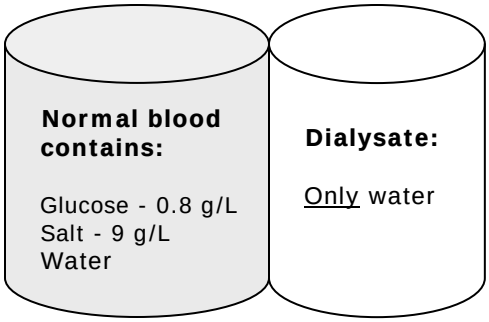
1. Explain why the membrane in a dialysis machine cannot carry out active transport.

   _____

2. Name two essential body substances that diffuse out of the blood but are needed in the blood to maintain homeostasis.

   _____ and _____

3. Observe the diagram on the right. Explain why glucose and salts would be lost from the patient's blood if the dialysate contained only water.



4. According to the diagram, what concentration of glucose and salt should be present in the dialysate to prevent the diffusion of these substances from the patient's blood?

5. Explain why urea is not added to the dialysate liquid.

6. Complete Column 3 in the chart on page 2 to indicate the substances that should be added to the water in the dialysate to maintain homeostasis.

In addition to using a hemodialysis machine, there is another option for cleaning waste substances from blood. This technique is called peritoneal dialysis.

Use the information in the colored sheet titled "Peritoneal Dialysis" to answer the following questions.

7. Describe two ways that hemodialysis and peritoneal dialysis are similar.

8. Describe two ways that hemodialysis and peritoneal dialysis are different.

9. Explain one reason why a patient might choose hemodialysis instead of peritoneal dialysis.

10. Explain one reason why a patient might choose peritoneal dialysis instead of hemodialysis.