Diabetes Learning Lab in Stella 10

Glucose concentration levels in blood

Designing the future from within

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Abstract

In this activity, the body reaction in the intake of food will be simulated: Food amount; type of food; when the intake of food took place; how fast the digestion occurs; reaction time of the pancreas; the connection between the blood glucose concentration and the insulin production.

The content will also cover the subject between the coordinated and harmonious functioning of the pancreas (which secretes insulin), the liver, and the body's cells (insulin receivers). The Homeostasis: Process that regulates the blood concentration. Together we'll discover the cause-effects cycles that characterize the problem and how they become an important part of the solution.

This article will span the effect of pancreas' insulin production in diabetes type I, as well as the cells' glucose uptake and their rejection to insulin, all this with the intention of visualizing how it breaks into the cause-effect cycles that regulates the blood glucose concentration in the body, triggering the imbalance in health.

Keyword: **Learning Labs, Social Sciences, Biology, system dynamics, diabetes, glucose, insulin, Cause-effect cycle, public health, modeling and simulation.**

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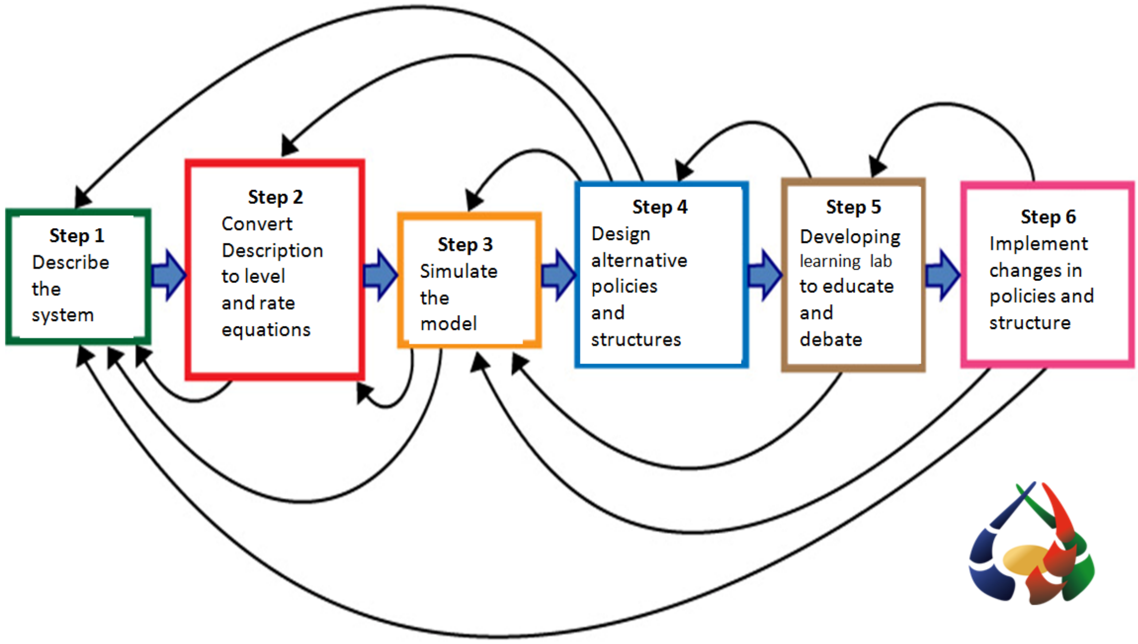
Introduction:

When I was studying the Chemical Engineering and Systems degree in the Instituto Tecnológico de Estudios Superiores de Monterrey (I.T.E.S.M.) in 1979, I had the opportunity to study a really hard subject named “Sistemas de Control” (Control systems) in the mechanics field which introduced us to the establishment of the regulatory mechanisms of water levels in a tank, or temperature in a room, or open and close gates on a dam and some other issues like that. In those years it was necessary a deep understanding of higher mathematics and lots of theory that we could only imagine in our minds since there were not computers to display a basic representation of the behavior over the time of such systems and thus be able to visualize in a clearer way the impact of our decisions when altering these control mechanisms.

I remember with great clarity an occasion that my Professor Enrique González (who was a great teacher in the subject that could have been the hardest class I took in my career). We were assigned a task to go to the library (though there was not internet) to find examples of self-regulatory systems within our body. I was rather surprised to see that we are full of those systems, everywhere, if we examine what happens to our circulatory system with many control cycles that regulates the blood flow valves automatically. In addition we must mention the mechanisms that regulate temperature, breathing, heart rate, etc. The truth is that I was embodied with this discovery. Human body is truly a perfect machine. It’s a wonder of God in the creation.

Who could imagined that 30 years later, all this issues would connect to the content of this article developed to understand in a better way the **Diabetes,** its negative feedback cycles regulate self glucose level concentration in blood to a healthy limit, which connects every meal to the release of glucose in the digestive process, with the pancreas and insulin secretion, liver, kidneys, bloodstream and the energy required by cells.

Steps to develop learning laboratories.



Background: Glucose and Insulin and the Role of Pancreas.

We get most of our glucose in the digestion process from sugar, starch and carbohydrates. Foods such as rice, pasta, cereals, potatoes, fruits, some vegetables and, processed candies already classified as carbohydrates. Our digestive system, in addition to the bile and enzymes, work breaking down the starch and sugar founded in food turning it into glucose. This functional form of energy is then absorbed through the small intestine into the bloodstream. There, combined with glucose, a chemical known as insulin is secreted by the pancreas. Together, they're absorbed by cells in the muscles and brain, allowing glucose to bring the needed energy for developing activities such as lifting a book or remembering a phone number.

Due to the fact that it is a vital form of energy, and it interacts with both the digestive and endocrine systems, to maintain glucose within a normal range is critical to health. Our body is adapted to maintain this ideal glucose level by storing excess of sugar as glycogen in the liver, so it can be reabsorbed when sugar levels drop.

Glucose.

Glucose, a simple sugar, is the main source of energy for most organisms. The human body makes glucose from food and transports it to cells through the bloodstream. Glucose is measured in milligrams per blood deciliter {mg / dl}. The average of a healthy human being is about 60 {dl} of blood (6 liters) and, between every meal, blood glucose levels about 100 {mg / dl} or 6000 mg circulating in the blood. (The range average of a person who is fasting is {70 to 120 mg / dl}.)

The amount of glucose in blood varies with food intake and also with fat breakdown by the liver to produce glucose. The glucose release is measured in {mg / min}.

Pancreas.

The pancreas controls the level of blood glucose by secreting the hormone insulin in response to an increased glucose level. The pancreas secretes insulin in beta cell groups called islets of Langerhans, after the German scientist with this name was the first describing them.

As insulin circulates in the blood, the body's cells take glucose from the blood. Therefore glucose level decreases, causing the pancreas to secrete less insulin. This interrelationship between glucose and insulin is an example of many other feedback cycles, and it works similarly to the way that a home thermostat controls the temperature of the room.

Insulin.

Insulin helps cells to take glucose. It makes the cell membrane more permeable to sugar. The rate of normal insulin secretion is about 500 {mg / min}, this is the amount needed to maintain the balance between insulin and glucose. This balance is essential for homeostasis, which is the normal and healthy condition in the internal environment of the human body. The level of insulin is measured in units (1 unit = 1 mg) and the rate of insulin secretion in {mg / min}.

Use of glucose.

Cells use glucose to provide their energy needs. The non essential glucose to produce energy is then converted into glycogen in the liver and the muscles. These cells convert the glycogen into glucose when the body needs it. The glucose excess is stored as fat in the body. The glucose usage rate is measured in {mg / min}.

Insulin decomposition.

Insulin is degraded shortly after the secretion. Every minute 1 / 18 of insulin are broken down in the blood (in other words, insulin has a useful lifetime of 18 minutes). As the insulin levels increase, the more insulin is degraded in the lower levels. That is, the degradation rate is faster in elevated insulin levels.

Homeostasis

It literally means "in the same state" and refers to the process of maintaining the internal environment of the body in a steady state or equilibrium when the external environment is changed. Much of the hormonal system and the autonomic nervous system are dedicated to the homeostasis, and its action is coordinated by the hypothalamus. There are many examples of living organisms that are operated by the Homeostasis, among it bears mentioning:

1. Breathing.
2. Heart rate.
3. The body temperature control.
4. The blood glucose control.
5. Water control in the blood.

All homeostatic mechanisms use a negative feedback cycle to maintain an unchanging value (called the set point). Negative feedback means that when a change occurs in the system, it automatically starts a corrective mechanism, reversing the occurred change and bringing the system back to the set point again (that is, the 'normal' state).

Thus, in a system controlled by a negative feedback cycle, the ideal level is never perfectly maintained, but it varies constantly on the set point. The oscillation size is minimized by an efficient homeostasis process. However, some variations would be allowed. Otherwise, both corrective mechanisms would try to operate at once! This fact is particularly true in the homeostatic mechanisms controlled by hormones (and most of them are) in which there is a significant time lag before the corrective mechanism can be activated. The reason this happens is because to initiate the synthesis of proteins, the diffusion of hormones into the bloodstream and circulation throughout the body and produce effect, takes time.

The Diabetes

Maintaining an equilibrated blood glucose level is critical for the human body. If the amount of glucose in the blood is too high or too low, serious physical problems may occur.

In people with diabetes, the body can not properly control its blood glucose level. Diabetics need to adjust their diet and exercise style, inclusive; in some cases they might use medication.

There are other natural remedies in medicine that are being very effective in the treatment of diabetes. One of them is the tea leaves of Neem tree from India, which is very cheap and extremely effective.

Homeostasis: cause-effect cycles 1

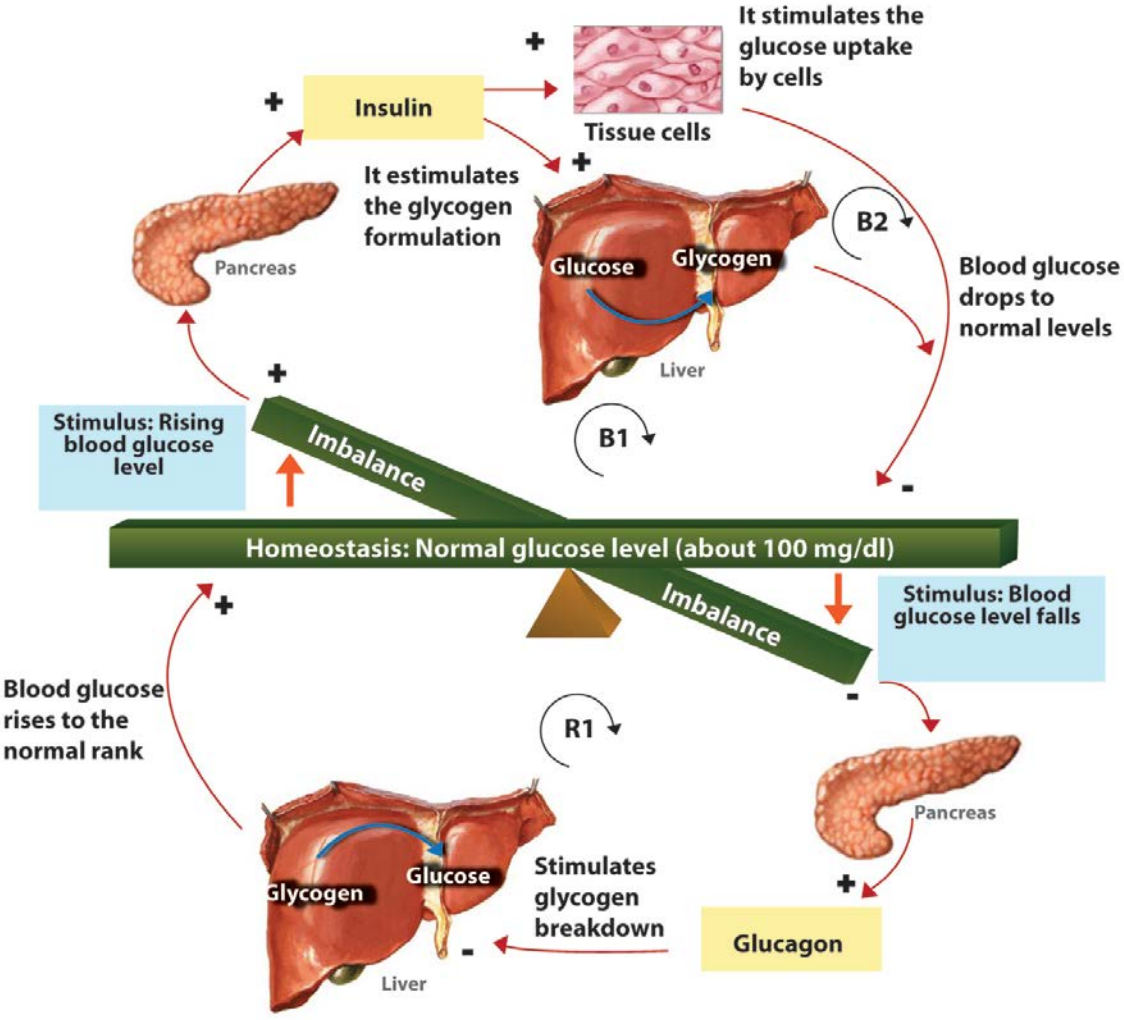


Figure 1: Diabetes cause-effect cycles of Homeostasis.

Homeostasis: cause-effect cycle 2.

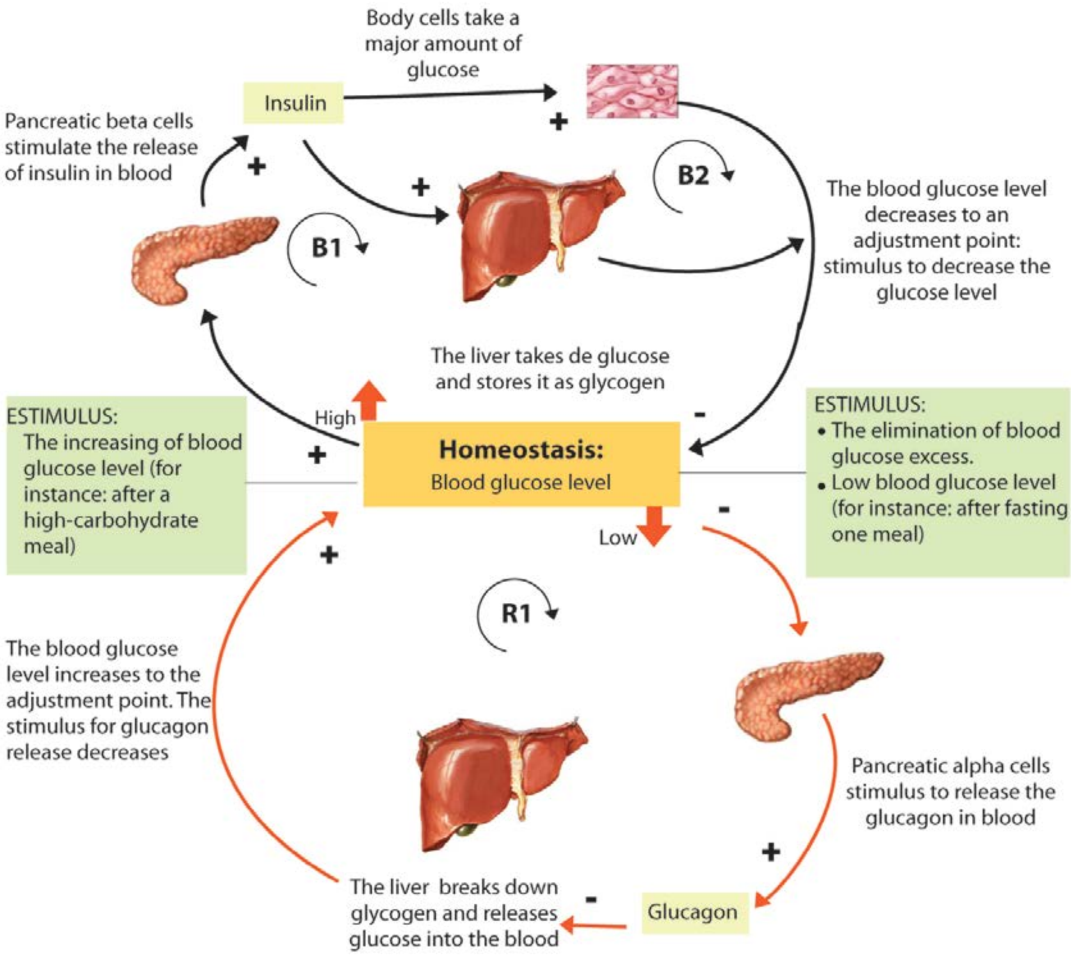


Figure 2: Diabetes cause-effect cycles of Homeostasis ilustrated.

Diabetes type I.

In diabetes type I, beta cells secrete insulin in a little amount or not. Type I is often known as juvenile diabetes because it is more common in young people.

Diabetes type II.

In diabetes type II, the pancreas secretes insulin at healthy rates, but the body cells do not take the glucose because they do not respond well when insulin works to give them the glucose. Diabetes type II is often called Diabetes of the Adult or non-insulin-dependent diabetes mellitus.

The Glucose Tolerance Test.

A glucose tolerance test is often used to diagnose diabetes. The test measures the body's ability to use glucose. Before, a fasting for 8 to 12 hours is needed, and then a solution containing 75 grams of glucose is taken. During the next 3 hours, four blood samples are taken at equal time intervals. For a healthy person, the blood glucose concentration is lower than 195 {mg / dl} after 1 hour, less than 160 {mg / dl} after 1.5 hours and, less than 140 {mg / dl} after 2 hours.

Conditions after a glucose tolerance test of glucose are shown in the table below:

Condition	Glucose concentration {mg/dl}	Blood level {dl} deciliters	Blood Glucose Total Amount of {mg}
Normal Blood Glucose Concentration	80-110	60	4,800 – 6,600
Hypoglycemia	< 40	60	< 2,400
Renal Threshold	160 - 180	60	9,600 – 10,800
Hyperglycemia	> 210	60	> 12,600
Glucose Healty Level of the Model.	*100*	60	6,000
Insuline Healty Level of the Model.	*150*	60	9,000
Renal Threshold for the Model.	*160*	60	9,600

Table 1: Glucose condition's, glucose reference bands in a healthy person with a blood level of 6 litters.

Model.

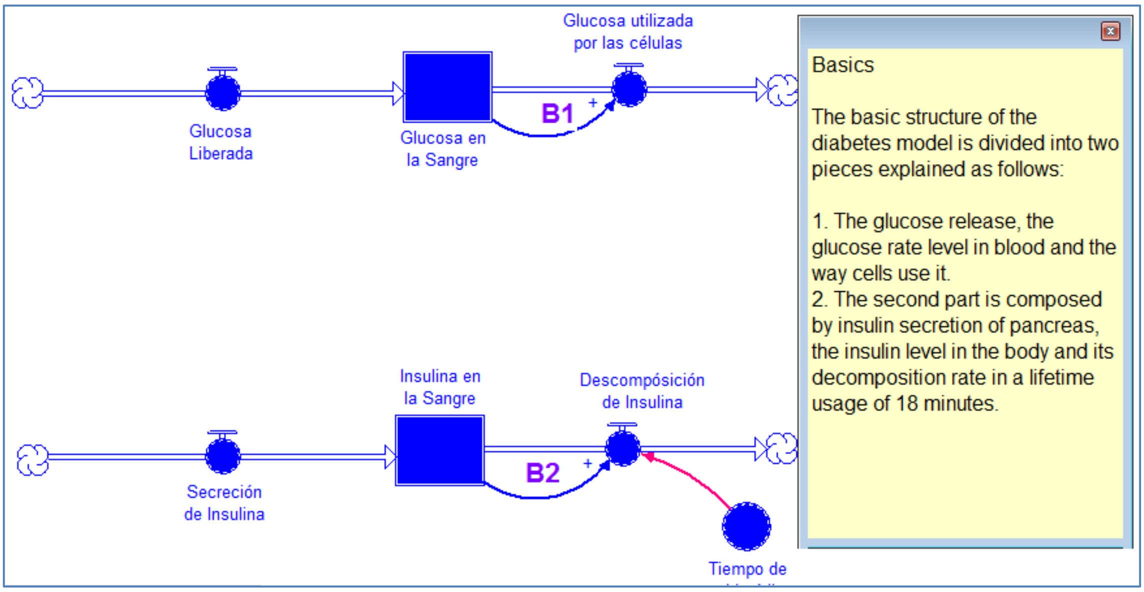
This model simulates the body's reaction when the intake of food has place: food amount, type of food, when does the intake of food took place, how fast the digestion occurs, and reaction time of the pancreas. The insulin secretion rate is defined as a graphical-function, based in the blood glucose excess.

If the glucose level is normal (homeostasis), there isn't a glucose excess. The surplus is zero and the insulin secretion rate is about 500 {mg / min}, maintaining the equilibrated state also called homeostasis.

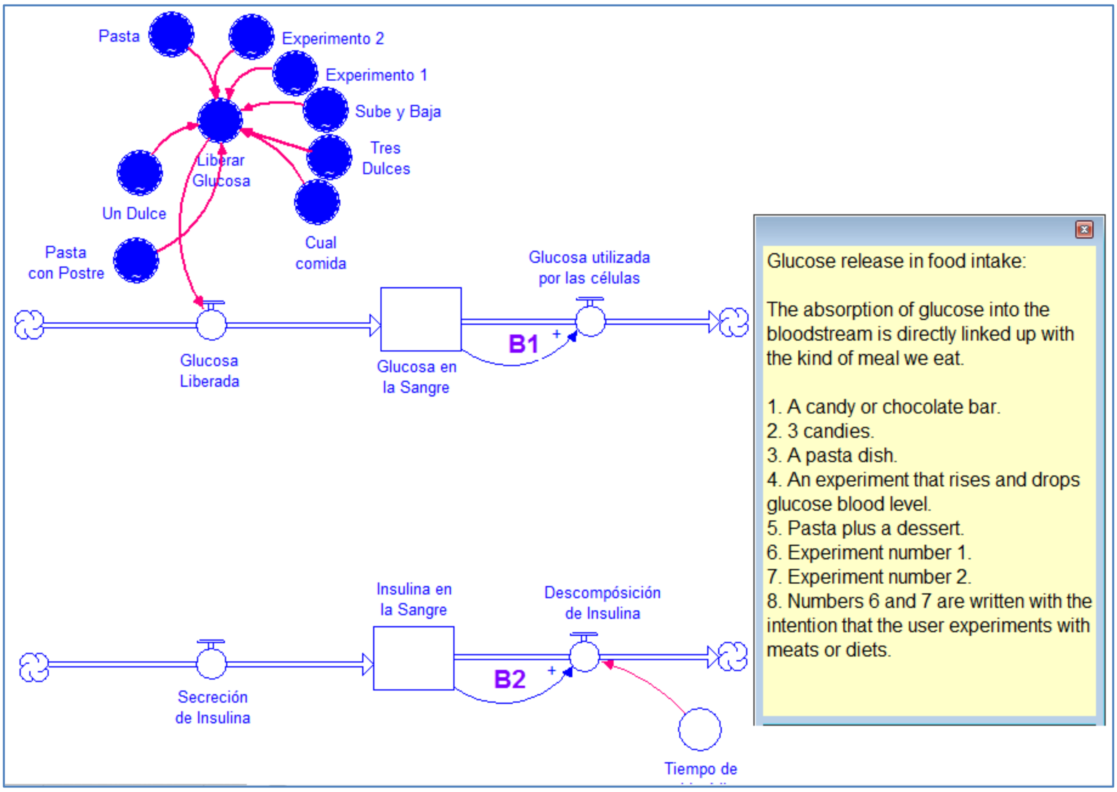
If the surplus is positive, then the insulin secretion rate increases to a level that beta cells can not keep. The rate begins to decline despite a high level of glucose.

If the surplus is negative (a fewer glucose level than homeostatic), the insulin secretion rate decreases as the body conserves glucose by decreasing the speed at which cells take it. Beta cells also have a lower limit in the insulin production. In the model this limit is set at zero, although the beta cells are always making some insulin.

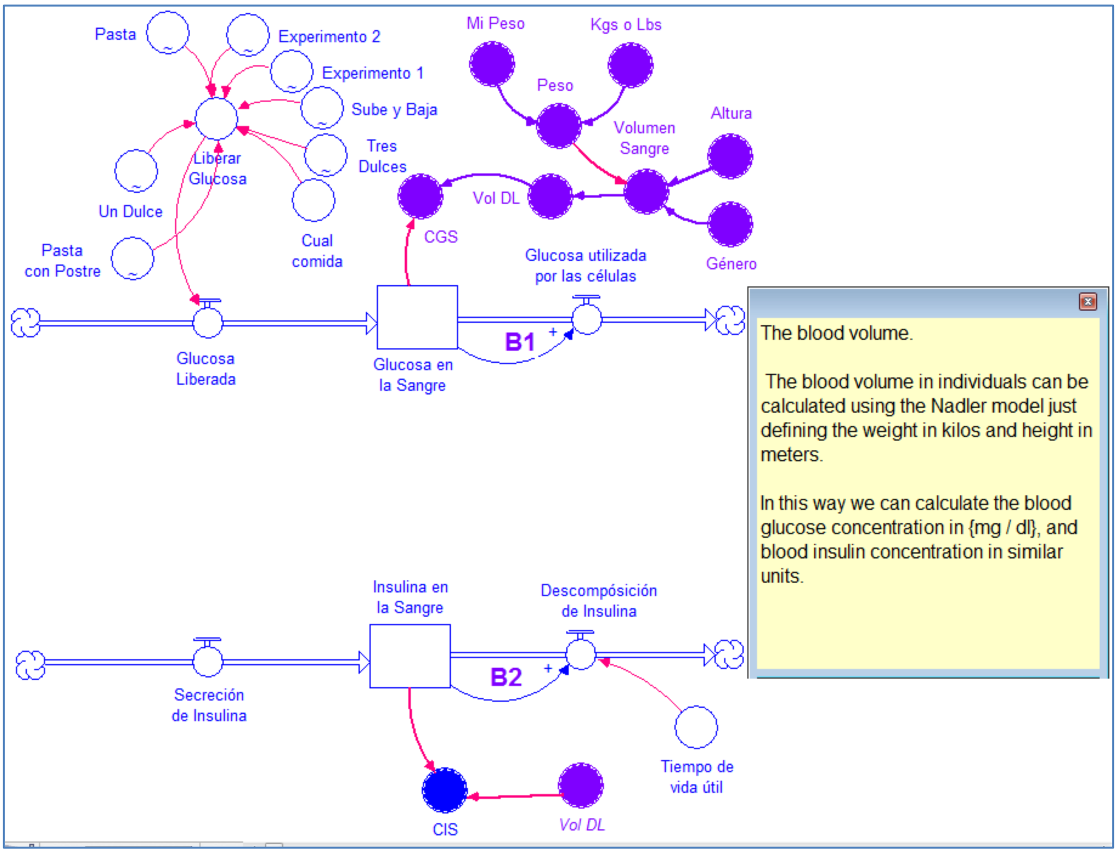
The Basic Structure.



Glucose release.



Estimative rough of blood volume.



Formulas used to calculate the blood volume.

Based on the gender, **weight** {kilos} and **height** {meters} of an individual given, it is possible to calculate the **blood volume** {liters} of his body, using the Nadler model.

If he is a man:

Blood volume = 0.3669* (height)^3 + 0.03219* (weight) + 0.6041 {liters}

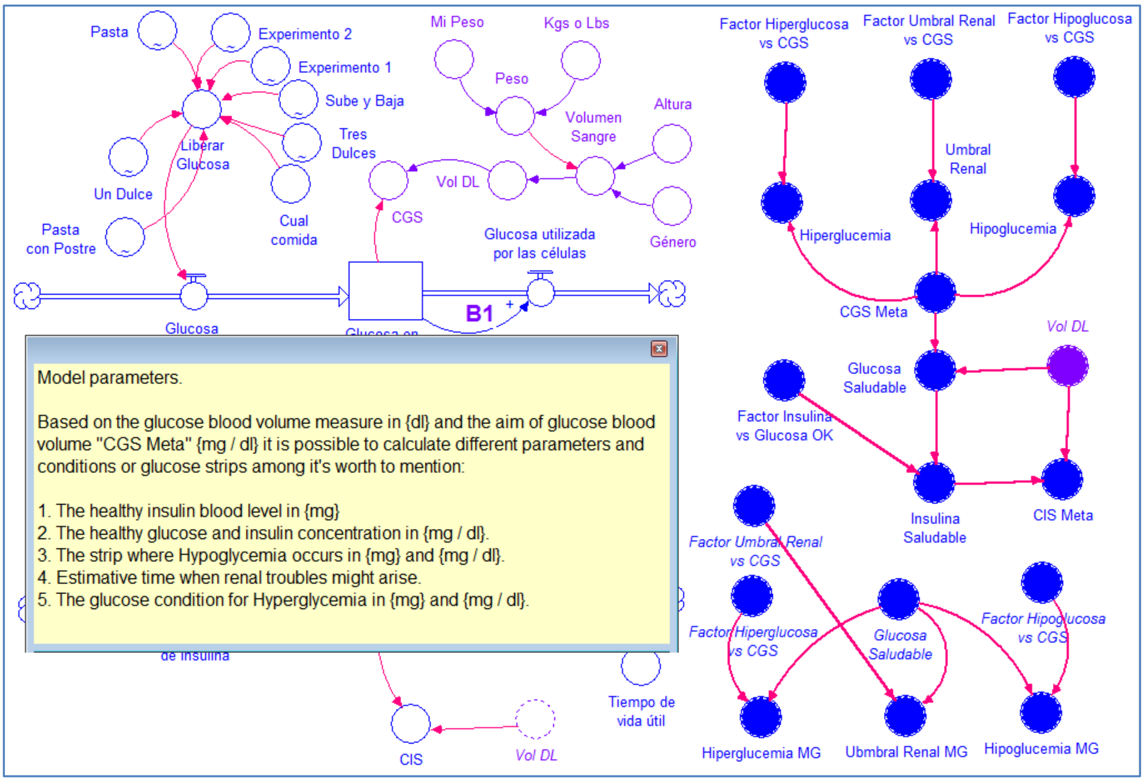
If she is a woman, then is used:

Blood volume = 0.3561* (height)^3 + 0.03308* (weight) + 0.1833 {liters}
This model gives us a blood volume accurate result of an individual in {liters}, due to our model needs the volume in {dl}, then the previous result needs be multiplied by 10, turning out as follows:

Vol DL = Blood Volume * 10 {dl}

Litters can also be expressed as {lt}, the deciliters are also represented as {dl}, kilos {kg} and meters are abbreviated as {mt}. When we talk about blood volume glucose **(CGS)** or insulin volume glucose **(CIS),** this is expressed in units of {milligrams/deciliters} or abbreviated as {mg / dl}.

Parameters and conditions of blood glucose.



Characteristic of the person and the key factors in the model.

For the basic calculations of the model, select a healthy man whose weight and height turns out in a blood volume of 6 liters {lt} or 60 deciliters {dl}, it is assumed that the healthy concentration of glucose (CGS Meta) about 100 {mg / dl} and its equivalent insulin concentration (CIS Meta) of 150 {mg / dl}, based on these data, we can do the calculations on lines (1) and (2) of the following table.

Number	Condition	Concentration {mg/dl}	Total Amount {mg}	Factor {Unite number}
1	**Aim of glucose blood volume**	100	6,000	
2	**Aim of insulin blood volume**	150	9,000	1.50
3	**Hypoglycemia**	40	2,400	0.40
4	**Renal Threshold**	160	9,600	1.60
5	**Hyperglycemia**	210	12,600	2.10

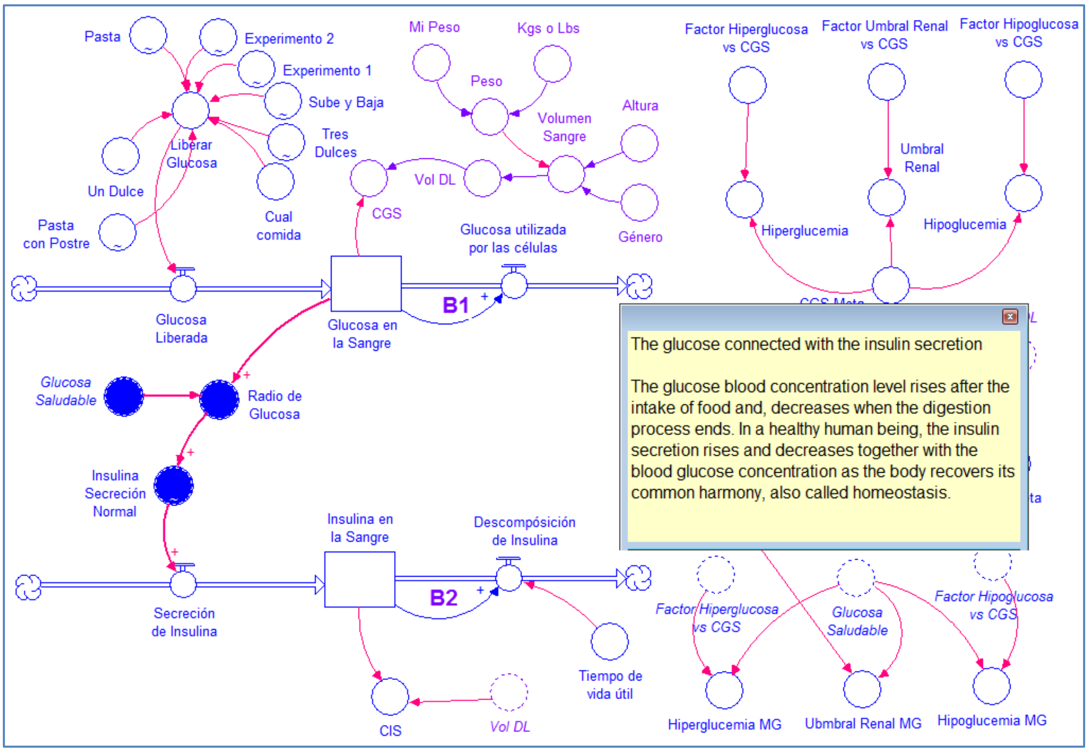
Table 2: The factor is calculated as the ratio between each condition or glucose strips.

The Data for strips or conditions of glycemia in hypoglycemia, renal threshold and hyperglycemia are widely reported in scientific papers related to glucose and there are not exact figures. Always mentioned within a small range, for instance the normal renal threshold is always reported between 160 to 180 {mg / dl}, we have to select 160 {mg / dl} to be used in our calculations. The factor column for lines (3), (4) and (5) is calculated as the ratio of the band about healthy glucose amount.

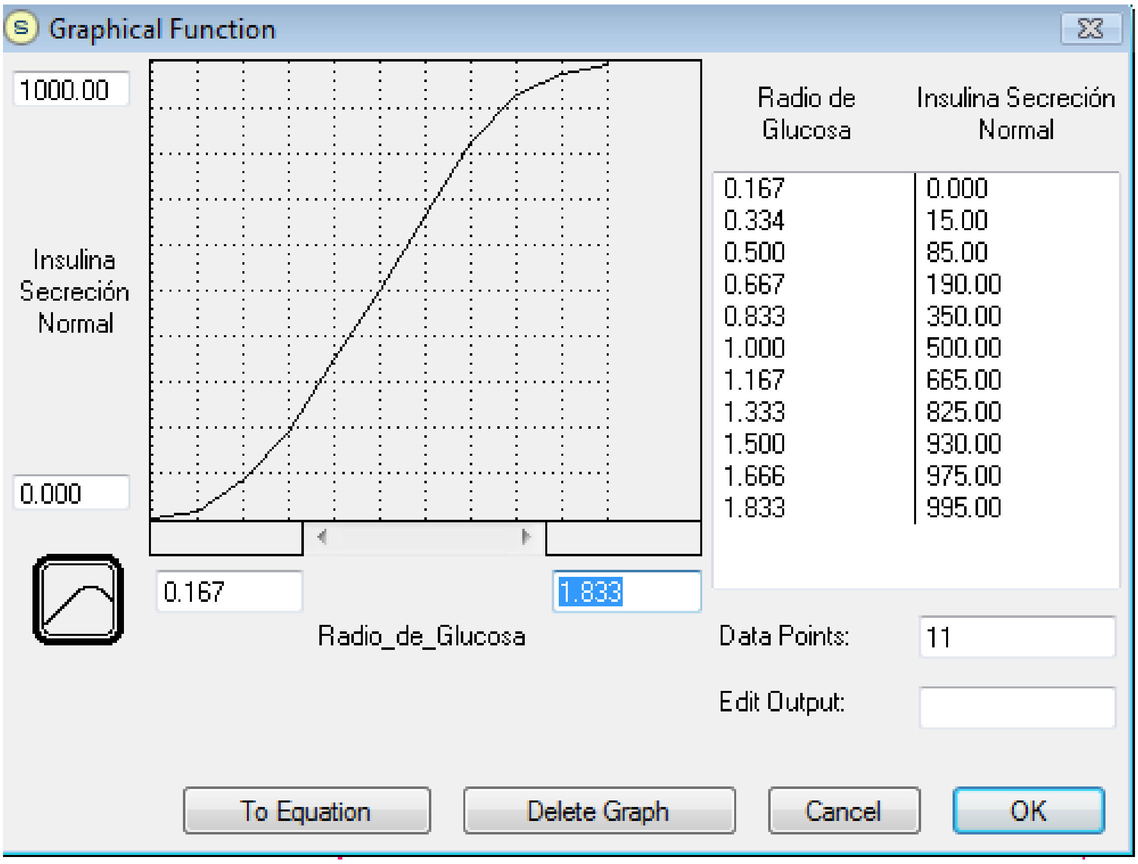
Another important consideration is that the total amount of glucose in the blood of a person can not be calculated due to it would be necessary to stir all the body's blood turning it impossible and impractical. What is usually done is to take a small blood sample about a deciliter at most, the glucose amount in this blood sample is measured {mg / dl} and, based on this data to infer the total amount of glucose in the body.

Based on the above reasoning, with only three key data which are a blood volume of 60 in {dl}, healthy glucose concentration levels (CGS Meta) 100 {mg / dl} and healthy insulin concentration levels (CIS Meta) 150 {mg / dl}, combined with the factors calculated in Table 3, it is possible to apply this model to any other individual with a different high, weight and gender. Obviously, the total amount of glucose and insulin in {mg} changes, but not the value taken from the strings {mg / dl}.
Even for the case that a doctor would base on a different value about the healthy glucose concentration (CGS Meta) in {mg / dl}, using the column of factors in Table3, it is possible to recalculate the new concentration levels of the string in {mg / dl} and, to extrapolate the calculation for this new condition. In this way t we expand the usage of the model.

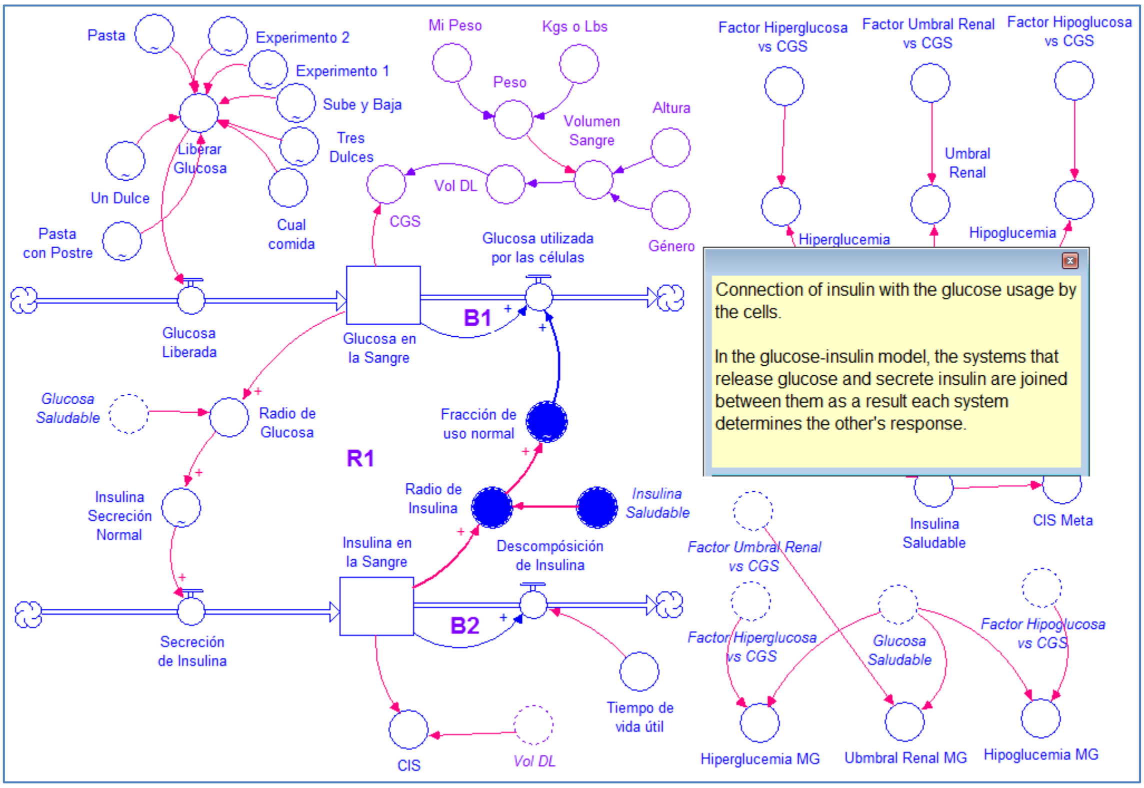
Connection between glucose and insulin secretion.



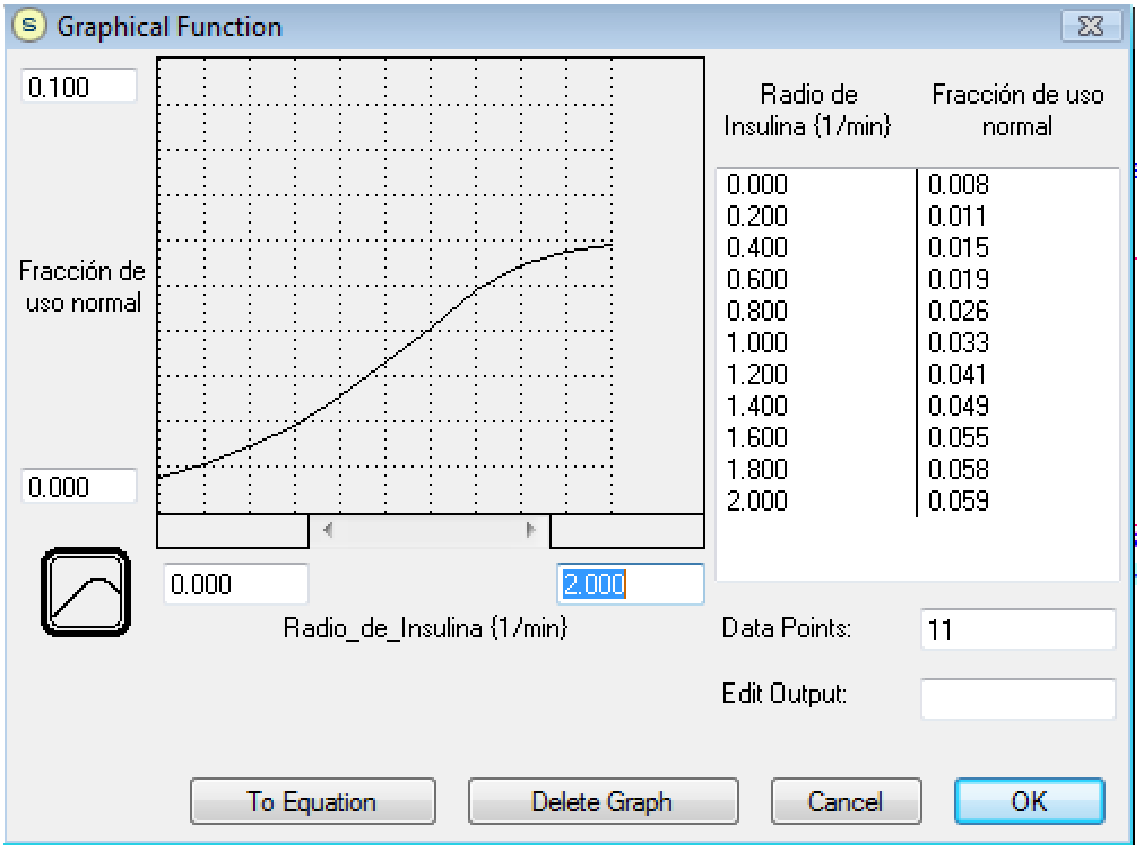
Graph: Insulin common secretion.



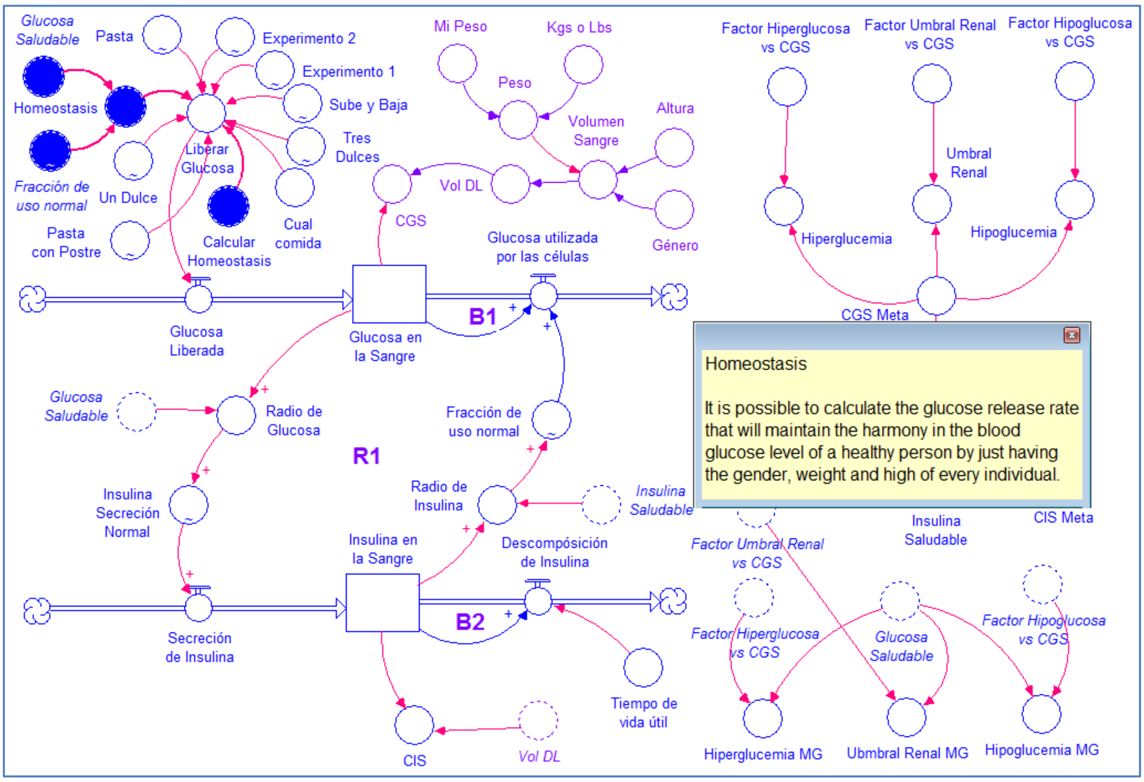
Insulin connection with the glucose usage of cells.



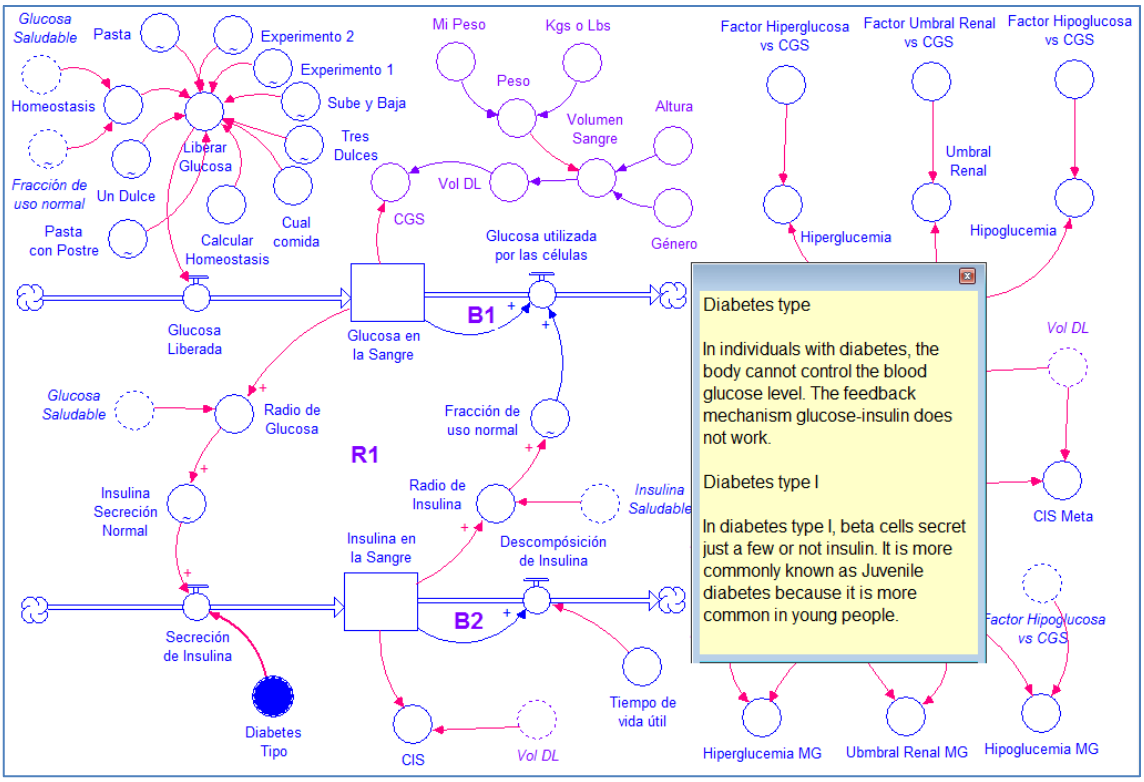
Graph: Fraction of normal glucose utilization.



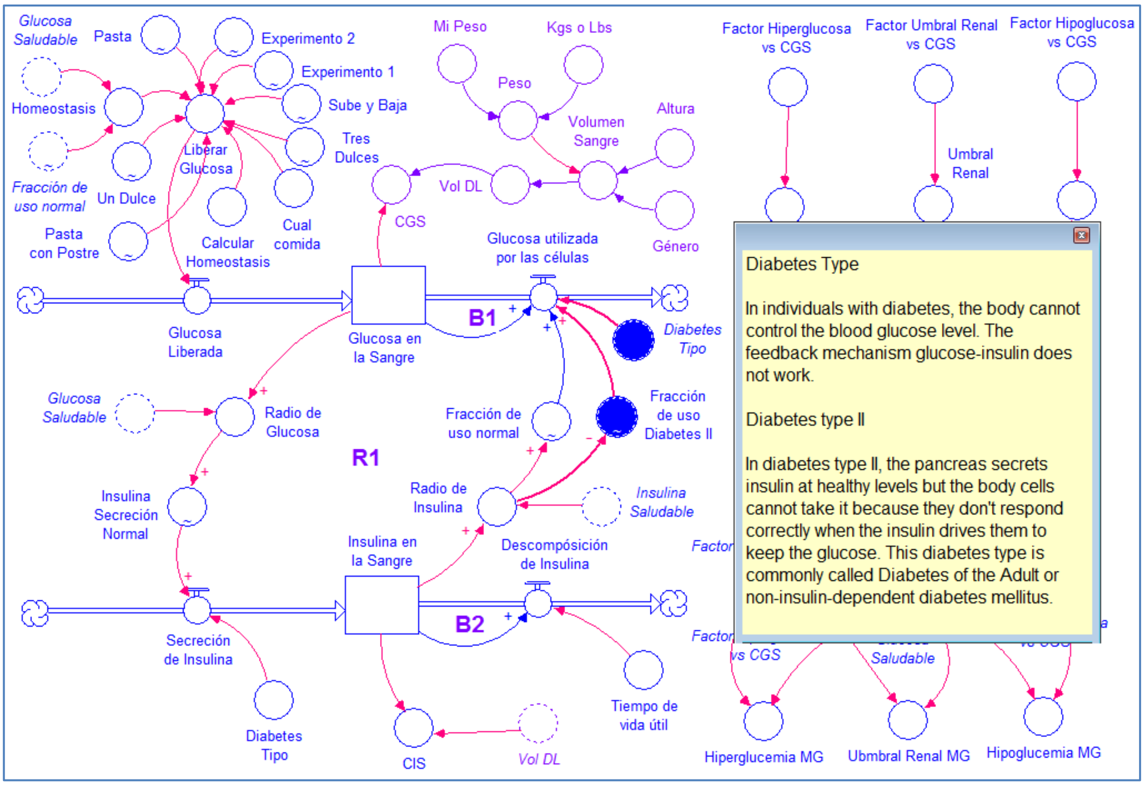
Homeostasis: Rate calculation of blood glucose release.



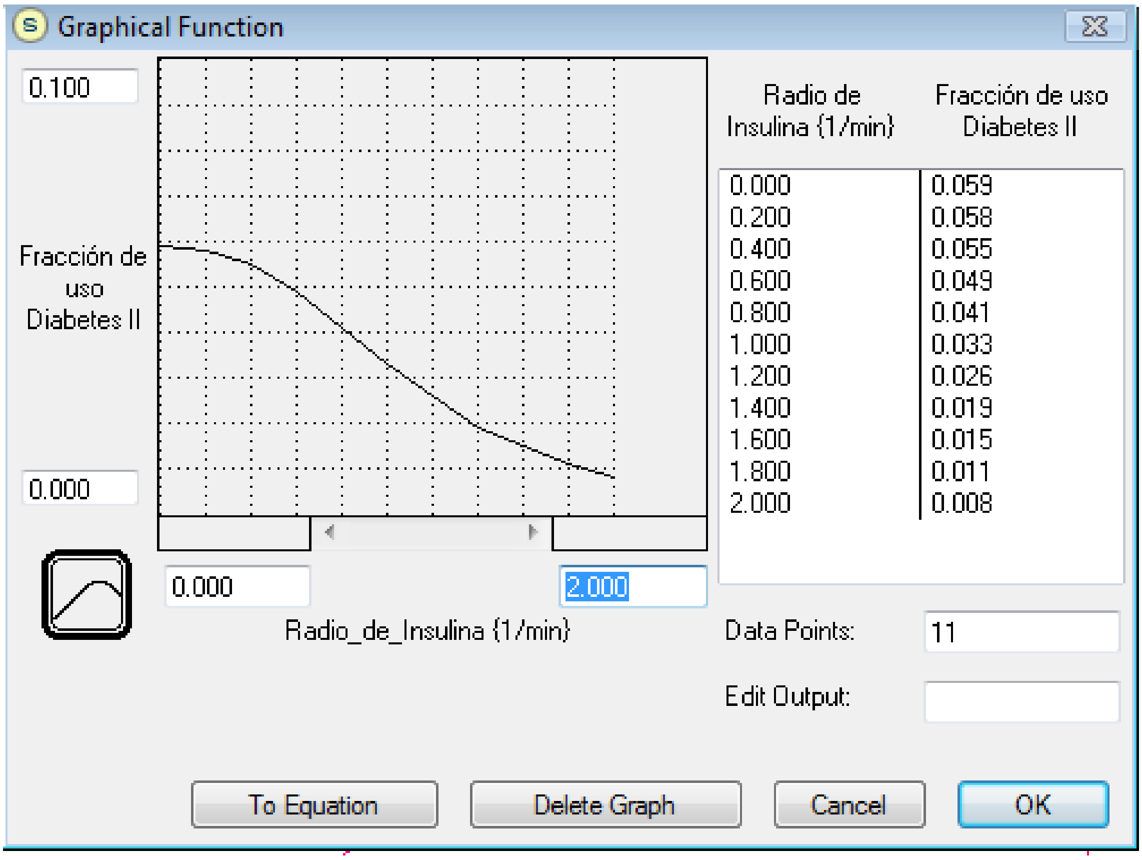
Diabetes type I



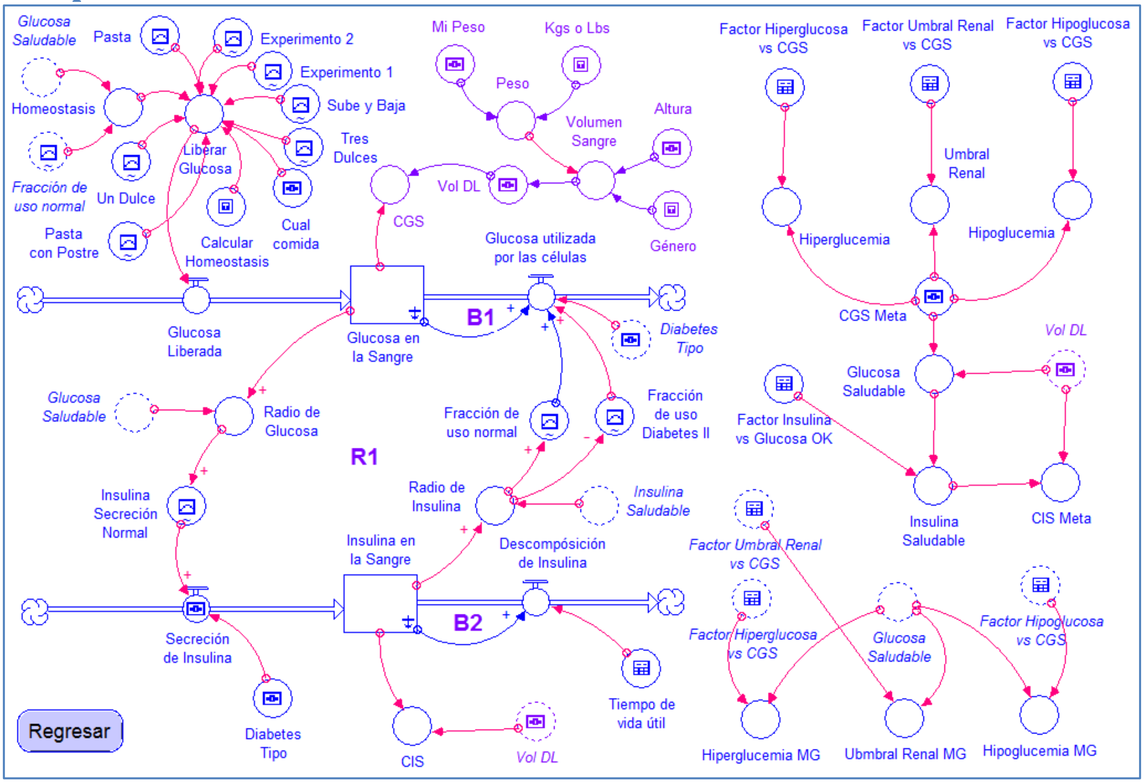
Diabetes type II.



Graph: Fraction of glucose utilization in diabetes type II.



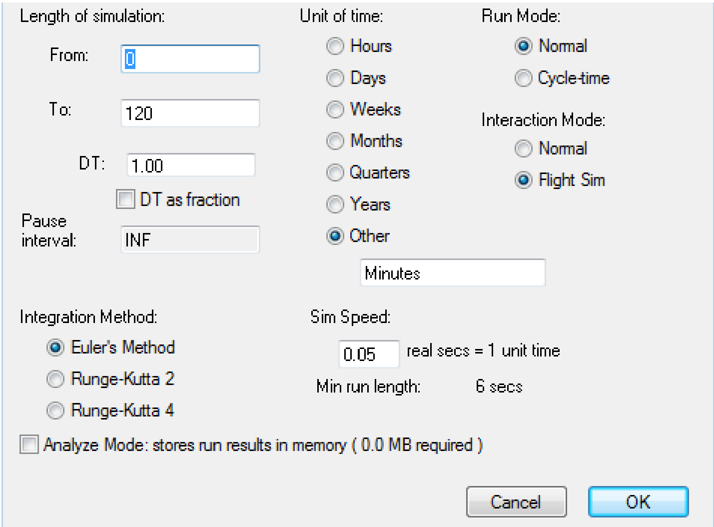
Complete model of Diabetes.



CGS Model Equations.

Glucosa_en_la_Sangre(t) = Glucosa_en_la_Sangre(t - dt) + (Glucosa_Liberada - Glucosa_utilizada_por_las_células) * dt
INIT Glucosa_en_la_Sangre = Init(Glucosa_Saludable) {mg}
INFLOWS:
Glucosa_Liberada = Liberar_Glucosa {mg/min}
OUTFLOWS:
Glucosa_utilizada_por_las_células = if Diabetes_Tipo=2 then Glucosa_en_la_Sangre*Fracción_de_uso_Diabetes_II {mg/min}
else Glucosa_en_la_Sangre*Fracción_de_uso_normal
Insulina_en_la_Sangre(t) = Insulina_en_la_Sangre(t - dt) + (Secreción_de_Insulina - Descompósición_de_Insulina) * dt
INIT Insulina_en_la_Sangre = Init(Insulina_Saludable) {mg}
INFLOWS:
Secreción_de_Insulina = if Diabetes_Tipo=1 then 0
else Insulina_Secreción_Normal
OUTFLOWS:
Descompósición_de_Insulina = Insulina_en_la_Sangre/Tiempo_de_vida_útil {mg/min}
Altura = 1.76 {mts}
Calcular_Homeostasis = 0 {1=si, 0=no}
CGS = Glucosa_en_la_Sangre/Vol_DL {mg/decilitros}
CGS_Meta = 100 {mg/dl}
CIS = Insulina_en_la_Sangre/Vol_DL {mg/decilitros}
CIS_Meta = Insulina_Saludable/Vol_DL {mg/dl}
Cual_comida = 3
Diabetes_Tipo = 0 {No Unidades, 1= si,, 0= no}
Experimento_1 = GRAPH(time)
(0.00, 665), (12.0, 415), (24.0, 405), (36.0, 415), (48.0, 760), (60.0, 785), (72.0, 770), (84.0, 405), (96.0, 450), (108, 525), (120, 545)
Experimento_2 = GRAPH(time)
(0.00, 310), (12.0, 415), (24.0, 510), (36.0, 525), (48.0, 520), (60.0, 610), (72.0, 565), (84.0, 520), (96.0, 490), (108, 465), (120, 310)
Factor_Hiperglucosa_vs_CGS = 2.1 {No Unidades}
Factor_Hipoglucosa_vs_CGS = 0.40 {No Unidades}
Factor_Insulina_vs_Glucosa_OK = 1.5 {No Unidades}
Factor_Umbral_Renal_vs_CGS = 1.6 {No Unidades}
Fracción_de_uso_Diabetes_II = GRAPH(Radio_de_Insulina {1/min})
(0.00, 0.059), (0.2, 0.058), (0.4, 0.055), (0.6, 0.049), (0.8, 0.041), (1.00, 0.033), (1.20, 0.026), (1.40, 0.019), (1.60, 0.015), (1.80, 0.011), (2.00, 0.008)
Fracción_de_uso_normal = GRAPH(Radio_de_Insulina {1/min})
(0.00, 0.0075), (0.2, 0.0105), (0.4, 0.0145), (0.6, 0.019), (0.8, 0.0255), (1.00, 0.033), (1.20, 0.0405), (1.40, 0.049), (1.60, 0.0545), (1.80, 0.0575), (2.00, 0.059)
Género = 1 {1=hombres, 0=mujeres No unidad}
Glucosa_Saludable = Vol_DL*CGS_Meta {mg}
Hiperglucemia = CGS_Meta*Factor_Hiperglucosa_vs_CGS {mg/dl}
Hiperglucemia_MG = Factor_Hiperglucosa_vs_CGS*Glucosa_Saludable
Hipoglucemia = CGS_Meta*Factor_Hipoglucosa_vs_CGS {mg/dl}
Hipoglucemia_MG = Factor_Hipoglucosa_vs_CGS*Glucosa_Saludable
Homeostasis = Init(Glucosa_Saludable)*Init(Fracción_de_uso_normal) {mg/dl}
Insulina_Saludable = Glucosa_Saludable*Factor_Insulina_vs_Glucosa_OK {mg}
Insulina_Secreción_Normal = GRAPH(Radio_de_Glucosa)
(0.167, 0.00), (0.334, 15.0), (0.5, 85.0), (0.667, 190), (0.833, 350), (1, 500), (1.17, 665), (1.33, 825), (1.50, 930), (1.67, 975), (1.83, 995)
Kgs_o_Lbs = 1 {kg=1, lbs=0}
Liberar_Glucosa = if Calcular_Homeostasis=1 then Homeostasis {mg/min}
else
if Cual_comida=1 then Homeostasis {mg/min}
else if Cual_comida=2 then Un_Dulce
else if Cual_comida=3 then Tres_Dulces
else if Cual_comida=4 then Pasta
else if Cual_comida=5 then Sube_y_Baja
else if Cual_comida=6 then Pasta_con_Postre
else if Cual_comida=7 then Experimento_1
else Experimento_2
Mi_Peso = 105.487523628 {Kg}
Pasta = GRAPH(time)
(0.00, 400), (12.0, 400), (24.0, 400), (36.0, 400), (48.0, 400), (60.0, 400), (72.0, 400), (84.0, 400), (96.0, 400), (108, 400), (120, 400)
Pasta_con_Postre = GRAPH(time)
(0.00, 198), (12.0, 300), (24.0, 380), (36.0, 400), (48.0, 400), (60.0, 370), (72.0, 705), (84.0, 800), (96.0, 800), (108, 305), (120, 198)
Peso = if Kgs_o_Lbs=1 then Mi_Peso else Mi_Peso/2.204 {kg}
Radio_de_Glucosa = Glucosa_en_la_Sangre/Glucosa_Saludable {No Unidad}
Radio_de_Insulina = Insulina_en_la_Sangre/Insulina_Saludable {No Unidad}
Sube_y_Baja = GRAPH(time)
(0.00, 400), (12.0, 400), (24.0, 100), (36.0, 100), (48.0, 100), (60.0, 100), (72.0, 100), (84.0, 100), (96.0, 100), (108, 100), (120, 100)
Tiempo_de_vida_útil = 18 {min}
Tres_Dulces = GRAPH(time)
(0.00, 198), (12.0, 900), (24.0, 400), (36.0, 295), (48.0, 400), (60.0, 900), (72.0, 400), (84.0, 295), (96.0, 400), (108, 900), (120, 198)
Ubmbral_Renal_MG = Factor_Umbral_Renal_vs_CGS*Glucosa_Saludable
Umbral_Renal = CGS_Meta*Factor_Umbral_Renal_vs_CGS {mg/dl}
Un_Dulce = GRAPH(time)
(0.00, 198), (12.0, 198), (24.0, 900), (36.0, 198), (48.0, 198), (60.0, 198), (72.0, 198), (84.0, 198), (96.0, 198), (108, 198), (120, 198)
Volumen_Sangre = if Género=1 then {1= hombres, 0=mujeres}
0.3669*Altura^3 + 0.03219*Peso + 0.6041
else 0.3561*Altura^3 + 0.03308*Peso + 0.1833 {lts}

Data specification to start the simulator.



Graphic results of the model to a healthy person.

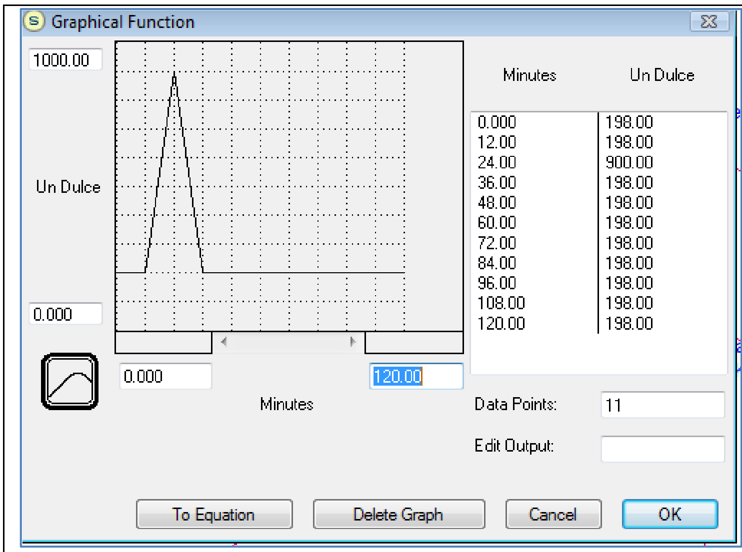
Case 1: Eating simple sugar, a candy or chocolate bar.

Eating a candy bar will release a significant amount of glucose into your bloodstream giving you what is often called a "high-sweetened".

To give you an idea, a typical candy bar contains about 30 grams (30.000 mg) of simple sugar. To drink regular soda (not diet) of 12 ounces contains 41 grams of sugar.

The digestive system moves rapidly the simple sugar into the bloodstream. A candy or a soda can be totally absorbed in a time of 20 to 30 minutes. How, do you think, should be the graph behavior of the blood glucose and insulin concentration after eating the candy?

Rate release of blood glucose when eating a candy {mg / min}



Eating a candy - Rate release of blood glucose {mg / min}

Below, in conjunction with the graphs that show the behavior of blood glucose concentration in {mg /dl}, there are also the glucose bands or conditions to easily visualize when our health is in danger. Similarly we'll show what happens with the concentration of insulin {mg / dl}. The results are also plotted in {mg}.

Page 1 - Graph of blood glucose concentration in {mg / dl} eating a candy.

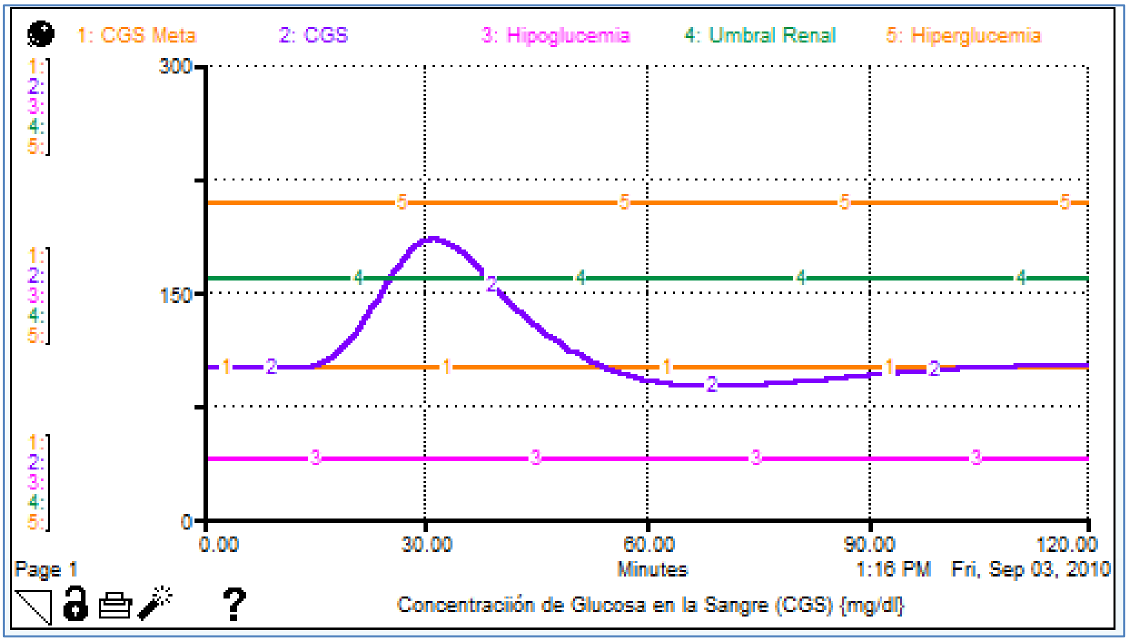


Figure 1: Page 1 - Graph of blood glucose concentration in {mg / dl} eating a candy.

It is really interesting that we have the opportunity to compare the glucose behavior in conjunction with the condition of glucose stripes that can help us to visualize potential problems, as in this case, the renal threshold is exceeded by minutes, the kidneys cannot respond as they should and glucose could starts spilling by the urine. The impact caused by a simple candy in the organism is alarming.

Graph of the total amount of blood glucose {mg}.

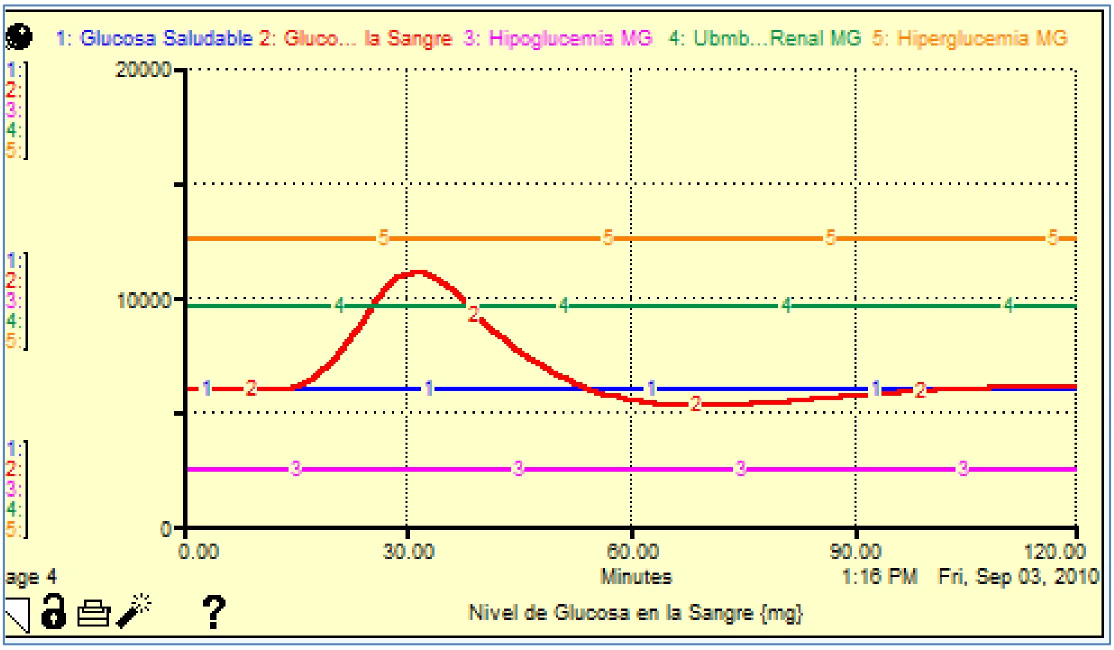


Figure 2: Page 4 - The level of the total amount of blood glucose {mg}, when eating a candy.

Graph of the glucose-insulin concentration in blood {mg / dl}.

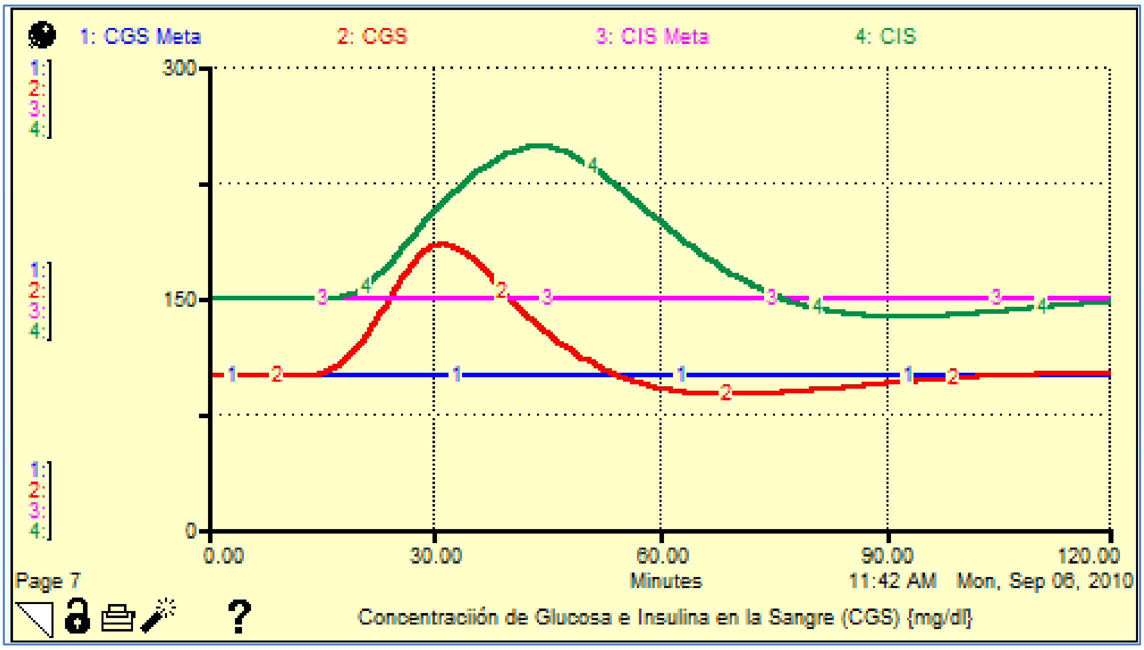


Figure 3: Page 7 - insulin glucose concentration in blood {mg / dl} when eating a candy.

Graph of the total amount of blood glucose-insulin {mg}.

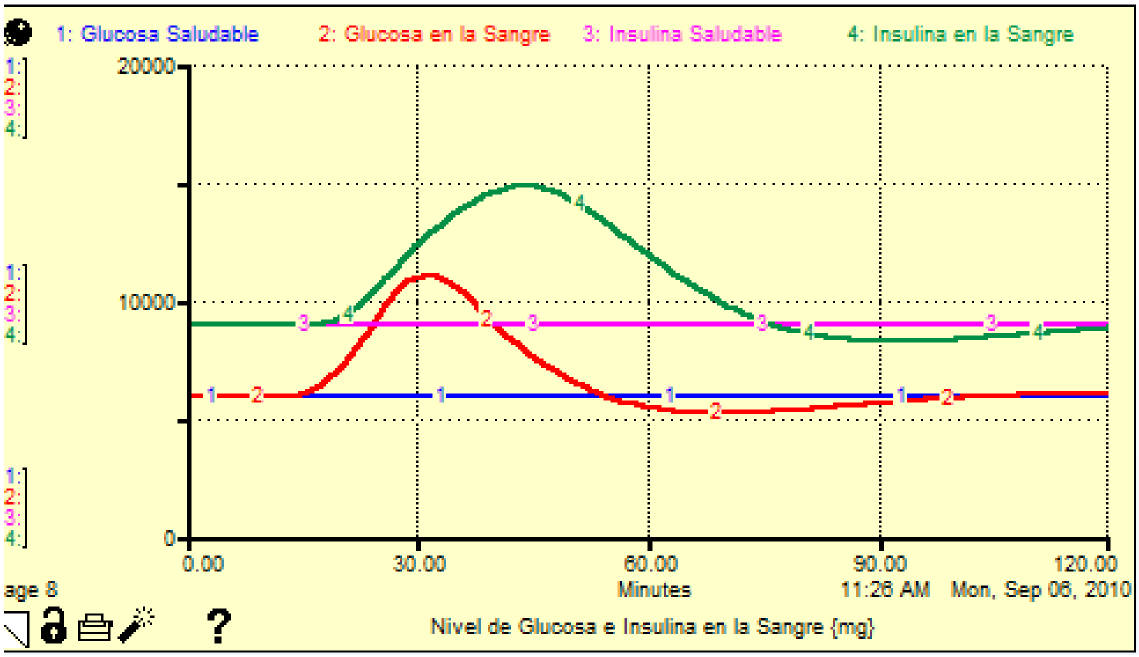


Figure 4: Page 9 total amount of blood glucose –insulin {mg}. When eating a candy.

Case 2: Eating 3 candy bars.

Rate release of blood glucose when eating 3 candies {mg / min}

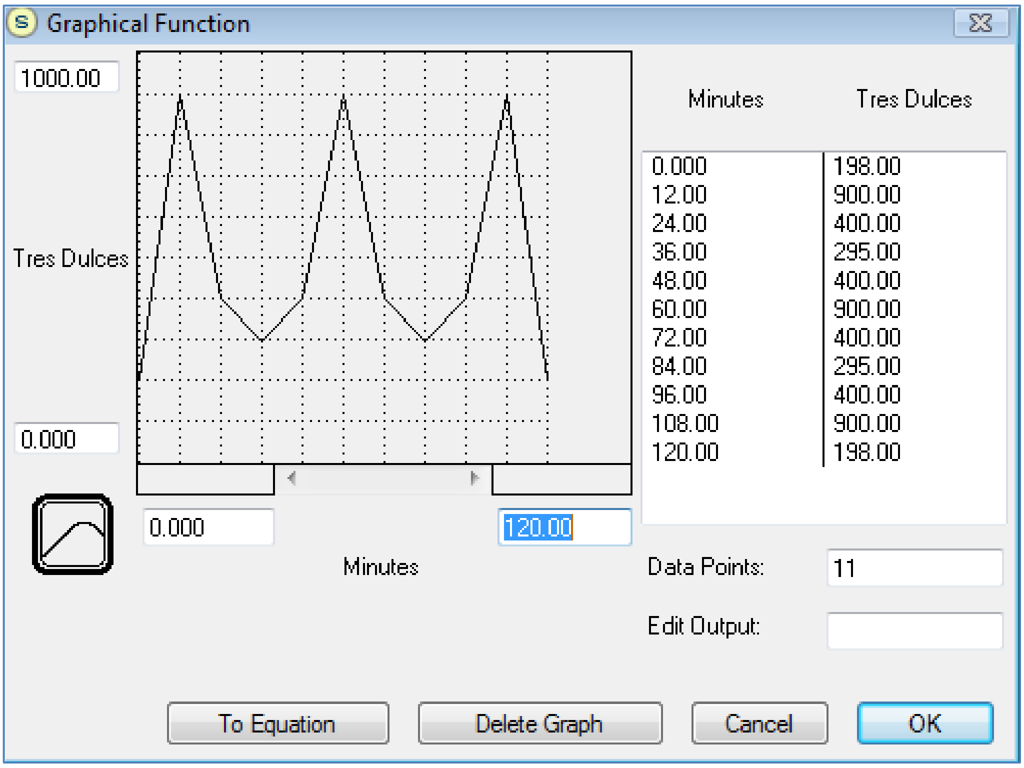


Figure 5: Rate release of blood glucose when eating 3 candies {mg / dl}

Graph of Rate release of blood glucose {mg / dl} when eating 3 candies.

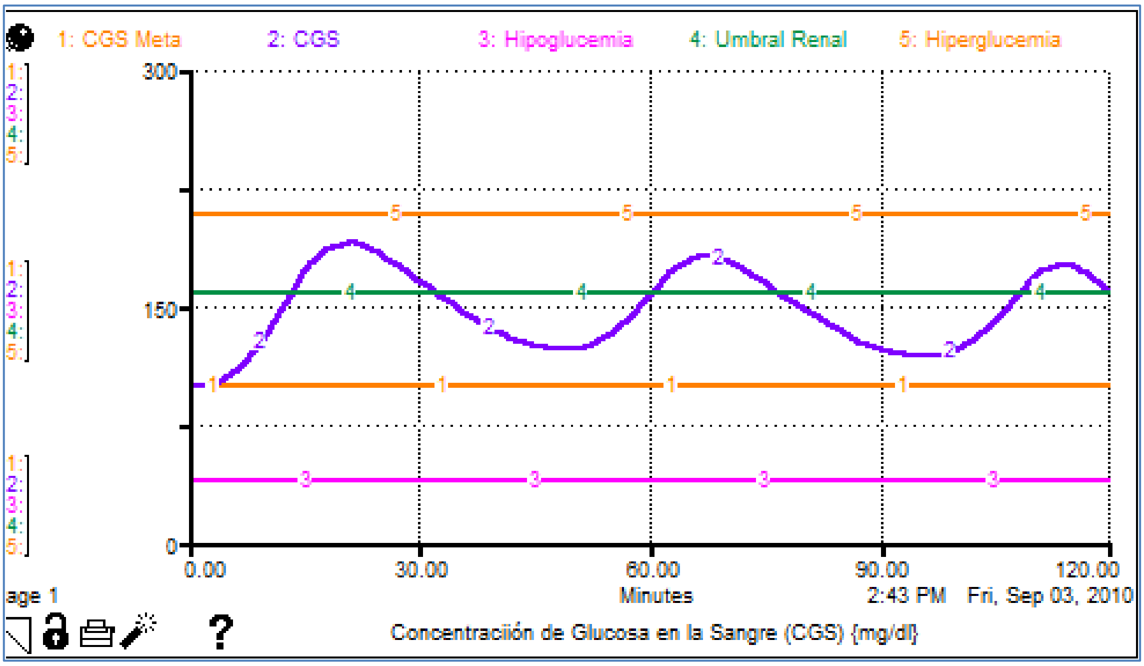


Figure 6: Blood glucose concentration {mg/dl,} eating 3 candies.

Graph of Candies – Blood concentration of Glucose-insulin

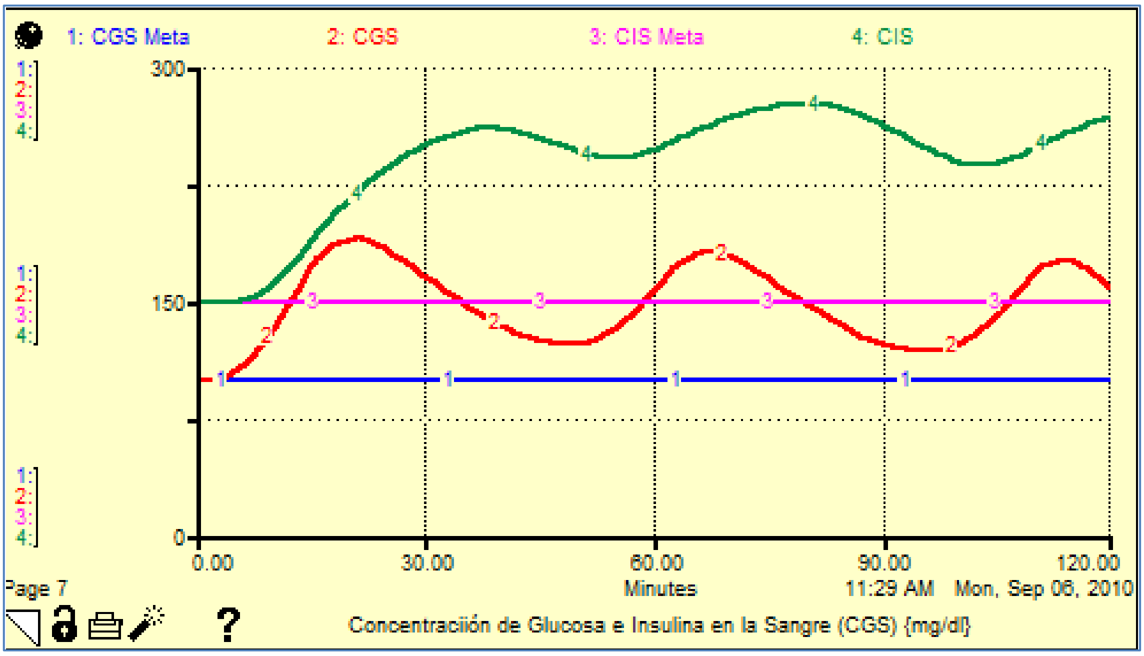
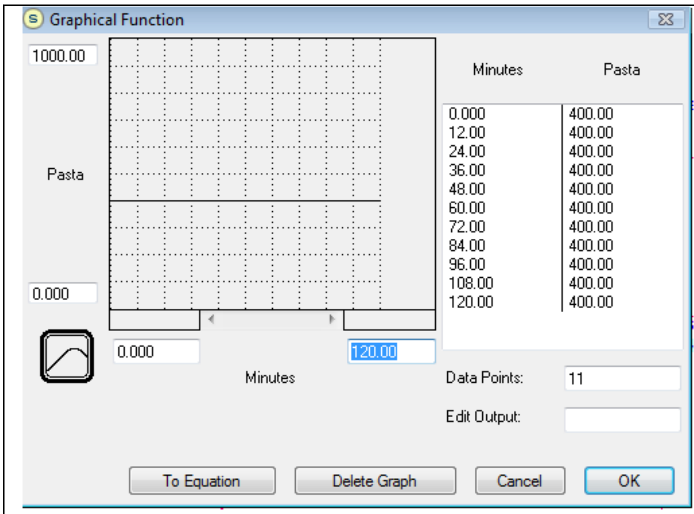


Figure 7: Blood glucose-insulin concentration {mg / dl}, when eating 3 candies.

Case 3: Eating complex carbohydrates as pasta and then a delicious dessert

Foods like beans, rice, oats and other cereal grains, flesh fruits, vegetables, bread and pasta, contain combined sugars and starches. Digestion turns on these complex carbohydrates into glucose in a more equilibrated speed the rapid absorption of simple sugars. In this occasion, we will simulate the body's response to a pasta meal, followed by a delicious dessert.



The rate release of blood glucose of pasta is not as high as that of a candy, it might remain stable at 400 {mg / min} as shown in this data.

Figure 8: Rate release of blood glucose of the pasta {mg / min}.

Rate release of blood glucose of the pasta and the dessert {mg / min}.

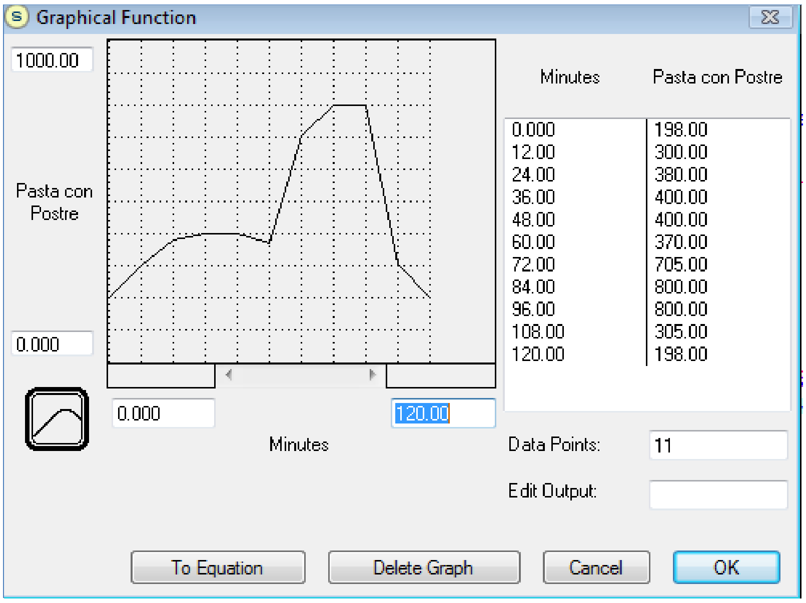


Figure 9: Data for the rate release of blood glucose when eating a pasta and dessert in {mg / dl}.

Graph of Blood glucose concentration when eating pasta and dessert {mg / dl}.

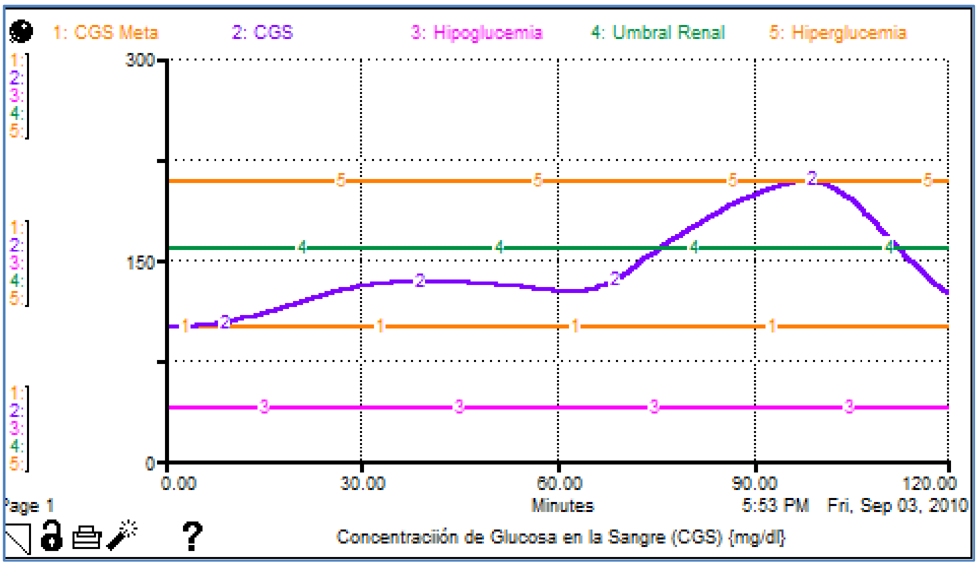
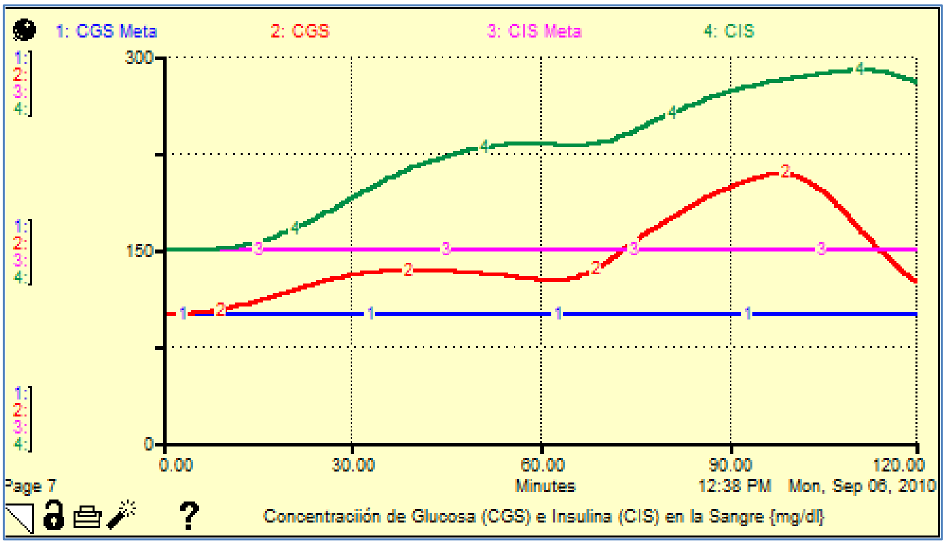


Figure 10: Blood glucose concentration when eating pasta and dessert {mg / dl}.

How impressive is the impact on the rising blood glucose concentration. For a while, the band reaches to the hyperglycemia that would cause extensive damages to our bodies. How many times have we eaten dessert twice and then having some ice cream and some cups of coffee without being aware of what is happening inside of our bodies? Who would imagine that only 30 grams of sugar from a single candy bar would cause all this within us! How many times we've eaten whole bags of candy? It is desperately important to be conscious about it and to reflect on diabetes prevention.

Graphic about blood concentration of glucose-insulin when eating pasta and dessert. {mg / dl}



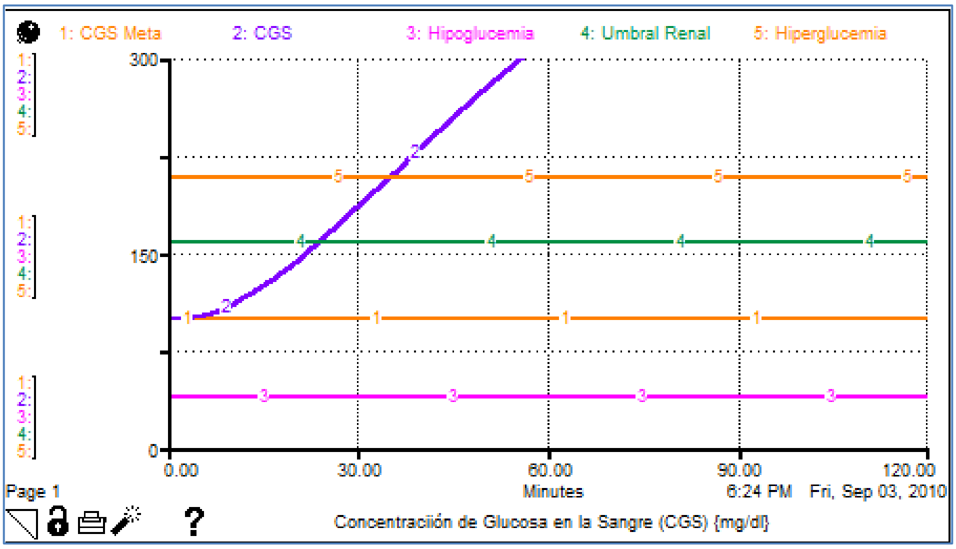
Graphic results of a model in a person with diabetes, eating pasta and dessert.

I do not want to imagine what would happen with a diabetic person (type I or II) who takes a similar meal like the one already shown. In individuals with diabetes, the body cannot control the blood glucose level. The feedback mechanism glucose-insulin does not work.

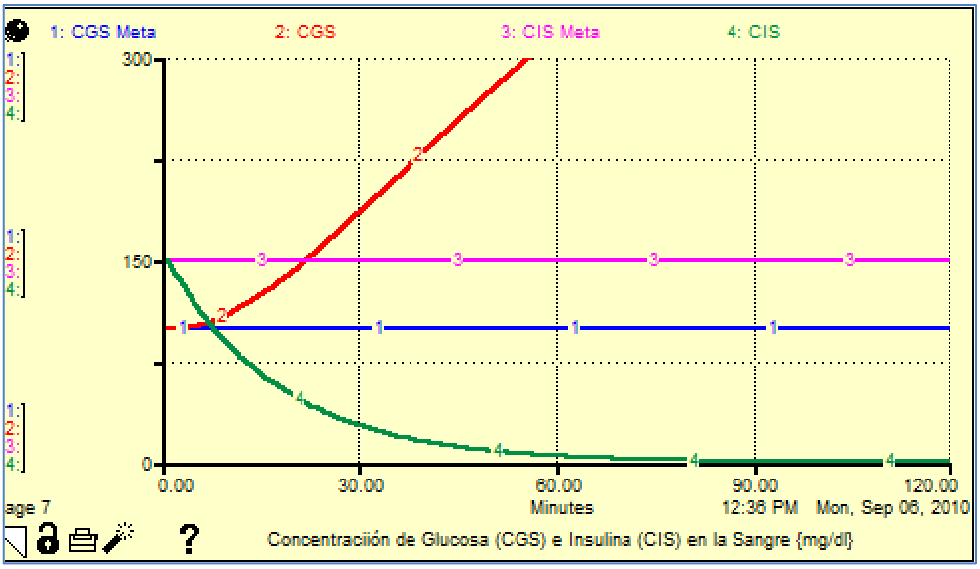
Diabetes type I.

In diabetes type I, beta cells secret just a few or not insulin. It is more commonly known as Juvenile diabetes because it is more common in young people.

Graph of Blood glucose concentration when eating pasta and dessert {mg / dl} - Diabetes I



Graph of Blood glucose-insulin concentration {mg / dl} - pasta and dessert - Diabetes I

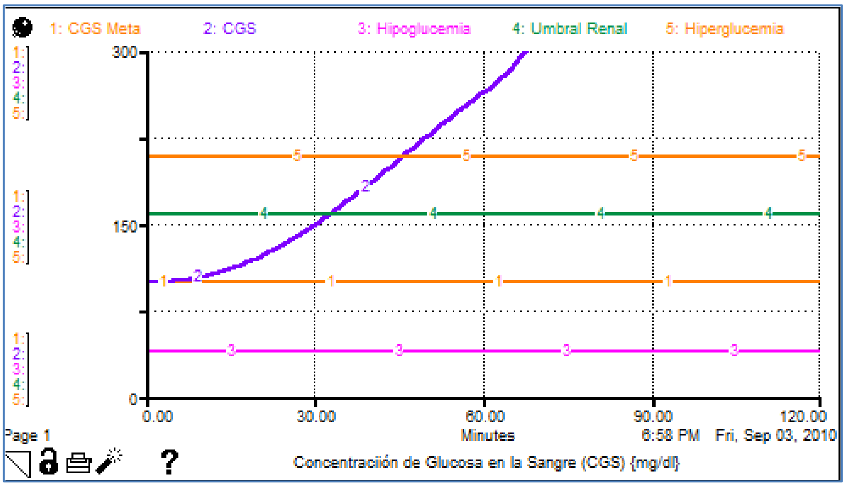


As a kid I had friends in my hometown M. Muzquiz, Coahuila, who had diabetes and injected themselves insulin every day, now I understand why they did it. It is clearly shown in Figure 14 that the insulin is not secreted by the pancreas in diabetes type I. 40 years ago we had just little information about this disease. When insulin is not secreted in a natural form, then it must be obtained from external fonts.

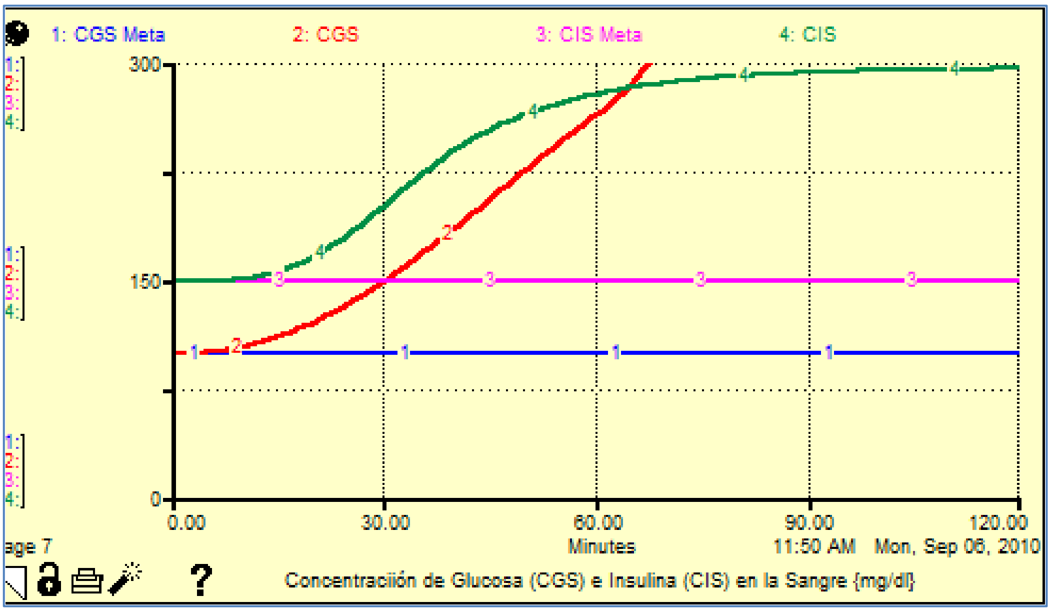
Diabetes type II.

In diabetes type II, the pancreas secrets insulin at healthy levels but the body cells cannot take it because they don't respond correctly when the insulin drives them to keep the glucose. This diabetes type is commonly called Diabetes of the Adult or non-insulin-dependent diabetes mellitus.

Graph of Blood glucose concentration when eating pasta & dessert {mg / dl} - Diabetes II



Graph of Blood glucose-insulin concentration {mg / dl},, pasta and dessert-Diabetes II



Now it is very clear to me that for diabetics type II, the problem is not the lack of insulin, as shown in Figure 16, insulin is secreted normally. The problem is founded in the cells that reject insulin, avoiding the brought help to use glucose, adding to this the insulin accumulation. Reason why there must be a special care, because both deficiency are harmful to health.

Facts that a diabetic should take into account.

A diabetic who has not taken enough insulin or whose cells are resistant to insulin is essentially starving because glucose (the principal source of energy) can not enter into the body cells. A diabetic who injects him/herself too much insulin, causes the glucose excess entering into the cells (type 1) or an insulin excess is accumulated in the blood (type 2).

Any of these conditions can lead the person to serious consequences for the physical life as the diabetic coma. Managing diabetes requires a special attention to the body's response of the different blood glucose levels to maintain homeostasis.

Lifestyle changes.

What changes would you make in your lifestyle if you were diagnosed with diabetes type 1 or type 2?

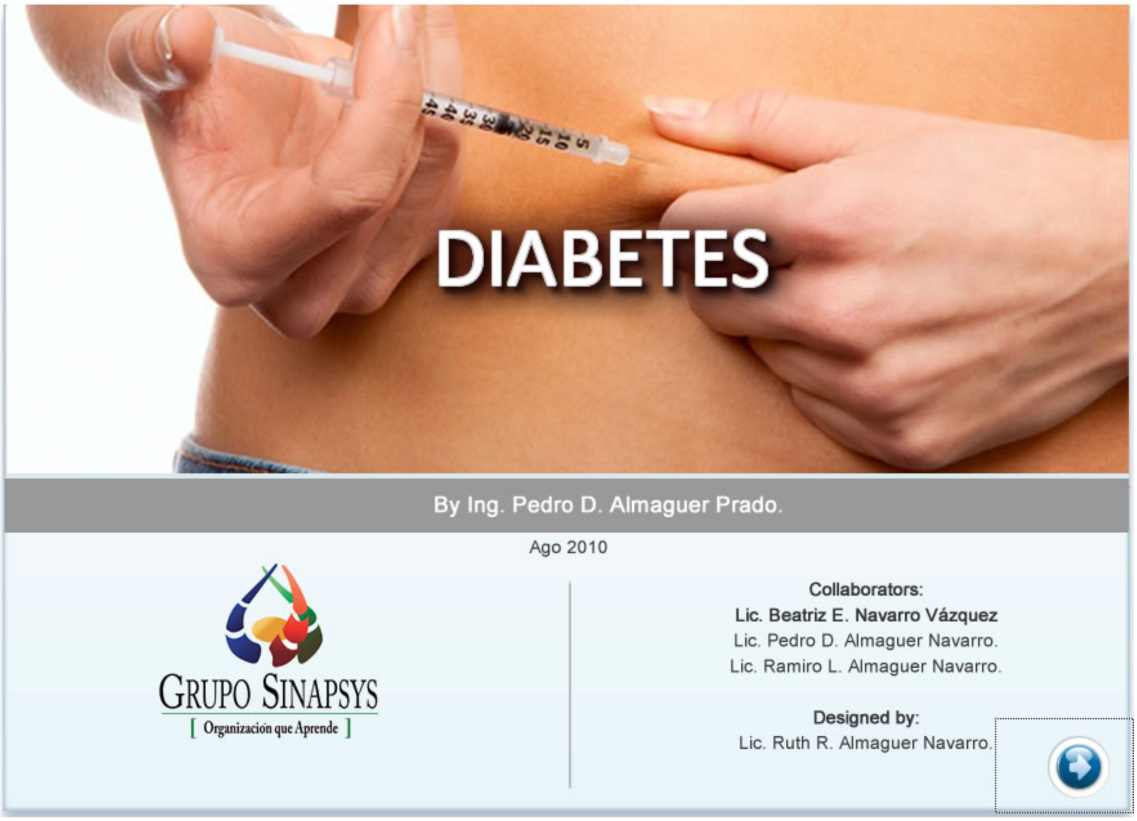
1. Exercise more to use more glucose.
2. Do not eat simple sugars. Eliminate candy bars, chocolates and regular sodas.
3. Eat complex carbohydrates such as fruits, vegetables, pasta and processed foods elaborated with whole grains or whole wheat flour.
4. Eat a variety of foods that take more time to be absorbed.

5. Eat small amounts of meal at frequent intervals, for a constant supply of glucose.

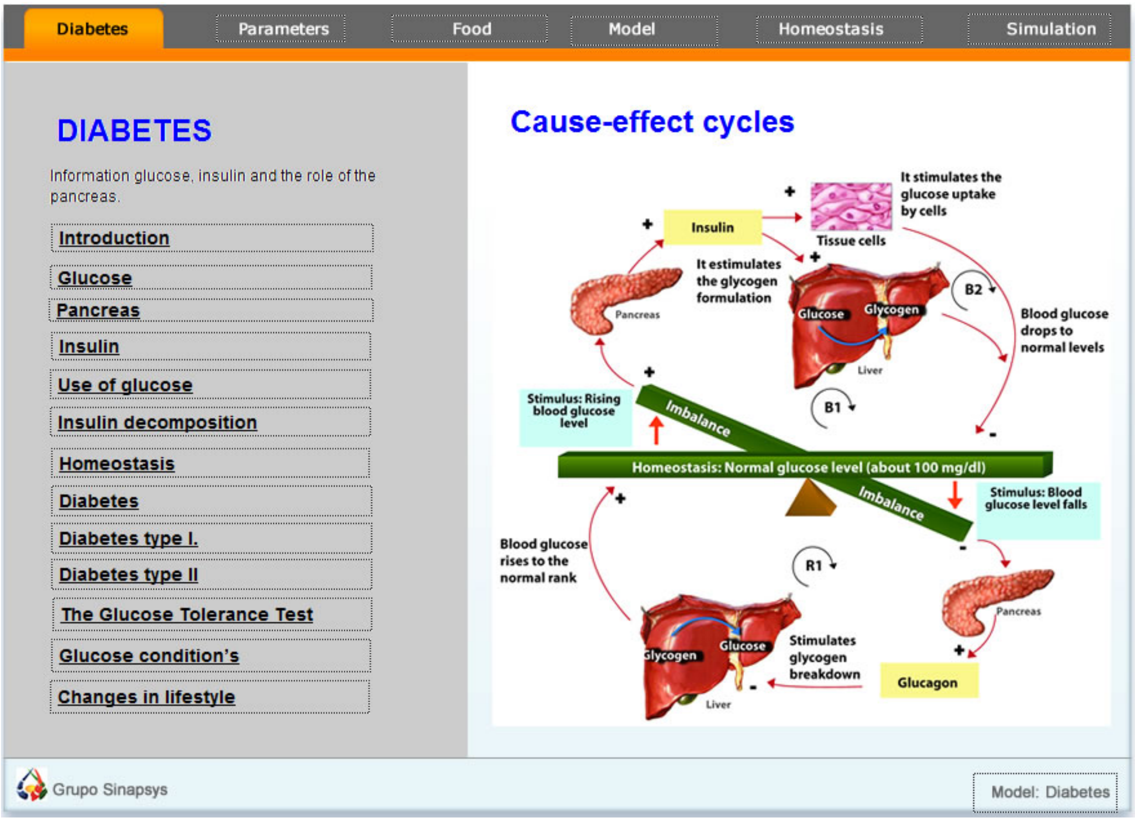
New study areas to experiment.

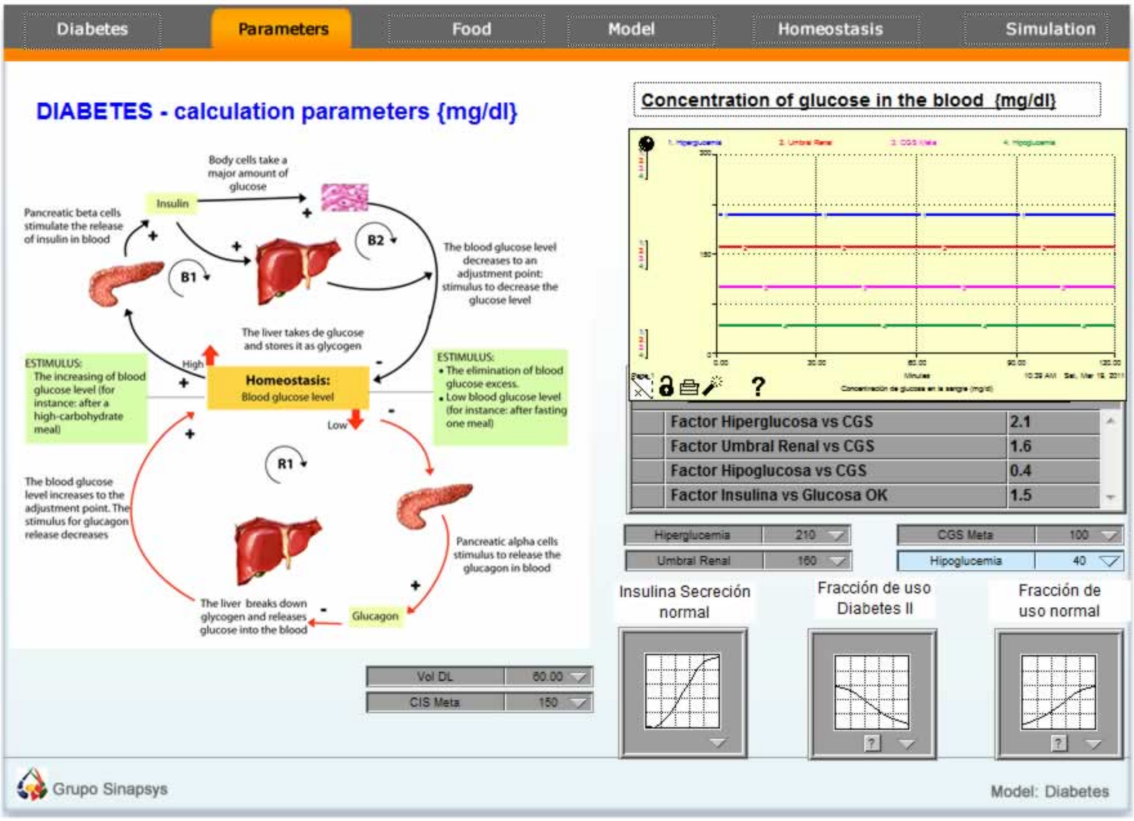
Our model contains more study cases already prepared. Also there have been added two more for the user to experiment with different meals and observes the impact over the time of the behavior in the blood glucose concentration of insulin.

Diabetes learning lab - in Stella 10 (English)

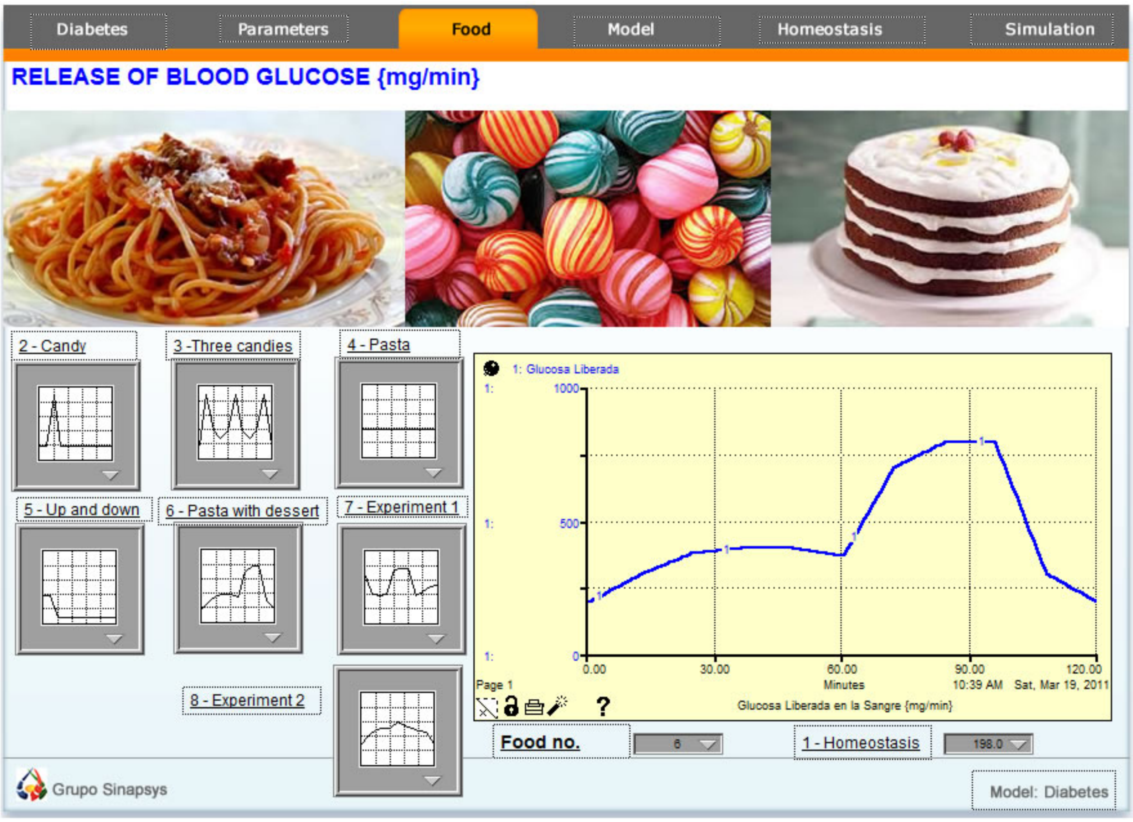


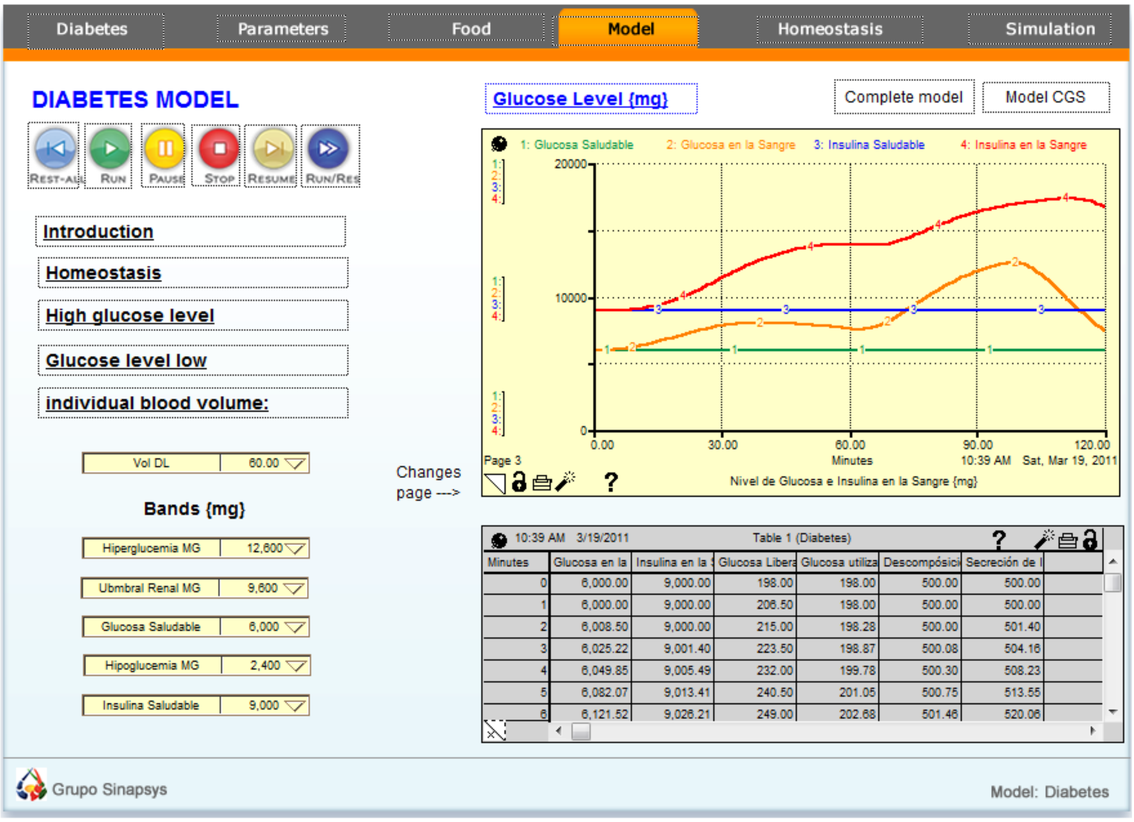
Diabetes: Glucose concentration level in blood

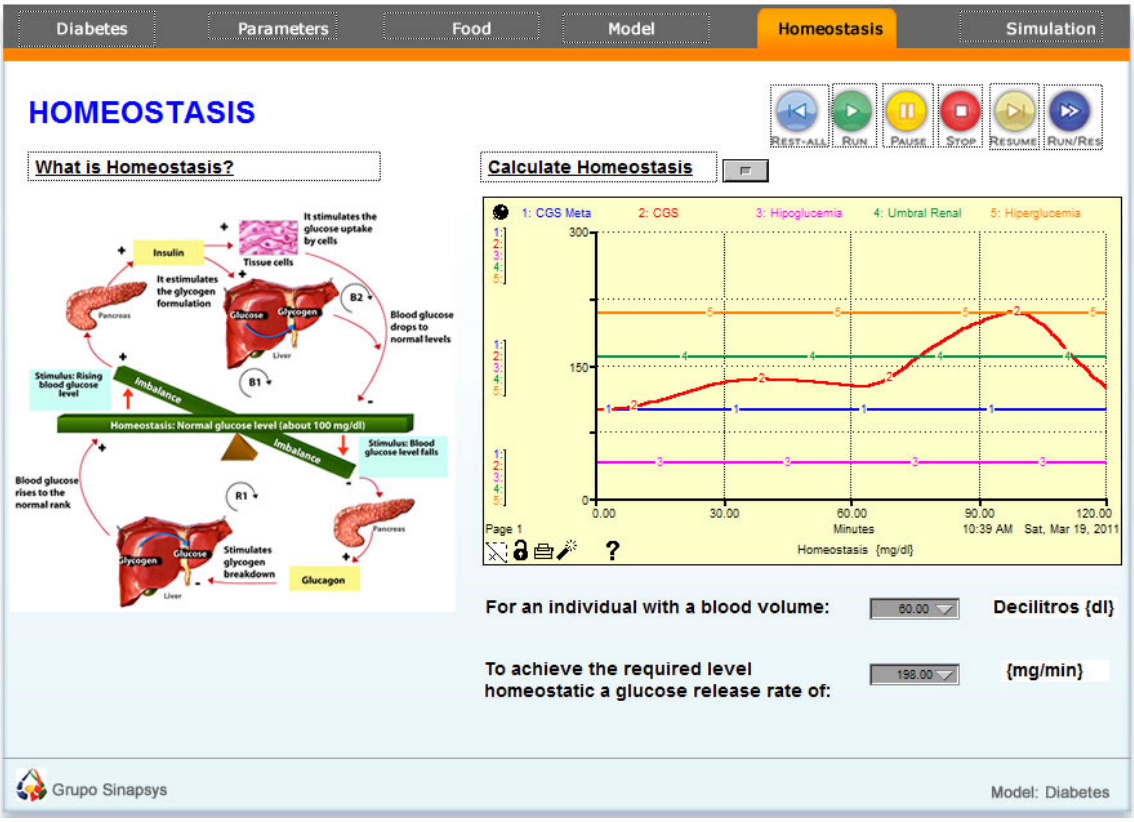


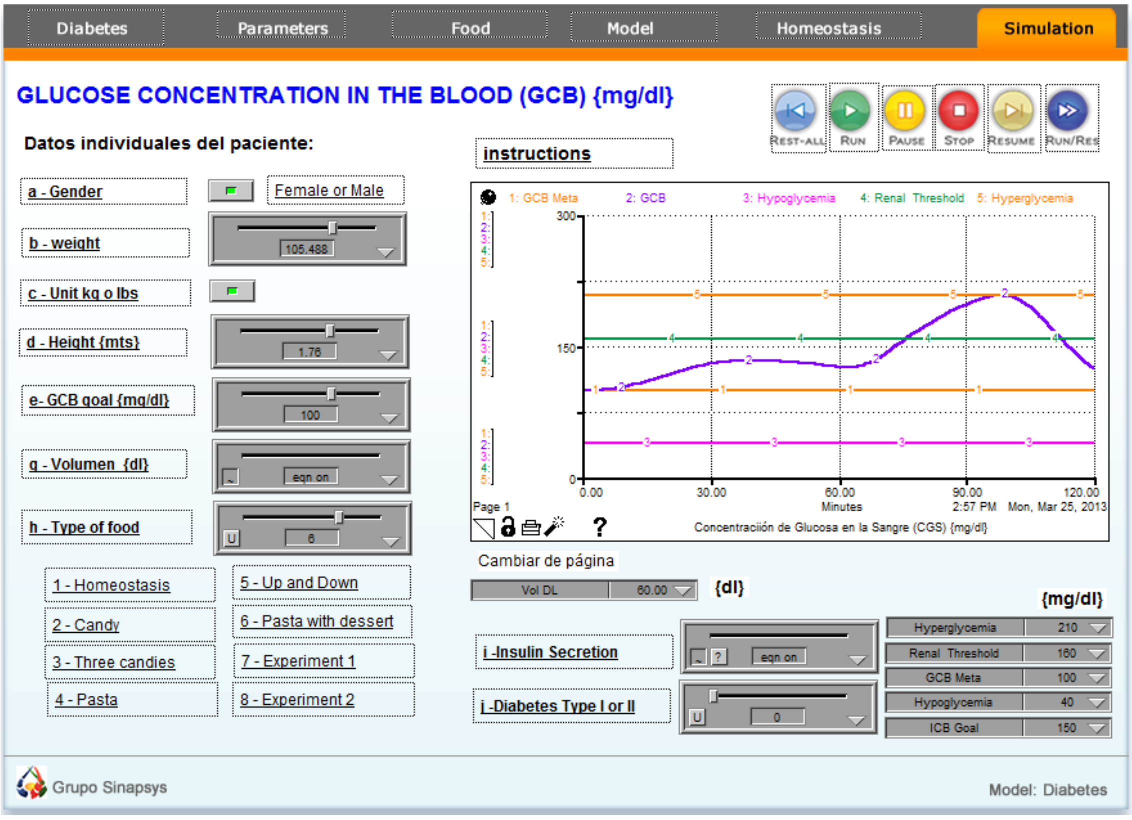


Diabetes: Glucose concentration level in blood






Diabetes
Parameters
Food
Model
Homeostasis
Simulation
HOMEOSTASIS
What is Homeostasis?
Calculate Homeostasis
Insulin
It stimulates the glucose uptake by cells
Tissue cells
It estimulates the glycogen formulation
Pancreas
Glucose
Glycogen
Liver
Blood glucose drops to normal levels
Stimulus: Rising blood glucose level
Imbalance
Homeostasis: Normal glucose level (about 100 mg/dl)
Stimulus: Blood glucose level falls
Blood glucose rises to the normal rank
Stimulates glycogen breakdown
Glucagon
1: CGS Meta
2: CGS
3: Hipoglucemia
4: Umbral Renal
5: Hiperglucemia
Minutes
Homeostasis {mg/dl}
For an individual with a blood volume:
60.00
Decilitros {dl}
To achieve the required level homeostatic a glucose release rate of:
198.00
{mg/min}
Grupo Sinapsys
Model: Diabetes


Diabetes
Parameters
Food
Model
Homeostasis
Simulation
GLUCOSE CONCENTRATION IN THE BLOOD (GCB) {mg/dl}
Datos individuales del paciente:
instructions
a - Gender
Female or Male
b - weight
105.488
c - Unit kg o lbs
d - Height {mts}
1.76
e- GCB goal {mg/dl}
100
g - Volumen {dl}
eqn on
h - Type of food
6
1 - Homeostasis
2 - Candy
3 - Three candies
4 - Pasta
5 - Up and Down
6 - Pasta with dessert
7 - Experiment 1
8 - Experiment 2
1: GCB Meta
2: GCB
3: Hypoglycemia
4: Renal Threshold
5: Hyperglycemia
Minutes
Concentración de Glucosa en la Sangre (CGS) {mg/dl}
Cambiar de página
Vol DL
60.00
{dl}
{mg/dl}
i -Insulin Secretion
j -Diabetes Type I or II
Hyperglycemia 210
Renal Threshold 160
GCB Meta 100
Hypoglycemia 40
ICB Goal 150
Grupo Sinapsys
Model: Diabetes

Conclusions

What an interesting model and its **learning laboratory** to help our young people to understand in a better way the health impact of diseases such as diabetes. The positive way in which the teaching work can lead to new habits and lifestyles in prevention of diseases that can bring down the life quality of our people and our public health systems.

It has been the Diabetes turn. Developing its model to understand better what happens with the mechanisms of self-regulation control and the blood glucose level, show us what is healthy and what is not for our body. Our wellbeing depends on the release rate of glucose entering the bloodstream during digestion.

Once the food is converted into glucose, it is important to visualize the cause-effect cycles that underlie the disease and its connection to other organs. Pancreas and insulin secretion, liver, bloodstream, which transports into cells the energy that glucose brings them, kidneys needed to release the glucose excess in urine, the hormonal system, etc. Forming together the negative feedback cycles responsible for regulating the blood glucose level to avoid severe damages to our body.

Using our learning lab, our youth will have the opportunity for experiencing what happens inside our bodies at the intake of different meals, what happens when the renal threshold bands and hyperglycemia are exceeded, or when hypoglycemia is presented, as well they would understand better how these cycles are broken by diseases like diabetes type I and II and the balance and harmony within us is disrupted.

The most important fact is to be proactive in the prevention task, to work in the appropriate time to change their habits and lifestyles improving their nutrition. It is also remarkable the importance of exercising when an individual suffers the disease. The glucose is in an excessive amount due to insulin is not secreted and it must be eliminated (Diabetes Type I) or even when having insulin and the cells reject it (diabetes type II), therefore glucose should leave and the best way to eliminate it is exercising.

Finally, returning to the old dynamic control class received since more than 30 years ago connected with the development of this learning laboratory for diabetes, it would be interesting to apply this knowledge in future works to model the behavior of other regulatory mechanisms such as the body temperature control, the heart rate, the water amount contained in the blood and breathing. All of these systems share similar structures like cause-effect cycles with negative feedbacks mechanisms that allow homeostasis and regularizes any changes in the parameters of a healthy person.

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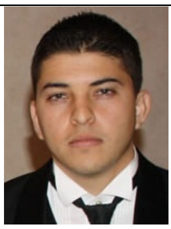	Modeling: **Ramiro Luis Almaguer Navarro** Education: Licenciado en Administración de Empresas Email: rmalmaguer@gmail.com
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