What is the Effect of Food and Exercise on your Glucose Levels and Metabolism?

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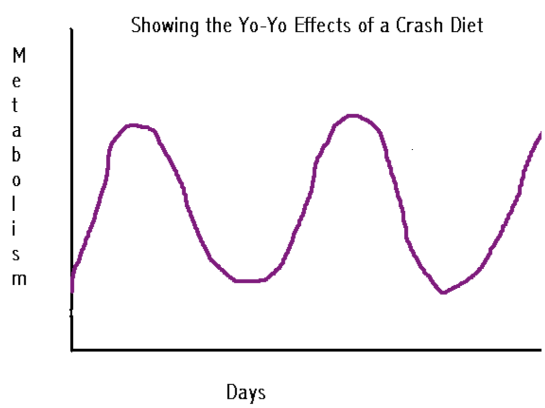
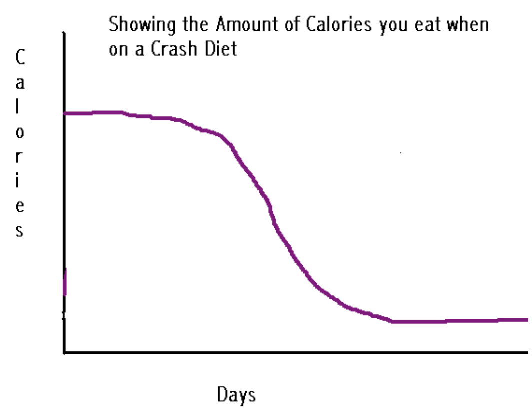
Introduction:

The problem that I am investigating in this model is how dieting and exercise affect your body. We constantly see on TV and in magazines models with the "perfect" tiny figure. Many people take this to the extreme by going on "crash diets." While crash diets can be a quick way to lose weight, they can also lead to major and irreversible health problems. I wanted to look into the effects of going on a crash diet and take a look into the best way to lose weight, or just stay healthy. By making a model of this issue it can help to predict what would happen instead of having to do an actual research study with real people. Also, using a model is useful in giving us numbers to show if the exercise you do and the food you eat could be so harmful as to make you either hypoglycemic or hyperglycemic.

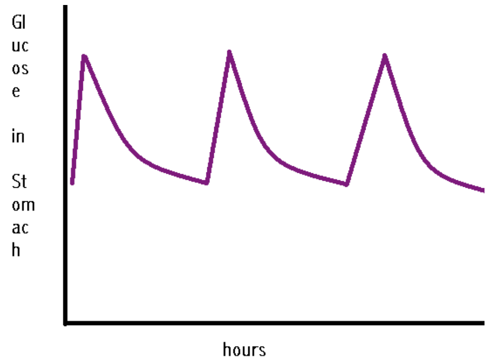
I made Behavior Over Time Graphs (BOTG) of all of the stocks I thought would be important. On epigee.com I found that when you go on a crash diet that your metabolism often fluctuates up and down and is not steady. I felt that this would be an important thing to try and model so I made a BOTG of it in my graph of *Metabolism*. The BOTG that I made of *Calories* is showing how before you go on a crash diet you are eating a specific amount of calories, but in a short time you drop the calorie intake to a very low amount.

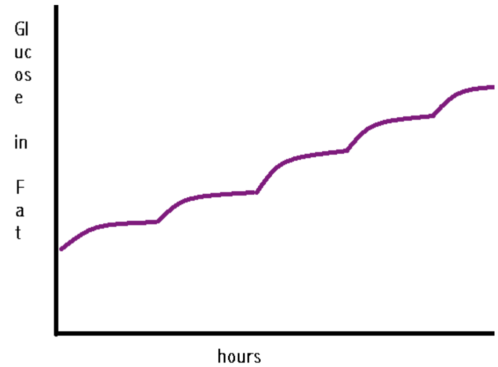


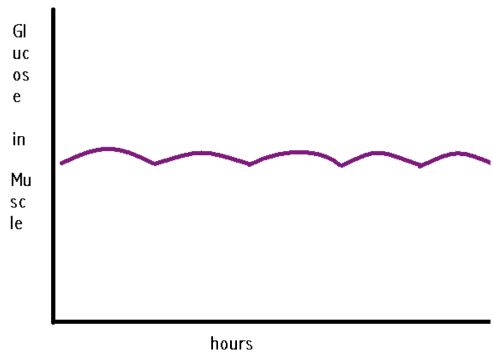


Figures 1 and 2: The two stocks of my first model. Fig. 1 shows the "yo-yo" effects on your metabolism. Fig. 2 shows the change in calorie intake when you start a crash diet.

When I realized that the model of metabolism and calories was not working I had to create new BOTGs to show the new stocks that I was creating. I did not make a BOTG of *Glucose in Liver* or of *Glucose in Blood* because they do not relate to weight and are not important to what I am trying to model. My BOTG of *Glucose in Stomach* shows when you eat food that has carbohydrates in it your glucose levels go up and then while you are not eating the glucose levels go back down. The BOTG of *Glucose in Fat* only rises because glycogen cannot be removed from the fat. The glucose levels don't continue to rise in a straight line because glucose isn't always entering the fat, so instead it goes up only at some points. The BOTG of *Glucose in Muscle* looks similar to *Glucose in Fat* because it also has the "bumps." The difference between the two is that since the glucose can leave the muscle, it can go back down to its normal level after it fluctuates.







Figures 3, 4, and 5: These are the BOTGs for the second and third version of my model. Fig. 3 shows the effect of food intakeon the glucose concentration in the stomach. Fig. 4 shows the effect of food intake on glycogen in the fat. Fig. 4 shows the effect of food intake on glycogen in the muscle.

The Process of Model Building:

My first model was designed to show how a crash diet affects your metabolism. To do this I made two stocks, *Metabolism* and *Calories.* It showed how the amount of calories you eat affects your muscle weight (because it is taking the glucose out of your muscles to help keep energy up), which in turn affects your metabolism. According to iVillage.co.uk, when you go on a crash diet your body goes into starvation mode and then takes the glucose from the muscle. When you start to lose the muscle, it makes your metabolism go down as well because it can't burn calories as quickly. It is best to stay away from this because when your metabolism becomes unstable it can bring many health problems. The converter, *Resting Metabolic Rate*, shows the amount of calories burned just by sleeping and breathing. I got the equation for *Resting Metabolic Rate* from caloriesperhour.com. This model seemed simple when I first started making it, but I soon got stuck trying to figure out different convertors. Eventually I realized that the model I was creating was an impossible model to create. My problem was that I needed to know an average amount of muscle mass for a person and a way to find the amount of muscle you had in your body at that moment. This is impossible to find because muscle mass depends on so many different things. Because the model was getting nowhere, I had to fully restart.

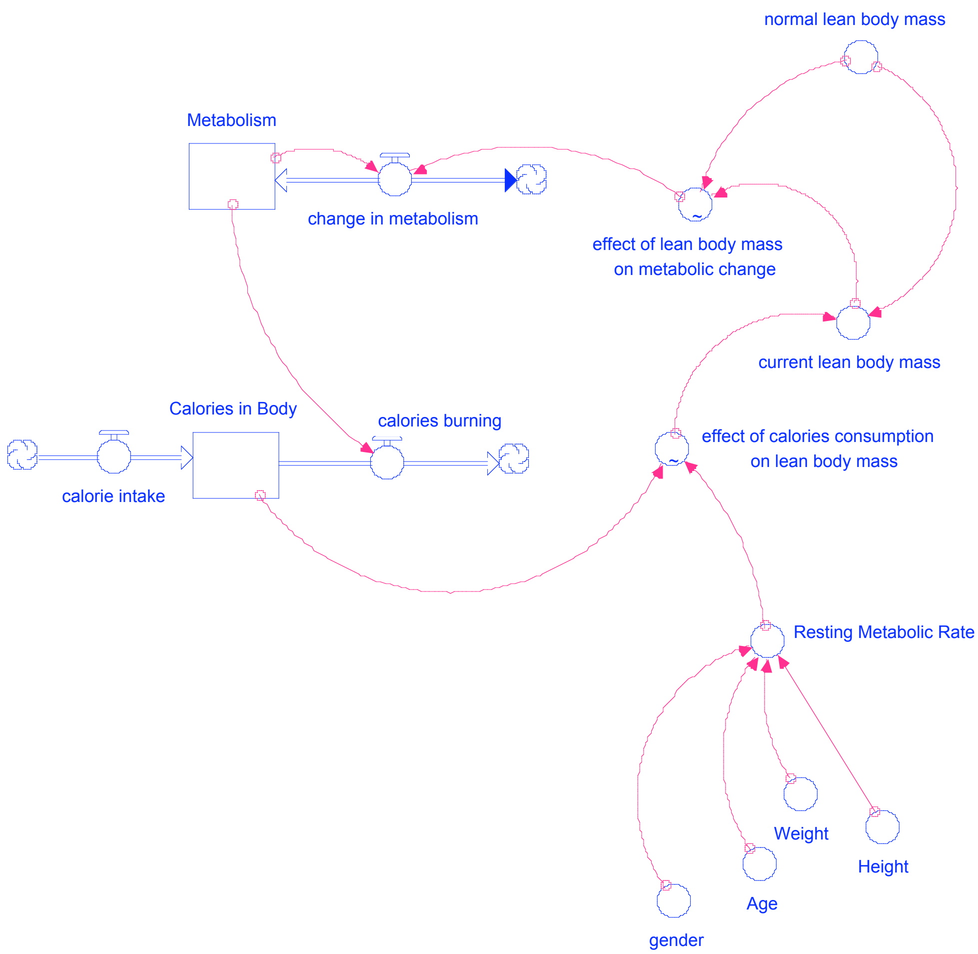


Figure 6: This is the first version of the model.

The second time I began to create the model, I based it off of glucose going through your body. I got this idea from an article by Tarek K. Abdel-Hamid, titled "Exercise and Diet in Obesity Treatment: An Integrative System Dynamics Perspective." In this article he spoke about a more advanced model of what I am trying to show in my model. From his explanations I came up with a basis for my model. In my model I showed how when you eat carbohydrates, glucose enters into you stomach. When the glucose enters into the bloodstream it is then stored into one of three places: the liver, muscle, and fat. Normally the glucose goes into the liver and muscle where it can be taken out as well. Because the liver can hold only 100 grams of glucose and the muscle can hold only 200 to 400 grams of glucose (I found these numbers from bodybuilding.about.com), once they are filled, the glucose begins to enter the fat. Once glucose enters the fat it cannot be removed, so it is best to try to keep glucose from going into the fat. Another important factor that I put into this model was insulin. Insulin is what takes the glucose from the blood and into other places in the body. Without insulin, your glucose metabolism would not work. I made *Insulin* a converter because it does change but it is not important enough to want to regulate it consistently.

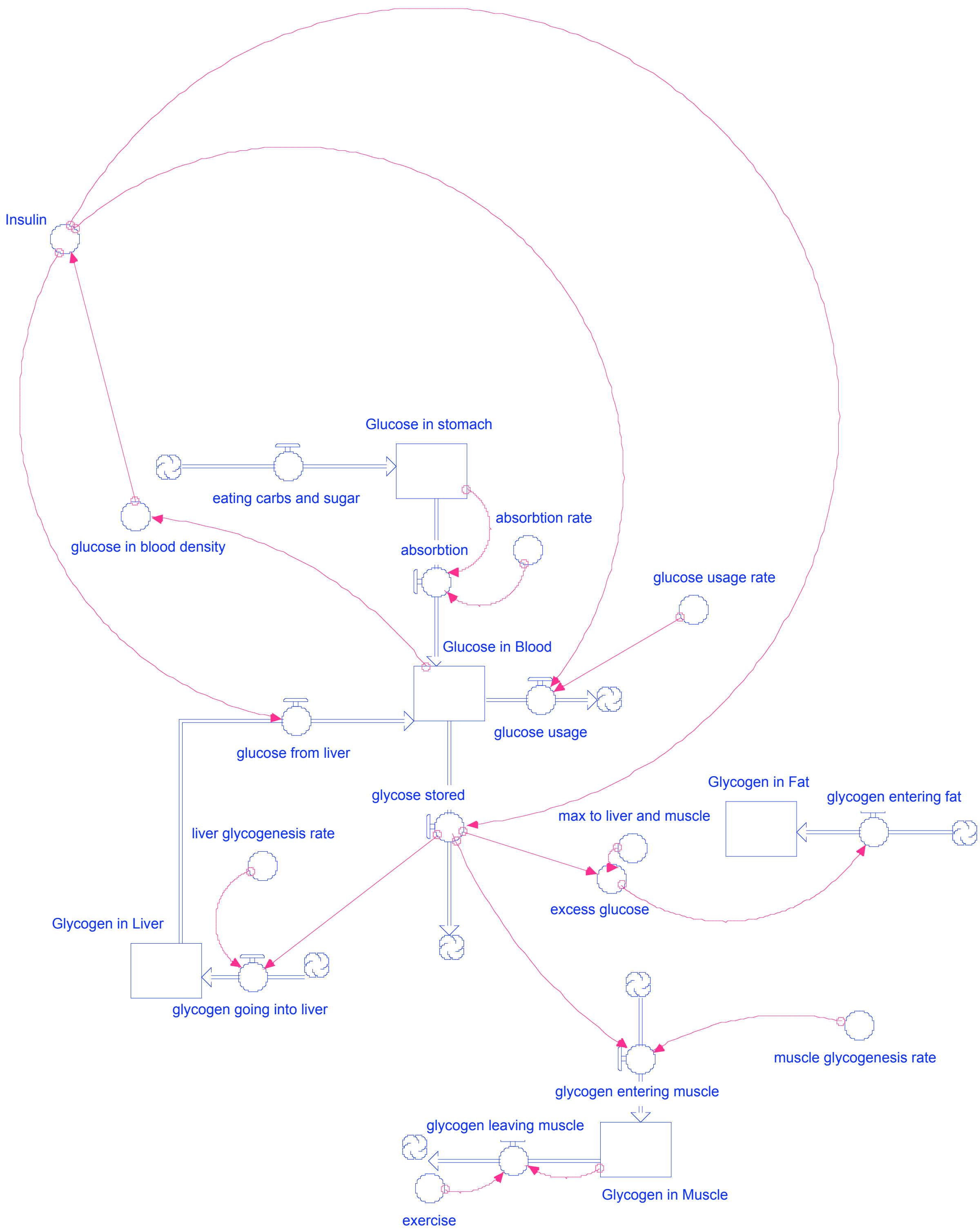


Figure 7: This is the second version of the model.

The Finished Model and How It Works:

The final version of my model shows the effects of both carbohydrate intake and exercise rate on your glucose levels in different areas of the body. Five main areas of the body where glucose is found are the stomach, the liver, blood, muscle, and fat. In these different places, the glucose is regulated and used in different ways. The *Glucose in Stomach* is the glucose that has come in from food intake and is preparing to enter into the blood. The *Glucose in Blood* is the glucose that has been absorbed by both the stomach and the liver and is preparing to be dispersed to the liver, muscle, or fat.

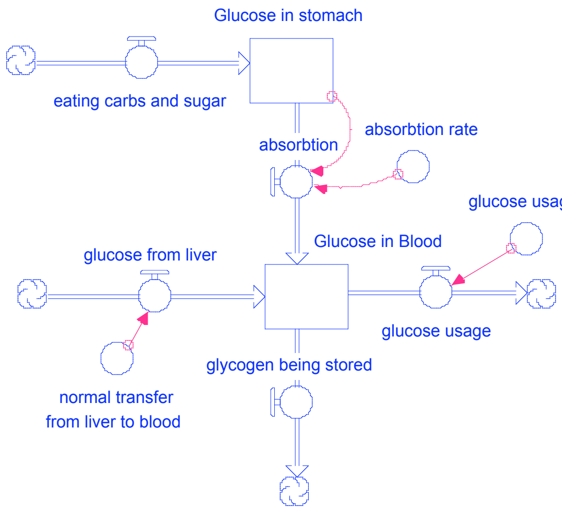


Figure 8: This is a diagram of a closer look at one section of the model.

The glucose is dispersed to the different areas of the body by the insulin. When there is more glucose in the blood, more insulin is secreted. The *actual percent of insulin secreted* is then used in transferring *glucose from liver* back into the blood, in helping with *glucose usage*, and in *glucose being stored*.

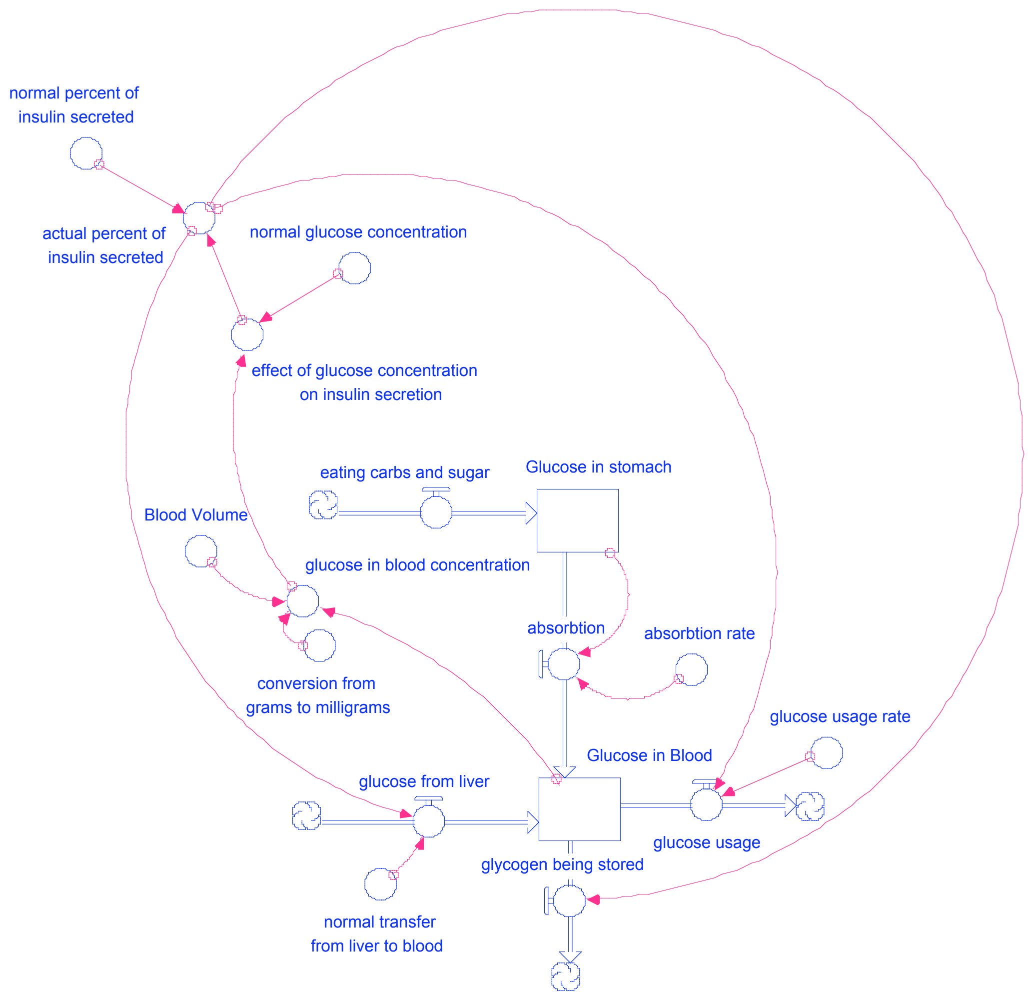


Figure 9: This is a diagram of the section of the model shown in Figure 8, but with insulin converters added

When the glucose is stored into *Glycogen in Muscle*, it can leave the muscle through exercise. When glucose is stored into *Glycogen in Fat*, it cannot leave; the cells can only get smaller.

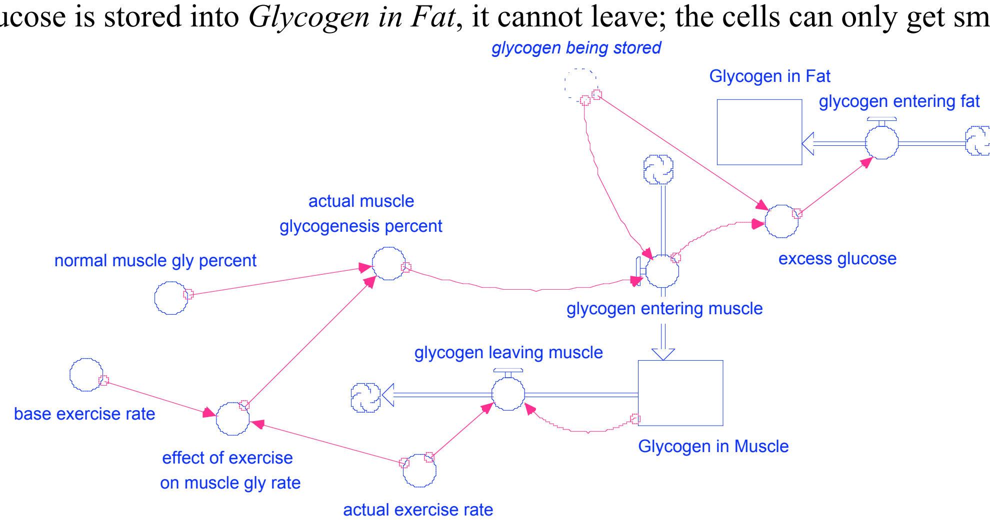


Figure 10: This is a diagram of the section of the model that shows *Glycogen in Muscle* and *Glycogen in Fat*.

It is possible to prevent glucose from entering the fat. This can be achieved by either going on a diet, and/or increasing *actual exercise rate*. The diet makes your glucose intake go down, therefore making less go into the fat. Exercise works to decrease the flow of glucose into the fat because glucose only enters the fat when the liver has 100 grams of glycogen and when the muscle has 200 to 400 grams of glycogen. By exercising you decrease the amount of glycogen in your muscle, therefore making more room for more glycogen to enter back in, and not into the fat.

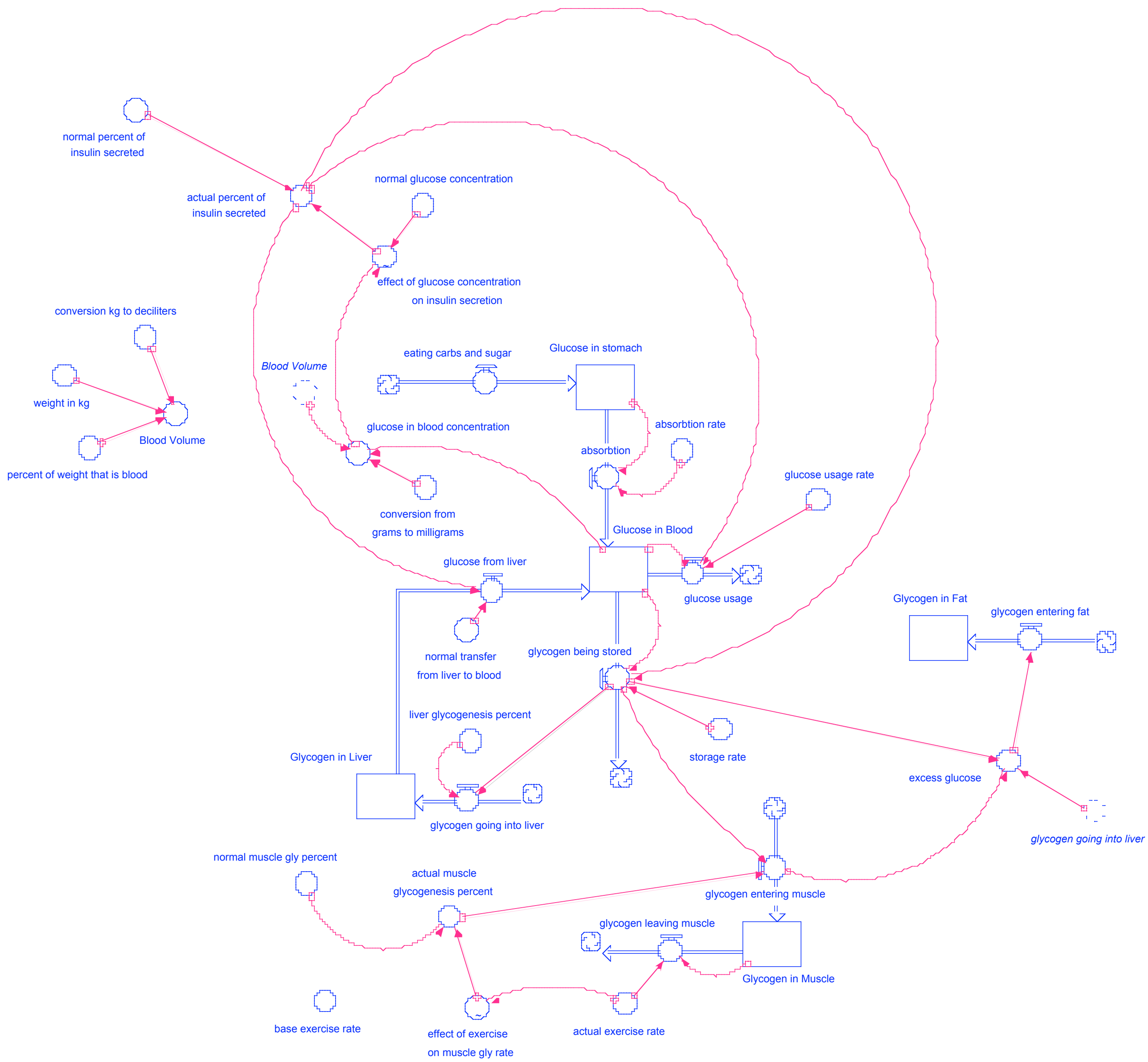


Figure 11: This is the final version of the model.

The Model Feedback & Loop Story

There are two feedbacks in this model. They are both counteracting. In the first feedback loop it shows that when *Glucose in Blood* rises it makes the *glucose in blood concentration* rise, which in turn makes the *actual percent of insulin secreted* rise as well. When the insulin secretes more glucose, it takes it out of the blood, therefore making the *Glucose in Blood* go back down. This feedback loop is shown in figure 12, below.

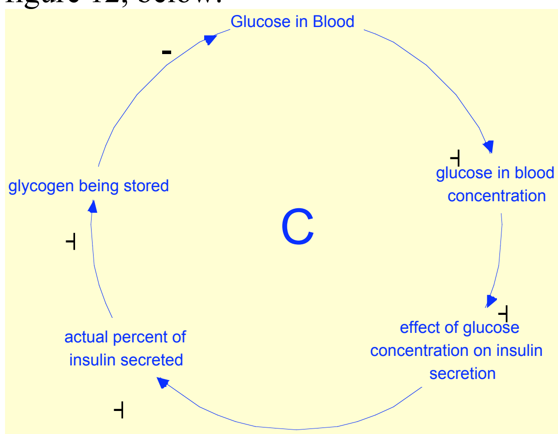


Figure 12: This is the feedback loop in the final model that includes *glycogen being stored.*

In the second feedback loop it shows that when *Glucose in Blood* rises it in turn makes the *actual percent of insulin secreted* go up. When more insulin is secreted, the *glucose usage* goes up, which makes the *Glucose in Blood* go down.

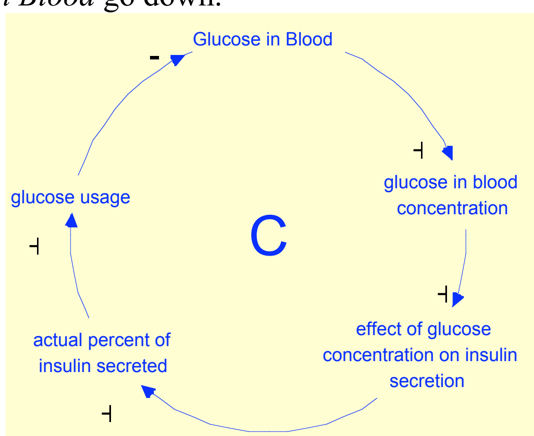


Figure 13: This is the feedback loop in the final model that includes *glucose usage.*

Both feedbacks affect the whole system because *Glucose in Blood* is where glucose goes once it enters the body, and where it stays until it is dispersed into either the different parts of the body or is used. The feedback in Figure 12 controls the level of glucose in the blood by storing the glucose. The feedback in Figure 13 controls the level of glucose in the blood by using the glucose. By being stored or used, the glucose leaves the blood and keeps the levels of glucose in the blood at a relatively balanced level.

The model generates the behavior of interest endogenously. This is a model of a human's body, and all parts of the body work in relation to each other.

The Model Boundaries

This model has many things missing from it, and the main reason for their omission is the fact that it is difficult to make such a complicated model in a short amount of time. One part that I left out was being to actually be able to determine the weight of the person using the model. I left this out because it would have been very complex and I didn't find it necessary. The reason I didn't find it necessary was because I was able to show the bad effects on your body from going on a crash diet just by showing glucose. Another part I left out of the model was hormones. Hormones can also affect the glucose levels in the body. I found that information in "Exercise and Diet in Obesity treatment: An Integrative System Dynamics Perspective." I also left out foods other than carbohydrates that you might eat. The reason I left that out was because I was only looking at glucose levels, and carbohydrates were the only things that I found to put glucose into your system.

I decided to make the model be simulated for 24 hours. This is because I wanted to look at the effects in one full day of what you eat and the amount of exercise you do.

Model Testing

When I tested my model I only changed either the inflow of *eating carbs and sugars* or the *actual exercise rate*. Whenever a graph says either more or less of something, it is in comparison to the control graph. By decreasing the carbohydrate intake, it shows the effects of going on a diet. By increasing the exercise rate it shows the effects of doing more exercise. I did five tests on the model.

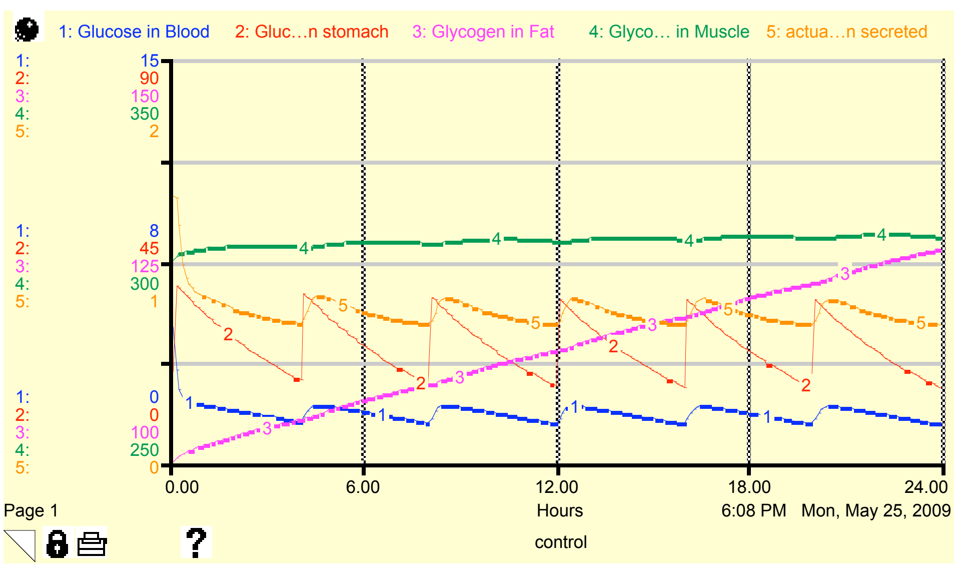


Figure 14: This is the "control graph." It shows when *eating carbs and sugar* is pulsed every 4 hrs at a rate of 20 and when *actual exercise rate* is pulsed every 4 hrs at a rate of .01.

The first test was of increasing exercise. The graph that resulted from this made sense because the *Glycogen in Muscle* declined and the *Glycogen in Fat* didn't rise as quickly as it did in the control test.

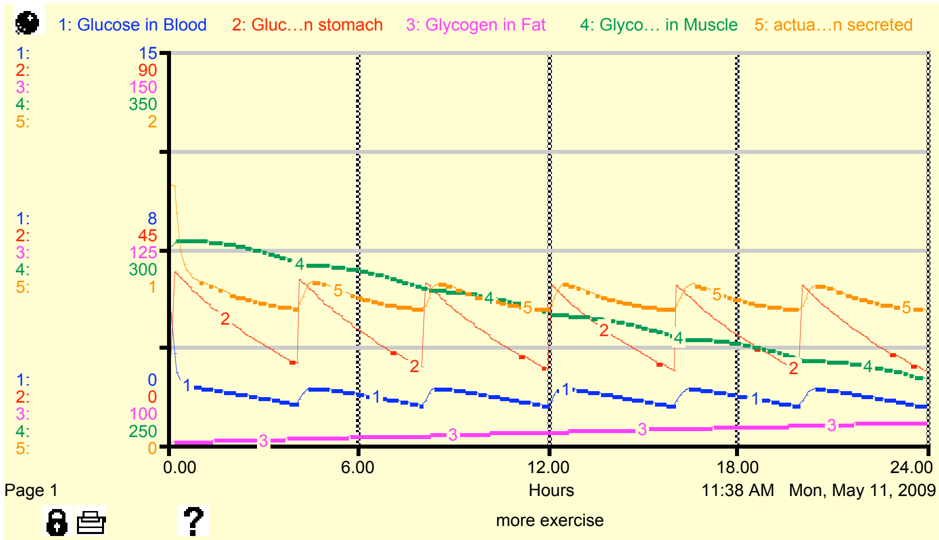


Figure 15: This is the "more exercise graph." It shows when *eating carbs and sugar* is the same as the control, but *actual exercise rate* is pulsed every 4 hrs at a rate of .02.

The second test was increasing carbohydrate intake. The graph that resulted from this made sense because both *Glycogen in Muscle* and *Glycogen in Fat* rose higher. This shows that when you eat more, more glucose enters into your body and goes into the muscle and fat.

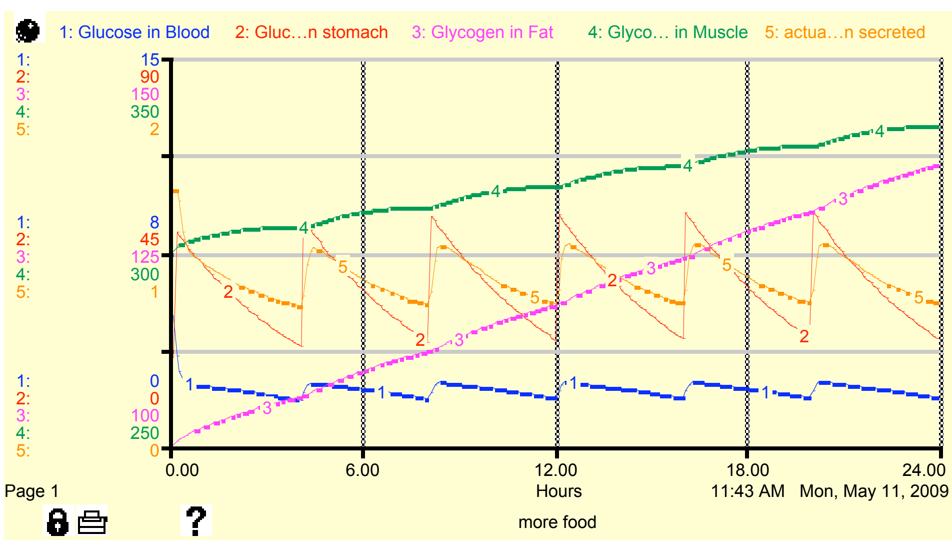


Figure 16: This is the "more food graph." It shows when *actual exercise rate* is the same as the control, but *eating carbs and sugar* is pulsed every 4 hrs at a rate of 30.

The third test was increasing food and exercise. I did this test to see if it is possible to maintain weight even if you eat more food. The graph that resulted did show this because the *Glycogen in Muscle* stayed relatively the same as it had in the control.

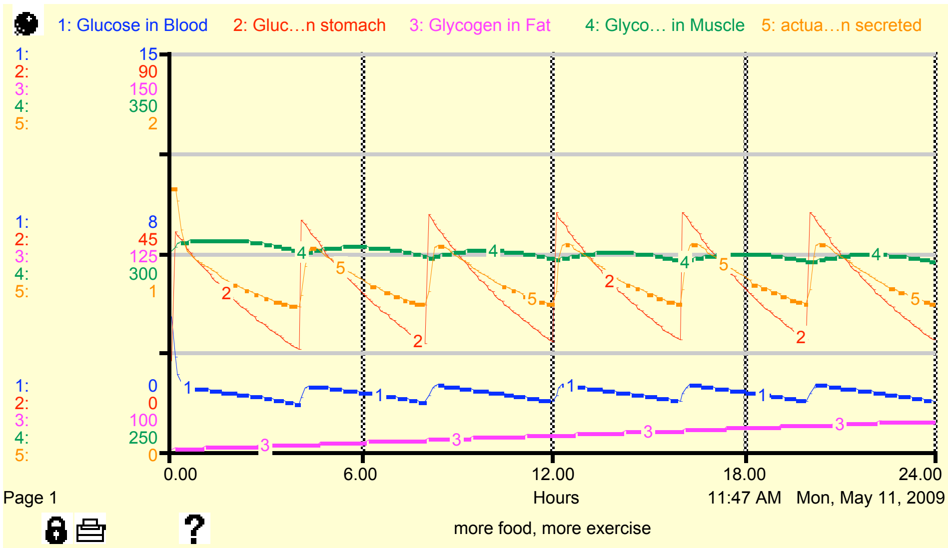


Figure 17: This is the "more food, more exercise graph." It shows when *eating carbs and sugar* is pulsed every 4 hrs at a rate of 30 and *actual exercise rate* is pulsed every 4 hrs at a rate of .02.

The fourth test was decreasing food and increasing exercise. This test shows what most people do to lose weight. The resulting graph was similar to the test of increasing exercise, except that *Glycogen in Muscle* decreased much quicker. This shows that when trying to lose weight, exercise is the most important factor.

Figure 18: This is the "less food, more exercise graph." It shows when *eating carbs and sugar* is pulsed every 4 hrs at a rate of 10 and *actual exercise rate* is pulsed every 4 hrs at a rate of .02.

The fifth test was decreasing food. The graph showed that the *Glycogen in Muscle* went down, but the *Glycogen in Fat* still went up a lot. This helps to support the theory that going on a diet is the worst way to lose weight.

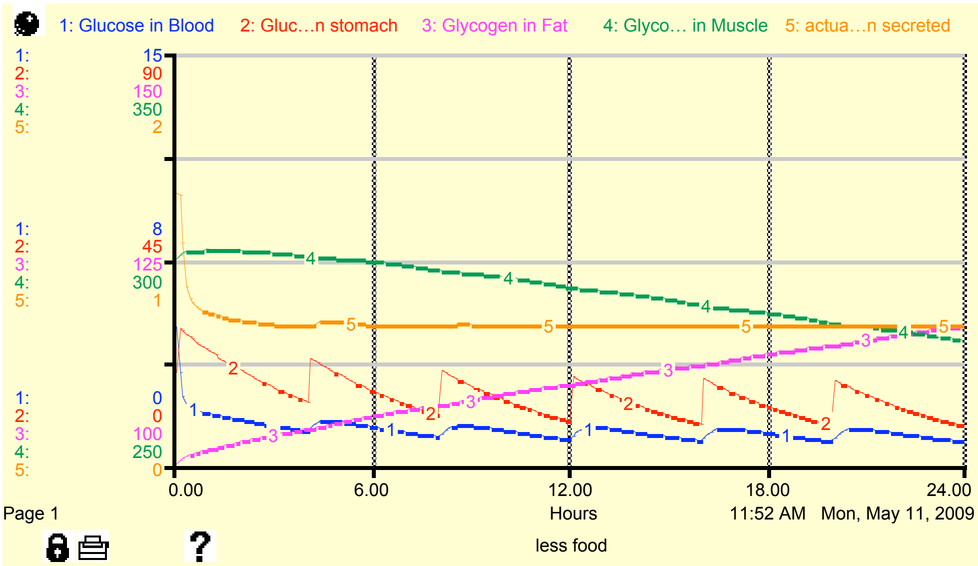


Figure 19: This is the "less food graph." It shows when *actual exercise rate* is same as the control, but *eating carbs and sugar* is pulsed every 4 hrs at a rate of 10.

The model agrees with my BOTG. As I predicted, the graphs of both *Glycogen in Fat* and *Glycogen in Muscle* have a bumpy shape.

I made a sensitivity analysis of *Glycogen in Fat* and how it changes based on *actual exercise rate.* The first line shows what happens when exercise is .01. The second line shows what happens when exercise is .02. This shows that by doing more exercise, less glucose enters the fat.

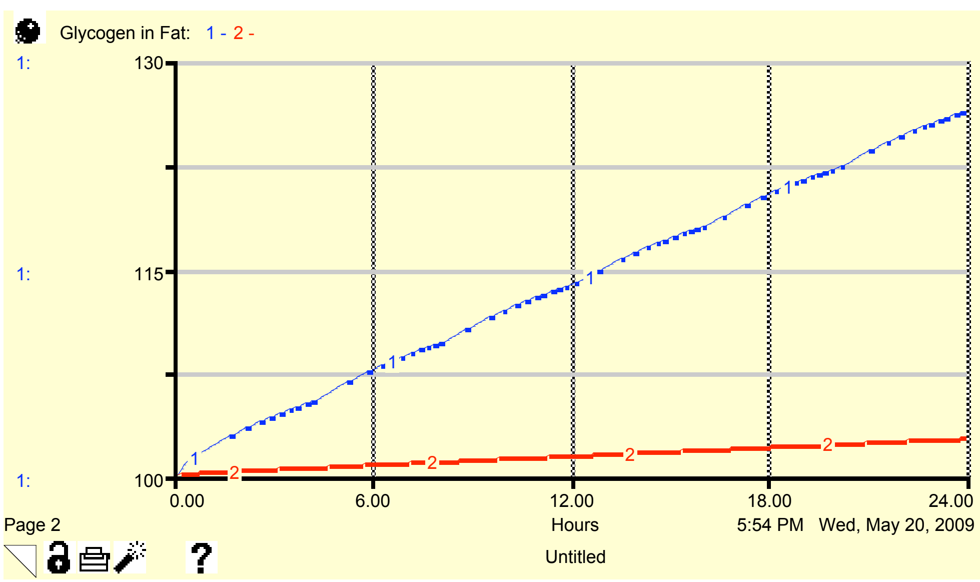


Figure 20: This is a sensitivity graph of *Glycogen in Fat.* Line 1 is of when *actual exercise rate*=.01. Line 2 is of when *actual exercise rate*=.02.

The Results of Modeling and Thinking

By making this model it helped to show that when trying to lose weight, a crash diet is your worst option. It instead showed that exercise is more important to keeping glucose from entering into the fat.

I chose two graphs as my final graphs. They are the graphs of fewer carbohydrates and of more exercise. I chose them to show the comparison between the two ways to lose weight, diet and exercise. The graph of a diet shows that when going on a diet it does not prevent glucose from entering the fat as well as the graph of increased exercise.

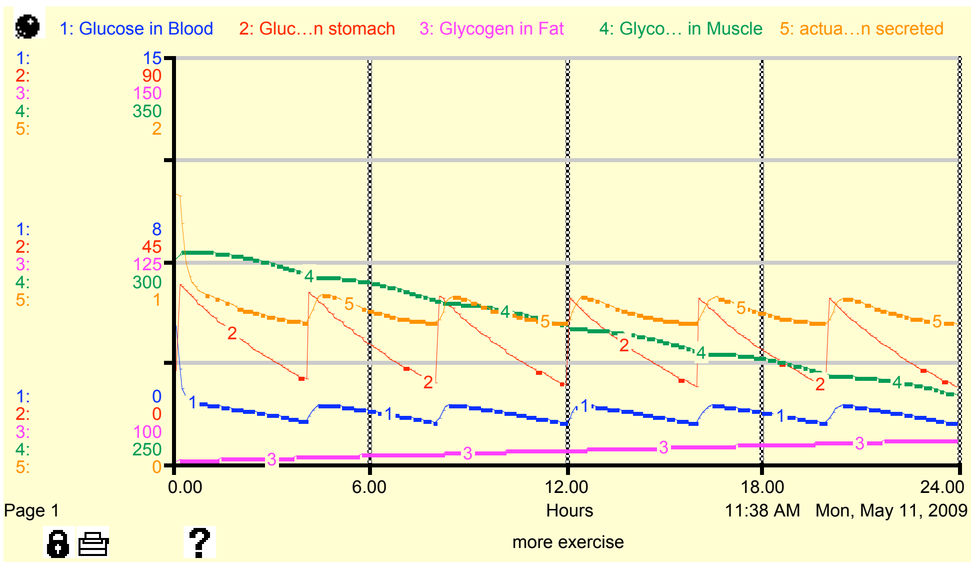


Figure 15: This is the "more exercise graph." It shows when *eating carbs and sugar* is the same as the control, but *actual exercise rate* is pulsed every 4 hrs at a rate of .02.

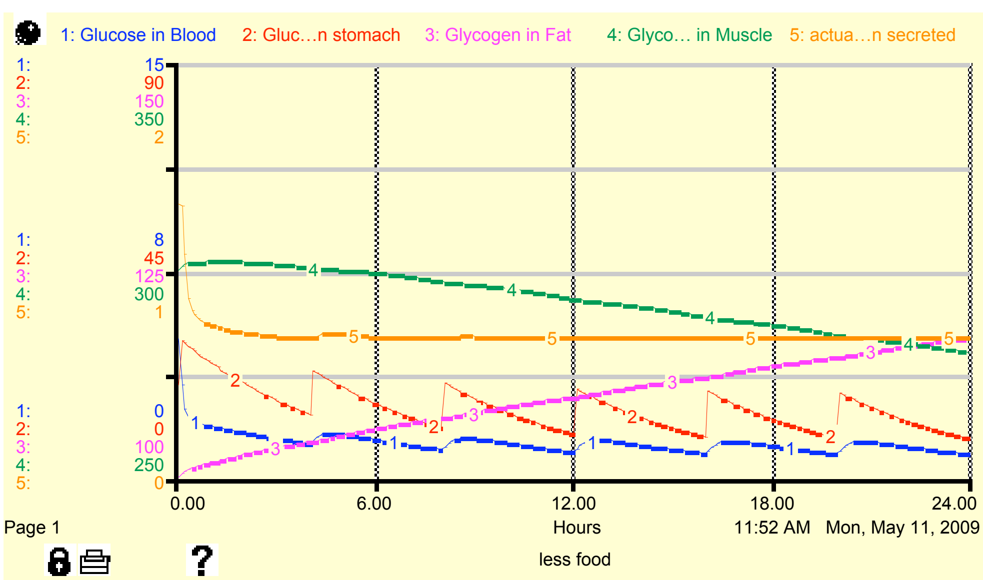


Figure 19: This is the "less food graph." It shows when *actual exercise rate* is same as the control, but *eating carbs and sugar* is pulsed every 4 hrs at a rate of 10.

The Key Learning from the Modeling Process

- I learned that crash diets are not healthy, and that you should exercise instead.
- I learned that many different factors are related to the way your body works and it is important to understand your own body.
- I learned that the human body is complex and that each part interacts with other parts and do different and important things.
- I learned that weight loss and gain is based on many different factors, such as metabolism and glucose levels.
- I learned how difficult it can be to create a good, working model. This is because it can be difficult to find the right numbers and create equilibrium.

What is the Effect of Food and Exercise on your Glucose Levels and Metabolism?

By creating this model I learned that by either increasing exercise or decreasing food intake, it helps to the glucose levels in fat down. The difference between food and exercise, though, is that by decreasing the amount of food you eat it decreases metabolism, while exercise increases metabolism.

To test other ideas I might find real numbers. By doing this I would be able to actually add into the model things such as *actual weight*. This model would be very difficult to create, but it would be able to show the actual effects of diet and exercise on your weight. I also might be able to expand the model by adding in other things that affect a person's metabolism. For example, there is weight, body temperature, and many other things. By adding these things it can show how complex the human body is and help show all the relationships between different parts of the body.

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Appendix

EQUATIONS:

Omitted