NATIONAL CANCER INSTITUTE
NCI Alliance for Nanotechnology in Cancer

NCI Alliance for Nanotechnology in Cancer | **Monthly Feature** | January/February 2007

Academic Cross-Training in Nanomedicine

Nanotechnology offers new possibilities for dealing with old problems in diagnosing, treating, and preventing cancer. To realize this potential, scientists from disparate fields are collaborating on wide-ranging projects, bringing their different skills and mindsets to the table. Research teams comprising engineers, chemists, biologists, surgeons, and pathologists are becoming the norm in the cancer nanotechnology world, in large part because of prompting and encouragement from the National Cancer Institute's (NCI) Alliance for Nanotechnology in Cancer.

However, even researchers motivated to work with colleagues in other fields are finding that such cross-disciplinary cooperation is not easy. The tools and language that engineers use are unfamiliar to many biologists, and vice versa. So, too, are the ways in which engineers and biologists, or chemists and cancer researchers, think about how to solve a given problem.

So yes, the old expression "two heads are better than one" still holds true, but only if those two heads can get their ideas across to one another. "People need to be able to speak the same language," said Carolyn Anderson, Ph.D., an imaging scientist at Washington University in St. Louis (WU) and researcher with The Siteman Center of Cancer Nanotechnology Excellence (CCNE).

In fact, the emphasis on developing interdisciplinary research teams goes beyond just tapping the expertise of each discipline. Anderson explained the difference between multi- and inter-disciplinary approaches. "Multidisciplinary is when you train people to be in their specific discipline," she said. They interact with others, but then "they go back to their own lab and continue to do the thing they do best. That's probably how I've been trained."

The new goal of interdisciplinary research, as expressed by the NCI and National Institutes of Health, is to take "bits and pieces from the contributing disciplines and integrate them in ways that produce a new conceptual framework." Programs sponsored by the NCI Alliance for Nanotechnology in Cancer are working with everyone from established professionals to schoolchildren to train a new generation of interdisciplinary scientists.

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Reaching Out to Professionals

Sarah Blair, M.D., assistant clinical professor of surgery at the University of California, San Diego and member of the Moores UCSD Cancer Center, said the UCSD nanotechnology team is working to facilitate interaction amongst established professionals. "We have put together seminars to present our data and try to get everybody on the same page, in terms of what the problems are that clinicians see and how nanotechnology can solve these problems," she said. They are also developing a course to help practicing engineers and clinicians understand how nanotechnology can be applied to cancer medicine.

In her own research, Blair provides the clinical perspective in a collaboration with engineers, pathologists, and chemists that has resulted in an antibody-based method to detect individual cancer cells in the body.

Ultimately, such a technology could reduce the need for second operations by enabling surgeons to confirm at the time of the operation that they have removed all tumor cells, rather than waiting days or weeks for traditional pathology reports. The project came about from the synergy created by bringing together a diverse group of scientists under the umbrella of the UCSD Center of Cancer Nanotechnology Excellence, the Center of Nanotechnology for Treatment, Understanding, and Monitoring of Cancer (NanoTumor). "Here is an example of how getting people together spins off a lot of stuff," Blair said.

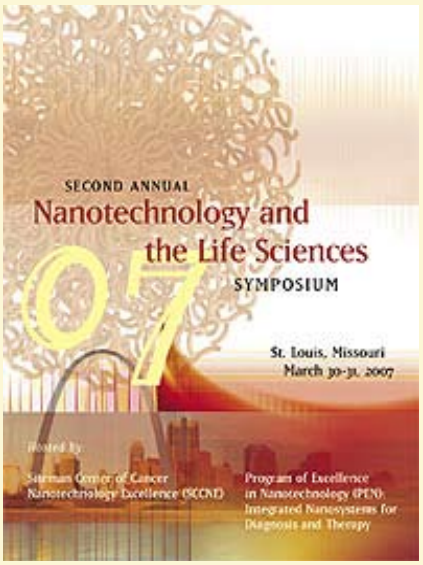
In another effort to bring clinical scientists and nanotechnologists together, the 2nd Annual Nanotechnology and the Life Sciences 2007 workshop will be held on March 30-31, 2007 at the Washington University Medical Center in St. Louis, MO. With presentations by leading experts, local faculty, and students, the symposium will highlight how nanoscale materials can apply to cancer and cardiovascular medicine. This year the symposium will be hosted by the Siteman CCNE and the Program of Excellence in Nanotechnology (PEN), which is sponsored by the National Heart, Lung, and Blood Institute (NHLBI); last year's host was the Burnham Institute in California. The hope is that other CCNEs and PENs around the country will continue the annual tradition.

Training an Upcoming Generation

In addition to bringing together established professionals, universities are also developing programs to train students in life science nanotechnology. New interdisciplinary coursework challenges students from different majors. For example, Anderson teaches an Imaging Science course at Washington University that attracts engineers, biologists, and chemists.

"The chemists and biologists had to work harder in the first half of the course that included the math, and the engineers didn't do so well in the descriptive component," Anderson said.

Such an interdisciplinary challenge was exactly what graduate student Eric Pressly was looking for when he enrolled in a new nanomedicine course offered at Washington University in the Fall of 2006. As a student in materials science, he knew the life sciences aspect would push him. "I think to be successful in this area you have to force yourself to go outside your comfort zone," he said. "The class definitely helped me to learn the biology that I need to know to work more in this area, as far as which receptors are important for the field, as far as the interactions go, and a little bit along the lines of diseases that could be treated with nanotechnology."



The Second Annual Nanotechnology and the Life Sciences meeting will be held March 30-31, 2007, at Washington University in St. Louis, MO. The event will be hosted by the Siteman Center of Cancer Nanotechnology Excellence (SCCNE) and Program of Excellence in Nanotechnology (PEN): Integrated Nanosystems for Diagnosis and Therapy. *Courtesy: Washington University*

Because the field is so young, professors are developing teaching materials from scratch. "There are not many standard textbooks out there for nanotechnology," said Monica Shokeen, Ph.D., a postdoc in radiology at Washington University School of Medicine and a teaching assistant for the nanomedicine course. The newness of the field also requires that course content change rapidly to stay current.

"The course will be dynamic," she said. "It will cover what is going on in the field, what is going on right now, because nanomedicine is an emerging area of science."

The first offering of the course obviously had cross-disciplinary appeal, with a couple of anthropology majors enrolled.

"The term 'nano' attracts many youngsters," Shokeen said. "The anthropology students were undergraduates testing the waters."

Technology is playing a key role in the creation of new courses. The entire nanomedicine course was developed with distance learning in mind, which allowed five students from the University of Santa Barbara (UCSB), including Pressly, and one from Georgia Tech to take the class remotely.

"As the cursor would move on the screen of a TabletPC, students could see what the lecturer was pointing at," Shokeen said. "They even gave student presentations remotely. There was no chalkboard teaching in this course; it was all PowerPoint to accommodate the distance learners."

By opening courses to other institutions, distance learning allows widespread use of the work that goes into developing a class. In the future, students and postdocs at the University of North Carolina (UNC) might be able to take the WU nanomedicine course as part of a Certificate in Nanomedicine being set up at UNC, according to Susan Wohler Sunnarborg, Ph.D., assistant director of the Carolina Center of Cancer Nanotechnology Excellence.

"The course would have several benefits," Sunnarborg said. "First, it has a broad focus from materials science to imaging and clinical applications. Second, it would provide a unique opportunity to gain a perspective on nanomedicine from another leading institution. Third, it would be another avenue for interaction with another of the CCNEs whereby our trainees would get to know investigators and trainees from WU (and any other students at remote locations), and the resources at their CCNE would contribute to education within the broader Alliance for Nanotechnology in Cancer."

In such a new and interdisciplinary field, it helps to draw on experts not just from different departments at the same university, but also from different institutions across the country. The distance-learning setup enabled two guest lecturers to present to the class from their home institutions of UCSB and the Burnham Institute.

"Technology allows you to tap into expertise at other universities," Anderson said. "I don't know that there's anybody out there who knows how to teach to a wide variety of students with such different backgrounds."

Technology also facilitates communication in the research setting. Pressly is working on his doctorate as part of the Program of Excellence in Nanotechnology at Washington University, but he is enrolled at UCSB. His research group holds monthly meetings via remote connection to share ideas and progress. For guidance on his study of the use of nanoparticles to better visualize damaged arteries, he relies on the expertise in Imaging Science offered by WU and the expertise on nanoparticle synthesis at UCSB.

Monica Shokeen, Ph.D., a postdoc in radiology (left), and Carolyn Anderson, Ph.D., an imaging scientist, both of the Washington University School of Medicine. *Courtesy: Washington University School of Medicine*

"I think the collaboration is very beneficial because it allows me to learn more radiology than I would just working on a project like this without that collaboration," he said. "I get to talk to people as opposed to just reading the literature."

Even so, Pressly said there is no substitute for being there in person. He found one week of "getting his hands dirty" in the WU lab to be enormously helpful in learning the imaging science.

Graduate students in the program of Nanopharmaceutical Engineering and Science at Rutgers University also benefit from hands-on learning at host institutions. As the principal investigator of an Integrative Graduate Education and Research Traineeship (IGERT) grant, funded by the Alliance for Nanotechnology in Cancer and administered by the National Science Foundation, Fernando Muzzio, Ph.D., said he hopes to send a few students abroad each year.

"I'm hoping to send three or four students to various labs around the world to try to get them exposed to what is going on in other countries and laboratories," Muzzio said. "They'll spend six to eight weeks working with recognized, prestigious colleagues, learning methodologies and learning how to think about problems from other angles."

The idea is for students to work on projects a little bit outside of their dissertation research. "We don't look for exactly the perfect match because then the learning is less," Muzzio said. "We want to push them a bit, but on the other hand you don't want something so unrelated they don't really find any value in it."

In addition to funding for some international travel, the IGERT funding provides students with a fellowship and tuition. Rutgers is using its IGERT funding as part of a collaboration with the New Jersey Institute of Technology, the University of Puerto Rico-Mayaguez, and Purdue University to develop programs in nanopharmaceutical engineering. These programs will merge materials science, chemistry, engineering, and pharmaceutics and will focus on developing drugs that will be ready for market in the short term.

"The focus of what we do is concentrated on scalable manufacturing systems," Muzzio said. "We are interested in doing things that will be used."

The partnership with the University of Puerto Rico-Mayaquez is a natural offshoot of the emphasis on bringing products to market. About 80 percent of pharmaceuticals manufactured for the U.S. market are made in Puerto Rico, according to Muzzio, so partnering with UPR-Mayaquez allows the team to work with both manufacturers and scientists.

The practical nature of the research objectives lends itself to crossing disciplines. "We're approaching the problem from a manufacturing angle. That means there is mostly engineering activity," said Muzzio, who is a professor of chemical and biochemical engineering at Rutgers. "That is where the intrinsically interdisciplinary nature of our work is, because we take engineers, but we have to teach them enough about biology and the interactions of materials with tissues so they can do the engineering piece with a knowledge of what will happen when that material is put into a person."

In addition to visiting other laboratories, Muzzio said the advising system also helps encourage students to push the limits of their learning. "Every single student has to have two advisors, and in every case we look for advisors who belong to different disciplines," he said. "If the advisor is an engineer, the co-advisor must be a pharmacist, or a chemist, or a food scientist. In some cases we allow two engineers if they are working on different enough things, and usually when we make that exception it is because they are in different institutions."

Muzzio and his colleagues are also developing new coursework to address the cross-disciplinary questions in their field. "We developed a few new courses. One, developed by Professor Patrick Sinko, is called nanotechnology-based drug delivery, which the engineers and the pharmaceutics and the chemistry students take all together as a team," he said. "Next semester we'll have one on organic nanoparticle processing, developed by Professor Benjamin Glasser, which focuses on the process components you need to put in place so that you can turn chemicals into nanoparticles and nanoparticles into products – what you do when you make kilograms of stuff, rather than milligrams."

To make the new courses adaptable for different outlets, Muzzio said they are working with a new format. "In many cases we have broken courses down into one-credit modules. That gives a little flexibility in terms of scheduling and what the students take," he said. "A one-credit module can also be taught as a two-day continuing education course because it's about 15 hours of contact, or it can be tweaked and included into an undergraduate course. It is sort of like a discrete amount of material you can customize for various purposes."

Fitting the new format into existing university schedules can be tricky, because the system is designed for semester-long courses. Muzzio said they are working on that issue.

Reaching the Next Generation

The excitement of a hot topic like nanotechnology appeals to younger students as well, and Muzzio's IGERT is reaching out to foster that enthusiasm. Both in Puerto Rico and in New Jersey they are developing a traveling bus filled with hands-on activities to teach high school students about nanotechnology and its applications to the life sciences. Also, high school students and undergraduate students can apply to work in research laboratories. High school science teachers can also attend a summer camp, in which they work in the laboratory on a modest research project, and go home with curriculum materials for their classes. "We try to do things that will touch as many young people as possible," Muzzio said.

With the creative approaches that today's cancer nanotechnologists and others are taking to reach across disciplinary borders, interdisciplinary research might be standard practice for tomorrow's scientists. Given the increasingly broad reach of today's most important biomedical research problems, this change can only bode well for future advances in treating, diagnosing, and preventing cancer.

—Barbara Maynard