IPRO 308

Creating an Artificial Pancreas

Grant Application to the NCIIA (in lieu of Final Report)

Instructor	Dr. Emmanuel Opara
Mentor	Raymond DeBoth
Sponsors	The IPRO office
Student Leader	Michael Morley
IPRO Team	Amanda Babicz Linda Goldstein Malgorzata Kochanek Rohan Mathews Walatta Mesquitta Devnaradev Narasimhan Bhavin Patel Amir Rahnavard Kirthi Reddy Maryum Riaz E-Faan Saung David Thomas

Illinois Institute of Technology

November 30, 2007

Grant Application to NCIIA

Introduction:

The problem with current glucose detection and insulin injection methods for diabetics is that they must prick their fingers multiple times per day, which is unpleasant, especially for young children and the elderly. Our project seeks to develop a way to perform these functions without the use of painful invasive procedures like needle pricks.

History and Context

The whole team was split into subcommittees in order to increase efficiency. These subcommittees included a research, an extraction, and a measurement subcommittee. The research subcommittee did an extensive patent search, as well as supporting the experimental teams by providing information and supplemental funding. They searched for patents for glucose measurement through the use of NMR spectroscopy, which is a back-up solution, in case Emission and Impedence spectroscopy does not become a viable option. They also searched for the frequencies at which glucose resonates and did a lot of research into what kind of material could be used for the experiments dealing with the extraction of interstitial fluid from skin, as human skin could not be used due to ethical considerations.

After numerous sessions in the laboratory, the extraction subcommittee was able to analyze the working of the vacuum suction on the speaker, as well as the use of sonophoresis to open the pores of the pig skin. Preliminary studies show a presence of moisture on the speaker after the process though the source can not be proven to be interstitial fluid as of yet. Analysis under a microscope showed marginal details as proof for enlargement of the pore size after the use of sonophoresis (Figures attached). This subcommittee also analyzed the working of a data acquisition device that permitted the collection of information regarding the differential voltage when the device was connected to the vacuum/pump. The voltage was measured and then converted into a pressure value. First it was necessary to determine the calibration curve before any pressure values could be obtained (Graph attached). A linear regression equation was used in order to convert the voltage (V) to pressure (psi) values. The first tests involved experimenting with the maximum allowable pressure. This was achieved by plugging the end of the vacuum tube against the skin. This ensures that no leakages were present. The results of the test could be found in the attached figures. The maximum vacuum pressure was found to be -4.64 psi. Due to leakages in the speaker system itself, the tests with the speaker have been delayed until a better testing device can be achieved to ensure no leakages are present. Different gasket materials have been acquired and will be tested for optimum suction. Every gasket has a different durometer setting. The durometer setting is a measure of softness, and each gasket will be tested to determine the best fit for our suction device. From the research and outputs of the extraction group, the team is exploring the possibility of pulling a vacuum through multiple points on the gasket at the base of the speaker rather than drilling a hole through the magnetic material at the base of the speaker. The conductive epoxy used on the previous model is to be replaced with a metal base plate as well as conductive Aluminum foil attached to the speaker's voice coil. This should provide a better control system for the current being applied to the skin as well as hopefully improve the quality of the suction being caused by the vacuum. Even though this model is larger in dimensions than its predecessor, the team believes size is a problem that can be dealt with at a later time should the results prove successful.

The measurement subcommittee has run several experiments to determine glucose concentration at

physiologically significant levels within faux interstitial fluid i.e. Krebs Ringer Buffer. Concentrations of glucose from six serial dilutions were measured repeatedly at 1000nm using a photoemissions spectrophotometer. In extracting the absorbance values for the standard calibration curve, it was found that the concentrations of glucose in these dilutions didn't allow for reliable readings. Because the wavelength of absorbance (1000nm) is below that required for a truly linear Beer Lambert's law curve, and there were significant time constraints, it was decided to begin transforming the procedure to allow measurement at a lower more reliable wavelength. This has required the introduction of Benedict's reagent solution to the initial faux interstitial stock. By measuring glucose concentration of faux interstitial fluid using photoemissions spectroscopy, it should be possible to assess the reliability and efficacy of this particular method in measuring actual blood glucose concentrations. The current method is one of several being examined as a means of measuring blood glucose concentration within the developing prototype. If it is possible to obtain reliable measurements through this method, then steps could be taken to miniaturize the technology involved to allow incorporation of ES as the standard measurement component for the final product. Upon experimentation, difficulties in achieving reliable, representative readings at the initially selected wavelength (1000nm) were encountered. Therefore, the team decided to adapt the initial protocol to allow for measurements at a more reliable (500nm) wavelength, permitted by the addition of Benedict's Reagent Solution to the experimental stock. Benedict's is a deep-blue alkaline reagent solution containing cupric sulfate, sodium citrate, and sodium carbonate, and used as a test for the presence of reducing sugars such as glucose. Addition of Benedict Reagant solution to the initial stock solution of Ringer buffer and glucose makes it possible to obtain a more linear Beer-Lambert's plot, but at a lower wavelength (500nm), that would resolve an issue from the work of previous teams. Additionally, a part of this team has decided to focus on measuring the glucose concentration through the current produced during the oxidation of glucose via glucose oxidase. It is a standard technique used in many blood glucose sensors on the market but has not been tested to see whether it can be fine-tuned to measure glucose concentrations in the interstitial fluid.

Team

We have a balanced, multidisciplinary team made up of students, faculty, and advisors from a variety of disciplines ranging from Technical Communications and Psychology to Aerospace Engineering and Molecular Biochemistry and Biophysics. The members of the team have very diverse backgrounds and include groups traditionally underrepresented in invention, innovation, and entrepreneurship, including women and minorities. All of the students on this team are juniors and seniors enrolled in the Inter-Professional Project (IPRO) 308 course at the Illinois Institute of Technology in Chicago, IL. The members of this IPRO are advised by the same two people every semester, even though the students on this team can change from semester to semester. The students who are not graduating have the option to continue working on the project, so there is some student continuity. The turnover rate from semester to semester is approximately 88%. Data is transferred between semesters of the project through binders containing lab notes and research material, as well as a web site.

All of the students working on this project have chosen to work on it due to either being interested in diabetes and wanting to help the people that suffer from it or wanting to use their expertise to create an affordable device that could directly benefit human health. Based on their expertise, each member of the team will be a part of a subcommittee that will concentrate on one aspect of developing the artificial pancreas, such as glucose concentration measurement or interstitial fluid extraction. Members of each of the subcommittees may be further divided to work on one specific way of achieving the goal of the subcommittee.

Dr. Opara, a research professor in the Pritzker Institute of Biomedical Science and Engineering Department of the Illinois Institute of Technology, is one of the two advisors of this group. He is an expert on diabetes research and is well-qualified to lead such a research and development team.

Mr. Ray DeBoth is a retired electrical engineer who works with the IPRO office at the Illinois Institute of Technology as an at-large-engineer. He is the second advisor of the group. Due to his experience and knowledge, he is well-qualified to help lead the team and to assist in building a prototype.

Work Plan and Outcomes:

Ambitions:

The IPRO 308 team's intention is to make progress in the attempt to develop an artificial pancreas. The hope is ultimately for an instrument that not only functions efficiently in non-invasive measurement of glucose and administration of insulin, but also a convenient design and affordable model for broad use.

Time Table (Grant Period):

The time table set for completion of a working prototype to measure interstitial fluid through a non-invasive method was set to be three semesters. In the first semester, the Spectrophotometer group will confirm the Benedict/Krebs method of analyzing the concentration of glucose in the interstitial fluid. During this time, the Glucose-Oxidase team will be working to see if it can limit the amount of interstitial fluid required for its method to work. Only one of these teams needs to be successful in order for the prototype to work. The Extraction team is still in the preliminary stages of extracting the interstitial fluid. The first and second semester may have to be devoted to building a working prototype. The third semester will be incorporating the measurement results (either spectrophotometer or glucose-oxidase) with the extraction results, into a working prototype. The grant will cover Phase 1 of the project, which involves development of an apparatus able to extract the interstitial fluid and measure the glucose concentration.

After Grant Period:

Assuming the extraction and measurement processes has been successfully implemented into a single apparatus; the second phase of the project will begin in developing a way to administer the proper amount of insulin in the same instrument. The IPRO is designed to recruit students of different disciplines for the completion of a project headed by an experienced faculty member. As was done for previous semesters, the necessary expertise for the next steps of the project will be heavily recruited. With the ability to recruit students from the different departments at Illinois Institute of Technology, the IPRO 308 project to develop an artificial pancreas becomes a very real possibility.

Evaluation and sustainability plan

We will know if our project has succeeded overall when we have a device that can detect the level of glucose in a person's bloodstream without taking blood from them, calculate the amount of insulin that should be administered, and administer that amount of insulin without using a needle.

We set very definite short-term goals to keep our project moving and motivated.

Our internal measures of success:

- successful extraction of enough interstitial fluid to put through a measurement device
- correct detection of glucose concentration level in prepared saline solution with a known

amount of glucose added
- create suction of 13-15 inches of mercury
- identify the possible pore size after applying sonophoresis and vacuum
- extract interstitial fluid using ionophoresis

Equipment

Extraction group Equipment:
Dissecting Kit: **$35.00**
Speaker : **$20.00**
Pressure Gudge and transducer: **$200.00 ** can use for more than one semester****
Pressure pump: **$75.00 ** can use for more than one semester****
Extraction Device: **$400.00 ** can use for more than one semester****
Resistor and logic chip to control reverse-ionophoresis: **$20.00**
Compound microscope with camera software: **$2500.00** ** can be use more than one semester
Some lab charges to use Electron microscope hourly: **$ 160-$200** her hours. We may need to use electron microscope for total 5 hours per semester than total cost is **$1000** per semester

Since Extraction group requires 3 semesters to come up with a working prototype, each item is multiplied by 3 unless it says it can be used for more than one semester

Total: $6400.00

Spectrophotometer group Equipment:
200 Cuvettes: **$ 42.20**

6 PTCelement enclosureheater,110W 100-240V: **$ 256.20**

15 LEDs: **$109.50**

15 detectors: **$87.00**

Total: $494.90

Glucose-oxidase group Equipment:

Oxygen electrode**: $140.00**

It was not specified if this can be used for more than one semester. Since the Glucose-oxidase group requires 2 more semesters, this total was multiplied by 2.

Total: 280.00

FINAL EQUIPMENT TOTAL: $7,176.00 (It was asked to be rounded to the dollar)

Materials

Extraction group Materials:
Pig Skin : **$50.00**

Since Extraction group requires 3 semesters to come up with a working prototype, this item is multiplied by 3

Total: $150.00
Spectrophotometer group Materials:
D-(+)-Glucose: **$ 32.00**
Krebs-Ringer Solution**: $ 16.80**
Sodium Bicarbonate Solution**: $ 9.20**
Benedict Solution**: $ 38.20**

Spectorphotometer group requires 2 semesters to complete a working prototype so these items were multiplied by 2

Total: $192.40

Glucose-Oxidase group Materials:
Test strips**: $100**
Glucose oxidase: **$36**
Bovine serum albumin**: $698.25**
Phosphate buffer**: $52.84**
25% glutaraldehyde**: $18**

Since the Glucose-oxidase group requires 2 more semesters, this total was multiplied by 2.

Total: $1,810.00

FINAL MATERIALS TOTAL: $2,153.00 (rounded to the dollar)

Student stipend: The limit for the student stipend is $7,500. Since it does not require an explanation I just set the total to $7,500.00

Travel:

Estimated cost for city travel to get supplies fro 3 semesters (i.e. pig skin): $**200.00**

Expense Category	Amount	Percent of Total
Equipment (Describe **briefly** below in Justifications area.)	$7,176.00	41.89%
Materials & Supplies (Describe **briefly** below in Justifications area.)	$2,153.00	12.57%
Student Stipend(s) - *May not exceed $3,000 per student or $7,500 t*	$7,500	43.79%
Faculty Stipend(s) - *May not exceed $5,000*	-	0.00%
Travel Expenses (Describe **specifically** below in Justifications area - re: # of trips and # of people traveling.)	$200.00	1.17%
Prototyping	-	0.00%
Consulting	-	0.00%
Other Expenses (Describe **very specifically** below in Justifications area.)	$100.00	0.58%
Total	17,129	**100.00%**

Resumes:

Team Member: Amanda Babicz

Contact Information:

[redacted]
babiama@iit.edu

Education:

Illinois Institute of Technology Chicago, IL Graduation: May 2008

Major (Specialty): B.S. Aerospace Engineering

[redacted]

Work Experience:

IIT Admissions (May 2005-2007):
Orientation Counselor

IIT Psychology Department (September 2006-2007):
Tutor

Sandia National Labs (May 2005-August 2005)

Student Intern

Activities:

IIT Varsity Swim Team

Intervarsity Christian Fellowship
Member

Kappa Phi Delta Sorority
President, Various executive board positions

Accomplishments/Awards:

- 3-year scholarship swimmer
- Participant NAIA National Championships
- 4-time NAIA All-American
- record holder 7 individual and 4 relay

Secretary: Linda Goldstein

Contact Information:

lgoldst2@iit.edu

Education:

Illinois Institute of Technology Chicago, IL Graduation: May 2011

Major (Specialty): B.A. Technical Communications

Pierce Community College Woodland Hills, CA Graduation: 2006

Major (Specialty): Associate of Arts

Work Experience:

TechNews (IIT newspaper) (Sept 2007-present):
Layout Editor

IIT Marketing Department (January 2007-present):
Teaching Assistant

Technical Associates (Canoga Park, CA) (July 2007-August 2007)
Executive Assistant

Activities:

GLAM
Executive Board

IIT Hillel
Secretary

Research Group Leader: Margaret Kochanek

Contact Information:

[redacted]
mkochane@iit.edu

Education:

Illinois Institute of Technology Chicago, IL Graduation: May 2009

Major (Specialty): B.S. Biology and Psychology, Pre-Medicine

Work Experience:

Perfect Mold, Inc., Addison, IL (August 2004- May 2007)
Secretary

Club Demonstration Services, Schaumburg, IL (July 2005-August 2006):
Sales Advisor

Activities:

Alexian Brothers Medical Center, Elk Grove Village, IL (June 2006-May 2007):
Volunteer

Team Member: Rohan Mathews

Contact Information:

[redacted]
rmathew4@iit.edu , rohan.mathews@gmail.com

Education:

Illinois Institute of Technology Chicago, IL Graduation: May 2009

Major (Specialty): Electrical Engineering, Applied Math Minor

Work Experience:

Sigenics Inc. (October 2007-Present)
Intern

Pritzker Institute of Medicine, IIT (June 2007-October 2007)
Laboratory Assistant

ECE Department, Illinois Institute of Technology (September 2007 – Present)
Brushless Motor Researcher

Activities:

Dance 101 (2006-Present)
President

Motor Sports Fan Club (2006-Present)
Public Releations and Advertising

Accomplishments/Awards:

- Fluent in spoken and written English and French
- High understanding of Hindi and Spanish
- Head Boy of West African College of the Atlantic (2003-2005)

Team Leader: Michael Morley

Contact Information:

[redacted]
morley.michael@gmail.com

Education:

Illinois Institute of Technology Chicago, IL Graduation: May ‘08

Major (Specialty): Biomedical Engineering with a specialization in cell and tissue engineering.

[redacted]

Work Experience:

Ministry of the Environment- Oviedo, Spain, (Fall 2005-Spring 2006):
Official Translator

Provena Mercy Medical Center - Aurora, IL- (Summer 2005):
Hospital Technician and Interpreter

Bovis Lend Lease Construction- Chicago, IL- (Summer 2004):
Field Engineer

Activities:

Union Board, IIT's student activities planning organization
President

Biomedical Engineering Society
Social Planning Chair

Accomplishments/Awards:

- Stryker "Freshman Student of the Year" Award –*(2005)*
- Coauthor of publication: "Stiffness of Extracellular Matrix Has Opposite Effects on Angiogenesis and Vasculogenesis *In Vitro*." Medimond *(2007).*
- "Universidad de Oviedo"- Oviedo, Spain. Matriculated– *(Sept. 2006-Aug. 2007)*
- 100% Fluent in conversational and written Spanish
- Richard Babcock Leadership Award (IIT Student Leader of the year)-*(2007)*
- Daily Herald Leadership Team Finalist-*(2004)*
- "Service Above Self" Rotary Award-*(2004)*
- Full Tuition Camras Scholorship, Illinois Institute of Technology- *(2004-2008)*

Extraction Group Leader: Bhavin V. Patel

Contact Information:

[redacted]
bpatel71@iit.edu

Education:

Illinois Institute of Technology Chicago, IL Graduation: May 2008

Major (Specialty): B.S. Biomedical Engineering, Minor in Mathematics

Oakton Community College

Major (Specialty): Pre-Engineering, Pharmacy Technician Certificate

Work Experience:

Medical Imaging Research Center at Illinois Institute of Technology (January 2007 – Present)
Student Assistant

Tutoring Center at Oakton Community College (September 2005 - July 2006)
Mathematics Tutor

Biology laboratory at Oakton Community College (April 2004 - January 2007)
Student Aid Lab Prep Assistant

Activities:

Indian Students Association (2006-2007)
President

"Royal" Cricket Team
Team member

Math Club
Member

Team Member: Amir Rahnavard

Contact Information:

[redacted]
arahnava@iit.edu

Education:

Illinois Institute of Technology Chicago, IL Graduation: May 2009

Major (Specialty): B.S. in Biomedical Engineering, focus in cell and tissue studies.

Work Experience:

Illinois Institute of Technology
Student Ambassador, Admissions Institute

Biomedical Engineering Lab
Researcher, Lab Assistant

Tutor/Mentor
High school basic Sciences and Math

Activities:

Central Valley Medical Care Center (450hrs)
Volunteer

Torrance Memorial Medical Center (35 hrs)
Intern

Mercy Hospital (30hrs)
Volunteer

National Institute of Health Summer fellowship in Neuroscience and Neuroengineering (Summer 2007)

Tau Beta Pi engineering society
Member

Sigma Phi Epsilon
Executive Board member

IMAN (Iranian and Muslim association) youth Group
Member

Student Government association
Finance Committee member and associate

Biomedical Engineering society
Vice president

Accomplishments/Awards:

- Leadership academy scholar and member
- Bi-lingual (Farsi and English)
- Web Based Programming

Measurement Group Leader: Kirthi Reddy

Contact Information:

[redacted]
reddkir@gmail.com

Education:

Illinois Institute of Technology Chicago, IL Graduation:

Major (Specialty): Bachelors degree in Electrical Engineering with Premedical studies.

[redacted]

Work Experience:

Residence Life at IIT, Chicago, IL (Aug.07 – current):
Learning Assistant

Electrical Engineering and Computer Engineering Department (Aug.07 – current):
Teaching Assistant (TA)

Pediatric Clinic Dr. Litkouhi (Summer 2004, 2005):
Volunteer

Activities:

International Student's Organization at IIT
Treasurer

Tau Beta Pi, Engineering Honors Society at IIT
Recording Secretary

Residence Halls Association at IIT
Ex- Treasurer

Accomplishments/Awards:

- Recipient of the Camras scholarship at IIT
- Ranked in the top 0.1% in grade 10 (ICSE) and 12 (ISC) examinations
- Held the highest position of student leadership, Prefect in high school (The Modern High school, Dubai)

Team Member: E-fann Suang

Contact Information:

[redacted]
saunefa@iit.edu

Education:

Illinois Institute of Technology Chicago, IL Graduation: December 2008

Major (Specialty): B.S. Mechanical Engineering, automotive applications (engines, suspensions) and numerical methods

Work Experience:

Gamma Technologies, Inc – Chicago, IL (May 2006 –August 2007)
Student Engineer (Co-op),

Sprint, San Diego, CA (Summer 2005):
Customer Service Representative

Activities:

Formula Hybrid (SAE) (August 2007 – Present):
Steering, Engine and Vehicle Simulation, Team Member

Homogeneous Charge Thermal Ignition, (Fall 2007):
Engineering Measurements Research

IIT Swim Team (2005-2007):

Triangle Fraternity, (2004-Present):
Vice President of Recruitment and Special Operations

Accomplishments/Awards:

- IIT Swim Team record holder

Team Member: David Thomas

Contact Information:

[redacted]
[redacted]
[redacted]
d.piusthomas@gmail.com

Education:

Illinois Institute of Technology Chicago, IL Graduation: May 2009

Major (Specialty): Molecular Biochemistry and Biophysics

[redacted]

Work Experience:

Agape Villa Group Homes (2005-present)
Assistant Counselor

UMC Hospital
Volunteer

Activities:

IIT Amnesty International (January 2007-Present):
Founder/President

Honors Medical Society
Member

IIT Debate
Member

Accomplishments/Awards:

- Armour Scholarship
- Honors Medical/Engineering Program with Rosalind Franklin Medical School

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BIOGRAPHICAL SKETCH

Provide the following information for the key personnel and other significant contributors in the order listed on Form Page 2.
Follow this format for each person. **DO NOT EXCEED FOUR PAGES.**

NAME	POSITION TITLE
Emmanuel C. Opara	Research Professor
eRA COMMONS USER NAME oparae	

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, and include postdoctoral training.)*

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	YEAR(s)	FIELD OF STUDY
University of Nigeria, Nsukka, Nigeria	B.S (Hon)	1976	Biochemistry
University of Surrey, Guildford, Surrey, UK	M.S	1980	Clinical Biochemistry
University of London, London, UK	Ph.D.	1984	Medical Biochemistry
Mayo Clinic/Foundation, Rochester, MN	Post-doc	1984-86	Endocrinol/Metabolism

Please refer to the application instructions in order to complete sections A, B, and C of the Biographical Sketch.

A. Positions and Honors.

Positions and Employment

1976-1977 Laboratory Scientist on National Youth Service, State Hospital, Ado Ekiti, Nigeria
1977-1978 Food and Drug Inspecting Officer, Federal Ministry of Health, Port Harcourt, Nigeria
1978-1980 Clinical Biochemist, Epsom Hospital Laboratories, Epsom Surrey, England
1980-1983 Demonstrator (Instructor) in Biochemistry, Chelsea College, University of London, England
1984-1986 W.H.O. Fellow in Endocrinology and Gastroenterology Res, Mayo Clinic, Rochester, MN
1986-1988 Visiting Fellow, National Institute of Diabetes, Digestive and Kidney Diseases, NIH, Bethesda, MD
1988-1993 Research Associate, Department of Surgery, Duke Univ Med Center, Durham, NC
1991-2003 Member, Sara W. Stedman Center for Nutritional Studies, Duke Univ Med Center, Durham, NC
1994-1999 Assistant Research Professor, Department of Surgery, Duke Univ Med Center, Durham, NC
1996-2003 Assistant Research Professor, Dept. of Cell Biology, Duke Univ Med Center, Durham, NC
2000-2003 Associate Research Professor, Department of Surgery, Duke Univ Med Center, Durham, NC
2003-present Research Professor, Pritzker Institute of Biomed Sci & Engr, IIT, Chicago, IL
2003-present Senior Investigator, Human Islet Transplant Program, University of Chicago, IL
2004–present Co-Director, IIT Engineering Center for Diabetes Research & Education

Other Experience and Professional Memberships

1984- present Member, American Diabetes Association of Health, Bethesda, MD
1990-present American Federation for Medical Research
1995-present Member, American Gastroenterological Association
1998-present Member, Editorial Board of Pancreas
2000-present Member, Transplantation Society
2001 Chair, Clinical Research 2001 AFMR/VA Symposium on Islet Cell Transplantation**,** Marriott Gateway, Crystal City, VA
2002 Organizer & Chair, 2002 Experimental Biology Mini-symposium on"Type 2 Diabetes in Older Adults",New Orleans, Louisiana

Honors

1984.1986 World Health Organization Fellow, Mayo Clinic/Foundation, Rochester, MN
1986-1988 John E. Fogarty Fellow, NIDDK, National Institutes of Health, Bethesda

B. Selected peer-reviewed publications (in chronological order).(Some Publications in the last 10 years selected from >60 peer-reviewed publications)

Opara EC, Hubbard VS, Burch WM, Akwari OE. Addition of L-glutamine to a linoleic acid perifusate prevents
Cefalu WT, Werbel S, Bell-Farrow AD, Terry JG, Wang ZQ, **Opara EC**, Morgan T, Hinson W, Crouse JR. Insulin resistance and fat patterning with aging: relationship to metabolic risk factors for cardiovascular disease. Metabolism 47: 401-408,1998.
Garfinkel MR, Harland RC, **Opara EC**. Optimization of the microencapsulated islet for transplantation. J Surg Res 76: 7-10,1998.
Opara EC, Abdel-Rahman E, Soliman S, Kamel WA, Souka S, Lowe JE, Abdel-aleem S. Depletion of total antioxi-dant capacity in type 2 diabetes. Metabolism 48: 1414-1417,1999.
Charles K, Harland RC, Ching D, **Opara EC.** Storage and microencapsulation of islets for transplantation. Cell Transplant 9: 33-38, 2000.
Littman ED, Pitchumoni S, Garfinkel MR, **Opara EC**. Role of Protein Kinase C isoenzymes in fatty acid stimulation of insulin secretion. Pancreas 20: 256-263,2000.
Darrabie M, Freeman BK, Kendall WF, Hobbs HA, **Opara EC**. Durability of polylysine-alginate microcapsules. J Biomed Mater Res 54: 396-399,2001.
Ching CD, Harland RC, Collins BH, Kendall W, Hobbs H, **Opara EC**. A reliable method for isolation of viable porcine islets. Arch Surg136: 276-279, 2001.
Hobbs HA, Kendall WF, Darrabie M, **Opara E.C.** Prevention of morphological changes in alginate microcapsules for xenotransplantation. J Invest Med 49: 572-575, 2001.
Freemark M, Avril I, Fleenor D, Driscoll P, Petro A, **Opara E**, Kendall W, Oden J, Bridges S, Binart N, Breant B, Kelly PA. Targeted deletion of the prolactin receptor: effects on islet development, insulin production, and

glucose tolerance. Endocrinology 143(#4): 1378-1385, 2002.
El-Shewy H, Kendall Jr. WF, Darrabie MD, Collins BH, **Opara EC**. Polyvinylpyrrolidone: a novel cryoprotectant in islet cell cryopreservation. Cell Transplant 13: 237-243, 2004.
Kendall Jr. WF, Darrabie MD, El-Shewy H, Collins BH, **Opara EC**. Effect of composition and purity of alginate on microcapsules. J Microencapsulation 21: 821-828, 2004.
Koch TR, Petro A, Darrabie M, **Opara EC**. Effects of Esomeprazole magnesium on non-steroidal anti-inflammatory drug gastropathy. Dig Dis Sci 50: 86-93, 2005
Darrabie MD, Kendall WF, **Opara EC**. Characteristics of poly-L-ornithine-coated alginate microcapsules. Biomaterials 26: 6846-6852, 2005.
Darrabie MD, Kendall WF, **Opara EC**. Effect of alginate composition and gelling cation on microbead swelling. J Microencapsulation 23: 29-37,2006.

Book
Opara, E (editor). Nutrition and Diabetes: Pathophysiology and Management. CRC/Taylor and Francis Press, Boca Raton, FL, 2005.

Sample of Recent Invited Papers:
Kendall WF, Collins BH, **Opara EC**. Islet cell transplantation for the treatment of diabetes.
Expert. Opin. Biol. Ther. 1: 109-119, 2001.
Opara E.C. Oxidative stress, micronutrients, diabetes and its complications.
J Royal Soc Health 122: 28-34, 2002.
Opara E.C., Kendall WF. Immunoisolation techniques for islet cell transplantation.
Expert Opin. Biol. Therapy 2: 503-511, 2002.
Opara EC. Role of oxidative stress in the etiology of Type 2 diabetes and the effect of antioxidant supplementation on glycemic control. J Investig Med 52: 19-23, 2004.
Opara EC. Guest Editorial: Oxidative stress, and diabetes and its complications.
J Investig Med 52: 19, 2004.
Kizilel S, Garfinkel M, **Opara E**. The Bioartificial Pancreas: Progress and Challenges.
Diabetes Technology & Therapeutics 7: 968-985, 2005.

C. Research Support. List selected ongoing or completed (during the last three years) research projects (federal and non-federal support). Begin with the projects that are most relevant to the research proposed in this application. Briefly indicate the overall goals of the projects and your role (e.g. PI, Co-Investigator, Consultant) in the research project. Do not list award amounts or percent effort in projects.

Completed in the last 3 years:
RNA-binding proteins and Beta cell function
Principal Investigator: Bentley Cheatham, Ph.D.
Role: Co-Principal Investigator
Type: NIH SBIR/STTR
Period: 05/01/04 – 04/30/06
The experiments proposed in this project are designed as ‘proof of concept’ studies in which Ribonomics technology is applied to the □-cell, focusing on glucose-regulated insulin secretion and proinsulin biosynthesis and □-cell development. These studies are relevant to both Type 1 and Type 2 diabetes, as they will generate a list of candidate therapeutic targets for treatment of these diseases.

On-going:
Title: Development of an experimentally validated fluid dynamics model for future non-invasive glucose monitors
Principal Investigator: Ganesh Raman, Ph.D.
Role: Co-Principal Investigator
Funding Agency: Pritzker Institute, IIT, Chicago, IL

Period: 01/01/07 – 12/31/2008

Title: REU Site: Summer Engineering Research Experiences in Diabetes for Undergraduates
Principal Investigator: Vincent Turitto, D.Eng.Sci
Role: Co-Principal Investigator
Funding Agency: National Science Foundation
Period: 2/1/06-1/31/09

Pending:
Title: Bioengineering A Bioartificial Pancreas
Principal Investigator: Emmanuel C. Opara, Ph.D.
Funding Agency: National Institutes of Health