## **Interdisciplinary Research**



# BUILDING BRIDGES, FINDING SOLUTIONS

Complex scientific problems and socially relevant issues are challenging scientists to find new ways to integrate knowledge from multiple and disparate fields. Increasingly, collaborative approaches are changing the way science is done. **By Jill U. Adams** 

onsider obesity. It's a complex problem with no easy solution. Risk factors reside in your genes, the microflora in your gut, the food you ate as a child, the people who share your home, and the physical environment of your town. But how do the genetics interact with the availability of sidewalks in your neighborhood? How do the foods you eat affect the microbial population in your intestines?

These multifaceted questions are answerable if geneticists and urban planners or economists and immunologists—sit down in a room together and share their ideas. They may speak different dialects, use dissimilar methods, and experience personality clashes, but to succeed, scientists from diverse fields must find a way to shed preconceptions and make the effort to understand a foreign discipline.

"Interdisciplinary research is when you get people to work together enough that you go beyond disciplines working separately on the same issue," says **Barry Popkin**, director of the University of North Carolina's Interdisciplinary Obesity Program. To get people out of their comfort zone, he says, it takes time and inducement. "Sometimes it takes money."

Incentives might bring scientists to the interdisciplinary table, but they won't keep them there. To bridge disciplines takes "an extra effort," says **Carol Van Hartesveldt**, program director for IGERT at the National Science Foundation (NSF). IGERT stands for Integrative Graduate Education and Research Traineeship program and is the mechanism by which NSF encourages training in interdisciplinary research. "The focus is on funding projects with excellent, significant, timely, cutting-edge research. That's why people take the trouble to do this."

For administrators who want to encourage interdisciplinary research, it's important to define a central focus, to give it adequate time, and to keep people talking. Established researchers who enter the fray should work well with others, ask "dumb" questions, and stay open to possibilities. For postdoctoral and graduate students, it's essential to get comfortable exposing yourself to outside influences and alternative research fields.

#### **Finding Focus**

In industry, the focus is the product or unmet need. Teams work toward the company goal of getting a worthy creation on the market.

"I think it is part and parcel of the way biotech companies function and have to function, frankly, in order to do excellent and relevant work," says **Douglas Williams,** executive vice president and chief scientific officer of ZymoGenetics in Seattle, Washington. The market is so competitive, he says, that companies do whatever they can to keep ahead of the curve.

In addition to mixing scientific disciplines, companies also blend expertise at different stages of the product pipeline. "We're bringing together skill sets that are necessary for taking an idea all the way to a product," says Williams. "Project teams form, but the team structure tends to morph over time," he says, as the focus shifts from research to development and eventually to marketing and sales, as the product gets closer to the marketplace. continued »



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Barry Popkin

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"You rally people around a societal problem that transcends a particular discipline." — Bruce Wilcox



Because companies by definition have a strong product focus, one might think that they've got the interdisciplinary approach down pat. But that's not necessarily the case, says **John Tallarico**, group leader of chemogenetics at the Novartis Institutes for BioMedical Research in Cambridge, Massachusetts. A company has to be specifically structured for true cross-fertilization to occur. At Novartis, this means different categories of groups, some oriented by disease area, some specializing in methods, and some specifically created to build bridges among other groups.

"If things are classically broken down, the pharmacologists only care about pharmacology, the chemists only care about medicinal chemistry, the cell biologists only care about their bioassays," says Tallarico. "When there's a real silo effect, it's hard to be one of the groups who bridges those things, because people will always question you. What are you actually good at? What do you do?"

Many companies now boast about doing interdisciplinary work a sign that things are changing. But change takes time, even at a company like Novartis where the push for collaboration comes from the top, says Tallarico. Flexibility in thinking and a willingness to take risks—those are traits that Tallarico wants in his team members. And yet he acknowledges, "It's nontrivial to convince colleagues that these are the best people out there."

#### **Staying Flexible**

"What's exciting about Novartis is that you're going to have many different flavors of scientists at the table," says Tallarico. When interviewing, he wants to know if a candidate is intimidated or excited by that prospect. "Some people have a passion for learning new things—that's huge," he says. "If I had to phenotype my group, I'd say that they like to push the envelope. And if they're not being pushed themselves, they kind of get bored."

Some themes carry over to the academic side, including the truism that only some people are comfortable bridging disciplines. "You can't make everybody be an interdisciplinarian," says **Bruce Wilcox**, director of an NSF-funded IGERT in ecology, conservation, and pathogen biology at the University of Hawaii in Manoa. "You have to cultivate and develop those people with that inclination."

In Wilcox's training program, bridging disciplines begins with a student's application. "They have to find a mentor/sponsor who Fuel Cell IGERT at Rensselaer Polytechnic Institute fuelcell-igert.rpi.edu

Igert at University of Hawaii at Manoa www.jabsom.hawaii.edu/igert

> International Institute for Applied Systems Analysis www.iiasa.ac.at

National Science Foundation www.nsf.gov

NIH Roadmap for Interdisciplinary Research www.nihroadmap.nih.gov/ interdisciplinary

Novartis Institutes for BioMedical Research www.nibr.novartis.com

University of North Carolina Interdisciplinary Obesity Program www.cpc.unc.edu/idoc

> ZymoGenetics www.zymogenetics.com

ADDITIONAL RESOURCES: Merck/AAAS Undergraduate Science Research Program www.merckaaasusrp.org

must then interact with two or three other faculty—at least one of whom is in a different department," he says. The mentor team must then convince the selection committee that they will collaborate.

As for a defining focus, Wilcox says, "You rally people around a societal problem that transcends a particular discipline." In his case, the theme is understanding how biodiversity relates to human health, specifically with regard to emerging infectious disease. "We try to inculcate in the students that the research they're doing—in minute detail—also needs to be placed in a larger context." For instance, can they scale it up from a coral polyp to a coastal ecosystem, and relate it to the health of society?

Even when the motivation is there, scientists trained in different fields have different cultures, different jargon, and different ways of thinking. One goal of the IGERT program, says NSF's Van Hartesveldt, "is that students learn how to talk, discuss, and approach problems with people from other disciplines."

#### Institutionalized Roadblocks

In addition to disciplinary barriers, there are organizational sticking points that can hinder team research. In a university setting, faculty members face bureaucratic issues concerning money and recognition, says Van Hartesveldt. "When there are multiple authors on a publication or co-principal investigators on a grant, who gets credit? When there is overhead income [for indirect costs], which department gets it?"

The National Institutes of Health (NIH) is promoting interdisciplinary research as part of the NIH Roadmap and has addressed institutional obstacles directly. "Heretofore, if you were a co-principal investigator, it was tantamount to being partially pregnant. It had no meaning," says Lawrence Tabak, who is the director of the National

> Institute of Dental and Craniofacial Research and co-chair of the interdisciplinary research implementation group. "But now NIH has come up with a way of formally recognizing multiple PIs. We think that this is a big deal and will help universities recognize contributions related to team science."

> The more the implementation group tackled institutional barriers, says Tabak, the more they realized that NIH itself had its own impediments. First and foremost was that interdisciplinary research requires interdisciplinary review, he says. "When I've sat on study sections, anything that was interdisciplinary was met with one of two characterizations: overly ambitious or unfocused."

> In order to review proposals and evaluate programs, you have to define your goals, says **Elizabeth Wilder**, another implementation group member who is now acting associate director of NIH's Office of Portfolio Analysis and Strategic Initiatives. "The group spent a fair amount of time establishing the goals, both big and small." Training an interdisciplinary work force and continued »

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"Science is the foundation and the tool, but it is talented people who discover drugs." —John Primeau



making it easier for academic researchers to traverse departmental boundaries are overarching objectives.

Short-term goals are ones that can be measured—like publications. "You've got to do a cluster analysis," says Tabak. "If only biochemists, or only physicists, are citing a paper, maybe it's not truly interdisciplinary. But if you have social scientists citing it along with physicists ... now maybe you've got something cooking."

New ways to measure graduate student training are also needed. In the same way that a discipline-bridging project may get accused of lacking rigor, a lab-hopping graduate student may suffer some dilution of primary training.

**Michael Jensen**, who directs an IGERT on fuel cells at Rensselaer Polytechnic Institute in Troy, New York, admits that the time students need to work with different faculty is debited from any single effort. "But if we're looking at the professional growth of the individuals, then we should be encouraging them to take a broader approach," he says. "I think we turn out a much better prepared student."

Jensen has participated in many interdisciplinary projects over the years. "I know that it's these intersections of fields that can be the most productive areas for advancement," he says. "Even though people pay it lip service by saying that it's a great place to be, it's sometimes a very difficult place to work."

#### **Entrepreneurship and Public Policy**

Jensen's IGERT includes faculty and students from six different academic units, the most unusual of which is management. All the typical careers for Ph.D. scientists—academia, industry, or startup companies—require some aspect of entrepreneurship, says Jensen. "A faculty member has to come with an idea and sell it to get funding. Industry often wants a researcher to be the champion for a technology. And if you're starting you own company, you're definitely an entrepreneur."

With multiple skills, individuals can function as more than cogs in a machine. "Science is the foundation and the tool, but it's talented people who discover drugs," says John Primeau, executive director of infection chemistry at AstraZeneca in Waltham, Massachusetts. "In the past you'd have a smaller number of very smart people calling all the shots and directing the groups," he says. Primeau says his company lets the people with the expertise—the scientists doing the work—influence strategy. By empowering project teams, progress is faster and more efficient "because the people who have seen the data are also the people who are making decisions on the data."

Many proponents believe that interdisciplinary research is a must

to address complex problems in society. At the International Insti-

tute for Applied Systems Analysis (IIASA) in Laxenburg, Austria,

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**Leen Hordijk,** IIASA's director. An international research organization with scientists from 38 different countries, IIASA was founded as an east-west think tank at the height of the Cold War.

It's the societal aspect of research done at the institute that makes it a draw to many researchers, says Hordijk. "People want to contribute to that. It's the excitement of having real influence."

The scientific staff reflects IIASA's broad goals. Forty percent are social scientists, 20 percent are mathematicians, and another 40 percent come from engineering and the natural sciences. "The natural sciences covers a very broad range," says Hordijk, including atmospheric scientists, ecologists, evolutionary scientists, meteorologists, and limnologists, to name a few. "Most of the groups at the institute have a tool in development: a database or a model," says Hordijk. "These common tasks bring different disciplines together on major environmental, social, and energy problems facing our planet—work that is well beyond any one discipline."

#### Keys to Success

To get started, leaders have to get people talking. "You find targets of opportunity and you find ways to help people work together," says UNC's Popkin, who describes a retreat attended by 50 faculty members. "Three days produced a number of projects—people talking at lunches, breaks, and walking. It doesn't happen in any systematic way."

And they have to keep them talking, says AstraZeneca's Primeau. "The whole idea is to share," he says. "We're spread across the globe, so we're trying to put together the infrastructure—in terms of information technology systems—to allow people to share data freely. That's the biggest challenge because we move so much information now."

Institutions must provide "a long-term setting with long-term goals," says IIASA's Hordijk. "In universities, you seldom have enough time to build a relationship," due to short-term funding and staff turnover, both of which can "break a growing collaboration."

As a director of an academic interdisciplinary center, Popkin agrees. "It takes time to truly build teams. Not one or two years, it takes five years—for people to truly start talking to and understanding each other. And for the methods to start melding together—the measurement concerns, the statistical concerns, and the theoretical concerns."

With regard to individual team members, it takes time to internalize unfamiliar perspectives and to get educated beyond one's training. Maybe it just takes time for scientists to move beyond the indoctrination that comes with training in a particular field of study. NIH's Tabak calls it "checking your hat at the door."

To ZymoGenetics' Williams it's the play-well-with-others approach. "It's recognizing that you don't have all of the answers. The interdisciplinary teams that do it well are the ones that have no preconceived notions about where the next great idea is going to come from."

And the learning curve that comes from crossing disciplines can reinvigorate a passion for science.

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