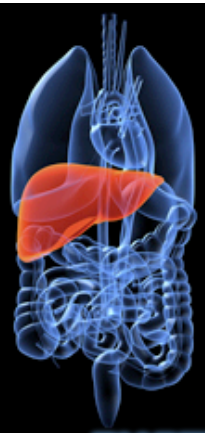
IPRO 308 : Developing the artificial pancreas



Mission Statement : IPRO 308 is dedicated to developing a closed-loop method of addressing type I diabetes involving a fully automated means of measuring glucose levels in the patient, determining the adequate insulin requirement and administering the dose, not only with minimal input and effort from the patient, but completely non-invasively and with no discomfort.

DIABETES

DIABETES AND INSULIN

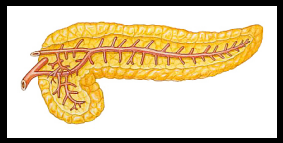
Insulin is a hormone normally released by pancreatic islet cells that interacts with cells to increase their permeability to glucose. Diabetes is a chronic condition that is rapidly becoming more prominent around the world and is linked with abnormal insulin production in the body.

-Types

Diabetes may be classified into two groups: Type I and Type II. In an individual with Type I diabetes, the pancreatic beta cells that normally produce insulin are nonexistent or are destroyed typically due to autoimmune destruction. In an individual with Type II diabetes, there is tissue-wide resistance to insulin and usually some impairment of beta cells as well. Therefore, although insulin production may be present it does not yield the necessary effect on the body. Type I diabetes is typically treated with frequent extraneous insulin injections, depending on the current blood glucose levels of the individual; however, in order to determine the glucose levels individuals subject themselves to periodic finger pricks through the day which is very uncomfortable and can be emotionally pressing as well.

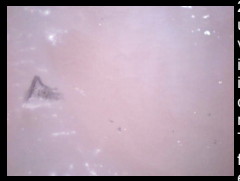
THE ARTIFICIAL PANCREAS

Mechanical devices for insulin delivery, also known as "artificial pancreases", are currently available in the marketplace. However, these devices are not only highly-invasive and painful, but also must be sanitized frequently to prevent infections. As a result, they are inconvenient and many diabetic subjects choose not to use them.

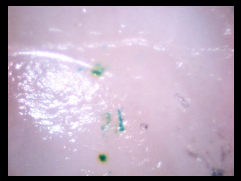


CLOSED-LOOP TECHNOLOGY

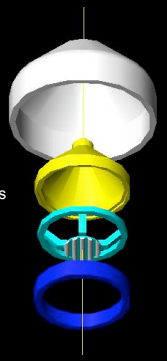
The Closed-Loop technology subgroup for the Spring 2008 semester picked up where the previous team had left off, testing the developed prototype on pig skin, attempting to extract interstitial fluid. Due to the limitations in volume of how much fluid would be extracted (4 µl), water mixed with a green food coloring was used to soak the skin. This would provide more volume but also make it visible under a microscope.

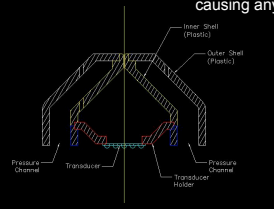


200X view of pig skin under sonophoresis, vacuum and iontophoresis, immersed in green colored solution reveals green spots. This proves the feasibility of the extraction of any fluid through skin without causing any harm.



Differences indicate that the solution has been pulled up through the pores by the processes. This is a major accomplishment and definitely brings us closer to being able to extract the fluid from the pores for glucose measurement.



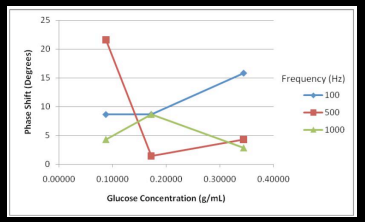


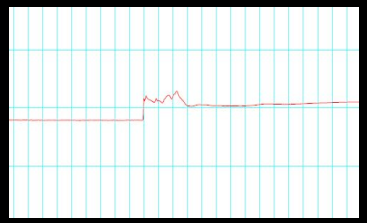
Research showed that acoustic intensity would be the major factor in the sonophoresis part of the extraction. Looking into the factors that contribute to acoustic intensity, it was determined that the speaker currently being used would be largely ineffective in the process. The necessary levels of intensity required indicated the need for an ultrasonic transducer.
Due to the nature of the transducer and our need for a prototype capable of insulin administration, the team proceeded to develop a new prototype with a dual vacuum, a transducer and ducts to ease the flow of the interstitial fluid.

GLUCOSE MEASUREMENT

AC Impedance

Any insulator placed between two points of differing potential (voltage) will act as a dielectric placed in a capacitor. By finding the resonant frequency of glucose, we can change glucose concentrations in a fixed volume capacitor, and measure the change in capacitance. To test this in the lab, we used a glucose concentration, along with a homemade capacitor, made from printed circuit board material. We then plotted an input wave and compared it with the wave against the capacitor and attempted to calculate the phase shift.
The major problem we ran into was that even though our solution was made of deionized water, the oxidation of the copper in the water produced inconsistent results. These are charted in the graph shown





Oxidation Reaction

Glucose oxidase reacts with glucose and as a byproduct, generates some free electrons, which can be measured as an electrical current. This can be seen as a pulse on an oscilloscope. An example of an actual pulse observed in lab is attached as measurement 2. There are a couple of different ways to use this pulse and that have been tested this semester. The first is to use a fixed glucose volume with differing concentrations and add a fixed volume of gluose oxidase. The idea is that the speed of reaction could be correlated with the glucose concentration. The other way is to try a fixed concentration, larger volume of glucose oxidase and react a small volume of varying concentrations of glucose. The plan is to plot the peak voltage from the spike and correlate that.

RESEARCH

The objectives of the Research Team were:
- Submit a grant proposal
- Complete the deliverables
- Do research for other sub teams
- Get an animal protocol approved for live rats

The animal protocol was approved, however delayed. The grant proposal is being written currently as one of the last objectives. All the otherdeliverables have been submitted.
Fortunately, we did not encounter very many problems other than finding sources for the grant proposal.

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