Race for the Pure:
Blood Cleansing in the Kidneys

Student Information Page 4B

Activity Introduction:

As you know, our circulatory system moves nutrients and oxygen to the tissues of our body. It then carries away the wastes produced as our bodies carry on all the processes that keep us alive. If there were not a system in place to cleanse them from our blood, over time these wastes would build up to dangerous levels, causing illness and eventually death. So, what are the waste materials produced by our bodies and what system cleanses our blood of these potential toxins? You will find out in this activity.

Activity Background:

Waste Materials and Drugs in Our Blood - Potentially Deadly Poisons

As our bodies use the nutrients we ingest to grow and repair cells, waste products are produced. We also ingest substances like drugs that must be filtered from the blood in order to stay healthy.

The Waste Products: Creatinine and Urea

For this activity you will be focusing on two of the major waste materials that must be cleansed from the blood, creatinine and urea. These two substances are known as nitrogenous wastes and are created when your body uses proteins.

What Happens

If creatinine and urea are not filtered from the blood, they build up to toxic levels and cause a condition called ***uremia. Uremia*** is a type of blood poisoning. This blood poisoning damages your tissue and your organs' ability to function. Feeling tired, itching and muscle cramping are some of the early symptoms. If the blood poisoning is not treated nausea, vomiting, convulsions, coma and death will eventually occur as the toxins destroy your body's tissues.

Drugs

Of course we know that illicit drugs like cocaine are toxic to our body's tissues. What most people don't realize is that legal drugs prescribed by the doctor (like antibiotics) or bought over the counter at the grocery store (like acetaminophen) can also be dangerous. This danger occurs when these drugs are taken in the wrong dose or over a long period of time. Even when taken the right way, if they were not filtered from our blood stream, these drugs would build up and begin to do serious damage.
So, what is this amazing filtering system that is cleansing our blood of toxins and waste materials?

The Master Blood Cleansers

Our body's blood cleansers are the ***kidneys***. As you have probably already figured out, we would be up to our eyeballs in poisonous stuff if they weren't performing their filtering function. The kidneys function to remove these waste products by ***filtering*** them from the blood. Because of the importance of keeping your blood

clean, the kidneys receive a larger volume of blood flow than any other organ. The heart receives about 270ml/min. of blood flow, the brain 700ml/min. while the ***kidney processes around 1000ml of blood every minute***. That is a lot of blood! This large flow of blood is the reason the kidneys are a dark red color and is necessary for cleansing the blood of waste materials at a sufficient rate to keep toxic levels low. The kidneys each have about a million special cells that filter the blood as it flows through the kidney. Blood containing wastes and toxins enters the kidney from the body through an artery, is cleansed by special cells, then leaves through a vein. See ***Figure 1 Parts of the Kidney***.

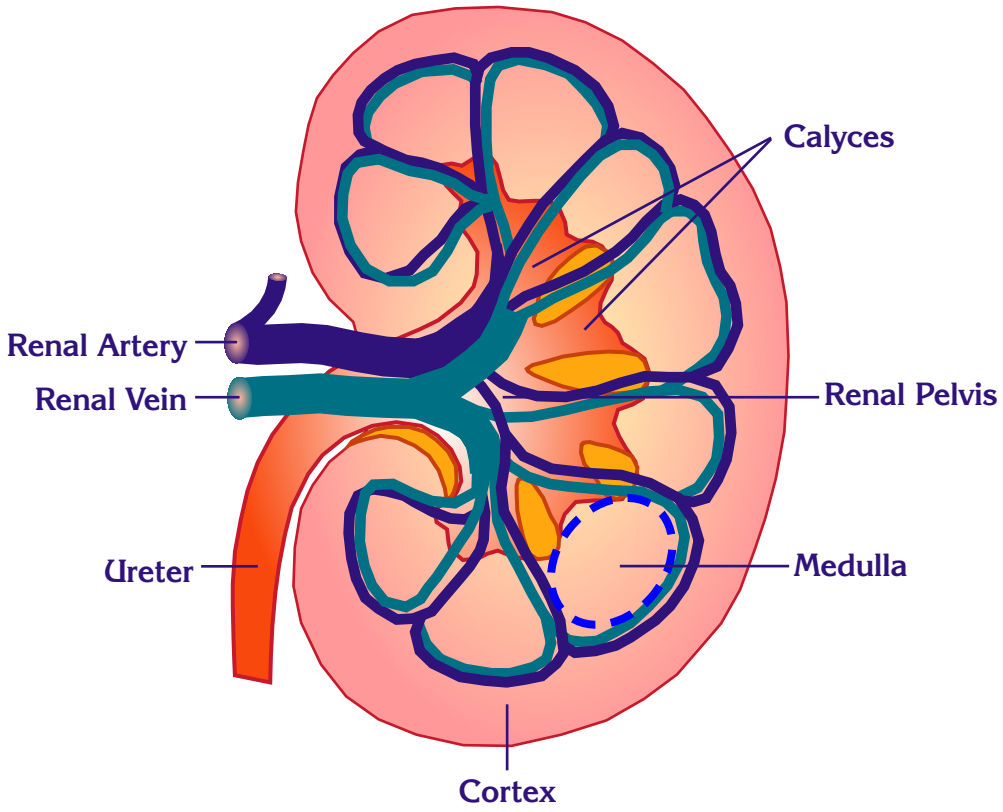


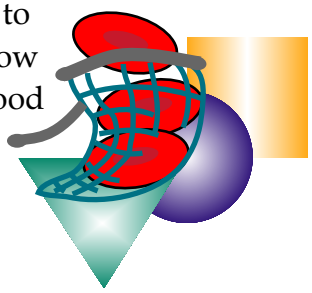
Figure 1 Parts of the Kidney

Not only do the kidneys filter wastes and toxins from your blood, they also:

- Make a substance that makes sure we have enough red blood cells to stay healthy
- Make a type of vitamin D that we need to grow and repair our bones
- Make a substance that helps keep our blood pressure at a normal level
- Keep the fluid and salt levels in our bodies normal

Kidney failure is a significant problem in the U.S., where over 100,000 people are diagnosed with the condition annually. When a person is in kidney failure, the kidneys are not able to filter wastes out of their bodies. The most common cause of kidney failure is diabetes.

African Americans, American Indians, and Hispanics/Latinos are more likely to develop diabetes and kidney failure than Caucasians. Researchers do not know why this happens. They do know, however, that high blood pressure and blood glucose levels increase the risk that a diabetic will develop kidney failure.



Diabetic kidney disease takes many years to develop. At first, the kidneys filter more than normal (***hyper filtration***) because of the diabetes. Over the next few years, small amounts of a protein called ***albumin*** leak into the urine; during this time, kidney filtration is normal. The next step involves more albumin leaking into the urine and less filtration taking place. Waste products, such as ***creatinine*** are found in the blood because the kidneys are not able to filter them out. As the kidney damage develops, blood pressure usually goes up. ***This is another example of how human organ systems affect each other.*** Usually, it takes 15 to 25 years for complete kidney failure to occur.

In addition to being a result of kidney disease, high blood pressure (***hypertension***) can cause kidney disease. How does high blood pressure harm the kidneys? It makes the heart work harder and can damage blood vessels all over your body. If the vessels leading to the kidneys are damaged, the kidneys may not be able to remove wastes and fluid from the body.

Blood tests can help doctors determine if kidney damage has occurred. If ***too much creatinine is found in the blood***, it indicates that the kidneys are not filtering as they should. Creatinine levels can be used to estimate the main kidney function called GFR (glomerular filtration rate). Another sign of kidney damage is having too much protein in the urine; a sign of damaged blood vessels.

People with kidney disease must avoid high protein diets. Reduced amounts of protein may even delay the onset of kidney disease, but a dietician and/or physician must supervise such a diet to ensure adequate nutrition.

Activity Materials: (per group of 3)

Kidney Model:

- 1 - 3 minute egg timer with kidney façade

Timer:

- ***Student Data Page*** to record times of each successive race
- 1- stopwatch

Filtering Materials:

- 1- Colander
- 1 - Bar magnet enclosed in a ziplock bag
  (Do not remove the magnet from the bag!)
- 1 250 ml clear container to hold nitrogenous wastes
- 1 large bowl

Blood Model Containing Toxic Materials:

- 1000 ml container to hold unfiltered blood
- "Red Blood Cells" = 700 ml volume of red kidney beans
- "White Blood Cells" = 200 ml volume of white lima beans
- "Nitrogenous Wastes" (urea and creatinine) = 100 ml volume of white rice (creatinine) and 100ml volume of white millet (urea)
- "Drug" = 20 ml volume iron filings
- 1 Class set ***Student Information Page***
- 1 Copy ***Student Data Page*** per student

Rules of the Race

1. Read and discuss the Activity Background with your teammates.

2. Assign tasks within your group. You will need a ***timekeeper***, and two people to manage the filtering tasks. When you repeat the race, rotate positions so everyone will get a chance to do different things.

3. A healthy, fully functioning kidney can filter ***1 liter of blood in 1 minute***. In this activity, you will be racing the timer to match the filtration rate of your kidneys. Look over your materials with your teammates and strategize the best method to achieve your goal.

4. Measure out the amount of materials (described in the materials section) to make your "blood" model. This is a dry model, so blood serum is not represented.

5. Set up your colander, bowl, and blood model so the "blood" can enter the kidney quickly when the timekeeper says "go".

6. For each race, turn the kidney timer to one minute and hold there until your ***timekeeper*** indicates "GO!"

7. Record the time of each race in the data table. You will have nine more trials in which to match the filtration rate of your kidneys, so discuss changes you need make in your procedure.

8. Complete your ***Student Data Page***.