**The Clean Up Crew:**

**Diabetic Kidney Disease by the Numbers**

**Activity 2B**

**Activity Objectives:**
Using background information and mathematical formulas, students will be able to:
- describe how the kidneys filter waste products from the blood
- calculate filtration rates
- analyze the effect of diabetes on kidney function
- graph results for comparison

**Activity Description:**
Our kidneys work silently day in and day out filtering waste products from our blood to maintain a healthy environment in which our cells can function. This healthy, balanced state is called *homeostasis*. So effective are our kidneys that they are easily taken for granted – but once something happens that causes them to work less efficiently, dire consequences result. In this activity, students will investigate the effect of diabetes on kidney function.

**Activity Background:**
The kidneys work as a clean up crew in our bodies, see Figure 1. They filter waste materials from our blood, maintaining a healthy internal environment in which our cells can function normally. This internal balance so necessary for life is called *homeostasis*. In order to keep this internal balance, blood enters the kidneys where it is separated into waste and useful proteins. The helpful proteins, such as albumin, stay in our blood and the waste gets eliminated in the urine. The speed with which our kidneys clean our blood is proportional to how much waste is in our blood. The more waste there is in the blood the faster the kidney needs to function in order to get the waste out. The speed at which kidneys filter is called the GFR (glomerular filtration rate). GFR is the best test to measure your level of kidney function. Let’s consider how much both healthy kidneys combined can filter in one minute using all 2 million of their tiny filtration units (*nephrons*). It turns out to be 125 ml per minute (this would be about 1/8 of a liter). This is a lot of filtering! In one day alone the kidneys filter about 180 liters.
A diabetic person who has not taken very good care of himself or herself will likely develop kidney problems. When damage to the kidney occurs, usually 5-15 years after getting diabetes, the kidneys stop functioning as well as they should. The first sign that the kidney has been affected is that some of the good substances that the kidney should filter out and return to the blood begin to be eliminated in the urine. For example, albumin (the most prevalent protein in the blood) begins to be thrown out with all the waste products. Albumin in the urine is the first sign that the kidneys have suffered glomerular damage. This is the beginning of a kidney disease called nephropathy.

Doctors can determine how much damage has been done to the kidney by measuring the GFR (glomerular filtration rate). The way they do this is simply by injecting a sugar called inulin into the body. Then by monitoring urine produced by the patient, doctors can determine how long it takes the kidneys to filter the inulin out of the body.

Remember: healthy kidneys should filter at a rate of 125 ml per minute.

Let’s take a look at the calculations that are involved in determining the GFR (glomerular filtration rate).

The Formula to Figure GFR

$$GFR = \frac{V(Urine) \times U(Inulin)}{Pi(Inulin)}$$

- **GFR** = glomerular filtration rate
- **V(Urine)** = volume of urine
- **U(Inulin)** = concentration of inulin in the urine
- **Pi(Inulin)** = concentration of inulin in the blood
Example: A patient who has been a diabetic for 12 years has just had a urine test and the test showed he has albumin in the urine. Here are the test results:

\[ V \text{ (urine)} = \text{volume of urine} = 0.98 \text{ ml/min} \]
\[ U \text{ (inulin)} = \text{concentration of inulin in the urine} = 120 \text{ mg/ml} \]
\[ PI \text{ (inulin)} = \text{concentration of inulin in the blood} = 1 \text{ mg/ml} \]

Let's calculate to see if the patient has significant kidney damage. Put the test result values into the formula used to calculate GFR:

\[ GFR = \frac{0.98 \text{ ml/min} \times 120 \text{ mg/ml}}{1 \text{ mg/ml}} = 117.6 \text{ ml per min} \]

By comparing this number to the healthy, ideal GFR of 125 ml per minute, you can see that the kidneys have suffered damage and they are now filtering at a slower rate.

*Note: Inulin clearance is considered the “gold standard” for calculating GFR, but in clinical practice, creatine is generally used. The concept is the same, however.*

**Activity Materials:** *(per student)*
- 1 copy of the *Student Information Page*
- 1 copy of the *Student Data Page*
- Calculator
- Ruler
- Map colors

**Activity Management Suggestions:**
Go over the background information with students prior to having them work on the activity. Work several examples using the GFR formula as a whole-group lesson. Then ask students to work one problem independently. Check for understanding, questions, etc. before allowing students to work independently on the remainder of the activity.

Be sensitive to the fact that some students may have diabetes or have family and/or friends with the disease. Stress to students that with *careful disease management* and *doctor supervision*, many diabetics can protect kidney health.
Extensions:
Students can research diabetic nephropathy and design a model that compares healthy kidneys to diseased kidneys.

Activity References Used:

National Kidney Foundation website:
http://www.kidney.org/kidneyDisease/

National Library of Medicine Website:
