IPRO 308
Developing an Artificial Pancreas

Group Members

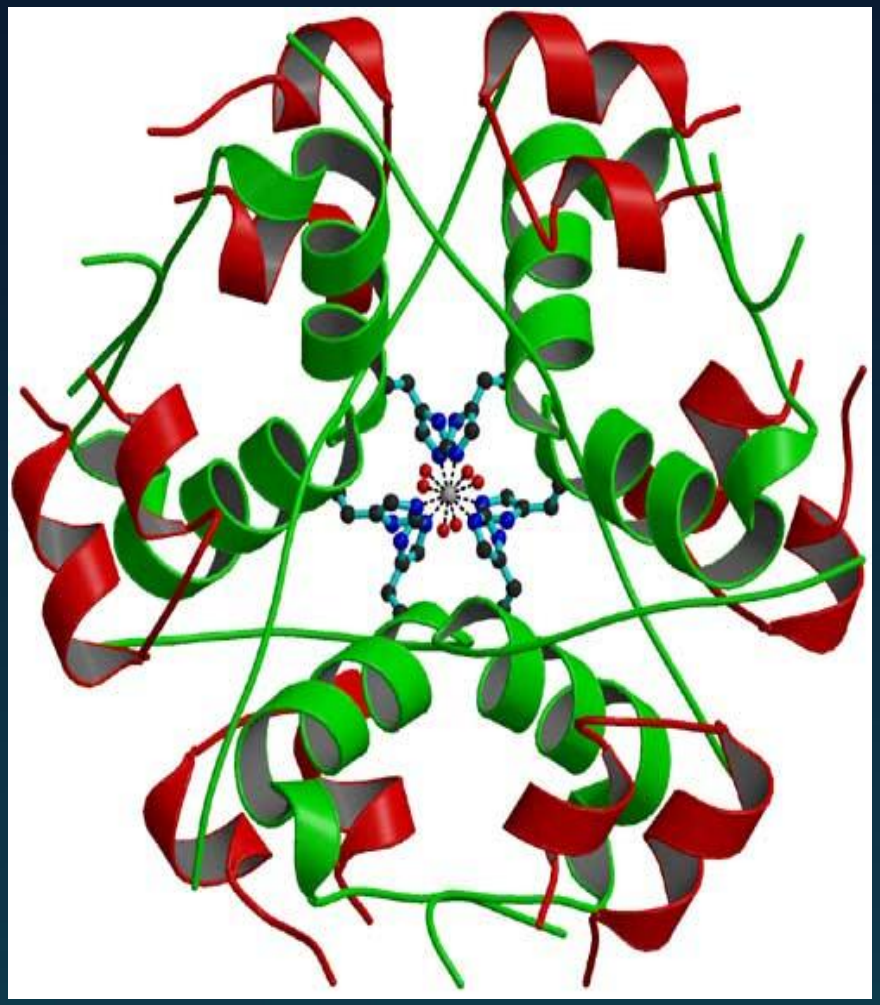
- Sean Callahan
- Jason Devgun
- Christie Ferraro
- Anthony Ferrese
- Medhavi Gudivada
- Renen Manuntag
- Neil Mashruwala
- Maje Nazim
- Dukmin Park
- Alok Patel
- Bhavin Patel
- Nathaniel Schuh

Breakdown of Presentation

- Background
- Project Design
- Project Implementation
- Accomplishments
- Conclusions

Diabetes

- Body does not make or properly use insulin
- Insulin required for metabolism of sugars
- 20 million Americans



Types Of Diabetes

Type 1

- “Juvenile”
- The body produces little or no usable insulin

Type 2

- “Adult Onset”
- Insulin resistance causes insulin to be less useful

Adverse Effects of Diabetes

Hyperglycemia

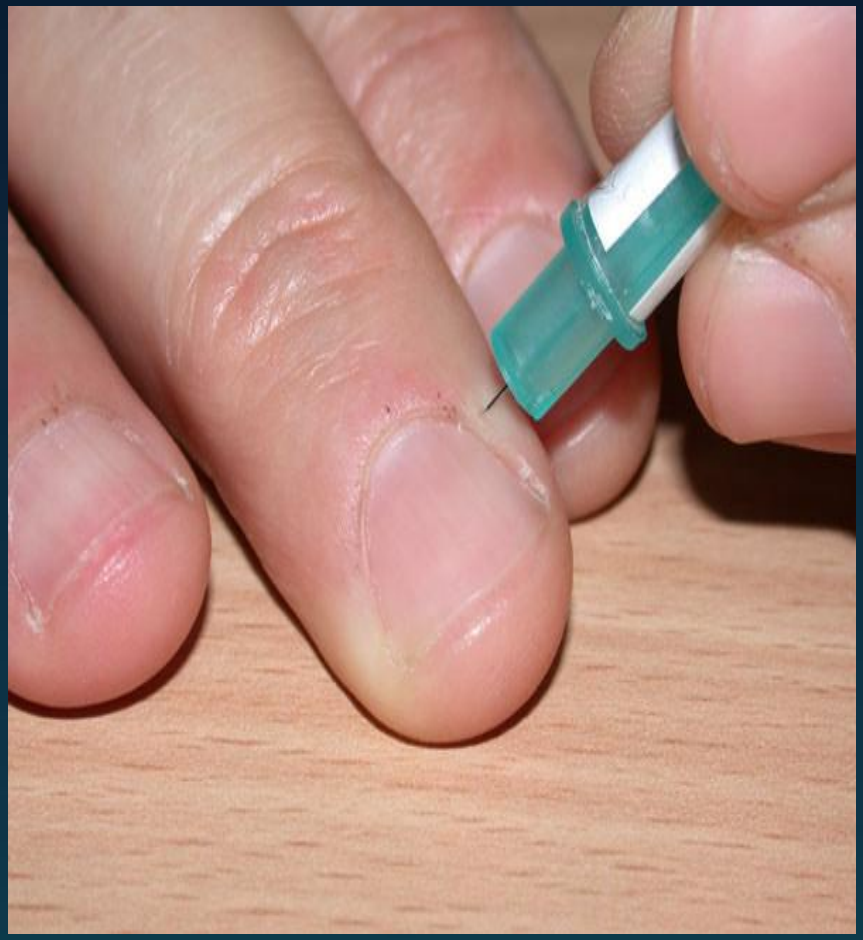
- Greater than 200 mg/dl
- High blood glucose
- Effects develop slowly
- Include: ocular neuropathy, poor circulation, and heart problems

Hypoglycemia

- Less than 40mg/dl
- Low blood glucose
- Medical emergency called ‘Insulin Shock’
- Results very quickly in slowed breathing, coma and even death

Monitoring and Delivering

- Blood glucose/insulin levels
- Venepuncture
- Painful and patient compliance suffers
- Non-Invasive techniques



Study Design – Project Goals

- Take ideas from last semester to lab settings
- Assessing the various components
  - Mechanical system
    - Vacuum pump
    - Ultrasound
    - Reverse Iontophoresis
  - Glucose measurement device
  - Vacuum trap for sweat/extracted sample
  - Microprocessor controller for insulin delivery

Past & Present

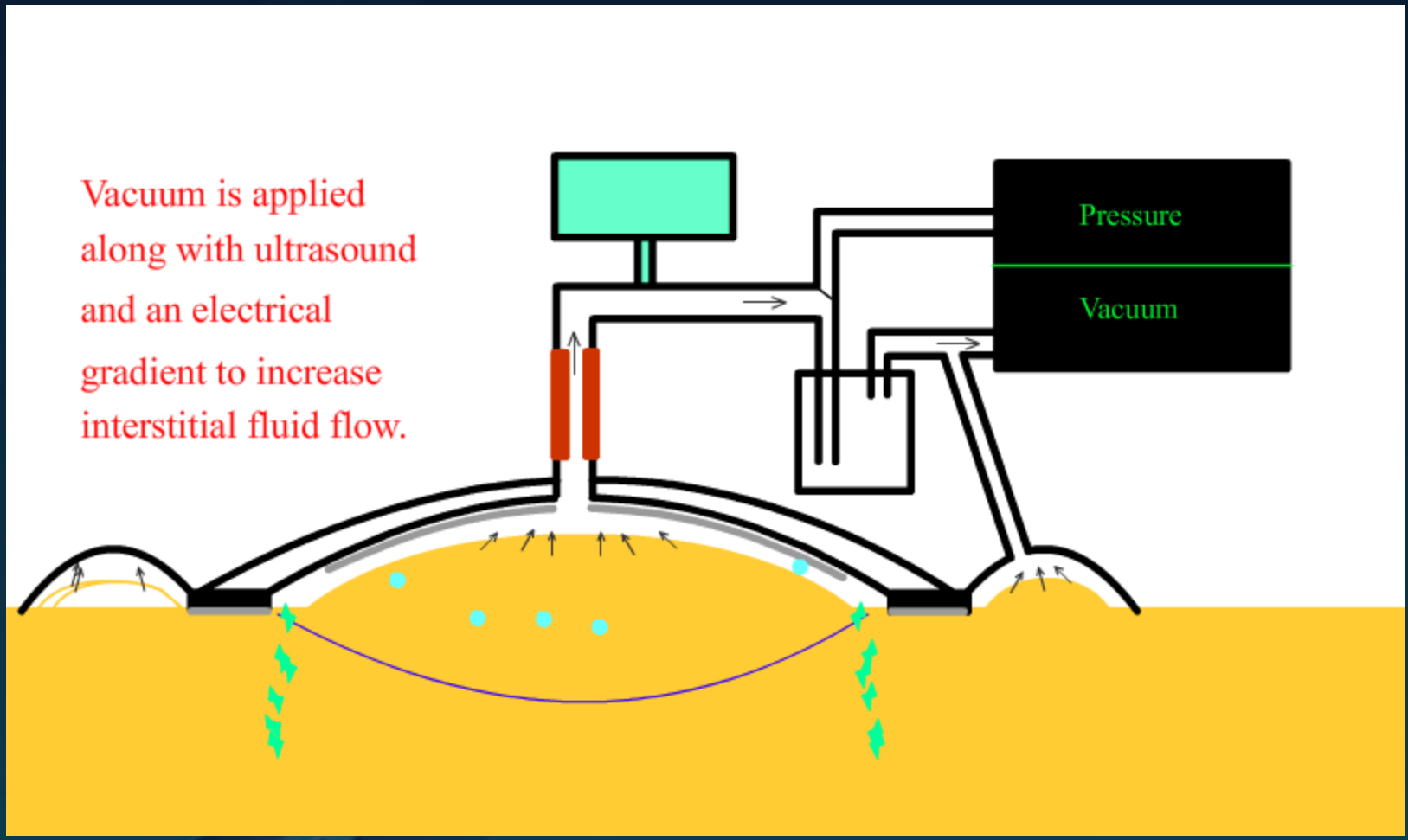
Fall ’06

- Primary ideas
- Interstitial fluid extraction
  - Ultrasound
  - Reverse Iontophoresis
- Glucose measurement
  - Electrical impedance

Spring ’07

- Ideas – lab settings/ pig skin
- IIT, Rush Medical college
- Glucose Measurement
  - Optical Absorbance and Electrical Impedance
  - Tested accuracy and limit of detection

Prototype Artificial Pancreas



Division of Work

- Three main groups
  1)Research
  2)Prototype
    - ISF extraction
    - Glucose measurement
      - Electrical impedance
      - Optical absorbance spectroscopy
  3)Patents

Ultrasound & Reverse Iontophoresis

- Ultrasound
  - increase pore size
  - facilitate transdermal drug delivery
  - punches microscopic holes in skin
- Iontophoresis
- Reverse iontophoresis

Electrical Impedance - Background

- Ohm's Law

$$R = \frac{E}{I}$$

- Z is a function related to R

$$Z = \frac{E(t)}{I(t)} = \frac{E_0 \cos(\omega t)}{I_0 \cos(\omega t - \phi)} = Z_0 \frac{\cos(\omega t)}{\cos(\omega t - \phi)}$$

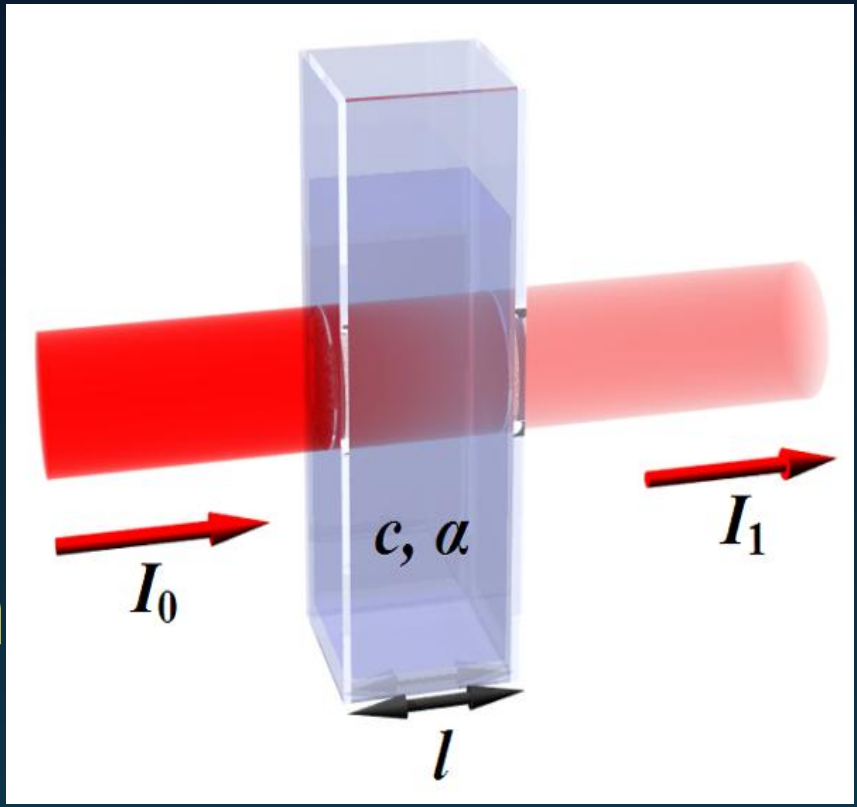
  - Z_0 = Magnitude
  - φ= phase shift
  - Current devices measure impedance through skin

http://upload.wikimedia.org/wikipedia/en/0/08/MSO6014A.JPG

http://www.gamry.com/App_Notes/EIS_Primer/EIS_Primer.htm

Optical absorbance – Background

- Beer Lambert Law
- Optimum wavelength needed for measurement
- Consistent ε allows glucose measuremen
  - Current devices measure through skin



$$A = \varepsilon l c$$

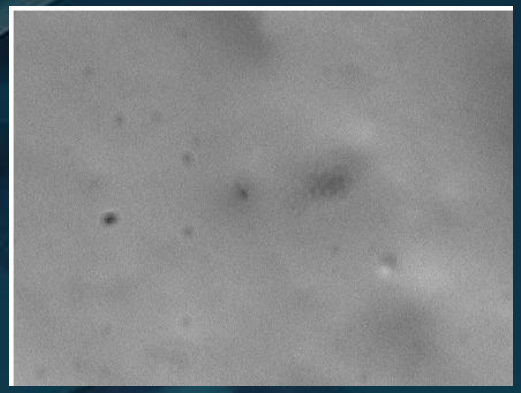
http://en.wikipedia.org/wiki/Image:Beer_lambert.png

Accomplishments

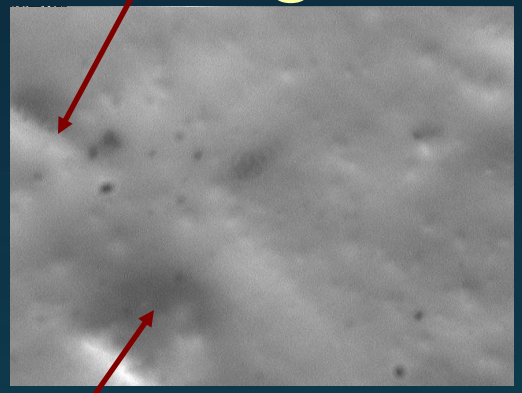
- Working ultrasound
- Extracted interstitial fluid
- Electrical impedance
- Optical readings
- Verification of Novel Idea

Prototype

- Theoretical Vacuum extraction
  - six hours
- Actual Vacuum extraction + ultrasound
  - six minutes at 26 mmHg



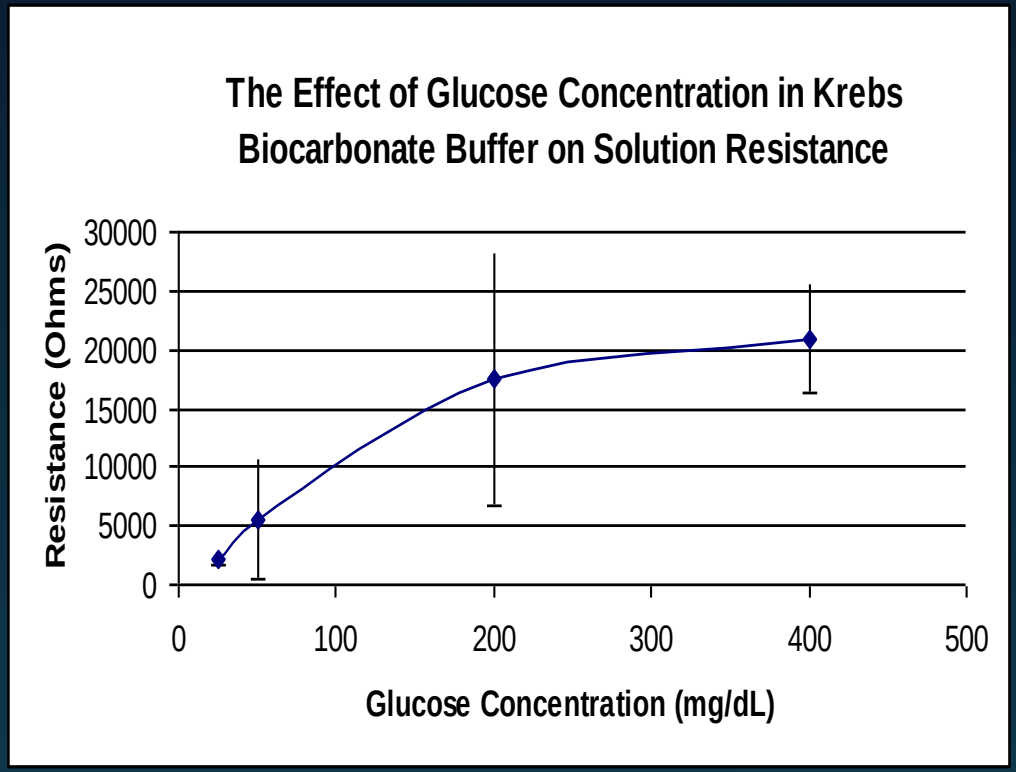
before



after

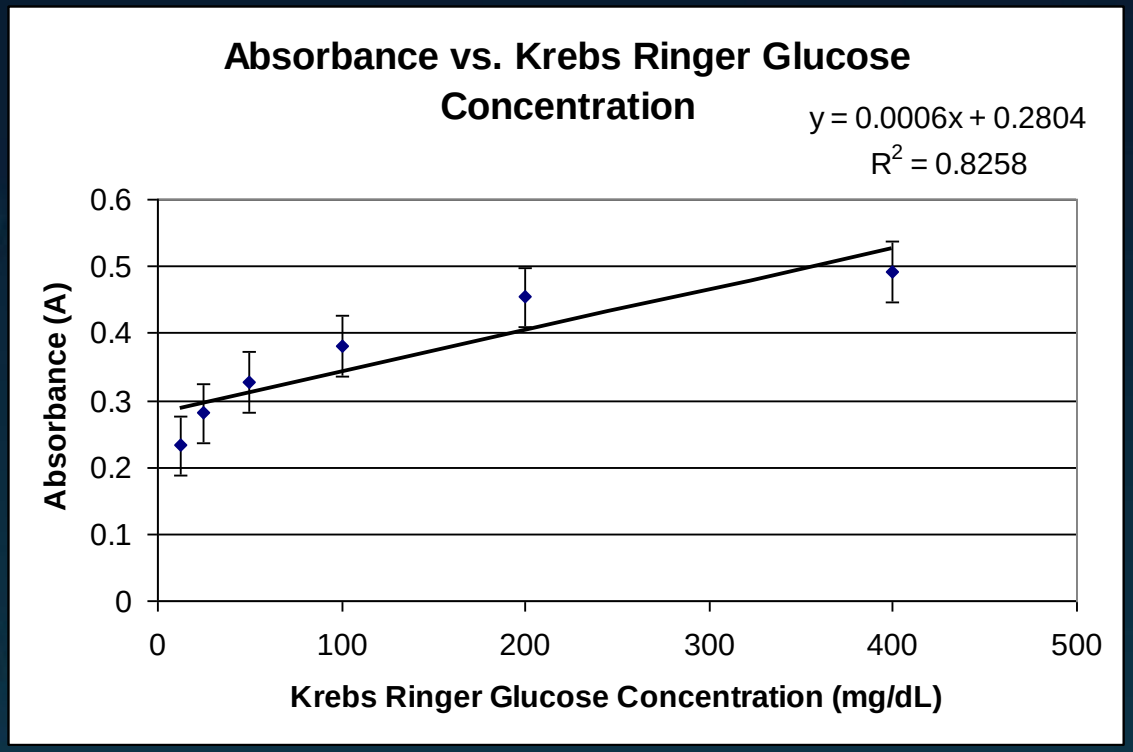
Electrical Impedance

- Glucose-D in Krebs Ringer solution tested
- Biophysics ECIS 1600 used to measure resistance of solutions



Optical Results

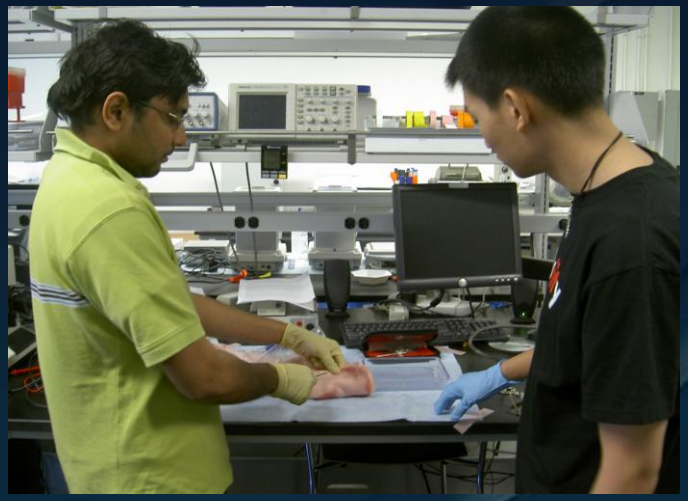
- Krebs Bicarbonate Buffer used to model interstitial fluid
- Glucose-D used

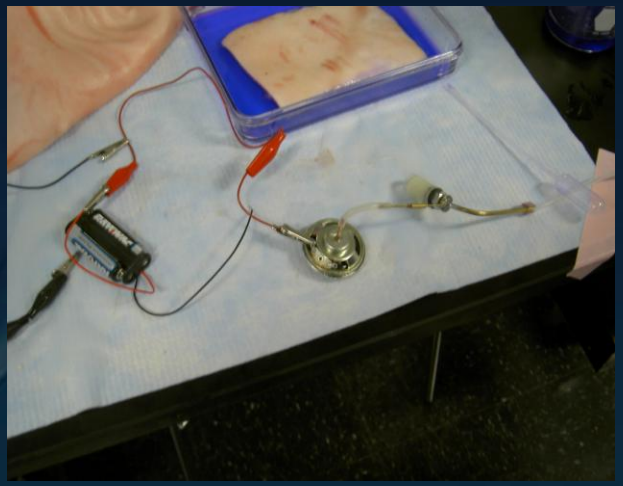


Patent Research & Results

- Search terms: ‘iontophoresis’, ‘trans-dermal patch’, ‘noninvasive’, ‘interstitial fluid’, ‘glucose sensor’
- Novel Points
  - Ultrasound + iontophoresis + vacuum simultaneously
  - Non-invasive insulin delivery transdermally
  - Automatic insulin calculation and delivery in a noninvasive device

IPRO 308 Team in Action





Also check out our website at:
http://www.iit.edu/~ipro308s07

In Closing…

- Progress

  This being said…

  - »Ultrasound + vacuum → Good
  - »Reverse Iontophoresis + Vacuum

↓

More work

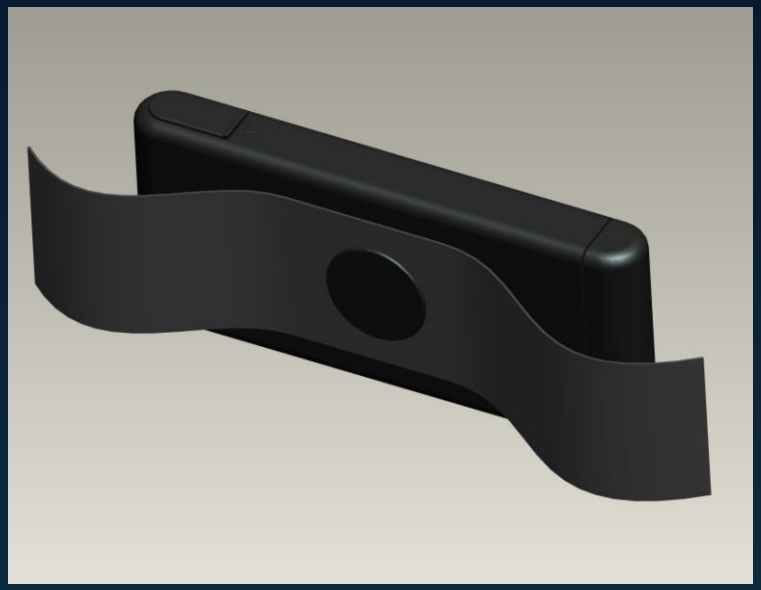
Tasks for Next IPRO

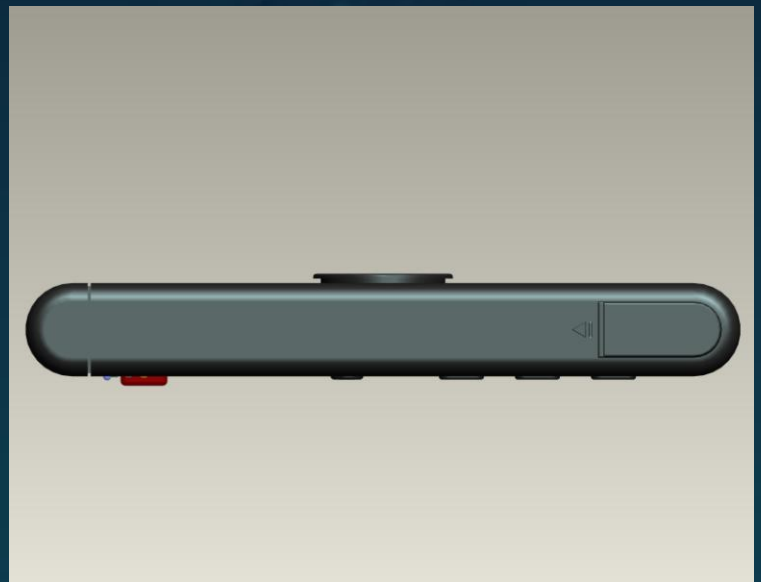
1. Technical assessment of reverse iontophores
2. Optimization of iontophoresis
3. Develop embedded control
4. Assessment of safety of device
5. Exploration of device miniaturization
6. Establish optimum design for the device

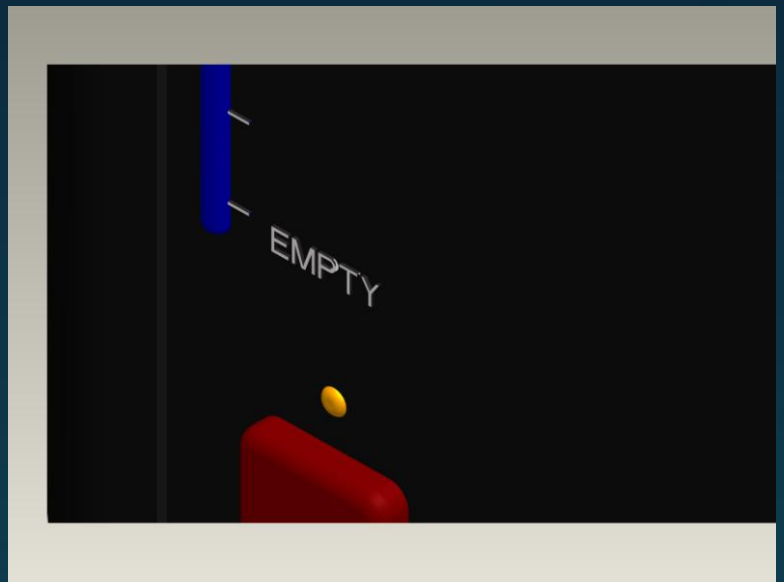
Business Opportunity

- Millions of Americans use insulin.
- Top spot up for grabs
- Market: 44 billion - 100 billion of revenue each year.

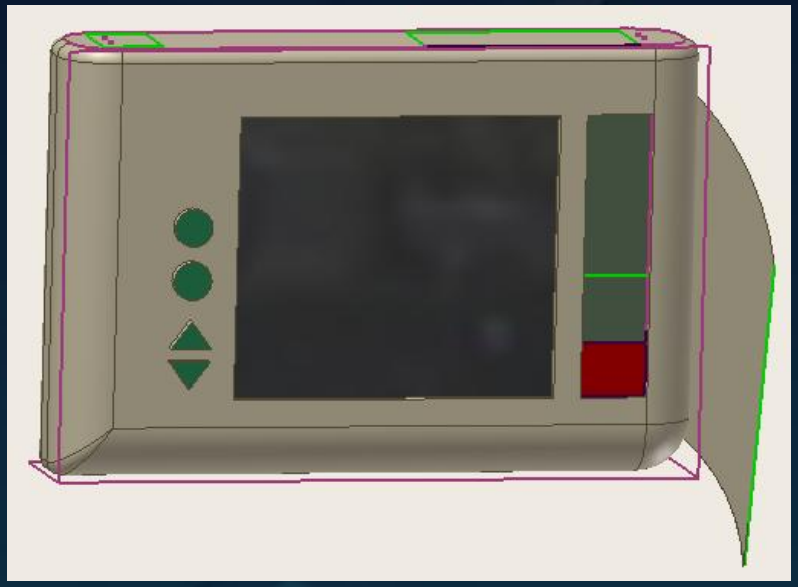
Proposed Design

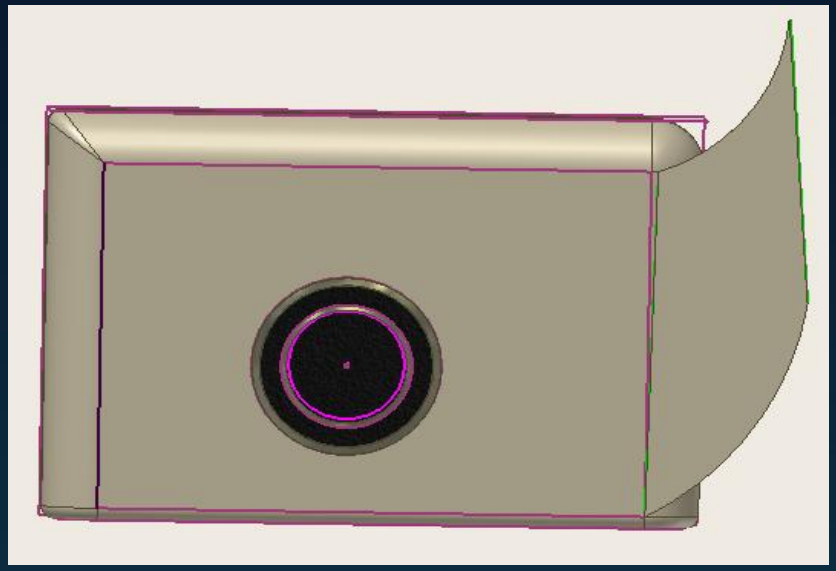


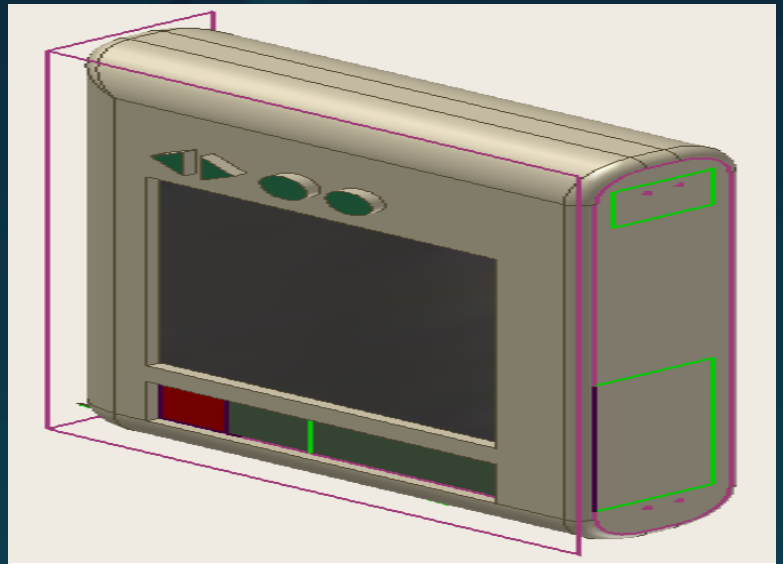


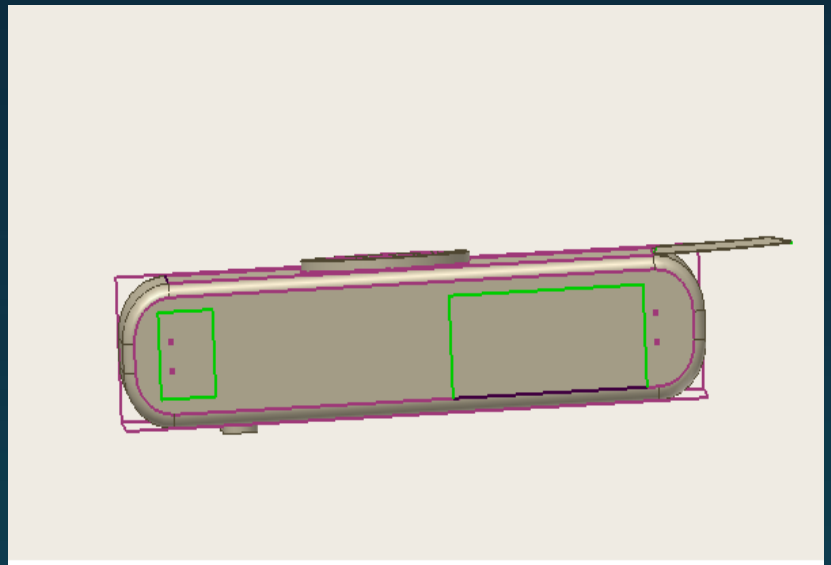


Proposed Design









Moral Benefits

- Everyone knows someone with diabetes
- Improved quality of life
- Plus, it feels good to help people…

Acknowledgements

- Dr. Emmanuel Opara
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