**Diabetes Simulator**

You probably know someone with diabetes. Perhaps a relative in your family or a friend from school. Approximately 10% of the US population suffers from diabetes. In the Seattle area, approximately 1 out of 300 children also have it.

**Diabetes** is a disease in which blood sugar is uncontrollable. When you eat, food gets converted to glucose, also known as “blood sugar”. Energy for your body comes from this blood sugar. Low blood sugar causes low energy or even death. High blood sugar also causes serious health problems. Your body works best when blood sugars are maintained in a “sweet” spot (no pun intended!). Your body uses the hormones **insulin** and **glucagon** to maintain this balance. Insulin lowers blood sugar, while glucagon raises it.

Diabetes is actually two different diseases, not one. **Type 1** diabetes, often called juvenile diabetes, is caused when the body’s immune system destroys the cells that produce insulin. **Type 2** diabetes, also called adult-onset diabetes, is caused when the body’s insulin stops working as efficiently.

This demo is an interactive simulation of blood glucose concentrations. A **simulation** is a mathematical prediction about how a system will behave over time. In this simulation you can observe how blood sugar changes in response to different inputs such as foods and insulin medications. By default the simulation mimics the behavior of a healthy person, but you can adjust the settings to create a diabetic condition.

**Systems & Synthetic Biology Lab**

Our lab specializes in simulation technology for biology. This simulation technology can be useful for the development of new medicines, new treatment strategies for disease, and new drug manufacturing processes.

**Simulation Controls**

Use the controls to start and pause a simulation. The first graph shows blood glucose. The two gray lines show the normal range for a healthy patient. The second graph shows insulin and glucagon. These are the hormones that work together to control blood sugar. The last graph shows how much insulin medication has been introduced into the body.

**Bolus**

A **bolus** is just a fancy word for a meal. You can click the buttons to find out the effects of different foods on blood sugar.

Q. What happens to blood sugar after you eat a meal?

A. Blood sugar rises, but the body quickly restores blood sugar to its natural **equilibrium** point.

Q. Which foods raise blood sugar the fastest?

A. Cake and rice cause blood sugar to raise rapidly. These foods include simple carbohydrates that are quickly converted to blood sugar. Pizza causes blood sugar to rise less rapidly. The extra protein in the pizza slows absorption of sugar from your gut.

Q. Based on the simulation, can you make a hypothesis about why you might feel a “sugar crash” after a meal?

A. After a particularly large or sugary meal, your body might overcompensate with the insulin it produces. This could cause blood sugar to drop below its normal range, which is why you might lose energy.

Q. Now look at the second graph. What happens to insulin levels when you eat something? What happens to glucagon levels when you eat something? What is the relationship between these two hormones?

A. Insulin lowers blood sugar and glucagon raises it. You might have noticed that when insulin goes up, glucagon goes down, and vice versa. This relationship is called **antagonism**. There are many other hormones in the body which have this kind of balanced relationship.

**Type 1 Diabetes**

You can simulate Type 1 diabetes by adjusting the slider that controls insulin production. Type 1 diabetes is caused when the body’s immune system starts attacking the cells that produce insulin. Adjust the slider, then wait a moment to see what happens to blood sugar.

Q. What happens when you decrease insulin production?

A. Blood sugar rises and reaches a new **equilibrium** outside the healthy range.

Q. Now “inject” 30 units of Lantus. What happens to blood sugar?

A. Lantus is a long-acting, **basal** insulin. It can help restore blood sugar to its normal values for a period of about a day.

Q. Now “inject” 5 units of NovoLog and eat a piece of cake. What happens to blood sugar?

A. NovoLog is a fast-acting, **bolus** insulin. It is usually taken with meals.

Q. What happens if you take too much insulin?

A. Taking too much insulin is very dangerous and very easy to do. Symptoms of low blood sugar include shakiness, cold sweats, and confusion. It can even be fatal. If you ever come across a diabetic who is having a low blood sugar, just give them sugar and they will quickly recover!

**Type 2 Diabetes**

Now return the Type 1 slider to its original position and adjust the Type 2 slider to increase insulin resistance.

Q. What happens to insulin levels in Type 2 diabetes?

A. At first, your pancreas makes extra insulin to make up for it. But, over time it isn't able to keep up and can't make enough insulin to keep your blood glucose at normal levels.