Building Bio-X

By Darwin Cruz and Ben Wang

Interdisciplinary Collaboratories: New Concepts, Old Parts

Rising up out of what was previously a parking lot between the School of Medicine, the Mudd Chemistry building, and the Gates Computer Science building, the construction of the elliptical building continues. The arcing frame of metal and glass is the sleek new skeleton of the soon-to-be James H. Clark Center for Biomedical Engineering and Sciences. The Clark Center's location is ideal to house the headquarters of the Bio-X program, a new concept with nothing new in its components.

The Clark Bio-X Center, Conceptual Model

The program unites faculty from all scientific disciplines - chemistry and physics to medicine and engineering - and puts them under one umbrella. This movement reflects the emergence of a solid interdisciplinary science program here at Stanford. "It is quite clear biologists have limited knowledge of the enormous capabilities in the engineering departments," says Developmental Biology and Genetics professor Matt Scott, director of the Bio-X program. "Conversely, there is limited knowledge in engineering of the mysteries of biology that people want to explore."

The Bio-X concept was forged in 1998 by three Stanford professors: chemical engineer Channing Robertson, biochemist James Spudich, and Nobel Prize winner and physicist Steven Chu. Recognizing the benefits of each other's input into their own research, they came up with the idea of promoting interdisciplinary research and teaching in bioscience, bioengineering and biomedicine. In a June 2000 *Stanford Daily* article, Spudich said, "We called it Bio-X because we never came up with a name that was short enough to describe the global nature of what we want to do here. It's really a philosophy, not a specific program."

The philosophy behind Bio-X is to encourage communication between investigators from different fields, pulling them from their isolated individual departments and into a comprehensive whole. By sharing insights about their respective fields with other scientists and physicians from different areas of expertise, researchers can offer broader perspectives that may ultimately influence the direction taken by their colleagues.

Although the promise of this philosophy is being highly touted and endorsed presently, it is not a new philosophy. Several interdisciplinary collaborations already exist at Stanford, exploring new innovative approaches to studying age-old medical problems. A cooperative team spanning the departments of ophthalmology, chemical engineering, and electrical engineering aim to combat the leading cause of blindness among people over age 65, macular degeneration. Harvey Fishman, Stacey Bent, David Bloom, and Mark Blumenkranz are working together to develop an "artificial synapse chip" with the hopes of bypassing injured retinal cells in the patient's eye.

"What's really interesting in macular degeneration is that the neurons are still intact," Fishman said in a symposium last year. "The neurons are ready to receive the signal; they're just not getting their signal. The biologic 'film' — the photographic film of your eye — is damaged." By adapting techniques developed by the computer chip industry, the goal is to build an artificial nerve connection made from silicon to promote regrowth of the microcircuitry between retinal cells.

Great strides are also being made towards understanding and alleviating the effects of dystonia, a condition characterized by involuntary movements of the limbs. Neurologist Helen Bronte-Stewart along with her colleagues Christoph Bregler and Jean-Claude Latombe of the Computer Science department and biomechanical engineer Eugene Alexander are analyzing 3-D

Project Focus: Cardiovascular Tissue Engineering

Dr. Judith Swain, an Arthur L. Bloomfield professor of Medicine and Bio-X faculty member, is exploring the many possibilities for advancement of cardiovascular medicine. Her primary interest focuses on the prospect of transplanting cardiovascular cells into the heart. "The holy grail right now in cardiovascular science is to get stem cells to differentiate into cardiovascular cells and transplant them," she claims. The need to develop this procedure stems from the current belief that each person is born with his or her entire complement of heart cells. The inability for the heart to regenerate its own cells portends that this invaluable organ will only lose cells over time, and thus, the heart will slowly deteriorate, resulting in common deadly heart diseases.

Professor Swain asserts that growing the cells is only half the battle. Scientists also need to find an effective way to transplant the lab-grown cells into the body, a process known as tissue engineering. Stem cells depend on tissue engineering to be of practical medical use.

In addition to cardiac cell transplantation, Swain is involved in *in vitro* blood vessel regeneration. Blood vessels are crucial components to a functioning cardiovascular system, and oftentimes demand replacement. "Currently we can only replace bad blood vessels in a patient with other blood vessels from [his or her] body," Swain explains. These blood vessels often originate from the legs. Unfortunately, some patients exhibit conditions or diseases that make it impossible for them to donate their own blood vessels to where they need them. Swain wishes to "create an *in vitro* blood vessel that stays open, assemble the blood vessels outside [the body], and then transplant them [into the patient]". Throughout this process tissue engineering expertise is vital.

Dr. Judith Swain

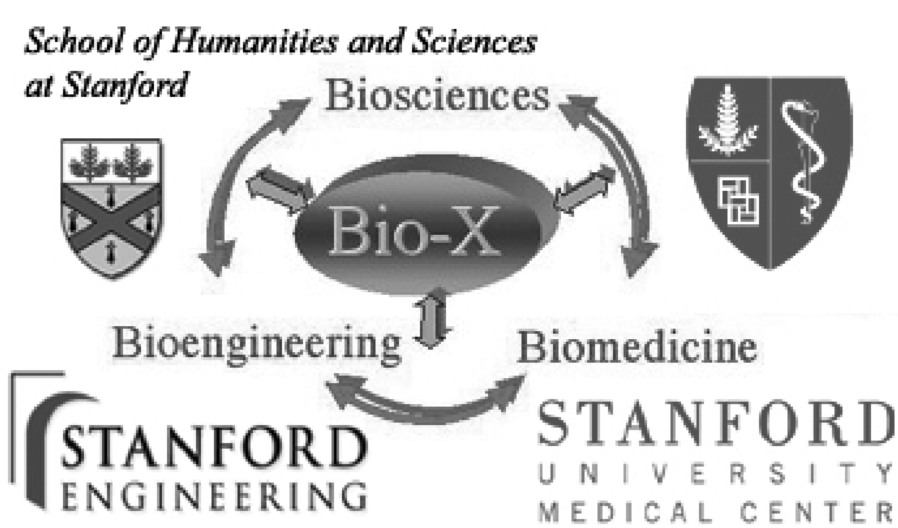
Swain's selection for participation in Bio-X relies on the fact that both sub-areas of her project depend on tissue engineering. Tissue engineering is an integral part of Bioengineering, a new department forming from the merger of transplant surgery and stem cell research. As Swain says, the new technology will be "one of the pillars of Bio-X."

limb movement in dystonia. Their "pacemaker" for the brain provides electrical stimulation to restore normal movement to patients.

The Bio-X program aims to make these collaborations commonplace. The approximately 200 faculty recruited into the program will remain in their respective departments, but will be urged to form research alliances with one another. Spudich says, "It is our belief that the time has come in the history of medical research, engineering, chemistry, physics, and biology. An interdisciplinary approach is needed."

Stanford is not alone in its attempts to form these ties between its departments. University of California-Berkeley, Princeton University, University of Chicago, San Diego's Scripps Institution, Harvard University and the University of Washington all have similar programs under way. California Institute of Technology is also on the verge of announcing the opening of a facility of its own.

Although planning at some of these universities is more extensive, Bio-X backers say Stanford has some advantages that will make its program difficult to surpass. As Judith Swain, a professor at the school of medicine, points out "You are privileged to be at



Stanford where collaboration is actively encouraged," a notion that she affirms is not as openly embraced at other universities where competition squelches the sharing of ideas. In addition, Stanford has top research programs in all the key scientific disciplines, as well as a considerable geographic advantage over two of its toughest competitors, Berkeley and Harvard. Only Campus Drive separates the research labs on Stanford's main campus from those at the Medical Center. In contrast, the San Francisco Bay separates Berkeley from its medical complex, and Harvard Yard is divided from its medical center by the Charles River. The Clark center will be able to serve has a vital physical link to bring together people from all the sciences under one roof.

Designed by MBT Architecture of San Francisco and Foster and Partners of London, the 146,000 square foot Clark Center consists of three pods surrounding a central courtyard. An aluminum canopy at the roof links the three pods to one another. The Clark Center construction will finish by the end of summer, in time to open this coming fall quarter. Once open, forty faculty members from over twenty departments along with their labs will move into the new building.

Funding for the center's construction was provided by Netscape founder Jim Clark's generous $150 million donation in 1999. He later rescinded $60 million of the donation in response to President Bush's conservative stem cell research policy. However, an anonymous donor later matched the $60 million to ensure the project's realization.

There has been much talk about the roots of Bio-X, its current status, and what it will accomplish in the future. Bio-X is not a new field of science; it is rather a way to study science. The program simply intends to break down traditional physical and academic boundaries between the departments. As Swain states, "The interaction itself will breed the next generation of things we can't yet figure out."

Project Focus: Coral Reef CO2

The project outline put forth by professors Jeff Koseff and Robert Dunbar of the departments of Civil and Environmental Engineering and Geological and Environmental Sciences, respectively, elicited excitement from the Bio-X selection committee. Their grant proposes the derivation of an experimental protocol to measure whether carbon dioxide is a net source or sink in a coral reef system. The ultimate goal of the technique is to determine if the health of coral reefs is based on the amount of carbon dioxide absorbed or emitted from the reef system – coral emitting excess carbon dioxide is healthy and growing, while coral absorbing the gas is dying and dissolving. Used on a designated region of the reef, the control volume technique measures the complex flow of various chemicals that enter and leave this area. Identifying specific endangered areas within a coral reef system is the first step towards treatment and restoration.


Professor Jeff Koseff

The carbon dioxide measurement technique has been met with initial success. In January 2002, Koseff and his team traveled to the Gulf of Aqaba in the Red Sea, between Egypt and Saudi Arabia for experimentation on its reef systems. Positive results led to the conclusion that their technique was accurate and held promise for future trials elsewhere. Despite this triumph, the expedition did not live up to its full potential. The original plan was to go in August 2001 with eight Stanford undergraduates accompanying them. Unfortunately, the conflict in the Middle East convinced Stanford Risk Management that having undergraduates on the trip would be too dangerous. Koseff regrets this decisions, as "it would have been an incredible opportunity for undergraduates to get involved in research."


Professor Robert Dunbar

Koseff anticipates future applications of this technique in the kelp forests near Santa Cruz and Santa Barbara. He also has hopes of conducting further studies in Australia, perhaps in conjunction with the Overseas Study Program at the University of Queensland. "If we can get the technique to become portable and easy to deploy, it can be a powerful tool to be used in any geochemical system."