Appendix 10: Rensselaer Polytechnic Institute/Center for Directed Assembly of Nanostructures Profile

I. Description

Institution: Rensselaer Polytechnic Institute
PI: Professor Richard W. Siegel
Co-PIs: none
Title: Nanoscale Science and Engineering Center (NSEC) for Directed Assembly of Nanostructures
Proposal: 0117792
Program Officer: David L. Nelson
Education Outreach Director: Dr. Linda S. Schadler, schadl@rpi.edu

II. Research Agenda

Research Focus: Our NSEC is addressing the fundamental scientific issues underlying the design and synthesis of nanostructured materials, surfaces, assemblies and devices with dramatically improved capabilities for many industrial and biomedical applications. Directed assembly is the fundamental gateway to the eventual success of nanotechnology. Therefore, our NSEC is focused on discovering and developing the means to assemble nanoscale building blocks with unique properties into functional structures under well-controlled, intentionally directed conditions.

NSEC Description: Our NSEC integrates research, education, and technology dissemination to serve as a leading national and international resource for fundamental knowledge and applications in nanoscale science and technology. Serving society, including educational outreach, is a major thrust (Thrust 3) of our NSEC**.**

III. Education Activities within the University

Description of activities
The Center's internal educational activities are focused on undergraduate and graduate education in the classroom and through research. We teach several courses on the Rensselaer campus and at our partner institution, the University of Illinois at Urbana-Champaign (UIUC). More than 75 undergraduates have worked in our laboratories. We also teach an on-site short course at Rensselaer through the Chautauqua program and host a variety of visiting scholars.

Program staff and expertise
The education and outreach program in the NSEC is supported by a half-time outreach staff member as well as part time support from a business manager and an administrative assistant. In addition, over 2/3 of the faculty in the Center are involved in either the internal or external educational activities of the Center. Numerous students and post docs have participated.

Goals and objectives
Each program has audience specific goals, however the overall aim is to increase interest in nanoscience and prepare students and professionals for successful research and development in this emerging field.

Target audience (educational levels, number of students at each level, etc.)
During the past four years our NSEC has engaged more than 23 undergraduate students, 75 graduate students, 18 postdoctoral researchers, 50 working professionals, and several visiting scholars.

Current activities
Undergraduate Research: This is an ongoing project with 23 students from RPI and UIUC having worked in our laboratories. The research has resulted in 13 publications and presentations.

Graduate Leadership Course: With NSEC support, The Archer Leadership Center at Rensselaer developed a graduate professional leadership series (PLS) open to all graduate students at Rensselaer. This non-credit course has been taken by about 60 students in the last 2 years. The course is now open to all Rensselaer graduate students and we are getting students from both science and engineering. The course meets once a week for 2 hours and includes Meyers-Briggs evaluation, a ropes course, ethics, leadership, team building, and several other related topics. Guest speakers from industry as well as Rensselaer administrators (e.g. the Dean of Engineering) visit the class and foster discussion.

Chautauqua Course: Between 15 and 20 college professors and industry researchers from around the United States have joined us each year for a 2-day NSF Chautauqua short course. The topics include nanocomposites, nano-bio interfaces, molecular modeling, and electrical and optical applications of nanoscale materials.

Graduate and Undergraduate Courses: We have developed two undergraduate level courses with significant nanotechnology content, and several graduate courses including an "Introduction to Nanotechnology," "Science of Carbon," and "Biomimetic Materials." These are well attended and well received. In addition, we teach a graduate course in the business school called "Business Implications of Emerging Technologies" that has included nanotechnology projects and involvement of Center faculty.

Nano S&E content focus
The content of the undergraduate research and technical courses has focused on the development of materials using nanoscale building blocks as well as the physics, chemistry, and biology involved in the synthesis of those building blocks. This requires background information on high surface area materials and often includes applications in areas such as sustainable energy and biomaterials.

IV. Education Activities Outside the University

Description of activities
Our NSEC conducts a multitude of educational programs that take place outside of Rensselaer and UIUC. Several of these programs have been highly successful. "Molecularium™: Riding Snowflakes," a magical, musical (digital dome video) adventure into the world of atoms and molecules was created to spark the interest of K-5 students in the nanoscale world. The Bouchet Outreach and Achievement in Science and Technology (BOAST) program at UIUC stimulates academically at-risk children's interest in science and serves as a national resource for hands-on science and Internet lessons. Nanoscope is a computer simulation of a real scanning electron microscope (SEM) that allows students to learn the SEM control interface and provides access to libraries of many samples at various levels of magnification. Our PUI program provides the means for a diversity of talented undergraduate students to engage in collaborative research at Rensselaer as well as their home institutions.

Program staff and expertise
Educational outreach programs are lead, run, and maintained by several research faculty including professors Akpalu (RPI), Braun (UIUC), Dordick (RPI), Garde (RPI), Keblinski (RPI), Lewis (UIUC), Nayak (RPI), Peters (RPI), Ryu (RPI), Schadler (RPI), Schubert (RPI), Schweizer (UIUC), Siegel (RPI), Shima (RPI), Vojack (UIUC), and Wong (UIUC). (A description of these professors is beyond the brief, 3-page scope of this document, but can be found at www.nano.rpi.edu) NSEC staff further supports these programs.

Goals and objectives
Our educational outreach programs aim to increase public science literacy, enrich primary and secondary school curricula with cutting-edge science, and enable diverse and talented college students to become successful scientists and nanotechnologists.

Target audience (grade levels, number of students at each level, school districts, etc.)
We are improving science literacy though the development of educational programs for people of all ages, which provide fundamental information about the emerging field of nanotechnology. We have reached hundreds of people so far and are on our way to reaching ever-wider segments of society. During the last four years our programs have engaged several hundred families, more than 400 K-12 students, and over 75 undergraduate students.

Current activities (Examples)
Our Signature Project – the Molecularium™ (www.molecularium.com)*:* We have taken up the grand challenge of improving science literacy by creating the Molecularium™ The Molecularium™ is a digital dome theater (like a planetarium) presentation but instead of taking the audience on a ride into the stars, the Molecularium ship takes the audience on a ride into the world of atoms and molecules. This fantastical ship can shrink to molecular sizes and move as fast as the speed of light. The concept is similar to that of the movie *Fantastic Voyage* (1966) or the *Magic School Bus*, but we have merged advanced scientific computation with state-of-the-art digital animation technology providing scientifically correct molecular motion. The first Molecularium show, Riding Snowflakes premiered at the Children's Museum of Science and Technology (CMST) in Troy, NY on February 4th. In this musical adventure aimed at K-5, Oxy, Hydra, and Hydro manage to navigate the ship (with the help of a computer) through the clouds, where they travel in a snowflake, watch it melt, and feel and observe the wind blowing past them. Musical segments emphasize the main message that *everything is made of atoms and molecules*. Children also learn about the three states of matter ("solids slow, liquids flow, gas is fast") and take a ride along a polymer molecule. Carbón (a carbon atom), who meets our trio on their brief journey through space, takes them to his favorite place, the Earth (a place teeming with life) where he retires to join a polypeptide chain and be part of life itself! These concepts are in agreement with typical state science based outcomes for K-5 students, but are taught such that all ages will learn.

Virtual Nanoscope: The virtual nanoscope is at its core a library of scanning electron microscope (SEM) images at various magnifications and focus. These images are stored, and accessed on a computer to give the impression of using an actual SEM. We have developed a library of 5 samples that can be viewed at several magnifications, several levels of contrast and both in focus and out of focus. This has the potential to be an extremely powerful teaching tool that we will build on over the next 6 years.

Primarily Undergraduate Institution (PUI) Partnerships: We have been collaborating for the past 4 years with faculty from Morehouse, Mount Holyoke, Spelman, Smith, and Williams colleges to provide a significant research opportunity for undergraduates and to provide collaboration between Center faculty and partner faculty. Each of these colleges has outstanding undergraduate programs; the group includes two of the

premier HBCUs and three of the premier women's colleges in the U.S. Through this collaborative effort, we have learned a great deal about how to partner with PUIs, completed some good research, and had about 20 students (16 of them from underrepresented groups in engineering) spend time at the Center.

Nano S&E content focus: This is similar to our internal emphasis, but adjusted to be age appropriate as required.

Nano S&E content consultants: In order to capture the interest of diverse audiences, our NSEC has consulted several educational professionals from various areas, such as primary and secondary educators, museum curators, and field experts. Projects such as the Molecularium™ have involved an even broader group including animators, composers, musicians, programmers, faculty, staff, students, etc.

V. Education Outreach Materials

Describe and provide examples of materials, outlines, demonstrations, etc. developed for outreach activities for the K-12 and/or informal audiences

The Molecularium™ is a great example of an educational outreach program in which several materials were produced. An animated, musical, digital dome presentation was produced to spark the interest of K-5 students. Many state mandated science standards and lessons were addressed. For example, the New York State curriculum including the three states of matter, and the understanding that "everything is made of atoms and molecules" were clearly reinforced through this show. An educational resource booklet was developed for teachers to prepare their students for the show and then reinforce lessons after the show. This booklet includes worksheets, hands-on activities, and lesson plans. A website, www.molecularium.com, was developed to educate children and is currently being expanded to include games and online activities for children. Furthermore, assessment tools were developed to measure the educational success of the Molecularium™.

Describe a recent successful education outreach activity
Our PUI summer students delivered their final research presentations in early August 2005. At the same time, these undergraduates completed academic papers on their topic, one of which was submitted for publication. The quality of their research and enthusiasm for participation was better than ever and we look forward to next summer.

VI. Education Outreach Evaluation

Summarize outreach evaluation plan
Our programs are assessed via surveys, open discussion, and professional assessment tools. We have used these extensively and seriously and have adjusted many of our programs based on the survey results.

Summarize outreach evaluation results
In general we are finding that the students are learning a great deal from our outreach projects and more importantly they gain a new enthusiasm for science. The Molecularium shows very specific learning and we are continuing to assess the latest version of the show.

VII. Lessons Learned

List 2-3 lessons learned to share with others embarking on a nano education outreach effort.

- Hire professionals where appropriate and do not try to be an artist, graphic designer, DVD developer, web designer, when there are professionals who can do it better.
- When interacting with secondary school educators, don't tell them what they need to do, ask them what they want and can use. It has to be collaborative.

Describe what you might do differently in the future

In the future, I would like to work toward a model in which the centers on campus doing education and outreach have a central staff with specific expertise in education and outreach (as several universities have done). This staff develops programs and makes the best use of faculty expertise and also supports the faculty's ideas and enthusiasm and directs that enthusiasm to the most effective projects and interactions. A lot of faculty time is lost in relearning lessons (such as the best way to interact with HS teachers and students).