Center for Arrhthmia Research

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Located at Hofstra University on Long Island, The Center for Arrhythmia Research is a collaborative activity between Beth Israel Medical Center (New York, NY) and the University. Founded in 1997, The Center and its partners use The NYSERNet Network and Internet2 to share data that enables researchers to study the mechanisms of heart disease and related dynamics. The Center's mission includes education and public outreach.

With the expectation that a better knowledge of their mechanisms may ultimately lead to improvements in the treatment of cardiac arrhythmias, The Center hopes to find causes and solutions to help prevent some of the 300,000 to 400,000 deaths a year in the United States alone attributed to sudden cardiac arrest. The term arrhythmia refers to any change from the normal sequence of electrical impulses (sinus rhythm), causing abnormal heart rhythms. Some arrhythmias are brief (for example, a temporary pause or premature beat) that the overall heart rate or rhythm isn't greatly affected. But if arrhythmias last for some time, they may cause the heart rate to be too slow or too fast or the heart rhythm to be erratic. In cases where the rapid degeneration of the cardiac electrical system from the regular sinus rhythm to an irregular rhythm in which the heart pumps less effectively, or in extreme cases fails to pump at all, heart disease, which is the number one cause of death in the industrialized world, becomes more likely.

Using Hofstra's supercomputing Beowulf cluster the Center for Arrhythmia Research (arrhythmia.hofstra.edu) can model the behavior of hearts in general or the hearts of specific patients. These virtual models help researchers understand the behavior of the heart's electrical systems, potentially predicting the effect of a particular treatment on the behavior of a particular heart. The combination of supercomputer and fast network connections is expanding computational cardiology from the study of simple models to the study of models incorporating realistic cell dynamics on realistic ventricular dynamics, (Fenton, F.H., Cherry, E.M., Karma, A., and Rappel, W.J. Modeling Wave Propagation in Realistic Heart Geometries Using the Phase-Field Method. Chaos 2004; 15: 013502). The synergy created by using supercomputers connected by fast networks such as the NYSERNet Network allows computational physicists to combine with medical researchers to pursue an entirely new approach to biomedical research using computers to model the behavior of systems. This kind of modeling "in silico" using silicon chips to create virtual systems to examine lets researchers test and repeat their experiments in ways that would otherwise not be possible.

The rich data that feeds these computational models is gathered by researchers at Cornell University, the University of Alabama, Birmingham and others, and fed to

Hofstra's supercomputing cluster via Internet2 and The NYSERNet Network. Supported in part by an NSF grant, the Beowulf cluster uses smaller computers working together to provide supercomputer computational strength in an affordable, expandable package. Harold Hastings of Hofstra University, PI on the research project, reports that there may soon be demand for even more cycles than Beowulf's 48 dual-processor nodes can provide. Hofstra's NYSERNet connection makes it possible for collaboration with other universities on a larger shared resource for which we are now pursuing funding.

The NYSERNet Network and Internet2 also provide a reliable path for both daily communications and large data sets shared among researchers such as Anna Gelzer, lecturer in cardiology at the College of Veterinary Medicine at Cornell, Richard Gray, Associate Professor in the Department of Biomedical Engineering at University of Alabama-Birmingham, Harold Hastings, Professor and Chair of Hofstra's Department of Physics, and senior researchers Flavio Fenton and Elizabeth Cherry, previously at Hofstra and now at Cornell. Students, too, benefit from the research underway at CAR. In a recent 2005 publication, an article detailed a project taking place at the CAR that studied the onset of "spontaneous activations" in the Belousov-Zhabotinsky reaction, a chemical system with dynamics analogous to the heart (Hastings, H.M., Sobel, S.G., et al.). The interesting aspect of this article was the inclusion of nine Hofstra students and two high school students who participated in all aspects of the research from running chemical reactions to analyzing data. The article was called "Spatiotemporal clustering and temporal order in the excitable BZ reaction" and appeared in the Journal of Chemical Physics. (2005; 123:64502) As with cardiac modeling, "in silico" chemistry offers a degree of repeatability and control not available on the laboratory bench.

The Center for Arrhythmia Research at Hofstra University has become a major research facility for the study of the heart. Current research is growing rapidly and opportunities for research in new and developing fields are now possible in part due to the NYSERNet Network. Specific recent projects in computational cardiology include understanding the role of unstable cellular dynamics in the onset of fibrillation (Cherry, E.M., and Fenton, F.H. Suppression of Alternans and Conduction Blocks Despite Steep APD Restitution: Electrotonic, Memory and Conduction Velocity Restitution Effects. Amer. J. Physiology 2004; 286: H2332-2341), how fibrillation might occur in the absence of this instability (Fenton, F.H., Cherry, E.M., Gray, R.A., Hastings, H.M., and Evans, S.J. Fibrillation Without Alternans in Porcine Ventricles: Experiments, Theory, and Numerical Simulations, winner of a 9th Michaelem Servetus Educational Hall Award for best poster at Madrid Arrhythmias and Myocardium 2005, Madrid, Spain), and work in progress on atrial fibrillation and the role of sodium channel defects in sudden cardiac death. Center Staff F.H. Fenton and E.M. Cherry recently won honorable mention in the 2006 Computer Visualization Challenge.

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