Spring 2007
IPRO 308 Project Plan

Developing an Artificial Pancreas

Team 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

1.0. Objectives

The objective of this IPRO is to improve the existing prototype to successfully extract interstitial fluid from pig's skin and effectively measure the glucose level in the interstitial fluid through both electrical impedance and light transmittance measurement and to secure grants in order to fund the testing and further completion of the prototype.

2.0. Background

Diabetes mellitus is a metabolic disorder characterized by hyperglycemia (high glucose blood sugar) and hypoglycemia (low blood sugar). There are two main forms of diabetes: type 1, type 2, which have similar signs, symptoms, and consequences, but different causes and population distributions. Type 1 is characterized by loss of the insulin-producing beta cells of the islets of Langerhans of the pancreas leading to a deficiency of insulin and is the main focus of this IPRO. Type 2 is characterized by tissue-wide insulin resistance and varies widely; it sometimes progresses to loss of beta cell function. Currently, type 1 diabetes can be treated only with insulin, with careful monitoring of blood glucose levels using blood testing monitors and involves daily insulin injections with frequent blood glucose measurements.

The purpose of IPRO 308 is to construct a device that automatically detects blood glucose levels in the blood without the use of a needle or other invasive methods and responds with delivering insulin accordingly. Currently there are no noninvasive methods for measuring blood glucose levels and for insulin delivery on the market; however, there has been significant research on determining blood glucose levels non-invasively. In previous semesters, it has been determined that it would be possible to measure blood glucose levels by extracting the interstitial fluid through applying a slight vacuum to an area of the skin, using ultrasound to break the meniscus barrier and using reverse iontophoresis. Through this method the interstitial fluid would be pulled through the pores of the skin and could be tested to determine blood glucose levels. After the glucose level is determined and the appropriate amount of insulin to be administered is determined, the insulin can be delivered using the reversal of the method for extracting the interstitial fluid. A slight pressure would be applied to the skin, ultrasound would be used to break the meniscus barrier, and iontophoresis would force the insulin in through the pores in the skin.

The goal of this IPRO is to take the research that the previous semesters have done and turn it into a practical application through the construction of a prototype. Simultaneously IPRO 308 will also work towards patenting the ideas used and applying for grant proposals to further research. This noninvasive artificial pancreas would be much more sanitary and convenient to the user than its invasive counterpart. This product will be evaluated in terms of its functionality, ease of use, reliability, and cost. In the process of development, the basic biological mechanisms of the endocrine pancreas, glucose chemistry and metabolism, physicochemical and biophysical processes, design and implementation, economics, and psychosocial factors will be reviewed.

3.0. Methodology

In order to complete the objectives of this IPRO, the group has been broken down into three main groups: Prototype, Materials and Research, and Grants. Each of these groups is working towards completing the objectives through a focus on several specific problems with the current prototype. A detailed description of the groups and the specific problems that they are working towards can be seen below.

1) **Prototype**:

- Extraction of interstitial fluid (ISF)
  - Identify needs and materials
  - Develop a tentative budget
  - Test speakers for successful ultrasonic emittance

- Glucose measurement
  - Use glucose concentrations (5-10 microliters) in some form of buffer and then measure electrical impedance.
  - Use saline solution to test Reverse Iontophoresis.
  - Use normal solution of (100mg/dL) ~5.5millimolar for lab testing.
  - Pathological level—400mg/dL~22.2mM
  - Research use of light transmittance measurement for detecting glucose levels

- Insulin delivery
  - It is similar and reverse to the extraction of ISF, work simultaneously on it.

2) **Materials & Research**

- Materials
  - Research pore size and a comparable polymer.
  - Find or create conducting rings with an equivalent derometer rating to current gasket

- Research
  - Research various techniques available for the measurement of blood glucose levels that could be used in our device.
  - Research resonant frequencies for interstitial fluid with various concentrations of glucose levels and their corresponding blood glucose levels.

- Safety
  - It is being looked upon simultaneously with the techniques and different procedures have different risks associated with it.
  - Research optimum ultrasound levels for its application on the skin.

- Device Design & Working
  - Look up procedures of ultrasound and the other techniques
  - Shift focus to the measurement of glucose

3) **Grants**
   - Look into both private and public grants available for biotechnology research.
   - Research private sponsorship

Members of the teams listed above are also involved in groups that are responsible for the deliverables. Each group presents their progress for the week on Friday during the first half of the meeting.

4.0. Expected results

Since many of the tasks to be accomplished in this IPRO are dependent on the completion of previous tasks and the required funding is not available yet, it is not expected that this IPRO will have completed a fully functional prototype by the end of the semester. Thus, the team has created a list of goals that we feel are both challenging and realistic. These are:

1) Improve the pseudo code developed by the last IPRO to control the artificial pancreas
2) Work towards patenting the prototype
3) Submit at least one grant proposal
4) Determine the resonance frequency for the electrical impedance
5) Determine the validity of using light transmittance to measure glucose levels
6) Successfully extract interstitial fluid.
7) Combine working pieces to improve the current prototype

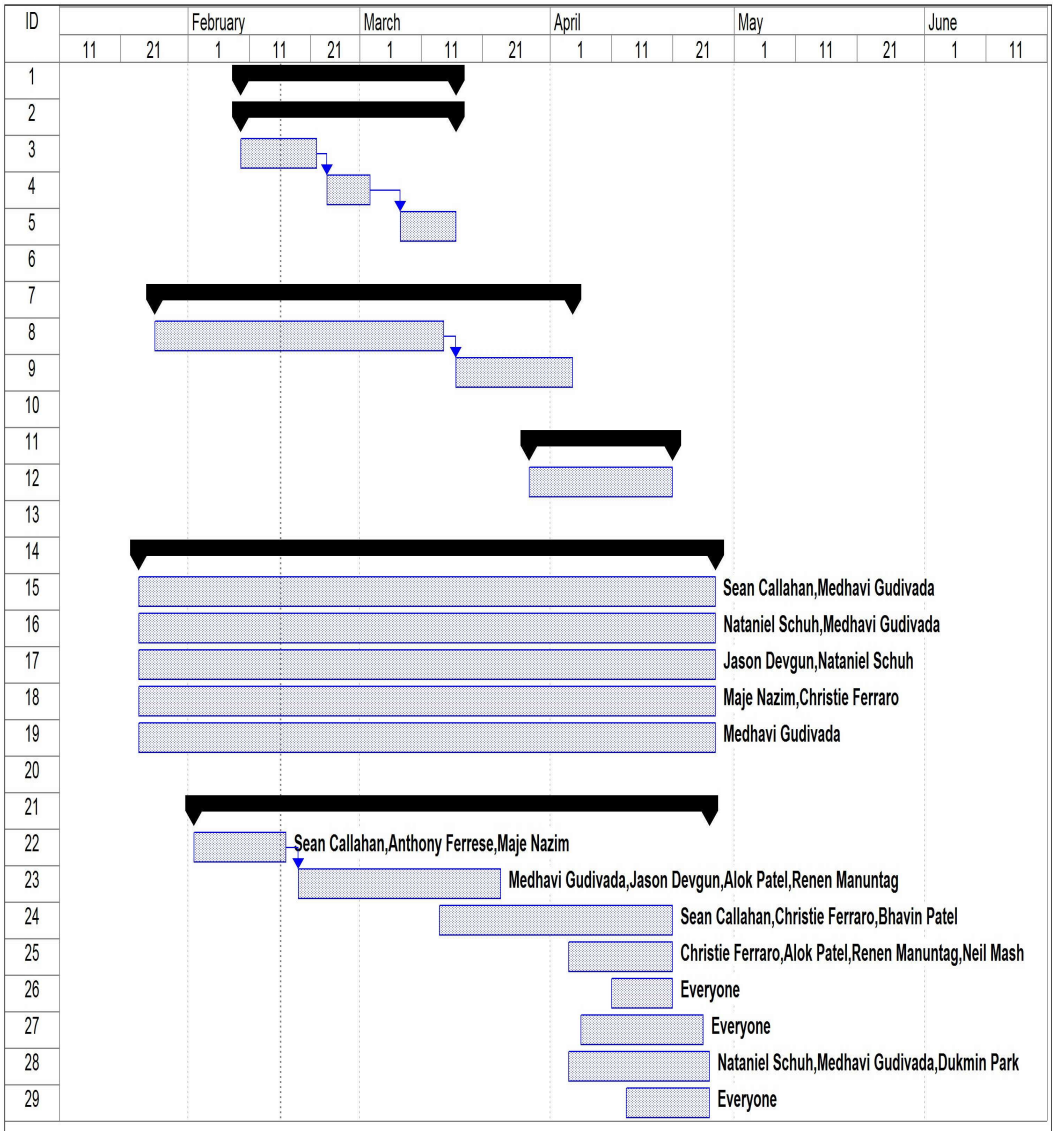
The successful completion of these goals will significantly improve the current prototype and bring the prototype substantially closer to completion.

5.0. Tentative Project Budget

Prototype		
Item	*Quantity*	*Cost ($)*
Speakers	10	25
Blood Pressure machines	2	150
Rubber with silver powder	3	85
Silver Epoxy Conductive Adhesive	2	40
Epoxy can	1	30
Bottle Caps (2-side pumps)	2	3
Pig skin/plastic/materials		200
Tubes		10
Misc prototype expenses		150
Total prototype expenses		*693*
Poster/Exhibit		
Spiral bound brochures	10	150
Binders	10	50
Exhibit decorations		50
Total poster/exhibit expenses		*250*
Other misc expenses		*100*
Tentative Budget for Spring 2007		**1043**

6.0. Schedule of Tasks/ Milestone Events/ Individual Team Member Assignments

ID	Task Name	Start	Finish	Prede	Resource Names
1	**Extract interstitial Fluid from tissue**	**Fri 2/9/07**	**Fri 3/16/07**		**Dukmin Park,Anthony Ferrese,Medhavi Gudivada**
2	**Analyze Prototype**	**Fri 2/9/07**	**Fri 3/16/07**		
3	Build a Second Prototype	Fri 2/9/07	Wed 2/21/07		
4	Assessment of vacuum Systen	Fri 2/23/07	Fri 3/2/07	3	
5	Testing and Development	Wed 3/7/07	Fri 3/16/07	4	
6					
7	**Glucose Measurement**	**Fri 1/26/07**	**Wed 4/4/07**		**Renen Manuntag,Alok Patel,Dukmin Park**
8	Research	Fri 1/26/07	Wed 3/14/07		
9	Testing and Development	Fri 3/16/07	Wed 4/4/07	8	
10					
11	**Insulin Delivery**	**Wed 3/28/07**	**Fri 4/20/07**		**Bhavin Patel,Alok Patel,Neil Mashruwala**
12	Testing and Development	Wed 3/28/07	Fri 4/20/07		
13					
14	**Ongoing Tasks**	**Wed 1/24/07**	**Fri 4/27/07**		
15	Materials Research	Wed 1/24/07	Fri 4/27/07		Sean Callahan,Medhavi Gudivada
16	Safety Research	Wed 1/24/07	Fri 4/27/07		Nataniel Schuh,Medhavi Gudivada
17	Device Design	Wed 1/24/07	Fri 4/27/07		Jason Devgun,Nataniel Schuh
18	Getting Patents and Grants	Wed 1/24/07	Fri 4/27/07		Maje Nazim,Christie Ferraro
19	Minutes	Wed 1/24/07	Fri 4/27/07		Medhavi Gudivada
20					
21	**IPRO Deliverables**	**Fri 2/2/07**	**Thu 4/26/07**		
22	Project Plan	Fri 2/2/07	Fri 2/16/07		Sean Callahan,Anthony Ferrese,Maje Nazim
23	Midterm Report	Mon 2/19/07	Fri 3/23/07	22	Medhavi Gudivada,Jason Devgun,Alok Patel,Renen Manuntag
24	Website	Wed 3/14/07	Fri 4/20/07		Sean Callahan,Christie Ferraro,Bhavin Patel
25	Exhibit/Poster	Wed 4/4/07	Fri 4/20/07		Christie Ferraro,Alok Patel,Renen Manuntag,Neil Mashruwala,Dukmin Park
26	Abstract	Wed 4/11/07	Fri 4/20/07		Everyone
27	Presentation	Fri 4/6/07	Wed 4/25/07		Everyone
28	Final Report	Wed 4/4/07	Thu 4/26/07		Nataniel Schuh,Medhavi Gudivada,Dukmin Park
29	Team Work Product; Team Minute	Fri 4/13/07	Thu 4/26/07		Everyone



Project: Ipro308_ProjectPlan
Date: Fri 2/16/07

Task	Rolled Up Task	External Tasks	
Progress	Rolled Up Milestone	Project Summary	
Milestone	Rolled Up Progress	Group By Summary	
Summary	Split	Deadline	

8.0. Team skills

Name	Major/Minor	Skills/strengths/ academic interests
Sean Callahan	Computer Science	Software design, implementation and research
Jason Devgun	Biomedical Engineering	Computer skills and critical reading
Christie Ferraro	Biomedical Engineering	Speaking, organization and patent research
Anthony Ferrese	Chemical Engineering	Analytical problem solving
Medhavi Gudivada	Biomedical Engineering	Device designing and cell and tissue research
Renen Manuntang	Biomedical Engineering	Writing, time management and neural engineering
Neil Mashruwala	Biomedical Engineering	Speaking, design and medical imaging
Maje Nazim	Molecular Biochemistry & Biophysics	Writing, management and organization
Dukmin Park	Biology	Creativity and time management
Alok Patel	Biomedical Engineering	Speaking and laboratory research
Bhavin Patel	Biomedical Engineering	Computer programming and organization
Nathaniel Schuh	Psychology	Writing, speaking/ cognitive processes, learning