CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY

Name(s)

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Project Number

J0913

Project Title

Adjusting Blood Sugar Levels to Address Diabetes

Abstract

Objectives/Goals

Diabetes patients face challenges to continuously check and adjust their blood glucose levels. My objective is to create a simplified artificial pancreas model that continuously checks glucose levels, automatically adjusts high glucose levels, and gives warning for low glucose levels.

Methods/Materials

My model contained two circuits: first to deliver insulin using peristaltic pump and second to warn using LED. I used acid-base chemistry and represented an acidic solution (vinegar) for high blood glucose levels, a neutral solution for normal glucose levels, and a basic solution (sodium bicarbonate) for insulin. I made a conductivity sensor that uses idea of electrolysis to represent the glucose sensor. As the conductivity sensor has low enough resistivity in acidic solutions, enough current goes into the transistor and pump runs delivering basic solution until the acidic solution becomes neutral. In the second circuit, I used a NOT gate to reverse the effects. LED turns on when the solution becomes neutral indicating acceptable glucose levels and off in basic solution showing low glucose. I tested the response of pump and LED. I measured original and attained pH of the solution and how much basic solution was used to neutralize.

Results

Pump started automatically in acidic solutions (high glucose) of pH 2.5, 4, and 5, and on average, stops at pH 6.28. On average, pump delivered 190 mL basic solution to neutralize 200 mL acidic solution (pH 2.5), 114 mL basic solution to neutralize 220 mL acidic solution (pH 4), and 139 mL basic solution to neutralize 270 mL acidic solution (pH 5). Pump did not deliver the exact same amounts of basic solution for the same pH of acidic solution, however, the variation is acceptable as pH is the negative logarithm of molarity of hydrogen ions in a solution. Pump did not start to deliver basic solution into neutral (normal glucose) of pH 6.5. LED turned on in neutral solutions. LED turned off in basic solutions.

Conclusions/Discussion

My system is able to automatically deliver basic solution, neutralizing the acidic solution. This represents delivering insulin to reduce glucose levels to an acceptable range. It does not deliver basic solution to neutral solutions (normal glucose). It gives warning in basic solutions (low glucose) through LED indicating patients need food. I will explore ways to convert my prototype into a practical, compact artificial pancreas.

Summary Statement

I created a model of an artificial pancreas that continuously checks blood sugar levels, automatically normalizes high glucose levels, and gives warning for low glucose levels.

Help Received

Father taught how to troubleshoot circuits and other difficult-to-understand concepts; Mother supervised me during my experiments.