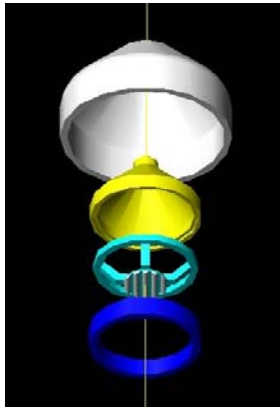


Looking into the factors that contribute to acoustic intensity, we concluded that the speaker currently being used would be largely ineffective. We decided that an ultrasonic transducer, which can supply higher intensities, would be the most effective for both interstitial fluid extraction and insulin administration purposes. The team thus proceeded to develop a new extraction model with a dual vacuum, ultrasonic transducer, and ducts to ease the flow of the interstitial fluid. The new model can be seen below.



Acknowledgements

The members of IPRO 308 would like to express their deepest gratitude to Dr. Derwent and Dr. Dhar for granting us laboratory space in which to conduct our research.

We would also like to extend our thanks to Mr. Ray DeBoth and Dr. Emmanuel Opara for their guidance and advice throughout the course of this innovative and challenging project.

The Future ?

This semester IPRO 308 conducted research that integrated the ideas and work from individuals from a wide range of disciplines. Building on the progress made by the Fall 07' and prior teams, members worked on components of the technology that suited their unique educational expertise. These were the extraction of interstitial fluid from porcine and rat skin, which can function as proxies for human skin, and the testing and development of two new measurement methods: Electrical Impedance, and Electrochemical sensory (using glucose-oxidase enzyme). Our goal with the now impending team transition continues to be the optimization of each component of our technology for integration into an efficient "closed loop" system for complete diabetes therapy. This semester, our extraordinary research team applied for grants to further fund the project, and to acquire the necessary technology so that the incoming team can:

**Further develop the electrochemical sensory method as a means of eventually measuring the concentration of glucose within interstitial fluid.*

**Design a efficient process for impedance measurement of glucose in interstitial fluid.*

**Test a new interstitial fluid extraction model that will allow for removal of physiologically useful quantities for glucose measurement.*



The Team: Kyle Laster, Walatta Mesquitta, Joon Park, Shezami Khalil, Richard Hanley, Michael Tishler, Zachary Estrada, Rohan Matthews, and William Wakeman

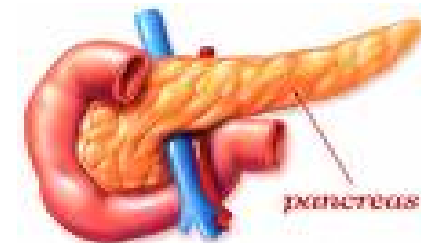


IPRO 308 The Artificial Pancreas



*An Integrative and Painless
Approach to Diabetes
Therapy*

Current methods of treating Type I diabetes are both inconvenient and painful. The goal of IPRO 308 is to develop an automated, non-invasive artificial pancreas that will integrate glucose monitoring with insulin therapy. The final device will be capable of measuring patient blood glucose levels and administering an appropriate amount of insulin to restore glucose to safe physiological levels. This semester IPRO 308 worked on the development and research of several innovative technologies that would enable this noninvasive "closed loop" treatment method.



Illinois Institute of Technology

Sponsor: University of Chicago.

The Nature of The Problem and Our Unique Treatment Modulus



The Glucowatch requires frequent finger pricks, and doesn't integrate glucose measurement with insulin therapy

Diabetes is an illness that is becoming more prevalent around the world and is associated with either abnormal insulin production or utilization.

Diabetes may be classified into two groups: Type 1 and Type 2.

In an individual with Type 1 diabetes, the pancreatic β cells that normally produce insulin are nonexistent, as they have been destroyed due to autoimmune response. In an individual with Type 2 diabetes there is tissue-wide resistance to insulin, and usually some impairment of β cells as well.

There are two problems with current Type I Diabetes treatment:

- * It requires frequent extraneous insulin injections, depending on the acute changes in blood glucose level of the patient. This requires periodic finger pricks throughout the day, which is both invasive and painful.
- * It is inconvenient in that measurement and insulin administration to restore glucose to safe physiological levels is physically and temporally separated.

⇒ IPRO 308 is committed to alleviating the pain and inconvenience associated with current diabetes treatment by developing a single device that integrates a noninvasive glucose measurement method with insulin therapy. This will require developing highly efficient methods for: noninvasive extraction of interstitial fluid through the skin; glucose measurement; and insulin administration. We are currently developing separately the technology for the first two phases of this process: extraction of interstitial fluid and glucose measurement.

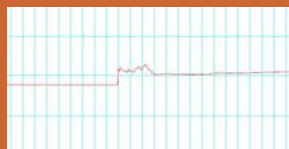
Our Research

⇒ Developing a Reliable Method for glucose measurement

We sought to develop glucose measurement this semester by experimenting with two exciting new technologies: Electrical impedance and Electrochemical sensory.

- ◆ **Electrical Impedance:** Electrical impedance is a procedure by which the capacitance and resistances in some electrical system is probed to establish an overall sum resistance value for some measurement application. In our impedance investigations, we created a capacitor with interstitial fluid as the dielectric or non-conducting element. Our experimental design required applying a set input frequency and then measuring with an oscilloscope the phase delay for the response signal (at the same frequency). We expected to observe a positive correlation between the concentration of glucose and the induced phase shift. After running several experiments using a homemade copper capacitor, we found that this was ionizing our solution (DI water + glucose), making reliable impedance measurements impossible. We have concluded that improving the reliability of this technology would require plating our capacitor with a non-ionizing agent such as solder, as well as performing our measurements at the resonant frequency of glucose, which will require the purchase of a Q meter.

- ◆ **Electrochemical sensory:** In our electrochemical sensory approach to glucose measurement, we used the enzyme glucose oxidase to catalyze the enzymatic conversion of glucose to H_2O_2 .



A representative voltage spike observed upon addition of glucose-oxidase enzyme to glucose solution.

Current generated by H_2O_2 reaction at the sensing electrode in our reaction vessel induces a voltage spike that we hoped could be correlated directly to glucose concentration. Though we did register voltage spikes with addition of the enzyme, there was no positive correlation between these and our glucose concentrations. We found that placement of the electrodes in the reaction vessel, their separation, and the rate of enzyme introduction could cause variance in these volt-

age spikes, and hope to integrate newer technologies into our procedure in the future that will allow for more reproducible and accurate measurements.

⇒ Extracting Interstitial Fluid for Glucose Measurement

The Closed-Loop technology subgroup for the Spring 2008 semester picked up where the previous team had left off, using the final prototype to attempt to extract interstitial fluid from permeabilized porcine skin. The team encountered numerous challenges over the course of the semester that have helped them refine the experimentation process, and establish what is necessary for an optimally functioning interstitial fluid extraction system



Due to difficulties in extracting sufficient interstitial fluid (4 μ l), and positively identifying pores,

the skin was immersed in green dye to both provide additional fluid volume, and help resolve the pores under the microscope. Results thus far have been inconclusive, suggesting the need for a higher resolution power.

For extraction results to be useful, we must use skin which in thickness and permeability is physiologically similar to human skin. The team has been consistently pursuing the acquisition of an optimal physiologically representative skin, experimenting for a time with rat skin acquired from the IIT Research Institute. Due to the minimal surface area available after harvesting, rat skin was deemed unsuitable for further research. The team is currently working with our research partners to acquire live rats, for which this harvesting will not be required.

Independent research by team members has shown that the acoustic intensity applied to porcine or rat skin is the major factor in increasing its permeability to fluid extraction or administration.