ILLINOIS INSTITUTE OF TECHNOLOGY

Transforming Lives. Inventing the Future.

IPRO 331

Non-invasive Blood Glucose Monitoring

What is Diabetes?

- Diabetes is a disease in which the body ineffectively uses blood glucose for energy.
  - Type I
    - Endocrine
    - Previously known as juvenile onset
  - Type II
    - Metabolic
    - Previously known as adult onset

Complications of Diabetes…

- Heart Disease
- Kidney Disease
- Eye Complications
- Neuropathy and Nerve Damage
- Podiatric Complications
- Dermal Complications

Complications of Insulin Treatment…

- Hyperglycemia
- Hypoglycemia

Current Methods

- Lancet/Syringe
- Glucose pump
- Glucowatch

Pros/Cons

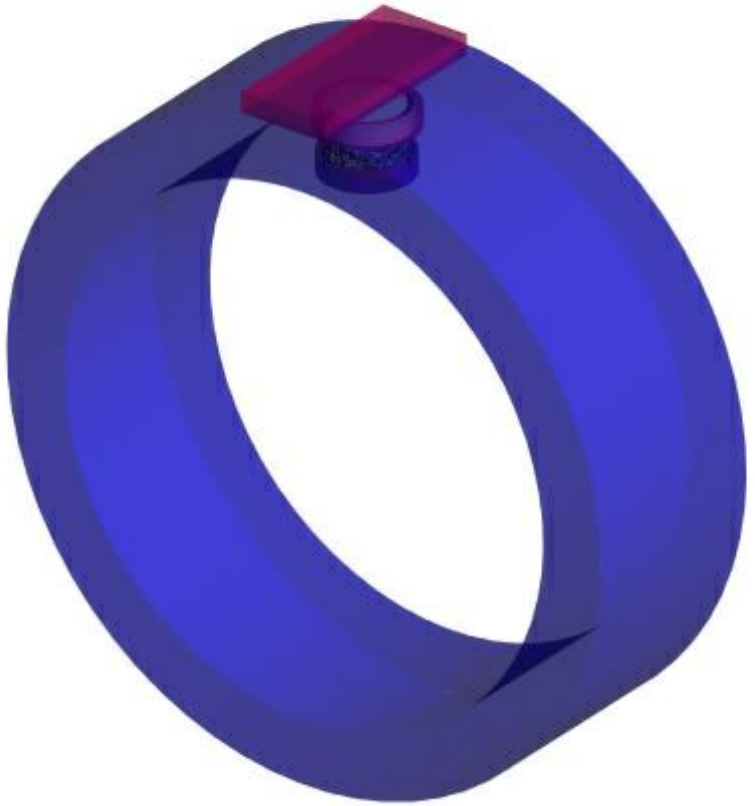
Method	Advantage	Disadvantage
Lancet/Syringe	Accurate/Quick	Invasive Painful
Glucose Pump	Accurate/Self-monitoring	Invasive, can malfunction
Glucowatch	Non-invasive convenient	Inaccurate Unreliable

Objectives for the Semester

- Create a design for a non-invasive blood-glucose monitoring system:
  - Simple in concept
  - User-friendly (especially for children)
  - Does not hamper a person's daily lifestyle
  - Cost-effective
  - Portable

Overview of Design

- Ultrasound
- Vacuum Suction
- Reaction Method
- Transfer of Data



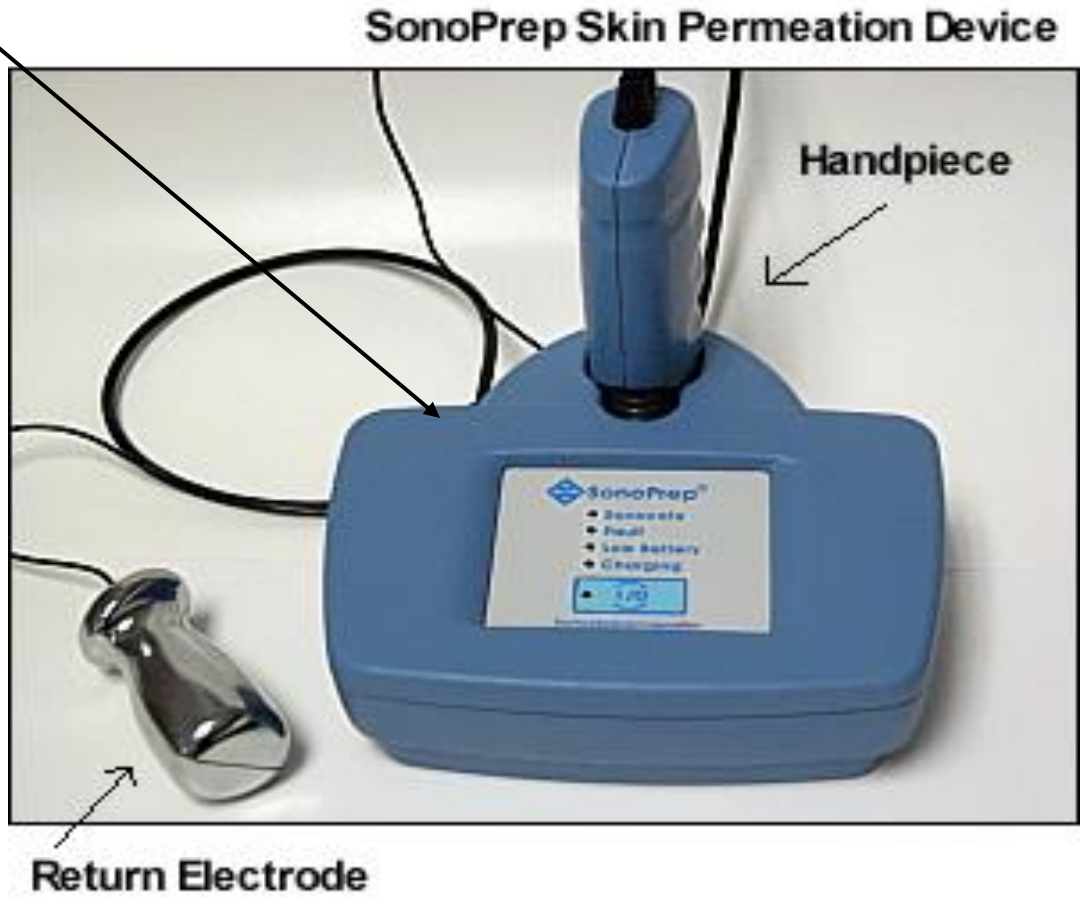
Ultrasound

Ultrasound Design

- Components
  - Transducer
  - Amplifier
- Frequency of 20 kHz
- Requires 20 W power (battery-operated)

Ultrasound Example

Ultrasound Transducer/Amplifier

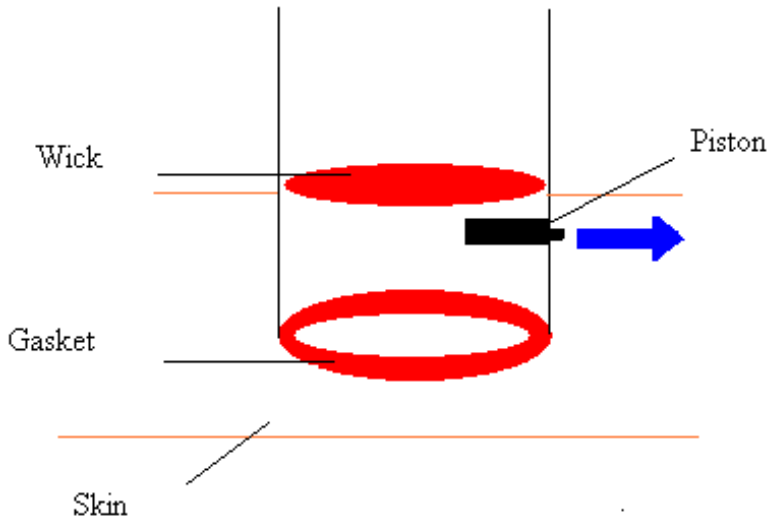


Vacuum Suction

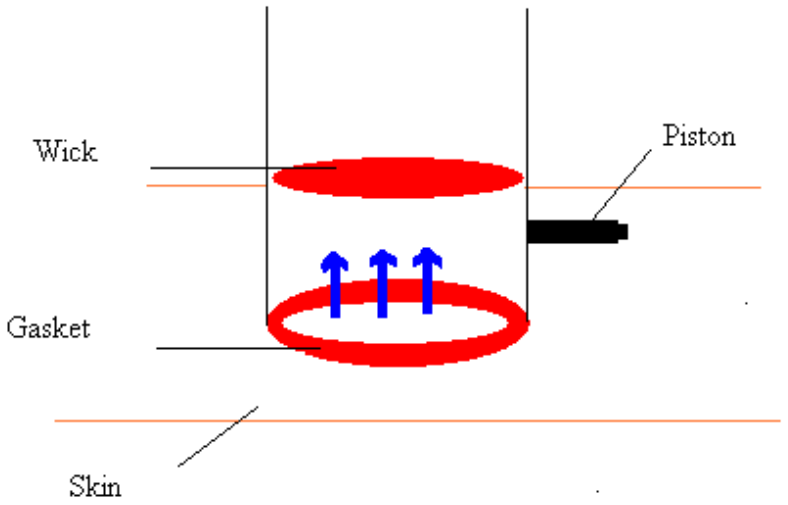
Purpose

To use vacuum pressure to draw interstitial fluid (ISF) continuously into the patch and over the glucose sensor inside it

Diagram



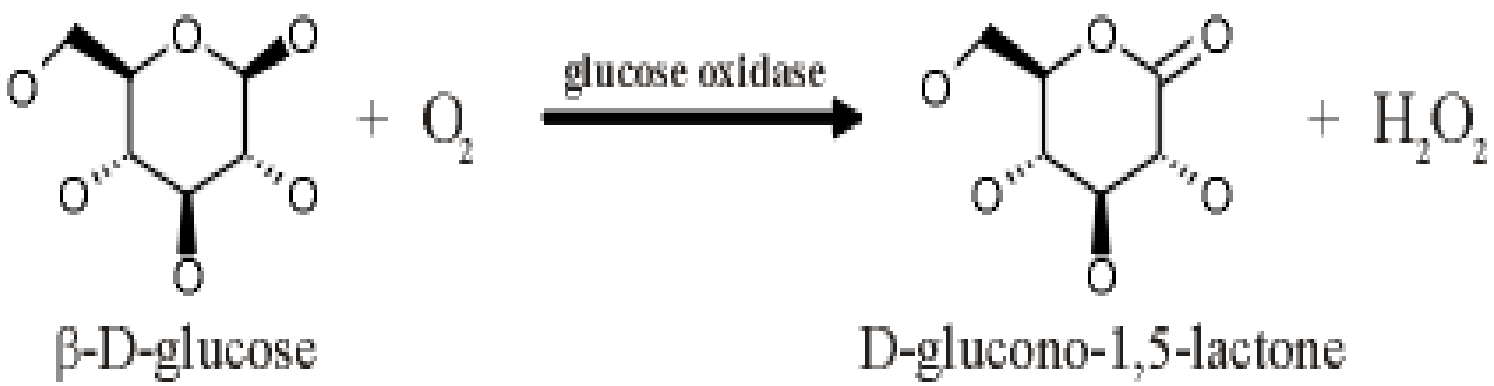
Activation of Piston



Upward movement of ISF

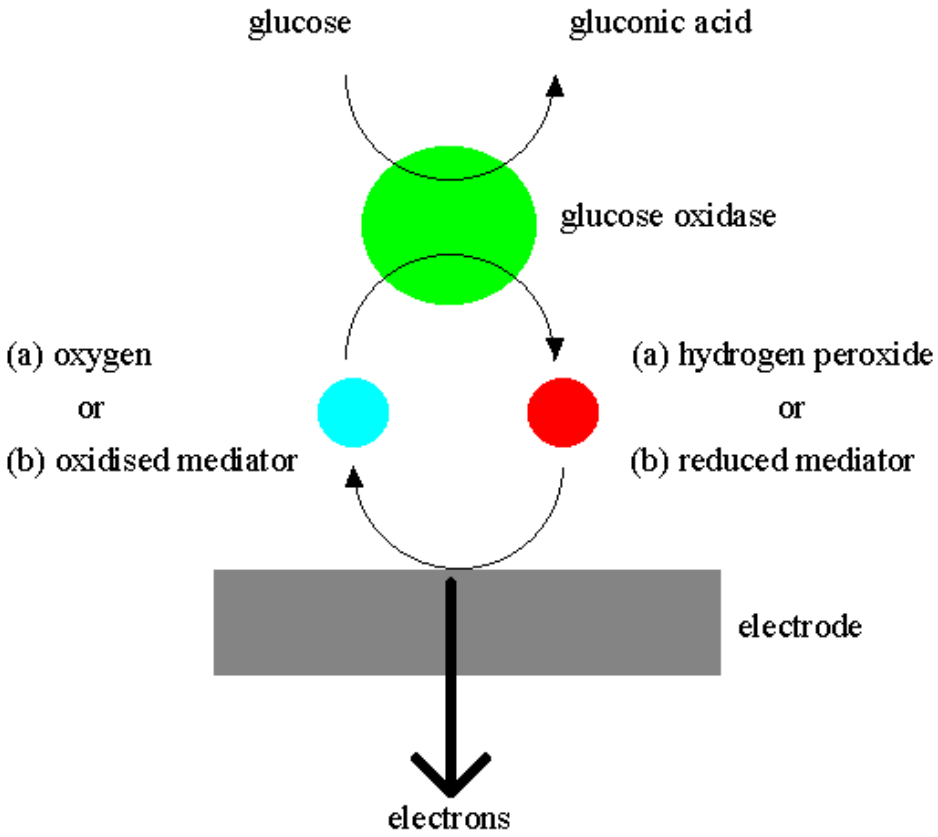
Reaction Method

Glucose Oxidase Reaction



Methods of Measurement

- pO2 Electrode
- H_2O_2 Electrode
- Mediator Electrode



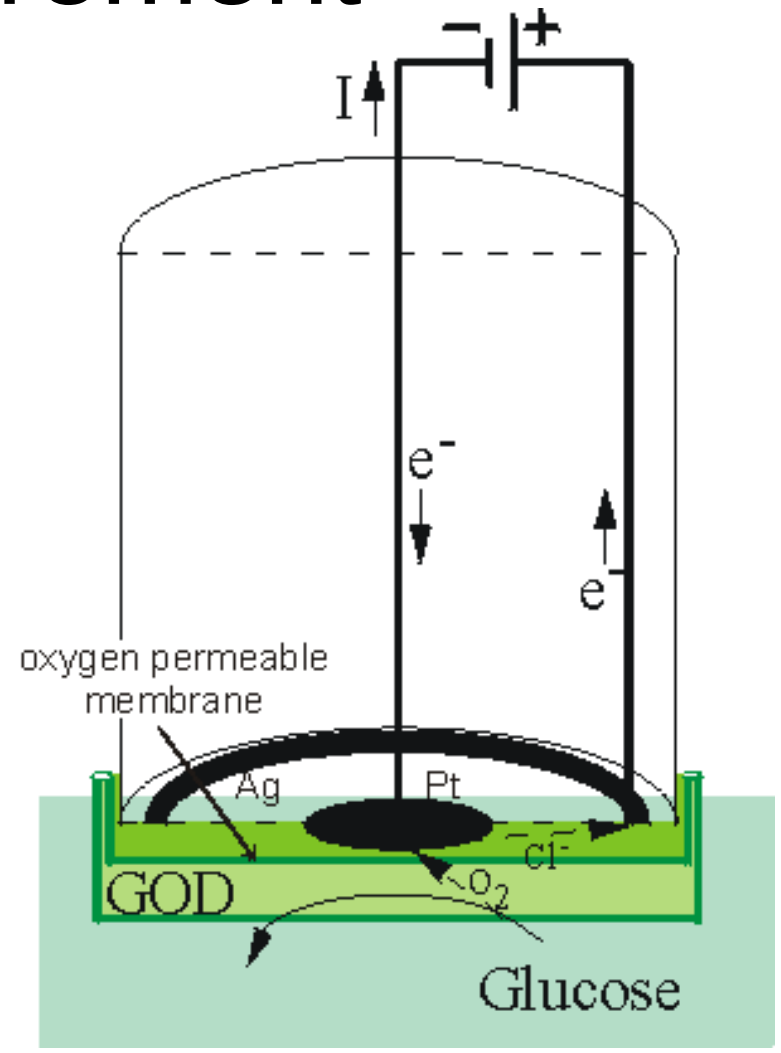


Diagram of pO2 Electrode

Comparison of Reactions

pO_2 Electrode: Set E = -0.6V, O_2 is reduced to H_20

H_2O_2 Electrode: Set E = +0.68V, H_2O_2 is reduced to $O_2 + 2H^+$

Mediator Electrode: Set E = +0.19V, Ferricinium$^+$ reduced to Ferrocene

*All electrode potentials (E) are relative to the Cl-/AgCl,Ag0 electrode.

- The current is then measured and using the following equation the rate of reaction can be determined:

i = nFAvA

I = current

n = number of electrons transferred

F = Faraday

A = electrode area

vA = rate of reaction

- Control the rate of reaction by diffusion using a membrane

- Electric current produced is proportional to the analyte concentration (independent of enzyme & electrochemical kinetics)

Data Transfer

Data Transfer

- Two types:
  - Direct – Automated measurement and periodic downloading
  - Indirect – Manual measurement and the data communicated via telephone or online services to the central receiver

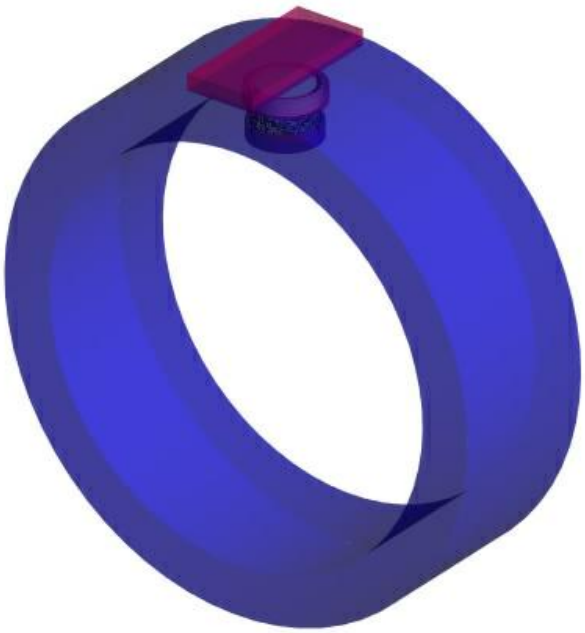
Data Transfer (contd.)

- Method of blood glucose measurement involves:
  - Transcutaneous biosensors (blood glucose conc. is an extrapolation)
  - Data Port
  - Computer
  - Diabetes Management Software

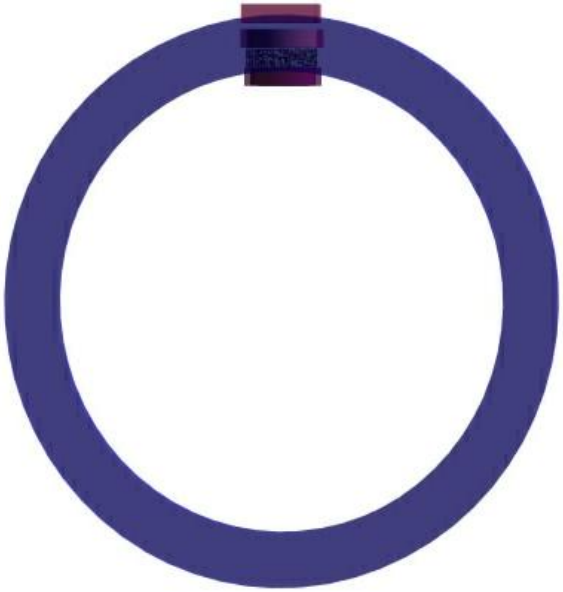
Data Transfer (Contd.)

- Advantage: Less prone to human error
- Disadvantage: Transcutaneous measurement of glucose is less precise

Aesthetics

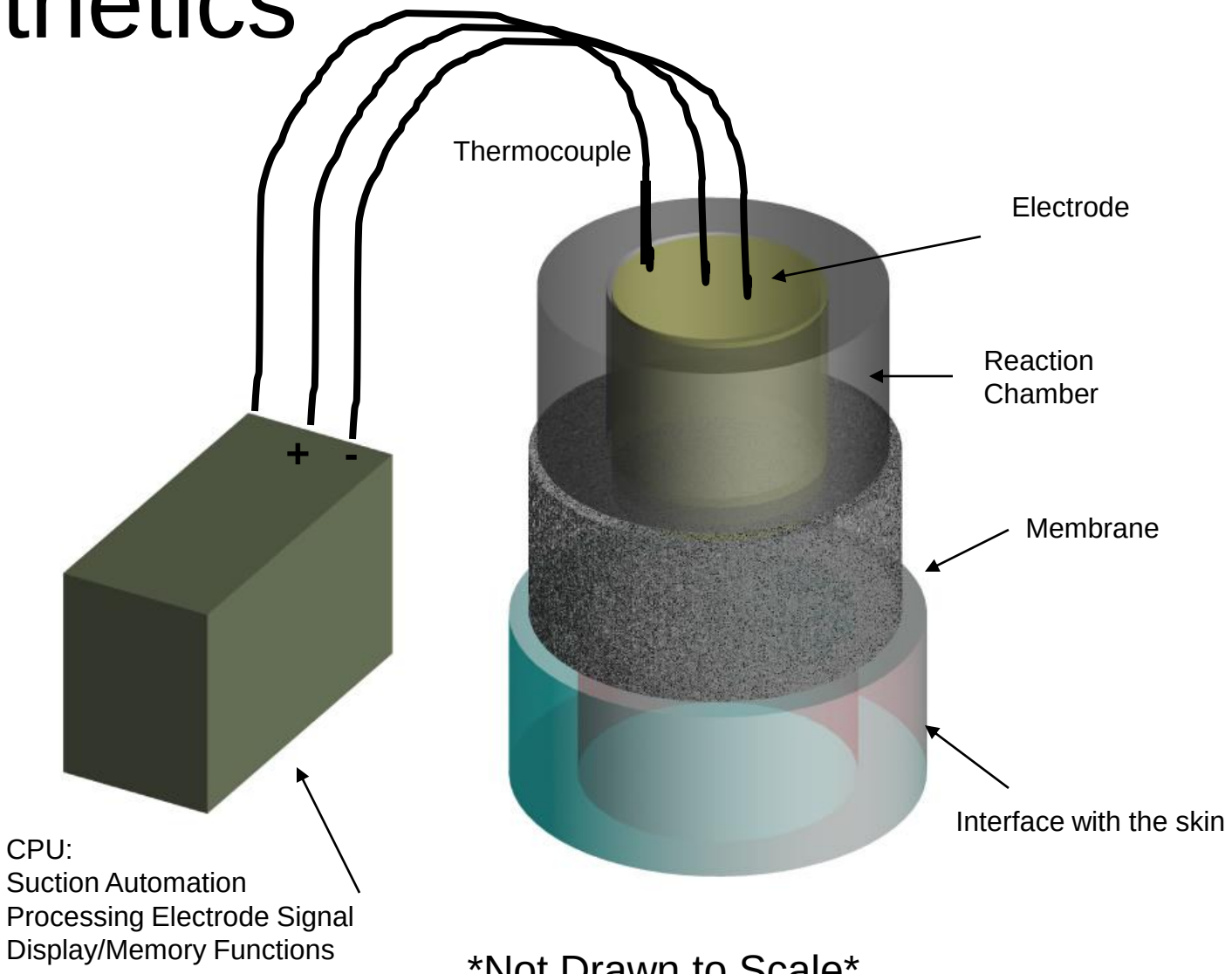


Angled View



Side View

Aesthetics



Not Drawn to Scale

Other Details

Total Estimated Cost

- Ultrasound- $25-$100
- Suction-$25
- Electrode-$50-$75
- Data Transfer-$25-$50
- Aesthetics-$10-20
- Total- $150-$270

Accomplishments

- Unique design and concept
- Integrated multiple aspects of the design
- Identified proper reactions
- Created visual prototype

Considerations

- Temperature affects the reaction
- Skin irritation
- Membrane clogging
- Make the device look like a common device
- Convince users that the device is accurate

Future Goals

- Company sponsorship
- Make a prototype
- Test the prototype
- Make improvements upon design
- Clinical testing
- Obtain a patent

Group Members

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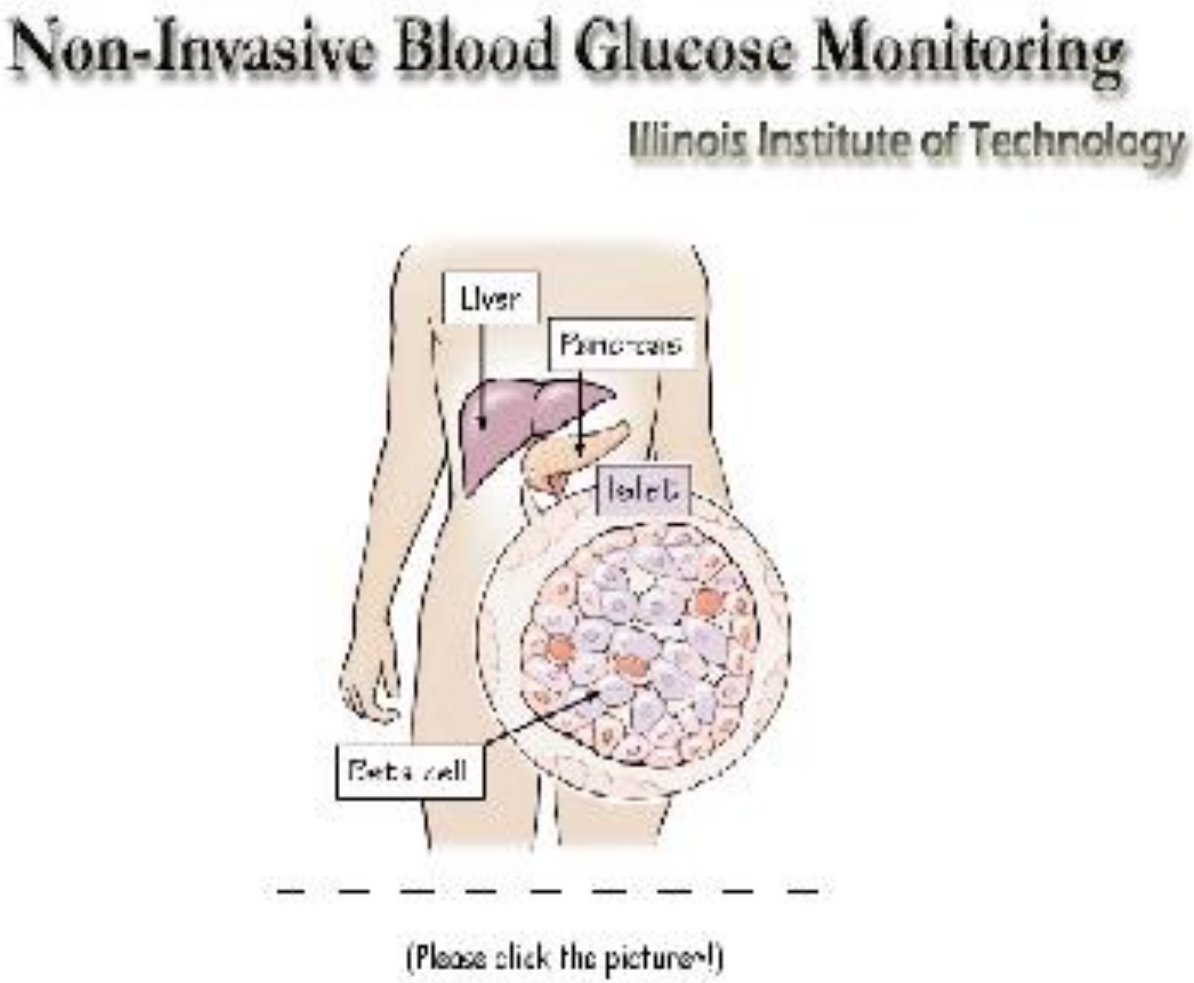
Website

Http://www.iit.edu/~ipro331s04/



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Questions/Comments