

Exploration of Diabetes

Goals:

- Be able to draw molecular structures.
- Know common biomolecules and their function within organisms.
- Review basic steps of Cellular Respiration

Introduction (Engagement)

In their second semester of college, Morgan started feeling tired all the time, and so they were taking naps every day after lunch. Despite all the naps, they were too tired to finish their homework or wake up for 8am biology lab. Morgan didn't know why they felt so exhausted.

After looking online for reasons why they might be feeling so tired, Morgan went to the Student Health Clinic where they recommended a standard blood panel to investigate multiple possibilities (for example: anemia, blood sugar, Vitamin D deficiency, elevated white blood cell counts which may indicate a persistent infection like Mono). Morgan scheduled an appointment for 7am because it is important to test 'fasting' blood sugar (before they ate breakfast). In the morning, a phlebotomist drew 10mL of blood from their arm.

The test results indicated that Morgan's fasting blood sugar was 118mg/dl. The doctor suggested that prediabetes may be reason Morgan often feels tired. This means that Morgan's metabolic homeostasis is slightly disrupted, and that they are at high risk of developing type 2 diabetes.

What is diabetes?

- Diabetes is a chronic (long-lasting) health condition that affects how your body turns food into energy.

Diabetes Facts

- **34.2 million** US adults have diabetes (10.5%)
 - 1 in 5 people don't know they have it.
 - Diabetes can be diagnosed by a fasting blood sugar test (Blood sugar over 126 indicates diabetes)
- In the last **20 years**, the number of adults in the United States diagnosed with diabetes has more than **doubled**.
- Diabetes is the **seventh leading cause** of death in the United States.
 - Diabetes is the **No. 1** cause of kidney failure, lower-limb amputations, and adult blindness.
- There is no cure for diabetes yet, but losing weight, eating healthy food, and being active can really help.

- Diabetes can be managed by taking medicine as needed, routinely exercise, diet and weight management.

Prediabetes

- In the United States, 88 million adults—more than 1 in 3—have prediabetes. More than 84% of them don't know they have it.
 - With prediabetes, blood sugar levels are higher than normal, but not high enough to be diagnosed as diabetes (fasting blood sugar concentration between 100-125mg/dl)
 - Prediabetes raises your risk for type 2 diabetes, heart disease, and stroke.
 - The good news is if you have prediabetes, a lifestyle change program can help you take healthy steps to reverse it.

Types of Diabetes

- There are three main types of diabetes: type 1, type 2, and gestational diabetes (diabetes while pregnant).

Type 1 Diabetes

- Type 1 diabetes is thought to be caused by an autoimmune reaction (the body attacks itself by mistake) that stops your body from making insulin.
- Approximately 5-10% of the people who have diabetes have type 1.
- Symptoms of type 1 diabetes often develop quickly. It's usually diagnosed in children, teens, and young adults. If you have type 1 diabetes, you'll need to take insulin every day to survive. Currently, no one knows how to prevent type 1 diabetes.

Type 2 Diabetes

- With type 2 diabetes, your body doesn't use insulin well and can't keep blood sugar at normal levels.
- About 90-95% of people with diabetes have type 2. It develops over many years and is usually diagnosed in adults (but more and more often children, teens, and young adults are being diagnosed with type 2 diabetes). You may not notice any symptoms, so it's important to get your blood sugar tested if you're at risk.
- **Generally, Type 2 diabetes can be prevented or delayed with healthy lifestyle changes, such as losing weight, eating healthy food, and being active.**

Gestational Diabetes

- Gestational diabetes develops in pregnant people who have never had diabetes.
- If you have gestational diabetes, you and your baby could be at higher risk for health problems.
- Gestational diabetes usually goes away after your baby is born but increases your risk for type 2 diabetes later in life. Your baby is more likely to have obesity as a child or teen, and more likely to develop type 2 diabetes later in life too.

Blood sugar provides cells with energy.

Blood glucose is needed to supply all your cells with chemical energy (which yields ATP through cellular respiration).

Recall:

- **Why do cells need ATP to survive?**
- **ATP is an acronym for what molecule?**
- **Which contains more energy: ATP or ADP?**
- **What is the general chemical formula for cellular respiration?**
- **Which organelle is primarily responsible for cellular respiration?**
- **What are the main steps of cellular respiration?**

How your food relates to blood sugar.

Carbohydrates in your food are broken down into simple sugars, and those monosaccharides are transported from your small intestine into your bloodstream. In other words: Enzymes in your digestive track break down complex sugars into simple sugars, and then membrane transport proteins move the simple sugars into your bloodstream, and this raises your blood sugar. For example: Starch is a large, branched polysaccharide that is digested into glucose monomers by the enzyme amylase.

- **Draw a diagram of a starch molecule using hexagons to represent the glucose monomers.**
- **What is the chemical formula of glucose?**
- **Draw molecular structure of glucose, making sure draw each atom and covalent bond.**

Blood Glucose Measurement

Glucose is blood sugar, and it is measured in milligrams of glucose per deciliter of blood (1 deciliter is equal to 100mL or 1/10th of a liter). Ideally, the concentration of glucose in blood is 80 to 100 mg/dL before a person eats a meal (fasting blood sugar level). If blood sugar drops too low, a person may slip into a coma. Blood glucose rises after a meal, and hopefully it does not rise over 180mg/dl. High blood sugar can cause many physiological and health related issues in humans (for example, kidneys can be damaged by consistent high blood glucose).

- **Why do people with blood sugar levels below 15 often slip into comas?**
- **Why do you suppose that constant tiredness and elevated fasting blood sugar levels are symptom of prediabetes? Specifically, how do you imagine that being tired is related to blood sugar levels that are TOO high?**

Glucose homeostasis

The human population evolved intricate homeostatic mechanisms to keep blood glucose levels between 80-180mg/dl. No matter how much sugary food you binge upon, your healthy body can usually prevent your blood sugar from raising beyond 180.

- After you eat, your blood sugar goes up, and that signals your pancreas to release the protein insulin into the blood. Insulin acts like a key to let the blood sugar into your body's cells for use as energy.
- As your blood circulates throughout your body, membrane transporters on individual cells move sugar from your blood into the cytoplasm.
 - Insulin activates membrane transport proteins to uptake sugar from your blood.
 - In your cells, sugar then goes through cellular respirations to generate ATP.
- If you have diabetes, your body either doesn't make enough insulin or can't use the insulin it makes as well as it should.
- Folks with diabetes have difficulty transporting simple sugars from the blood into their cells. Therefore, blood sugar levels are higher in people with pre-diabetes and diabetes, because the sugars are not being moved into the cells to be used.
- When there isn't enough insulin or if cells stop responding to insulin, too much blood sugar stays in your bloodstream. Over time, that can cause serious health problems, such as heart disease, vision loss, and kidney disease.

- **What are the monomers of proteins?**
- **Draw a generic amino acid, showing all atoms and covalent bonds. Draw a circle around the amino group, and a square around the carboxylic acid group.**
- **Draw a basic diagram of a skin cell with glucose transporters, mitochondria, and a nucleus.**