**POE #1: Halloween Night Crash**

**Topic**

Overview of A&P and the Cell (Homeostasis, Body Systems, Levels of Organization)

The case study below has been simplified for the purposes of this introductory anatomy and physiology course. As you progress in your academic and professional careers you may learn more extensive details related to this scenario.

**Introduction to the Phenomenon**

*As you read through the scenario below underline specific facts and information you find important to the situation*

Anticipation was building as 12-year-old brothers Billy and Johnny awaited the final school bell. They were anxiously waiting to rush home and begin preparing for Halloween night. Once school let out, they ran home finished their homework, put on their costumes, grabbed their pillow cases, and were ready to trick or treat. Before leaving, Johnny made sure to eat a protein bar and take his insulin medication for his condition. Johnny also increased his normal insulin dosage from one shot to two shots (double his normal dosage) to account for additional sugar consumption later that evening. Once they were ready, Billy and Johnny set out on their long evening of adventure. Billy and Johnny wanted to waste no time and get to as many houses as possible so they made sure to run from house to house as well as avoid eating any candy until they got home. Unfortunately, after two hours of trick or treating, their festivities were cut short when Johnny began experiencing shakiness, excessive sweating, and a rapid heartbeat. Johnny tried to continue on, but he became dizzy and lightheaded and started to stumble as he walked. Billy noticed something was wrong and quickly grabbed Johnny’s arm when all of the sudden Johnny became too weak to stand and he fainted. Billy immediately tried to wake Johnny up, while also grabbing a pack of gummy bears out of his bag of candy to give to Johnny as soon as he regained consciousness. As Johnny slowly awoke from his unconscious state he was still dazed and confused, but after consuming the gummy bears, he began to feel more stable.

**Driving Question(s)**

Why did Johnny experience abnormal symptoms and eventually faint? Why would gummy bears help Johnny in the situation described above?

**Initial Hypotheses/Predictions**

*In the box below, provide a possible answer to the driving questions above AND describe a condition(s) that Johnny might have?*

Answers will vary from student to student

Predictions and hypotheses should be scientifically based

Possible answers to the driving questions should be described in this box

**Relevant Data & Analysis Questions**

***ALL analysis questions are italicized in the pages below***

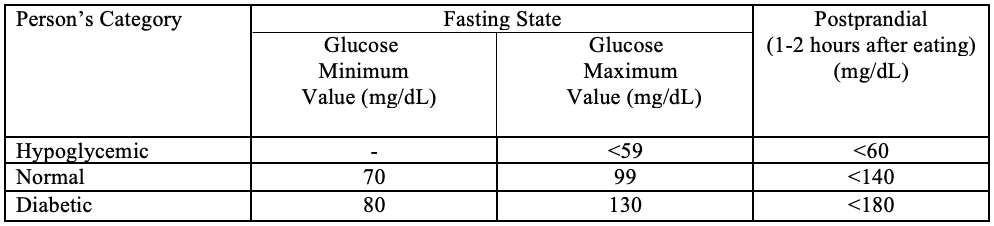
*When are Johnny’s blood glucose levels HIGH, LOW, and NORMAL on Halloween day? (Write HIGH, LOW, and NORMAL next to the appropriate value below)*

Johnny’s Blood Glucose Levels on Halloween Day:

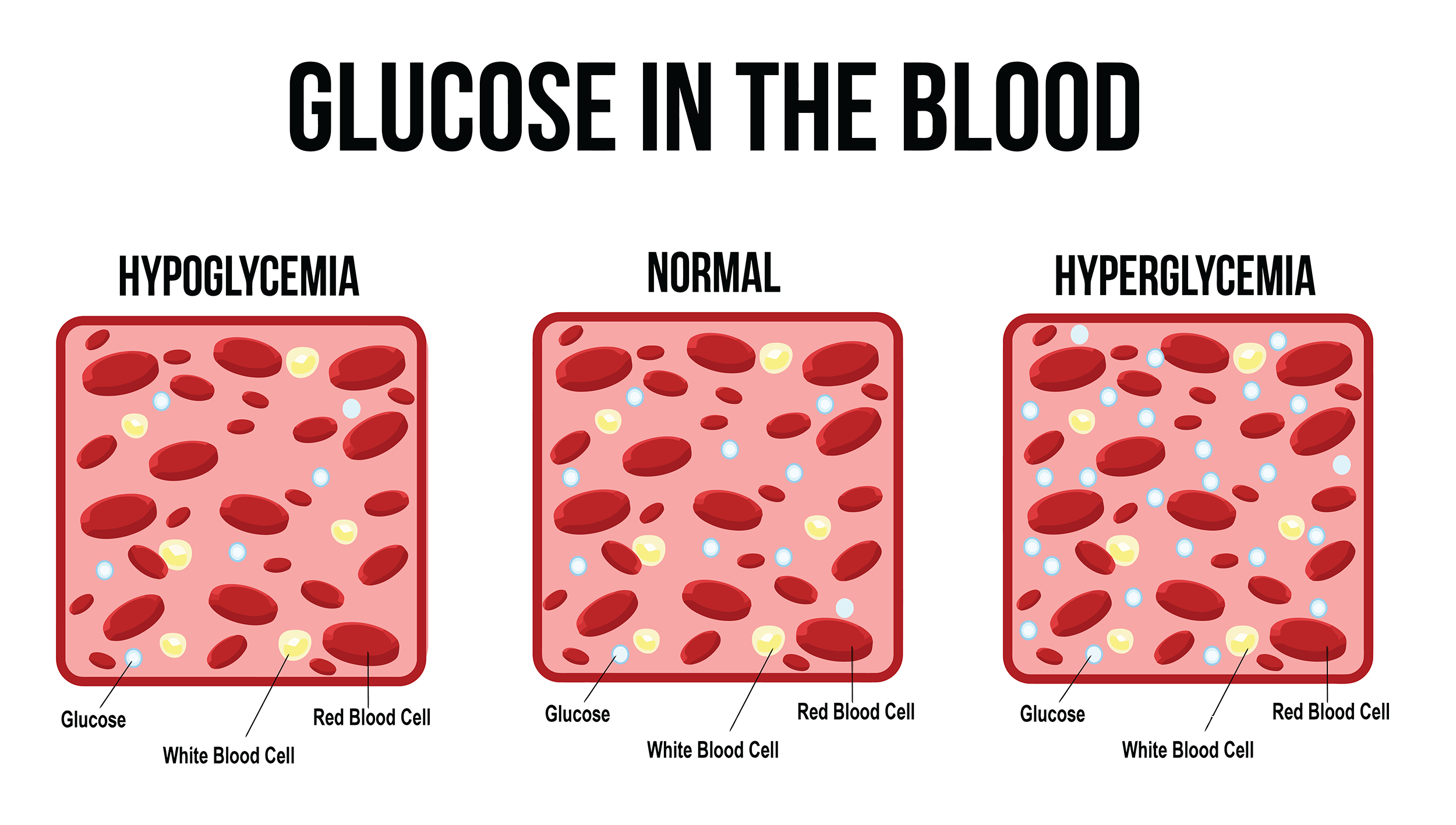
* Morning (Fasted): 128mg/dL *HIGH*
* Evening (2hrs. post-insulin shot (double dose)): 40mg/dL *LOW*
* Evening (Post gummy bear consumption): 115mg/dL *NORMAL*

**Blood Glucose Chart**

*Circle the values in this chart that are important to Johnny’s situation.*

****

*What does Johnny’s blood look like 2hrs. after his evening insulin shot? (Circle below)*

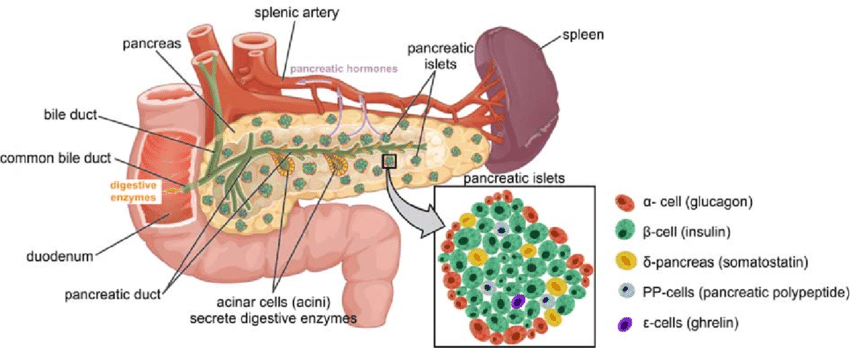
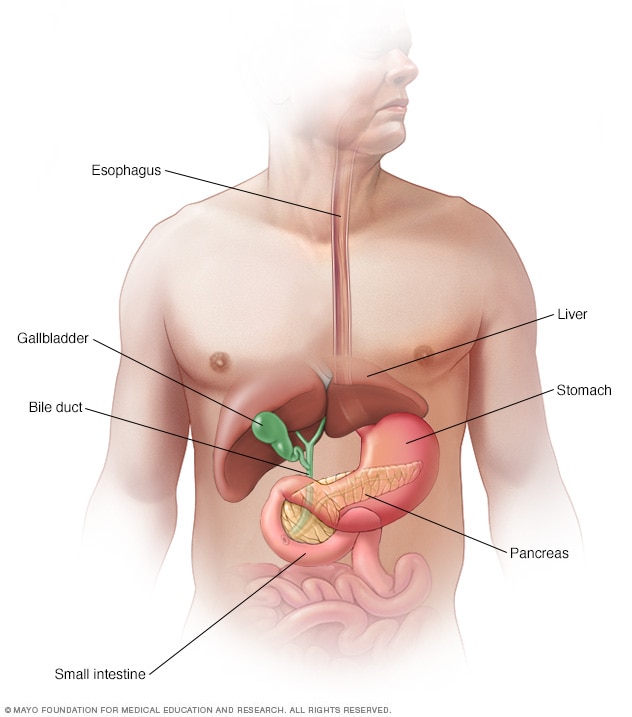


*https://www.lark.com/blog/what-is-hyperglycemia/*

*In the chart below, circle the symptoms Johnny was experiencing, underline the possible cause(s), and highlight/circle which blood glucose condition he was suffering from.*

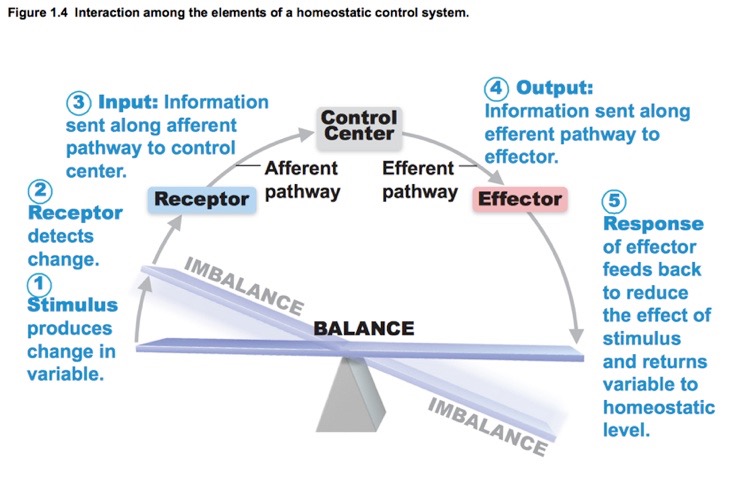
|  |  |
| --- | --- |
| **Hypoglycemia** | **Hyperglycemia** |
| Blood Glucose Level:  <70mg/dL | Blood Glucose Level: 180-200mg/dL (Fasted) |
| Causes:   * Medication Misuse (e.g. Improper insulin dosage) * Critical Illnesses (Kidney or liver diseases/anorexia) * Hormone deficiencies | Causes/Risk Factors:   * Insulin resistance * Inability to produce insulin * Inactivity * Poor diet (high sugar, highly processed) * Overweight/Obesity |
| Symptoms:   * An irregular or fast heart rate * Fatigue * Shakiness * Dizziness * Loss of consciousness | Symptoms:   * Fatigue * Confusion * Frequent Urination * Nausea |

**Pancreas Anatomy Images**



*Which pancreatic cells are important in Johnny’s scenario and what do they secrete?*

*Alpha cells which secrete glucagon are important in Johnny’s scenario, because Johnny is experience hypoglycemia (low blood glucose), and needs an increase in glucose in the blood. In order to get this increase he either needs his alpha cells to activate and release glucagon to signal the liver to release glucose, or he needs to intake glucose from a food source.*

****

*Based on the homeostasis graphic and the information above, describe blood glucose homeostasis using the terms stimulus, receptor, control center, effector, and response. Fill out the table below for both hypoglycemia and hyperglycemia*

*List and describe each component of blood glucose homeostasis below.*

|  |  |
| --- | --- |
| Hypoglycemia | Hyperglycemia |
| Stimulus: Low blood glucose / Decreased blood glucose levels/ Blood glucose depletion | Stimulus: High blood glucose / Increased blood glucose levels / Blood glucose saturation |
| Receptor: The pancreas- Senses low levels of glucose in the blood | Receptor: The pancreas-Senses high levels of glucose in the blood |
| Control Center: Islets of Langerhans (Pancreatic islets)/ Alpha Cells | Control Center: Islets of Langerhans (Pancreatic islets)/ Beta Cells |
| Effector: Alpha cells releasing glucagon | Effector: Beta cells releasing insulin |
| Response: Glucagon increases blood glucose levels back to the normal set point/ Glucagon signals the liver and muscles to break down glycogen into glucose so it can be transported into the blood to increase blood glucose levels | Response: Insulin decreases blood glucose levels back to the normal set point/ Insulin binds to cells and triggers glucose receptors (GLUT-4 receptors) to uptake glucose from the blood and store in the cells such as the liver and muscles in the form of glycogen |

Analyze the material in the following chart before proceeding.

*Highlight/underline important observations from the chart below to help you answer the driving questions*

|  |  |  |
| --- | --- | --- |
|  | Type I Diabetes | Type II Diabetes |
| Typical Age of Onset | Younger | Older |
| Causes | Immune system attacks your own body’s insulin producing beta cells in the pancreas (Mostly caused by genetic predisposition/ Autoimmune disease) | Generally due to factors such as poor diet, lifestyle, and certain genetic predispositions (Mostly caused by environmental factors) |
| Effects on Insulin | Cannot produce insulin due to the lack of beta cells | Become insulin resistant (Muscles, liver, and fat cells do not use insulin well) |
| Risk Factors | Genetic predisposition  Triggered by a virus or toxin  Autoimmune attack | Overweight/Obesity  Over age 45  Family history  Ethnicity  High blood pressure  Not physically active  History of heart disease or stroke  Poor diet |
| Symptoms | Unable to uptake glucose into cells due to a lack of insulin  Difficulty regulating blood glucose levels  Improper insulin dosage (i.e. too much) can lead to **hypoglycemia**  Forgetting to take insulin medication can lead to **hyperglycemia** | Depending on the severity of a person’s diabetes they will have varying degrees of difficulty up-taking glucose into cells due to **insulin resistance**  Insulin receptors become less effective, and even through the addition of more insulin the person is still incapable of up-taking glucose properly  Inability to properly use insulin can lead to **hyperglycemia** due to excess glucose building up in the blood |
| Treatment Options | Insulin medication  Continuous blood glucose monitoring  Insulin pump  Physical activity  Healthy food choices | Lose weight  Increase exercise (both cardio and weight training)  Eat more whole foods and less sugar/refined carbohydrates  Medication if needed initially to reduce symptoms caused by large swings in blood glucose levels |

*Based on the information in the chart above what type of diabetes does Johnny have? Explain.*

*Johnny appears to have Type I diabetes, because he meets many of the criteria listed above. Johnny is younger and healthy, he also requires insulin medication throughout the day, and he experienced hypoglycemia due to improper medication dosage. Also since he is taking insulin medication this is likely due to the fact that his body destroyed his own beta cells and he can’t produce his own insulin anymore.*

**Observations**

*After examining the data and answering the analysis questions above, describe interesting observations and patterns you believe are relevant to explaining the phenomenon. You can include both written and visual observations in order to help organize the data from above. You can also tie in ideas and concepts from lecture when recording your observations. (Include at least 10 observations below)*

Observations will vary from student to student

Example Observations Listed Below:

* Blood glucose levels are under homeostatic regulation
* The pancreas is responsible for controlling blood glucose levels
* Beta and alpha cells are found within the pancreas (pancreatic islets) and they respond to changes in blood glucose by secreting either insulin or glucagon
* Insulin is normally secreted in the body to take glucose into the cells and reduce blood glucose levels
* Glucagon is normally secreted in the body to break down glycogen in the liver and release glucose back into the blood.
* Blood glucose is maintained in a small range, and requires fluid and efficient communication between the blood, pancreas, liver, and muscles to maintain normal ranges
* Based on the diabetes comparison chart Johnny appears to have type I diabetes
* Type I diabetes leads to a destruction of beta cells and leaves the body incapable of producing its own insulin
* Type I diabetes requires insulin medication to regulate blood glucose levels, because the body is no longer capable of maintaining homeostasis
* Based on Johnny’s symptoms he is experiencing hypoglycemia which means his blood glucose is much lower than normal levels
* Hypoglycemia leads to low energy, dizziness, fatigue, rapid heartrate, and fainting, which Johnny experienced
* Johnny’s natural glucagon was not capable of bringing him out of his hypoglycemic shock due to his type I diabetes
* The combination of a high insulin dosage, no food intake after the insulin medication, running around and trick or treating, and his type I diabetes Johnny experienced a multitude of symptoms indicating hypoglycemic shock
* Important data:
  + Johnny’s fasted glucose 128mg/dL (fairly normal for type I diabetes/ high for a normal fasting value)
  + Elevated post-prandial glucose levels indicating signs of diabetes
  + 2hrs. post-insulin shot in the evening was 40mg/dL which is extremely low and indicates severe hypoglycemia, which explain Johnny’s symptoms and hypoglycemic shock
  + Hypoglycemia can occur when blood glucose levels drop below 70mg/dL
  + Johnny took a double dose of insulin medication in the evening after his protein bar to account for future sugar intake, but he took too much because he didn’t end up eating candy while running around and trick or treating
  + After experiencing hypoglycemic shock Johnny awoke and consumed gummy bears which raised his blood glucose levels back to 115mg/dL allowing him to feel normal again

**Explanation**

*Based on the data and analysis questions above, please provide an answer to the driving questions in the box below. Remember to include supporting data/evidence, important ideas from lecture, and the concept of homeostasis in your response.*

**Driving Question(s)**

*Why did Johnny experience abnormal symptoms and eventually faint? Why would gummy bears help Johnny after he regained consciousness*?

Explanations will vary from student to student

A detailed example explanation is provided below:

Normally blood glucose levels are homeostatically maintained within the body. This means that blood glucose is kept within an appropriate range (<100mg/dL fasted) to allow the body to function and perform optimally. Communication between the blood, pancreas, and liver allow for this balance to take place, and whenever there is a deviation from the natural set point a feedback-response system is initiated to correct for this deviation. For example, if blood glucose levels drop too low, which would be an indication of hypoglycemia, the body must alert different organ systems to initiate a correction response. In the case of hypoglycemia, the pancreas would sense the low levels of glucose in the blood, which would then alert the alpha cells within the pancreatic islets, to release glucagon. Once glucagon is released into the blood it signals the liver to break apart the stored glycogen into glucose molecules that can be transported out into the blood. Once glucose is excreted from the liver into the blood, the glucose levels in the blood rise and return to the normal set point, correcting for the hypoglycemic event. A similar response pathway is initiated if blood glucose levels rise too high, which would be a hyperglycemic event. In the case of hyperglycemia, the pancreas senses high levels of glucose in the blood, which alerts the beta cells in the pancreatic islets to release insulin. Once insulin is released into the blood, it binds to muscle and liver cells, and activates glucose transporters to allow glucose to be taken up and stored in these cells as glycogen. This response ultimately lowers blood glucose levels back to the normal set point.

The above explanations describe how the body normally functions and homeostatically regulates blood glucose levels. In the phenomenon for this unit, Johnny’s body was not able to normally regulate his blood glucose levels. Based on the data provided, and the evidence surrounding this phenomenon there a several reasons Johnny experienced abnormal symptoms and fainted. In the phenomenon description it was stated that Johnny took double his normal dosage of insulin after eating a small protein bar snack. The fact that Johnny was taking insulin medication was already a sign that he likely has diabetes. Based on the comparison chart of type I and II diabetes, Johnny’s young age, higher fasted blood glucose, and the fact that he takes insulin medication the data supports that he has type I diabetes. Generally, type I diabetes is experienced in younger children, it is a genetic disorder where the immune system attacks the insulin producing beta cells, and insulin medication is required to maintain stable blood glucose levels throughout the day. Since Johnny has type I diabetes, he has to carefully monitor his blood glucose throughout the day and he has to properly administer his insulin medication based on the food he eats accounting for sugar intake and his energy expenditure. The reason Johnny experienced symptoms of light headedness, rapid heart rate, dizziness, and eventually fainting was because he didn’t properly balance his insulin levels with his glucose levels. After his protein bar consumption Johnny took a double dose of insulin to prepare for eating more candy that evening, but he ended up not eating any extra candy and he was running around a lot, so the insulin dosage was too much for his body. Due to the overdose of insulin, his blood glucose levels quickly started dropping, which caused a large deviation from his normal homeostatic levels. Johnny’s blood glucose dropped to 40mg/dL after his insulin shots, and anything below 60-70mg/dL is considered hypoglycemia. Johnny’s levels deviated very far from his normal homeostatic set point (~110mg/dL), so he was experiencing severe acute hypoglycemia which caused him to feel dizzy, light headed, confused, and eventually he fainted.

Luckily Johnny was with his brother, so after fainting his brother knew he had to wake Johnny up, and upon regaining consciousness Johnny needed to consume sugar. The fastest way to increase blood glucose levels would be to consume a fast-digesting carbohydrate/sugar food source. The gummy bears in this case allowed Johnny’s blood glucose levels to rise, and as stated in the data after consuming them, his blood glucose levels rose back up to a more stable level of 115mg/dL. This would be a normal blood glucose level after consuming a carbohydrate. Also based on the analysis questions and data, the reason Johnny needed to consume gummy bears to increase his blood glucose levels, is because his body’s glucagon response was not able to compensate for the drastic drop in glucose levels. Normally in people who do not suffer from type I diabetes, their bodies can respond to larger glucose drops, but sometimes in type I diabetes a person’s glucagon response is also impaired. So ultimately an external source of glucose was required to correct the homeostatic imbalance of blood glucose experienced by Johnny.

*Explanation Continued:*

Luckily Johnny was with his brother, so after fainting his brother knew he had to wake Johnny up, and upon regaining consciousness Johnny needed to consume sugar. The fastest way to increase blood glucose levels would be to consume a fast-digesting carbohydrate/sugar food source. The gummy bears in this case allowed Johnny’s blood glucose levels to rise, and as stated in the data after consuming them, his blood glucose levels rose back up to a more stable level of 115mg/dL. This would be a normal blood glucose level after consuming a carbohydrate. Also based on the analysis questions and data, the reason Johnny needed to consume gummy bears to increase his blood glucose levels, is because his body’s glucagon response was not able to compensate for the drastic drop in glucose levels. Normally in people who do not suffer from type I diabetes, their bodies can respond to larger glucose drops, but sometimes in type I diabetes a person’s glucagon response is also impaired. So ultimately an external source of glucose was required to correct the homeostatic imbalance of blood glucose experienced by Johnny.