If you would like to be added to the CBAC email list to receive information on upcoming seminars, events, and news, or to be added to the CBAC mailing list to receive future newsletters, email cbac@biomed.wustl.edu or call 314.935.7887.

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Yoram Rudy, Ph.D., F.A.H.A., F.H.R.S., Director

An interdisciplinary approach to studying and treating rhythm disorders of the heart
The Cardiac Bioelectricity and Arrhythmia Center, CBAC, is an interdisciplinary center whose goals are to study the mechanisms of rhythm disorders of the heart (cardiac arrhythmias) and to develop new tools for their diagnosis and treatment. Cardiac arrhythmias are a major cause of death (over 300,000 deaths annually in the US alone; estimated 7 million worldwide) and disability, yet mechanisms are poorly understood and treatment is mostly empirical. Through an interdisciplinary effort, CBAC investigators apply molecular biology, ion-channel and cell electrophysiology, optical mapping of membrane potential and cell calcium, multi-electrode cardiac electrophysiological mapping, Electrocardiographic Imaging (ECGI) and other noninvasive imaging modalities, and computational biology (mathematical modeling) to study mechanisms of arrhythmias at all levels of the cardiac system. Our mission is to battle cardiac arrhythmias and sudden cardiac death through scientific discovery and its application in the development of mechanism-based therapy.

Visit the CBAC website at http://cbac.wustl.edu/ to get more information about the research, CBAC members and seminars. There is also a video archive from past seminars that is updated following each season of seminars that is available for viewing.

Molecular Structure of Cardiac Ion Channels

Structure/Function of Cardiac Ion Channels

Mathematical Modeling of Cardiac Cells and Tissue


Yang, K., Zhao, Z., Gross, R.W., and Han, X. Shotgun lipidomics identifies a paired rule for the presence of isomeric ether phospholipid molecular species. PLOS ONE 2007, 12:e1368.


On the other hand however, we lack the many years of experience with respect to the modeling of the cardiac system that is available in the CBAC. As a result, the benefit for Maastricht of the CBAC/Maastricht collaboration is to further establish our computational branch of the research in Cardiac Electrophysiology. For CBAC, one of the advantages could be the strong coupling between basic research in cardiology and clinical and experimental validations and applications. It is clear that the collaboration between CBAC and Maastricht is growing stronger and is very productive. One example is the joint publication of experimental work from Maastricht with a CBAC model (M. Bebarova, T. O’Hara, et al. Am. J. P. Heart 2008). Another example is the visit of a Maastricht Ph.D. student (myself) to the CBAC, and very importantly the appointment of Dr. Rudy as the Heinz J. J. Wellens Distinguished Professor 2008-2009 at Maastricht University. Also, the partnering of the Departments of Cardiology and Mathematics to host the “Frontiers in Computational Electrocardiology” workshop where myself, Dr. Rudy and Dr. Philip Cuculich, a Clinical Fellow in the Washington University Cardiovascular Division and a CBAC member, are all speakers illustrates these collaborations. For more information on the “Frontiers in Computational Electrocardiology” workshop visit http://www.unimaas.nl/computationalelectrocardiology/.

“Personally, I hope to obtain a lot of experience with respect to the modeling of cardiac electrophysiology from the CBAC/Maastricht collaboration in order to be able to help further establish the computational cardiology research in Maastricht. So far, I have already learned numerous things and I find it very interesting to work in this demanding but exciting environment.”

The CBAC hosted many visitors over this past year and we’ve taken this opportunity to share with you some of the experiences of the scholars who have crossed the continent for the opportunity to do research in the Rudy Lab. On page 3 is Jordi Haiman who will be in the Rudy Lab working on collaborative research until May 2009. Snapshots of his campus, Maastricht and his home in The Netherlands are featured.

(Above) The Sunny city of Perth, Australia. The CBAC had a special guest speaker for a seminar this summer, Dr. Livia Hool from the University of Western Australia, read more on pg.8. (U. of W. A.)

An interdisciplinary approach to studying and treating rhythm disorders of the heart

CENTRE HEARTBEAT

An interdisciplinary approach to studying and treating rhythm disorders of the heart
### CBAC Fall 2008 Seminar Schedule

Seminars are hosted on Mondays, 5:30PM—6:30PM unless otherwise noted. Hor'doeuvres reception is from 5:00PM—5:30PM

### Date  |  Speaker, Affiliation, Talk Title  
--- | ---  
**October 1, 2008**  
Thursday @ 4:00pm  
Whitaker Hall Auditorium  
Neils F. Olan, Ph.D.  
Sr. Research Associate  
Department of Biomedical Sciences, College of Veterinary Medicine, Cornell University, Ithaca, NY, "How Disturbances Propagate on Action Potential: What They Can Teach Us About Wave Break Up and Arrhythmia Control"  

**October 6, 2008**  
Thursday  
Darío DiFrancesco, Ph.D.  
Professor of Physiology and Biochemistry, Department of Molecular Sciences and Biotechnology  
University of Milano, Italy  
"Pacemaker Mechanism: Control of Heart Rate in Health and Disease"  

**October 13, 2008**  
Robin Shaw, M.D., Ph.D.  
Assistant Professor of Medicine  
Department of Medicine, Division of Cardiology, Cardiovascular Research Institute, Biomedical Sciences Program, University of California, San Francisco  
"Directed Targeting of Connexins: Can the Model Be Generalized?"  

**October 20, 2008**  
Timothy W. Smith, M.D., Ph.D.  
Assistant Professor of Medicine  
Cardiovascular Division, Washington University School of Medicine, St. Louis, MO  
"Advances in the Treatment of Ventricular Tachycardia"  

**October 27, 2008**  
Jacques Billette, M.D., Ph.D.  
Professor, Department of Physiology, Faculty of Medicine  
University de Montreal, Quebec, CANADA  
"What Does Arterio-Ventricular Node Rate Dependence Mean?"  

**November 6, 2008**  
Darío DiFrancesco, Ph.D.  
Professor of Physiology and Biochemistry, Department of Molecular Sciences and Biotechnology  
University of Milano, Italy  
"Pacemaker Mechanism: Control of Heart Rate in Health and Disease"  

**November 17, 2008**  
Yoram Rudy, Ph.D., F.A.H.A., F.H.R.S.  
The Fred Saigh Distinguished Professor of Engineering, Professor of Biomedical Engineering, Medicine, Cell Biology & Physiology, Radiology and Pediatrics  
"Noninvasive Electrocardiographic Imaging (ECGI) of Electrophysiology and Arrhythmias"  

**November 24, 2008**  
Dorothy A. Harb, Ph.D.  
Professor, Department of Medicine, Section of Cardiology  
University of Chicago, Chicago, IL  
"How to Make an Antiarrhythmic Drug Out of a Local Anesthetic: Drug Interactions with Voltage-gated Na Channels"  

**December 1, 2008**  
K. Martin Arthur, Ph.D.  
The Newton K. and Sarah Louisa Glasgow Wilson Professor of Engineering, Department of Electrical and Systems Engineering  
Washington University, St. Louis, MO  
"Electrical Remodeling of the Diabetic Heart"  

**December 8, 2008**  
Joseph (Jody) A. O'Sullivan, Ph.D.  
Professor of Electrical and Systems Engineering, Associate Professor of Radiology, Professor of Biomedical Engineering, Director of Electronic Systems and Signals Research Laboratory, Associate Director, Center for Security Technologies  
Washington University in St. Louis, MO  
"Dual Energy Quantitative X-Ray CT Imaging"  

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*See the CBAC website for seminar video archive, [www.cbac.edu](http://www.cbac.edu)"*  

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The CBAC travels across the seas to the city of Tainan, Taiwan where a collaborative relationship with National Cheng Kung University is flourishing. This collaborative activity was cultivated largely due to a relationship that was established some time ago when Dr. Ching Hsing Luo, Distinguished Professor of Electrical Engineering, was a student of Dr. Yoram Rudy’s at Case Western Reserve University. Dr. Luo remains a protégé of Dr. Rudy’s and is helping to cultivate a new generation of researchers who will continue to study cardiac electrophysiology. This summer, Dr. Luo and four of his students visited the CBAC. The students visited for the entire summer to observe and participate in research being done in Dr. Rudy and Dr. Jianmin Cui’s labs. One of the students is Hao-Kai Ken, a Ph.D. student in Biological and Biomedical Sciences at National Cheng Kung University who came to work in Dr. Cui’s lab on single cell biochip platform experiments using the patch clamp technique. We spoke to Hao-Kai about his interest in the biomedical sciences and what he hopes to accomplish with his research and he had this to say, “During college I studied biomedical engineering because I was interested in the applications between medicine and materials. I also investigated bone repair materials. I imagined the fields that I would be interested in and one day, I saw a poster of the Institute of Nanotechnology and Microsystem Engineering and suddenly I thought about combining biomedicine with MEMS fabrication. I enrolled in the Institute of Nanotechnology and Microsystems for my Masters Degree where I studied protein microarray. As a child, I always wanted to be a scientist and I’m happy to be studying in this Ph.D. program. Personally, I feel that my most important achievement to date is my research in protein microarray because I published two papers for journals which is very important to me. In the future, I would like to study stem cell differentiation and I will focus on cardiac stem cells. The CBAC is famous for their research in cardiac electrophysiology and I am interested in the patch clamp technique. I would like to combine the patch clamp with the single cell biochip platform. Moreover, I want to learn how to set up and operate the patch clamp and gene transfer and I believe that the CBAC is the best place to learn. The CBAC is great! The people are nice and friendly, the experiment instruments are all complete and perfect and every student works hard and owns their thoughts about their research. This is a good place to do research.” Fu-Chiang Young, also a Ph.D. student of Dr. Luo’s shared his story with me. “As a child, I worked with my father who was an electrical engineer. I was interested in electrical circuitry particularly to design a program to apply microchip to an interface card and also data acquisition to data analysis. Following my graduation, I began to work with Dr. Luo researching electrical physiology. I was introduced to the Luo-Rudy model of the cardiac cell which is famous in Taiwan, and I found the simulations of single cells amazing and exciting. The fact that a simple circuit could describe a cell membrane function was unbelievable to me. I gradually understood the subtleties of cell membrane behaviors as it related to many conditions. At this time my major research is about the protein function of ion channels. Of the work that I have accomplished so far, my Master research is something that I am very proud of. My research (cont.d. on page 7)  

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*An interdisciplinary approach to studying and treating rhythm disorders of the heart*  

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*An interdisciplinary approach to studying and treating rhythm disorders of the heart*
Recently, there has been much discussion of the relative importance (and hence funding priorities) of basic versus applied (translational) biomedical research. This debate has included the field of cardiac electrophysiology and arrhythmia. I believe that we are witnessing a "pendulum swing" towards translational research, at the expense of basic science. I do not think that we should treat this as an "either-or" issue; both basic and applied research are important and needed. However, I am concerned that by emphasizing short-term goals and outcomes, we are deemphasizing the critical and irreplaceable role of the long-term basic discovery process that is not driven by an application. Basic research is an essential part of our existence as thinking beings; it can often lead to the road is usually indi-

Basic science in general, (2) life sciences and medical research, (3) cardiac electrophysiology and arrhythmias. (1) In general, basic research is driven by the natural curiosity of mankind and our need "to know." Between 1599 and 1612 Johannes Ke-

Critical and takes a long time, and the end point is not predictable. I will illustrate this at several levels: (1) Basic science in general, (2) life sciences and medical research, (3) cardiac electrophysiology and arrhythmi

Yoram Rudy, Ph.D., FAHA, FIHRS. An interdisciplinary approach to studying and treating rhythm disorders of the heart.

Yoram Rudy, Ph.D., FAHA, FIHRS. An interdisciplinary approach to studying and treating rhythm disorders of the heart.
An interdisciplinary approach to studying and treating rhythm disorders of the heart

Igor Efimov, Ph.D., was promoted to full Professor of Biomedical Engineering. New appointment starts July 1, 2008.

Vadim Fedorov, Ph.D., was awarded the Beginning Grant-in-Aid from the Midwest Affiliate of the American Heart Association to study low-voltage atrial fibrillation. The funding period is from July 1, 2008 to June 30, 2010.

William J. Hucker, Ph.D.. On November 8, 2007 Dr. Hucker defended his Ph.D. thesis and was awarded the Doctor of Philosophy degree. Dr. Hucker is continuing his MD/Ph.D. training at the Washington University School of Medicine.

Leonid Livshitz, Ph.D., was promoted to Research Assistant Professor in the Department of Biomedical Engineering, Cardiac Bioelectricity and Arrhythmia Center in April 2008. Dr. Livshitz has been a member of Dr. Rudy’s lab since 2004 where he started at Case Western Research University as a post-doctoral fellow and moved to Washington University when Dr. Rudy accepted the invitation to St. Louis. His research interests are focused on the mechanisms underlying arrhythmogenic effects of cell calcium and calcium dependent regulatory pathways.

Ali Nekouzadeh, Ph.D., was promoted to Research Assistant Professor in the Cardiac Bioelectricity and Arrhythmia Center under Dr. Rudy in April 2008. Dr. Nekouzadeh has been with the lab for 2.5 years and his area of specialization in research is modeling mechanical and electrical properties of tissues, cells and cell components. He is currently working on modeling the molecular mechanism of ion channel gating of voltage dependent channels, in particular lks channels.

Thomas O’Hara, a Ph.D. student in the Rudy Lab received a two-year award from the Pre-doctoral Fellowship Program of the Midwest Affiliate Research Committee of the American Heart Association for his project on “Mathematical Model of Human Cardiac Ventricular Action Potential.”

Crystal Ripplinger, Ph.D., February 1, 2008. Dr. Ripplinger defended her Ph.D. thesis and was awarded the Doctor of Philosophy degree. Dr. Ripplinger moved to Harvard as a postdoc.

Jonathan Silva, Ph.D., April 18, 2008. Dr. Silva defended his Ph.D. thesis and was awarded the Doctor of Philosophy degree. Dr. Silva has moved to Chicago where he is a post-doctoral fellow at the University of Chicago.

An interdisciplinary approach to studying and treating rhythm disorders of the heart

The CBAC also hosted its youngest aspiring scientist to date, Yi-I (pronounced EE-EE) or Yi-I, undergraduate at Cheng Kung University in Taiwan. Yi-I’s visit was much shorter than that of Fu-Chiang and Hao-Kai but, she was very focused on her objective to watch and learn as much as possible while visiting the Rudy Lab. Dr. Luo recognized the promise that Yi-I embodies and introduced her to ion channel modeling by having her read several papers published on the subject. Yi-I subsequently became very interested in the subject and is now a member of Dr. Luo’s team. Yi-I, like Fu-Chiang was introduced to channel modeling by way of the Luo-Rudy model which inspired her to want to visit the CBAC. “I think Dr. Rudy’s lab is a great place for me to learn more about cell modeling. I’ve read papers about cell modeling written by members of the Rudy lab and I believe that this would be a great experience and will help tremendously in my future research endeavors.” Although she is not able to conduct formal research at her current academic level, she continues to be a sponge, absorbing all that she can from the research of others and from Dr. Luo. On her experience so far, Yi-I states, “At this point, I do not have a lot of research experience but I am glad that the field I have chosen is one of the most advanced in current scientific research. The hard work that we do can result in a small but precious process affecting the health of humankind enabling them to not be tormented by illnesses.” One of Yi-I’s greatest achievements is her programming skill. “Last summer, myself along with two classmates made a cooperative effort to write a computer RPG game. Although the game was only partially finished after two months of hard work, we still thought it was a great experience. I am positive that my programming experience will be a big help when I am building models. I have to say that CBAC is really a wonderful place for research! I intend to complete my studies with Dr. Luo and hopefully come to Washington University to pursue a Ph.D.”
On August 20-21, 2007, I chaired a workshop, "Systems Approach to Understanding Electromechanical Activity in the Human Heart" convened by The National Heart, Lung and Blood Institute (NHLBI) in Washington, D.C. The 13 workshop participants were expert cardiac electrophysiologists, cell biophysicists, and computational modelers. The objective of the workshop was to advise NHLBI on new research directions for developing integrative approaches to the study of human cardiac function and its alteration by disease. "Systems approach" can be defined as an integrative approach that, in contrast to the traditional reductionism approach of science, assembles the system (the heart) from its molecular, cellular and tissue components. The last decade has generated a wealth of information at the genetic, molecular and cellular scales of the cardiac system. It is timely and important to begin integrating this information within and between scales, to the level of the whole heart, as electromechanical cardiac function and its alteration by disease (e.g., heart failure, arrhythmias) occur at the organ level.

The Workshop resulted in specific recommendations to the NHLBI; details can be found on the NHLBI website at http://www.nhlbi.nih.gov/meetings/workshops/electro.htm; a paper summarizing the Workshop has been published in the September 9, 2008 issue of Circulation. 2008; 118:1202-1211.
Dr. Charles Antzelevitch

CBAC Seminar Topic: “Atrial Selective Sodium Channel Blockers as a Novel Strategy for the Management of Atrial Fibrillation”
Delivered on January 28, 2008

Charles Antzelevitch, Ph.D., F.A.C.C., F.A.H.A., F.H.R.S., is the Executive Director and Director of Research of the Masonic Medical Research Laboratory (MMRL), an internationally prominent biomedical research institute located in Utica, NY. He also holds an academic appointment as Professor of Pharmacology at the SUNY Health Science Center at Syracuse and an endowed chair in Experimental Cardiology (Gordon K. Moe Scholar) at the MMRL.

Dr. Antzelevitch was the guest speaker for the CBAC Spring 2008 Seminar on January 28th where he addressed “Atrial Selective Sodium Channel Blockers as a New Strategy for the Management of Atrial Fibrillation.” A synopsis of Dr. Antzelevitch’s talk to the CBAC group follows: “Current pharmacologic strategies for the management of atrial fibrillation (AF) include use of 1) sodium channel blockers, which are contraindicated in patients with coronary artery or structural heart disease because of their potent effect to slow conduction in the ventricles, 2) potassium channel blockers, which predispose to acquired long QT and Torsade de Pointes arrhythmias because of their potent effect to prolong ventricular repolarization, and 3) mixed ion channel blockers such as amiodarone, which are associated with multi-organ toxicity. The risk of developing severe ventricular arrhythmias and/or organ toxicity by currently available drugs has prompted the development of atrial-selective antarrhythmic agents. Until recently the principal focus has been on development of agents that selectively inhibit the ultra-rapid delayed rectifier outward potassium channels (K votes), taking advantage of the presence of these channels in atria, but not ventricles. Recent experimental studies have demonstrated important atrioventricular differences in biophysical properties of the sodium channel and have identified sodium channel blockers such as ranolazine and chronic amiodarone that appear to take advantage of sodium channel block as a new strategy for the management of AF.”

You can read more about Dr. Antzelevitch’s work at www.mmrl.edu.

An interdisciplinary approach to studying and treating rhythm disorders of the heart.
The CBAC has the honor of having some of the world’s foremost researchers and practitioners in the field of cardiology and cardiovascular research as part of its membership. Dr. Jeanne Schaffer is one of those extraordinary members whose love for science has translated into a dynamic career in cardiovascular research.

Dr. Schaffer is an Associate Professor, Department of Medicine, Department of Molecular Biology and Pharmacology in the Washington University School of Medicine. Among her many accomplishments Dr. Schaffer received the honor of being appointed as the Virginia Minnich Distinguished Professor of Medicine in February, 2008. Dr. Schaffer’s work is focused on the serious cardiovascular complications associated with diabetes and obesity. The risk factors for someone with diabetes or who is obese are very high for coronary artery disease, which tends to manifest itself in a much more aggressive form in these individuals than in those who are not challenged with these diseases. The goals of the studies in the Schaffer lab are to characterize the fundamental cellular mechanisms of lipotoxicity, and to understand how these processes contribute to organ dysfunction in rodent models of metabolic diseases.

Dr. Schaffer’s journey to the world of science and subsequently health care, began with a determination to prove that she was a formidable opponent to anyone who would think that women could not be good scientists. “My initial interest in science began as a purely ‘I will show you’ response to a sexist high school chemistry teacher. However, I quickly found enjoyment in learning about the intricacies of living cells. As part of my biochemistry major in college, I had an outstanding research experience in Matthew Meselson’s lab that sealed my decision to become a scientist. I chose a medical school program that focused on the training of physician scientists, so that I could both continue my scientific training and learn about human disease. Beyond my general biochemistry studies I initially had little idea of what I might pursue, either as a scientist or as a physician. However, during internal medicine training at the Brigham & Women’s Hospital, I enjoyed my time on the cardiology service, which helped me to decide on specialty training in that area. As a cardiology fellow I chose to work in Harvey Lodish’s laboratory at the Whitehead Institute for Biomedical Research, because Harvey had an outstanding track record of mentoring physician scientists. In his laboratory, I received training in molecular and cellular biology that has served as a foundation for my subsequent work. As a college and medical student at Harvard, I participated in research at each stage of my education. Clinical training in medicine and cardiology left little time for science, but I returned to the lab for a concentrated period of full-time training during fellowship. I spent five years as a visiting scientist at the Whitehead Institute. I left Boston in 1995 to take my first faculty position at Washington University where I have remained since.”

When asked what she is most proud of accomplishing in her career, Dr. Schaffer stated, “I am proud of my accomplishment in establishing a robust, independent scientific program, that is recognized internationally. My near term goals are to identify the mechanisms through which abnormalities in lipid metabolism lead to cell dysfunction and cell death in non-adipose tissues such as the heart. My group is also working to translate findings from our basic work to clinical studies. The overall long-term goal of my group is to advance our approaches to the diagnosis, treatment and prevention of cardiovascular complications of diabetes.”

And finally, of the CBAC, Dr. Schaffer states, “CBAC provides a terrific platform for interactions among scientists with a shared interest in cardiac bioelectricity and cardiovascular pathophysiology from both Washington University campuses.”

The CBAC congratulates Dr. Schaffer on her appointment to the Virginia Minnich Distinguished Professor of Medicine and we know that this will be a banner year of further growth and success for Dr. Schaffer.
In each issue of the “Center Heartbeat” we will feature not only the accomplishments and challenges of the faculty and staff members of the CBAC but, we will also shine the spotlight on students and fellows who are completing graduate or post doctoral work in CBAC affiliated laboratories.

In this issue, we are featuring Celine Marionneau, Ph.D. Dr. Marionneau is a Postdoctoral Research Associate in the department of Developmental Biology where she is a member of Dr. Jeanne Nerbonne’s lab. Dr. Marionneau is a native of France born in a small city in the region of La Vendée which is West of France. She then moved to Nantes, one of the biggest cities in France, where she began her studies at the University of Nantes. The University of Nantes is well known for its research in chemistry, food science, cancer and cardiac physiology. She received her undergraduate degree in biochemistry, MS in cell biology and PhD in biology. Dr. Marionneau talked about how her interest in science developed and how that subsequently resulted in her becoming a postdoctoral fellow at Washington University. “My decision to pursue science began very early on, while I was in high school. I wanted to be a medical researcher although I did not really know at the time what this entailed. I was initially discouraged by a high school work experience in a veterinary analysis lab where the work was repetitive and boring. This experience actually led me to consider medicine as a possible alternate. However, once I was introduced to a university research lab, I realized that I really wanted to be a scientist. I became interested in cardiac electrophysiology while attending classes given by Dr. Denis Escande at the University of Nantes. Denis was a tremendous and passionate teacher who had a remarkable career in cardiac electrophysiology research. I went on to do my PhD in his lab. Tragically, Denis died in November 2006, at the young age of 53. I am proud that I had the privilege of being one of the faculty and staff members of the CBAC but, we will also shine the spotlight on students and fellows who are completing graduate or post doctoral work in CBAC affiliated laboratories.

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Dr. Marionneau intends to return to France where she hopes to obtain a faculty position and continue her research that will focus on understanding the regulation of the functional expression of cardiac ion channels. In parallel with science, she looks forward to reuniting with the love of her life who has been waiting for her to return to France.
Dr. Rudy journeyed to The Technion Israel Institute of Technology, located in Haifa in May, 2008 as the liaison on behalf of the McDonnell International Scholars Academy. The purpose of this trip was to assist in building student and faculty exchange and research collaborations between Washington University and The Technion.

Tom O’Hara, a Ph.D. student of Dr. Rudy, traveled to Hungary and Ohio to do collaborative research. During the Fall 2007 semester, Tom spent a month with Professor András Varró in the Department of Pharmacology and Pharmacotherapy at the University of Szeged in Hungary. Tom participated in an experiment in which they measured various aspects of electrophysical behavior in human ventricular heart cells. Tom also spent several months in the Spring of 2008 with Dr. David Van Wagoner at the Department of Molecular Cardiology at the Cleveland Clinic in Ohio where they performed additional studies on human ventricular heart cells, looking at calcium currents in particular. Currently, Tom is working to combine results from the Hungary and Cleveland experiments into a study investigating basic ventricular calcium current behaviors. The study is special because the results have never before been measured in non-failing human ventricular heart cells. They provide a critical missing piece in the collection of available data Tom is using to construct a mathematical model for all major aspects of human ventricular heart cell electrical behavior.

Ralph J. Damiano, Jr., MD, cont’d.


Igor R. Efimov, Ph.D., F.A.H.A., F.H.R.S., Professor of Biomedical Engineering, Washington University, http://efimov.wustl.edu/

- “Biophotonic Imaging of Atrial Pacemaker Complex,” Cardiovascular Research Seminar, Washington University School of Medicine, St. Louis, MO. January 24, 2008.
- “Heterogeneous protein expression in the cardiac pacemaker and conduction system,” Department of Biochemistry and Molecular Biology, Saint Louis University, St. Louis, MO. December 12, 2007.