An innovative approach for diabetes therapy....

What Is Diabetes?

Diabetes is a condition which is defined by the inability of the body to produce or utilize insulin. There are two major types of diabetes: Type I and Type II. In an individual with Type I diabetes, the pancreas is unable to produce insulin. An individual with Type II diabetes is able to produce insulin, but the body's tissue cells are resistant to it.

How Is Diabetes Inconvenient To Your Life?

Current therapy for Type 1 diabetes requires multiple daily venipunctures for insulin delivery in response to changes in blood glucose concentrations. This treatment modality is both inconvenient and painful.

- ❖ **Sleeping:** glucose levels muvst be checked during the night to avoid slipping into a hypoglycemic coma
- ❖ **Eating:** meals have to be scheduled and they can only contain a calculated amount of carbohydrates
- ❖ **Exercising:** too much insulin during exercise can lead to a hypoglycemic coma
- ❖ **Social Activities:** leaving to check glucose levels or injecting yourself with glucose poses an awkward situation at parties or a restuarant.
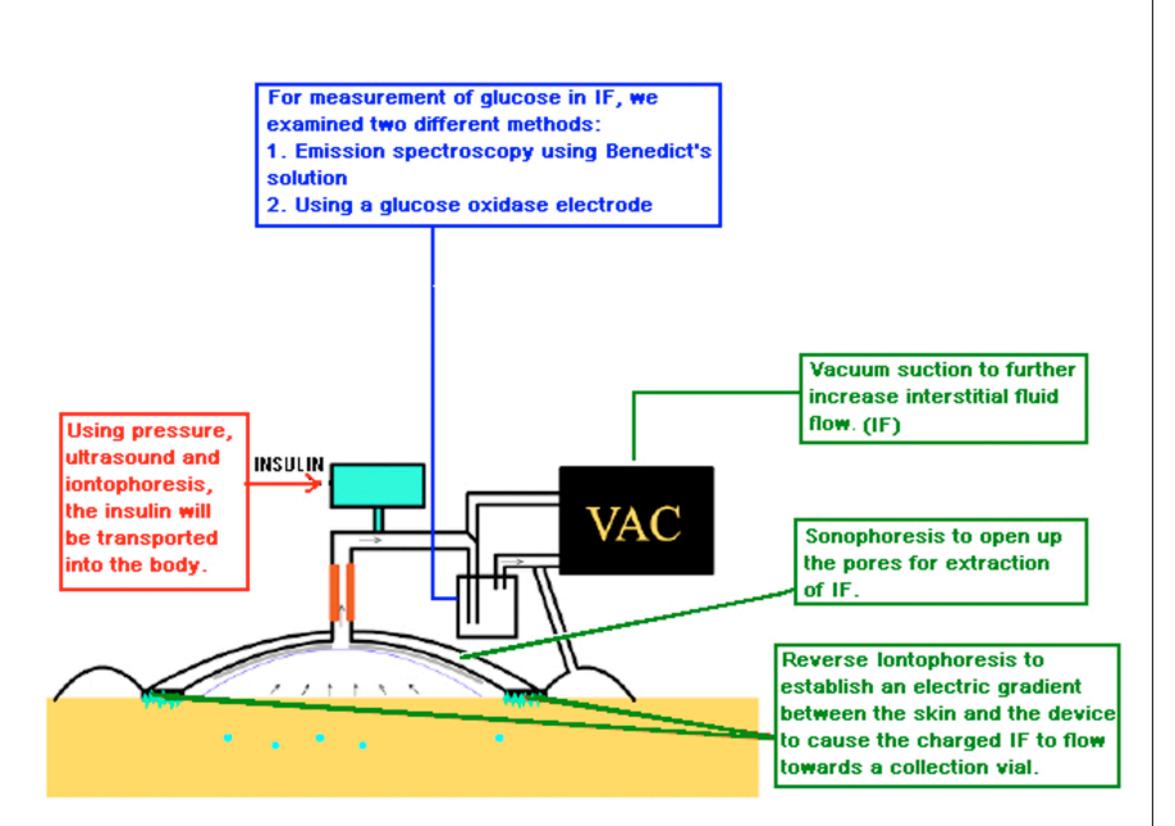
Objectives:

In previous semesters, members of this IPRO researched options for glucose measurement and insulin delivery. This semester we sought to:
1. Use a **non-invasive method for extraction** in order to extract a greater amount of interstitial fluid than achieved before.
2. Revise the prototype in order to improve vacuum efficiency.
3. Weigh the advantages and disadvantages of different glucose measuring techniques investigated and select the most effective one.
• Set up an experimental design using **Benedict's solution to test for glucose concentrations.**
4. Research and apply for **NCIIA and FORD grants.**

Market Opportunity:

Millions of Americans use insulin therapy to treat their diabetes. As such, the treatment market is exceptionally large, with estimates ranging from $44 billion to $100 billion per year. We believe that our innovative design of a self-automated, non-invasive insulin delivery and glucose monitoring system will prove very competitive in this substantial market.

What will our prototype comprise of?

For measurement of glucose in IF, we examined two different methods:
1. Emission spectroscopy using Benedict's solution
2. Using a glucose oxidase electrode

Using pressure, ultrasound and iontophoresis, the insulin will be transported into the body.

INSULIN

VAC

Vacuum suction to further increase interstitial fluid flow. (IF)

Sonophoresis to open up the pores for extraction of IF.

Reverse Iontophoresis to establish an electric gradient between the skin and the device to cause the charged IF to flow towards a collection vial.
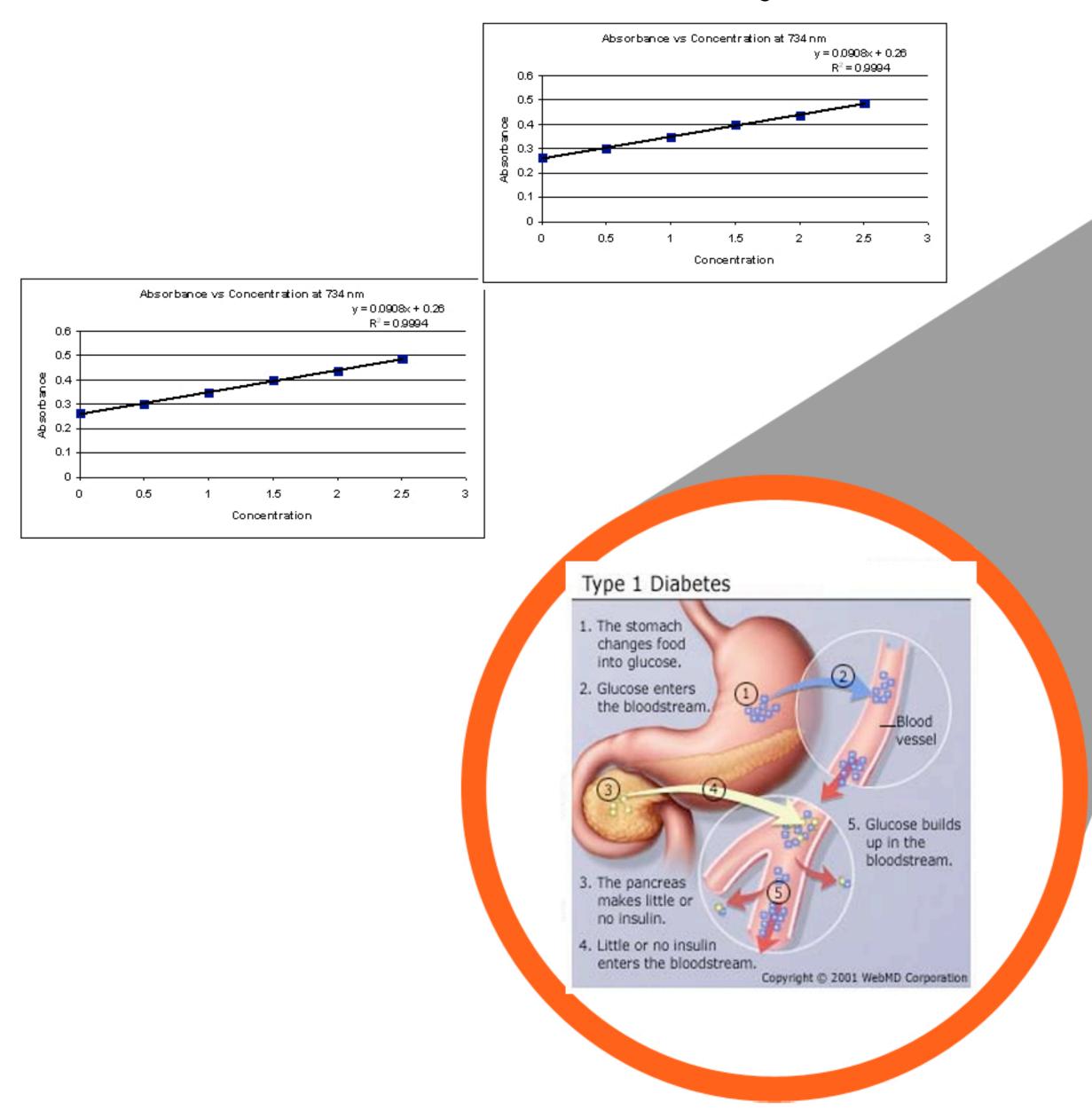
Our Accomplishments

Glucose Measurement

We used spectrophotometric methods to measure glucose concentrations. Spectrophotometry is based off of Beer-Lamberts law i.e. concentration of analyte in solution is proportional to the analyte absorbance at a certain wavelength.

$$A=\varepsilon bc$$

In order to use the traditional spectrophotometers which have a wavelength range of up to 1500nm, we implemented a method involving a glucose solution with Benedict's reagent.
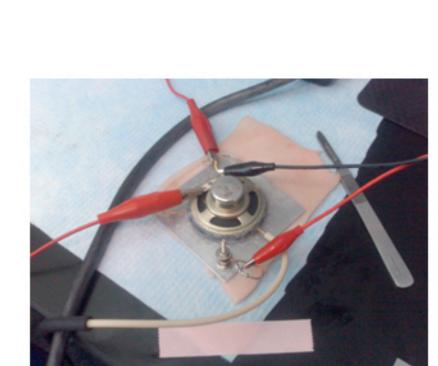
Spectrophotometric methods using Kreb's/Benedict's solution have yielded standardized curves at 500nm and 734nm wavelengths:

Absorbance vs Concentration at 734 nm
y = 0.0908x + 0.28
R² = 0.9994

Absorbance vs Concentration at 734 nm
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Type 1 Diabetes
1. The stomach changes food into glucose.
2. Glucose enters the bloodstream.
3. The pancreas makes little or no insulin.
4. Little or no insulin enters the bloodstream.
5. Glucose builds up in the bloodstream.
Blood vessel
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Interstitial fluid Extraction

Motor
Pressure Transducer
Electric connection
Aluminum sheet
gasket
Speaker

The team produced a new design which uses an aluminum (Al) plate with a gasket to ensure that vacuum pressure works effectively. We introduced perforations to the plate to increase device stability and prevent the skin from being sucked into the vacuum device. A PVC pipe end was incorporated to allow a watertight seal with the skin.

PVC pipe end
Speaker
Rubber O ring
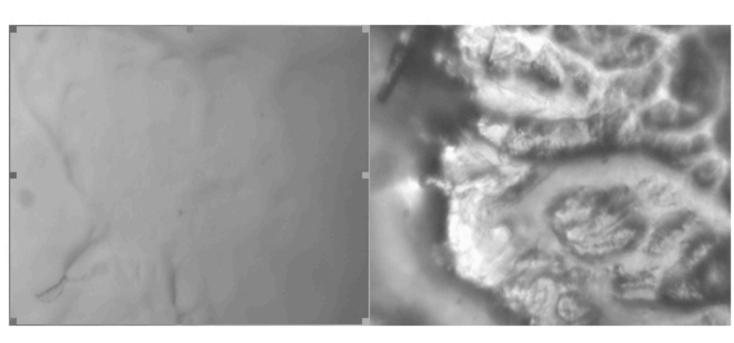Perforated aluminum plate

Pig skin was used for application of sonopheresis, iontophoresis and vacuum. Different types of pig skins were tested. Older skin was found to be most effective for experimental purposes. The pig skin was scythed to reduce fat to a level representative of that in normal human skin.
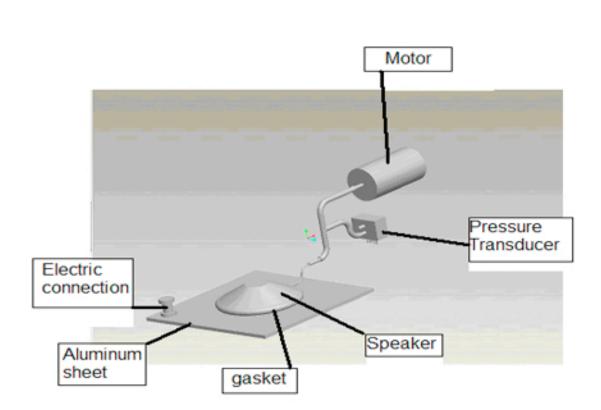
Scything the fat from pig skin.

Application of vacuum on pig skin

1)Pig skin before experiment   2)Pig skin after iontophoresis, sonophoresis and application of vacuum.
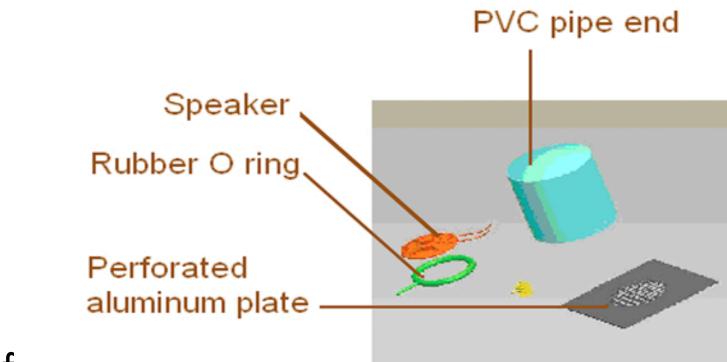
The images above were taken under a compund microscope at 20 xs. There was a significant difference in the pig skin before and after the experiment. Due to poor resolution and a lack of necessary equipment, we are unable to positively identify pores.

Dr. Deboth, Co-instructor   Dr. Opara, Instructor

Kochanek, Malgorzata PSYCH/ BIO   Goldstein, Linda, TC   Babicz, Amanda, AE

Morley, Michael, BME   Mesquitta, Walatta-Tseyon, MBB   Mathews, Rohan, EE

Narasimhan, Dev, BME   Patel, Bhavin, BME   Rahnavard, Amir, BME

Saung, E-Fann, ME   Riaz, Maryum, BME   Reddy, Kirthi, EE/ BIO

Thomas, David, MBB