BAY AREA
ECONOMIC
FORUM

*A Partnership of the Association
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THE FORUM REPORTS

A series of discussions on vital issues concerning the Bay Area

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Science, Technology and Innovation:

The Bay Area's Five New Research Centers

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Panel Discussion

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Science, Technology and Innovation:

The Bay Area's Five New Research Centers

Technology is at the heart of the Bay Area's economy, supporting jobs, trade and globally competitive industries. The region's scientific capacity – at its five research universities, five national laboratories, corporate laboratories and non-profit research organizations – is at the foundation of its capacity to innovate. These institutions are magnets for the human capital that supports the world-leading industries that the Bay Area is known for.

The strength and diversity of the region's research sector is critical to the long-term strength of its economy. The Bay Area Science and Innovation Consortium (BASIC), a partnership of the Bay Area's leading research institutions, works to support the region's scientific infrastructure and to facilitate collaboration among its members.

Development is currently underway at five major, new research centers in the Bay Area – centered at Stanford University, University of California San Francisco, University of California Berkeley, NASA Research Park and Lawrence Berkeley National Laboratory – that will expand the region's scientific base and help support its continued technology leadership. All are designed to produce cross-disciplinary research. No region in the United States or globally hosts a scientific community on the scale of the Bay Area, and it is extraordinary for any one region to host the creation of five new research centers simultaneously. Recent Bay Area Economic Forum exchanges with leaders at those centers show why the Bay Area is at the forefront of global technology innovation and how this will profoundly influence our future.

DISCUSSANTS

Regis B. Kelly, Ph.D.
Executive Vice Chancellor, Research
University of California, San Francisco

William Berry
Deputy Director
UC Santa Cruz Silicon Valley Center

Ruzena Bajcsy, Ph.D.
CITRIS Director
University of California, Berkeley

Matthew P. Scott, Ph.D.
Professor, Department of Biology & Genetics
Stanford University School of Medicine

Paul Alivisatos, Ph.D.
Director, the Molecular Foundry
Lawrence Berkeley National Laboratory

INTERVIEWER

Sean Randolph, Ph.D.
President
Bay Area Economic Forum

BAY AREA ECONOMIC FORUM
A Partnership of the Association of Bay Area Governments and the Bay Area Council

BASIC
Bay Area Science and Innovation Consortium

California Institute for Quantitative Biomedical Research (QB3)

Regis Kelly, Ph.D.
Executive Vice Chancellor of Research
University of California, San Francisco

I'll start with QB3's history. This began with a conversation between the Governor and Richard Lerner of the Scripps Institute of Biological Sciences in San Diego about what could be done to stimulate the California economy. Lerner suggested the creation of California Centers of Science and Innovation, and the Governor set up a competition at the University of California for innovative proposals in science. There were going to be three awards, and one of the 3 top ones was the QB3 project, the Institute for Quantitative Biomedical Research. There are three campuses involved: UC San Francisco, UC Berkeley and UC Santa Cruz (that's why it's called QB3). Of the other two, one was in nanotechnology at UCLA and the other was in computer science at UC San Diego. There were so many good proposals that the Governor then decided to give out money for a fourth, UC Berkeley's Center for Information Technology Research in the Interest of Society (CITRIS).

> *"The whole genomic era comes out of computational biology."*

We received $100 million from the State for capital expenses—for building. Currently there's no program money; we are in the process of constructing the buildings, and we're looking around for the program money to run it. There was a capital match from other sources including the private sector.

The obvious question is why was the State so interested in putting money into computational biology? There are two major reasons. Thinking about the science first, the growth of biological computation is remarkably fast now. I've seen data that show the demand for biological computation power increasing faster than Moore's Law, which means that if things keep on in the same way, the rate at which biology advances will be limited by the rate by which computers can grow.

There's a vast amount of data being generated in all sorts of ways and one of the problems and reasons for QB3 is that conventional biologists come from the chemical and biochemical fields, and that's how most people do molecular biology. But we don't have graduate students who are trained in the combination of molecular technology and computational biology. So we had to devise a new graduate program. This is one of the things that QB3 will be creating—graduate students trained for this new era. What sorts of things can you see coming out of this? The whole genomic era comes out of computational biology. It requires both fast sequencing machines and computational capacity. And it's not just computational power, it's storage as well. In fact, the NIH map was done by one of the people from QB3.

There's a vast amount of data you can get very, very quickly. What use is that? Well, the use only comes if you know what proteins come out of this gene. The DNA by itself doesn't tell you anything if you don't know what the proteins do. One of the things people are using computers for is this protein-folding problem. There are a couple of reasons why this is exciting to scientists. One is that this is a basis for biological nanotechnology. For example if you want to have a biosensor that recognizes anthrax and gives an electrical signal, you can do it very easily by designing a protein to recognize anthrax and devising a channel which opens up and lets current flow. You can make biosensors or you can make biomotors; you can make all sorts of machines and devices relatively easily and actually very inexpensively, because these things are grown in bacteria so you can get kilograms of machines for dollars. It's much, much cheaper than anything physics is ever going to deliver. So, there is a whole potential industry using biological machines once we learn how to fold proteins correctly and predict how they fold.

> *"You can make biosensors or you can make biomotors; you can make all sorts of machines and devices relatively easily and actually very inexpensively, because these things are grown in bacteria so you can get kilograms of machines for dollars."*

There's something else coming out of the genomic process: a whole era of new biomaterials. Things like shell. Shell is a very useful material that doesn't dissolve in water, doesn't go rusty, and so on. If we knew what proteins were used in making shell—the kind mollusks have—then we might have the capacity to design a whole new type of biomaterial: cups, saucers, anything you want made out of something which is completely natural. And the appeal of that is you can have a technology, which is based on renewable resources, that is non-degrading to the environment, and cheap once you know how to do that. All of this requires a vast amount of genomic power.

The third thing I wanted to mention is not so much knowing what genes you have, but how you use them. We have almost the same genes as a monkey; but if you look at what genes you're actually using, there's a huge difference between what they call the protein expression profiles—which genes are turned on in you, and which genes are turned on in the monkey. They are very, very different and easy to recognize. And similarly, although every cell in your body has the same DNA, the protein profiles are entirely different and you can recognize which proteins are made by looking at the RNA on one of these DNA chips. This is one of the most powerful new technologies that's come along and has been developed here by Joseph DeRisi. The key thing that he has been doing is trying to make these chips, which we can now do for just $2.00. They're sold for a thousand on the market, and he's trying to make the technology freely available so that everybody can use it.

"You can now subdivide types of breast cancer depending on which proteins are being expressed. One can see this leading to a very credible diagnostic procedure."

Currently, it's being used in its early stages in breast cancer—to decide what type you've got—so you can optimize the technologies for your therapy. You can now subdivide types of breast cancer depending on which proteins are being expressed. One can see this leading to a very credible diagnostic procedure. Perhaps you would go once a year and have your proteins checked, and your doctor would be able to say to you, "You are in 5 years time going to get such and such disease, or you've got prostate cancer disease coming on and you'll get it in 2 years, and we can start treating you now in a way which is very inexpensive."
So to jump where this computational biology is so important, a whole new biomaterials technology is possible and this allows us to go to the ultimate phase in medicine, which is pre-symptomatic diagnosis, where you're seeing people before they're getting sick.

In diagnosis you can do two things: one, you look at their genes to see predispositions towards disease. Much cheaper and more predictable would be to look at DNA chips and the protein expressions and that would allow you to detect diseases before you have them. By treating people before they're sick, you're moving to the presymptomatic curing of disease, instead of the current model which is to wait until you are half-dead, drag yourself to the doctor because you can't deny it anymore, and by that time the disease is so far progressed, heroic methods would have to be used to try and cure you. So the current mechanism of alleviating symptoms will be changed by this new change in quantitative biology into an era of pre-symptomatic diagnosis and cure.

Question

You say there are 3 campuses involved in QB3. How do they relate together?

Kelly

Actually, that's been very exciting. Before QB3, we didn't relate to each other at all. The University of California's campuses are very autonomous. But this situation, which required us to relate in order to get the $100 million, facilitates interaction. So we (the quantitative biologists from the 3 campuses) are now meeting and it's been exciting in many ways. We all know the science on our own campus very well; however, we don't know as intimately the science on the other campuses. When we got together we were really excited to learn what was going on at the other campuses, and not just what's been published but what's being planned in their labs and to see ways in which we could work together.

We're also hoping to set up summer courses using faculty from all 3 campuses and are exploring ways to get courses taught on all 3 campuses with the lecture part by video conference, and then the discussion sections and exams to be given locally. There's going to be more of this multi-site approach to big science as biology gets more like high-energy physics.

BAY AREA ECONOMIC FORUM

Question

Is QB3 focused entirely on teaching or is there also a research component?

Kelly

There is a basic research component and it's designed on 3 elements: genomics, proteomics, and imaging. We are trying to push the limits of what they call four-dimensional imaging, looking at three-dimensional data sets as a function of time, all the way from an individual cell up to the whole human body. So, research is QB3's primary mission; teaching is an auxiliary support segment. There will be a QB3 Building. It's going to be in Mission Bay adjacent to Genentech Hall because we wanted to get good connections between basic molecular science and quantitative biology. $55 million from the State's $100 million is going into that, $30 or $40 million is going to Stanley Hall in Berkeley, which is going to be a Center of Quantitative Biology, and the remainder is going to Santa Cruz for modifying one of its buildings for quantum biology.

> *"by treating people before they're sick, you're moving to solid medicine, which is pre-symptomatic curing of disease, instead of the current model which is to wait until you are half-dead, drag yourself to the doctor because you can't deny it anymore, and by that time the disease is so far progressed, heroic methods would have to be used to try and cure you."*

Question

Looking ahead, are there particular issues or obstacles you have to get past to make this hit its full potential?

Kelly

Yes, but let be backtrack a little bit before coming into this. Biomedical research is changing very rapidly, and it's changing because of the way medicine is paid for, the constraints on Medicare, MediCal, managed healthcare, and the demands put on physicians. Medical schools in the past had two elements, basic research and clinical research, and then translational research joined these two. The translational research was often funded by clinical income, and clinical income in all the academic health centers is dropping. Most academic health centers in the country are in financial difficulties because there's no fat anymore in the system. So where does the translational research come from? A lot of it is being moved to the biotech companies. Some terrifically good medical research is taking place at biotech companies—all focused and very good.

So the nature of biomedical research has changed. One has to have the basic research, as well as the translational component, which is often in the biotech community or big pharma companies. They develop the drugs, which comes back into the clinical community to be tested on patients, which is again done in a university setting or an academic health center setting. So, it would be ideal if we had biotech companies and big pharma companies adjacent to our hospitals and our universities. What has been a little disappointing so far is that we have not yet identified companies that will be next door to us here. But since the QB3 Building won't be up until 2005, this leaves 2 years to identify such people and get them to move in.

Question

Are there particular reasons why it's coming slowly?

Kelly

You could say San Francisco, for example, is a difficult City to be in, but so is Cambridge, Massachusetts, and building around Kendall Square is going up like crazy. You could say it's the cost of San Francisco but I think the rents—and they are changing—in Kendall Square are higher than what we charge in San Francisco. We could say this is a flat economy and people aren't moving, and that's true of biotech, but it doesn't seem to be true of the pharma companies. Companies are actually moving into the Boston area even though the rents are expensive. So, one of the problems may be (and we have to look at ourselves very closely) that perhaps we're just sitting, waiting on people to come. Perhaps we should be taking a more active role and going out and pointing out the advantages of companies locating in the Bay Area, which is a tremendously rich center of all sorts of biological sciences and particularly now quantitative biology.

> *"There's going to be more of this multi-site approach to big, big science as biology gets more like high energy physics. It's going to be multi-site, multi-campus consortia doing these things"*

Question

If you would clarify the relationship of the pharma companies to the biotech companies, does that involve joint research at the basic research level? Where does the connection first take place between biotech companies and the university?

Kelly

Two ways. We spin off about 4 companies a year from UCSF. That's a direct way in which one produces companies. Another more common way is that our technologies are licensed to biotechnology companies. We generate about 50 patent-able items a year and we rarely patent them unless we know someone is interested in licensing them. So our licenses go out to the local community as we generate intellectual property, which is value to biotech companies in the area. Of course, the major way that we help the biotech companies in this area is that we produce very well-trained graduate students and post-grads, as do Berkeley, Stanford and UC Santa Cruz. So we're populating all the biotech companies with people from our universities, which makes it easy to set up liaisons and consortiums.

> *"We're now involved with $800 million worth of building at Mission Bay. We've gone from a university which hadn't done any expansion in 10 or 15 years, to growing like a mushroom."*

There are also sponsored research agreements between the companies and the universities. But actually, the amount of money that comes into UCSF for sponsored research agreement is something like a fifth of what comes in from government grants, so it's a fairly small source of income.

Question

As a final question, can you say something about Mission Bay, since the QB3 facility is going to be located there?

Kelly

We're now involved with $800 million worth of building at Mission Bay. We've gone from a university, which hadn't done any expansion in 10 or 15 years, to growing like a mushroom. What we haven't spent too much time doing is thinking about what we're going to do after Phase I is completed. Phase I will have four different research labs, but there are nine other buildings on our master plan, which are laboratories that we're just beginning to think about. Currently, every proposal that comes to me is along the lines of having buildings that link basic research directly with clinical research, because you want to have a building where the basic scientist is next door to a translational scientist, next door to clinicians. We're really trying through our architecture to construct buildings that merge basic research, clinical research and clinical care all in one place.

NASA Research Park

Mr. William Berry

Deputy Director
University of California Santa Cruz, Silicon Valley Center

Going back to 1994, Moffett Field was identified in the Base Realignment and Closure process as a base that was no longer required for military use, and it was decided that the Field's future would best be dealt with if it were transferred from the Navy to NASA Ames. Congressman Norman Mineta was very instrumental in seeing that the transfer occurred, and the lands of Moffett Field, roughly about 1500 acres, were added to the 500 acres of the NASA Ames Research Center. Along with the 1500 acres came two runways and a superfund site. Hanger One is a seven or eight acre hanger space that was used in the 1930's for a dirigible that crashed off Big Sur, and now is in the process, as part of the development of NASA Research Park, to be turned into the California Air & Space Center.

> *"we're populating all the biotech companies with people from our universities, which makes it easy to set up liaisons and consortiums."*

NASA looked at many potential uses for the land and considered expansion of the runways for military purposes or for bringing in a commercial air cargo. None of these plans were particularly fruitful. The cities that surrounded the airfield here were adamantly against commercial air cargo. They were satisfied with a low-use federal airfield and did not want to see its expansion.

So in 1997, NASA took a fresh look at what it was going to do with Moffett Field. During that year some preliminary studies were undertaken and it was found that the value of the land that Moffett Field sat on, even with the fact that it was a Superfund site, was high. There was no contiguous property of that scale anywhere on the Highway 101 corridor between San Francisco and San Jose, and there was a tremendous opportunity here if we redirected the use of at least a significant portion of the land to activities that supported the strategic vision of the Ames Research Center and supported the needs of the communities around us.

In 1998 agreements were entered into with the University of California and Stanford. The initial agreements with Stanford and UC were to look at how the land could be used to develop campus-like activities focusing on research. NASA concluded that it could use the federal land for research activities as long as the research mission of NASA was recognized in its use.

NASA has broad authority under what's called the Space Act (enabling legislation that set up NASA) that allows it to enter into any type of agreement that furthers the mission of the Agency, whether it be contractual or simply what are called Space Act Agreements. So it was concluded that NASA had an opportunity to reinvent and reorient the mission of NASA Ames. In parallel with the studies of real estate, Ames' mission was changing. Ames originally had been very much a traditional aeronautics research center, looking at flight control, fluid dynamics and testing of large aerospace vehicles in its wind tunnels; but the reality of the world was that with the end of the cold war and the decline in military budgets to develop new advanced aircraft, and with the commercial market being somewhat stagnant, the need for those wind tunnels and the work that had been done for traditional aerodynamics was going to go away.

However, the Center was located in the heart of Silicon Valley and there was obviously an opportunity to redirect its activities to be more in line with both the Agency's future needs and the capability of the Valley in information technology. Looming on the horizon was not only biotechnology but also a budding field called nanotechnology. So in about that same period of 1997 – 98, the Center was redirected towards IT, biotechnology, and nanotechnology. From that point it was an easy decision to say, "let's leverage this valuable land at Moffett Field, and use it to accelerate the changes in the research program at Ames by bringing in partners that could help to not only develop the land but provide new ways for the Center to do research.

Stanford was very interested for about a year, and then made the strategic decision that they were going to focus on their own activities on campus and did not want to pursue what was at one time referred to internally as Stanford Research Park South at Moffett Field. UC became more interested in the project and decided it would look at a larger role in the NASA Research Park. Then out of the blue came another organization, Carnegie Mellon University. For their own set of strategic reasons they wanted to branch out from their Pittsburgh (Pennsylvania) campus. They had been basically exporting education, as some of their best alumni and best graduates were leaving the Pittsburgh area and coming to California for careers. They had a very strong alumni base in Northern California, so this was probably the right place for them to develop a campus. This was further accelerated by the fact that NASA Ames and Carnegie Mellon had a long history in doing collaborations in IT and robotics. NASA has a very strong interest in robotics for exploration of planetary surfaces, where it is difficult for humans to do these missions.

Carnegie Mellon has just opened a beachhead office in the historic district that was left behind by the Navy. They've signed an office space-use agreement with NASA to allow them to begin to renovate some of the old buildings on the military quadrangle as their initial campus.

The University of California was anticipating substantial growth in its enrollments and there was no UC campus in Silicon Valley. The closest campus is at Santa Cruz. UC Santa Cruz was interested in expanding their engineering and science and technology programs, so their Chancellor, M.R.C. Greenwood, saw this as an ideal opportunity to achieve alignment between her organization and NASA by building a campus in Silicon Valley. It turns out that many of the campuses of UC are captives as to how many students they can support. So this is an opportunity to grow a new capability in the heart of Silicon Valley. Also, just like Carnegie Mellon, UCSC has strategic alignments with NASA Ames, particularly in biosciences and astronomy.

The staffs of the schools and NASA Ames have worked together in several areas, with the further connection of UCSC having a mandate from the UC system to develop a new engineering school. If you're developing a new engineering school today, you don't look at the traditional mechanical engineering or chemical engineering skills that were offered in the past; the emphasis will be on IT, biotechnology, bioengineering and the emerging field of nanotechnology. So today, Ames is putting its emphasis on those three areas, and the UCSC engineering school is emphasizing exactly the same areas.

Since both Carnegie Mellon and UC were interested in being here, NASA made the decision to give temporary quarters to both universities. Today UCSC has a skeleton staff and we're in the process of identifying seven research teams. Their objective will be to build collaborations with NASA and surrounding Silicon Valley.

Getting back to the broader picture, what UC is looking at in the next 10 years is the potential for 2,000 students to be in education programs, either upper divisional or graduate education, located on the campus that we would build in the NASA Research Park. Most important, from the perspective of UCSC as a research campus, is to build a research relationship with NASA. Building that research collaboration is one of the highest priorities today. We are in the process of establishing a University Affiliated Research Center (UARC) that over the next five years will begin to work more closely with NASA, and will be aligned with the research interests the University of California. We're optimistic that the two organizations will be able to align themselves, and that there will be a collaboration funded in part with NASA research money, but with the support of not only UCSC but the entire UC system, to support the research needs of Ames. This is really a realignment of the interests of NASA and the University of California and the ways they do business to further collaborative relationships.

In addition, San Jose State, Foothill DeAnza Community College District and UCSC have formed an educational collaborative that is led right now by San Jose State University and supported by the other two organizations. We see them becoming an important feeder for programs that UCSC will establish here. So this completes the alignment in the Research Park: the junior colleges, SJSU and UC, each with their own capabilities of either education or research, each aligned to the strategic interest of NASA Ames. All in the Park will be enabled by the federal interest in research and the fact that NASA Research Park provides 200 acres with between three and a half and four and a half million developable square feet of new educational research facilities. The difference in the numbers depends on how much of the old facilities you tear down and replace with new ones.

> *"if you're developing a new engineering school today, you don't look at the traditional mechanical engineering or chemical engineering skills that were offered in the past; the emphasis will be on IT, biotechnology, bioengineering and the emerging field of nanotechnology."*

As I mentioned earlier, there's also a plan for the reuse of Hanger One, and it's about to get an infusion of Federal funding to deal with some of the environmental issues, which will make it a much more inhabitable space for large scale events. It does some of that today, but on a limited basis. The Federal investment will go a long way in helping improve the California Aeronautics and Space Center, which will take over Hanger One as a 501(c) 3 is established. It's gotten the interest of Valley businessmen, as well as the, first woman in space, and James Cameron, the 'Titanic' movie director, who are very interested in how we can better use that facility to not only serve the needs of the community, but to provide a venue for science and technology for the general public. The next step will be to raise funding beyond the environmental work, and do a thorough renovation of the hanger. Remembering that the insides cover about 800,000 square feet in surface, it's the largest potential venue probably anywhere in the country, let alone, Northern California. And it is uniquely situated right off of Highway 101. In the longer-term, the vision is that it becomes a site where the educational programs of San Jose State University, Foothill DeAnza and UCSC can come together. And in some visions, when the space shuttles are retired from flight, it would be an ideal place to show one of them off. That's a centerpiece we could build, but it's going to take some time.

Question

When you look at the kinds of research that will be done here at NASA Research Park, how do you see that translating into the economy? What kinds of products, technologies, or applications would be coming out of this facility?

Berry

One of the reasons that NASA wants to bring in universities and non-profits is because NASA does not do as good a job spinning off the products of its research into the commercial sector as it could. Of the organizations that NASA deals with, it more effectively works with universities and small non-profits than industrial organizations. NASA being part of the large Federal bureaucracy, there are hindrances in transferring technologies. There's a recognition that that needs to change, particularly since the mission of NASA Ames is going to focus on the fusion of biotechnology, IT and nanotechnology

So, one of the things that NASA sees is a role for the universities to help improve technology transfer from its labs and its investments, because universities are more adept in bridging the gap between basic research and its applications in commercial products. UCSF is extremely successful because it has been able to bridge the gap in biotechnology and medical technology between its research activity and what industry needs. UCSC sees a similar opportunity for itself in the fusion of IT, biotechnology and nanotechnology.

So what sort of products will come from this? I don't know what they will be, but I can tell you what NASA is interested in doing. What you ultimately want for robotic exploration of space is a device that can operate with almost complete autonomy once it's launched from earth, and if it gets into trouble in space can use that autonomous knowledge to adapt to a strange environment if it's damaged. And you want it to be very small. With the fusion of IT, biotechnology and nanotechnology, your robotic explorer can operate autonomously with a computer chip-based intelligence. On the surface of Mars, for example, it could conclude, "I have a pre-programmable route as I look around Mars, but there's a much more interesting green slime on the rock over there, which wasn't in my pre-programmable base. Maybe I'd better find out what that green slime is." Or, if it happens to stumble and break one of its legs, it has the ability to reconstitute that leg. There is always a large penalty for hauling things into space, so obviously, the smaller you can make them, the more things you can do. Thus, the drive for nanotechnology. So one goal is to conceive a device that in twenty years could operate autonomously at nanoscale and have the properties of biological systems.

Question

What are the hurdles of getting from here to there?

Berry

The remaining large hurdle is the real estate market in the Santa Clara Valley. One of the fundamental underpinnings of the NASA Research Park is that it's in a very desirable location and land is very valuable, but it was left with an infrastructure dating from the '40s, '50s, '60s and '70s. It's anywhere from 40 to 60 years old, and much of it needs to be replaced. In a real estate market where values are increasing and there's a high demand, you can easily drive the redevelopment of the Research Park. If there's no commercial demand for R&D space, which is the case today, then this project is going to lay quiet for quite a while, until the real estate market changes – it's really that simple.

The University of California, as it's driven by the need to increase its enrollment, and as its research programs grow, can go forward independent of that, but it will be paced to the market demand for its products, which are education and research. The development of the broader infrastructure is going to be driven by the state of Silicon Valley's economy, and the demand for R&D real estate.

Because the Research Park was designed to provide housing for close to two-thirds of all the workers and students that will be here, the plan calls for construction of housing, which is unlike any other development in the Bay Area. It's got a reasonable balance between housing and jobs. On that basis, we don't see it driving the infrastructure of the Cities of Mountain View and Sunnyvale. There will be some impact on the cities but it's something they are very willing to deal with to have a Research Park here.

> ***"There is always a large penalty for hauling things into space, so obviously, the smaller you can make them, the more things you can do. Thus, the drive for nanotechnology."***

The real issues here are aging electrical, sewer, storm drain systems and similar infrastructure that will have to be replaced. Some people estimate that to build it from scratch you would be looking at an investment of $100 million dollars. That's not a large number for what a developer would spend to develop a 200-acre facility. However, when there's no demand for that real estate, as happens to be the case today, and when there's a 25% vacancy rate in some cities for commercial real estate, that is going to be a ways off.

Question

Is the idea that private companies would actually locate here as well?

Berry

Basically, they would pay NASA to be here. The government owns the land, and the fees would be used to capitalize the infrastructure costs. This would be a community, with established standards for being part of the community. The standards are fairly simple: whatever you're doing here has to relate to the mission of NASA, has to fit existing law, and has to pass a perceptual test of the people outside that this is not a land giveaway. And the way you do that is to invite companies and organizations that make investments in research, that want to participate as members of the NASA community, and that pay the cost of building the infrastructure. And that's a reasonable thing to do. At one point, the land values here were probably $4 million an acre; that's for prime real estate on 101 two years ago. No one today knows what land valuations are because there's been so few land exchanges since the bubble burst. At $4 million an acre, it's easy to see the investment that the development incurs.

Question

Is there anything else in the country that you're aware of that's comparable in its context or direction?

Berry

The model Ames has established here is being adopted in part at other NASA Centers—all the NASA Centers are located not far from urban areas and they all have fairly large pieces of real estate and are all looking at ways to leverage their strategic locations.

Center for Information Technology Research in the Interest of Society (CITRIS)

Dr. Ruzena Bajcsy
CITRIS Director
University of California, Berkeley

CITRIS was created by the State, (when there used to be a surplus) to invest in biotechnology, information technology and nanotechnology. The Governor called for proposals from University of California campuses, and CITRIS is one of the four institutions that are the result.

One condition was that for every state dollar, the faculty raises between $1 and $2 in external funds from industry. The Berkeley CITRIS campus is a Northern California consortium between UC Davis, UC Santa Cruz, UC San Francisco and UC Berkeley. The idea was from the beginning that State money could be used only for construction, but external money would be used for supporting research activity.

> *"The objective of CITRIS is extremely noble and important for the economy. If we really want to energize customers we have to give them something new because the current applications have exhausted the number of customers."*

The goals are noble, with information technology at the core. The first question for CITRIS was how does IT apply to large-scale societal problems. Two things were identified in the original proposal. One was applications in energy conservation, environmental monitoring and education, transportation, disaster management (both man-made and natural), and health monitoring. The second technological push comes from electrical and computer sciences.

Question

So is the idea that CITRIS would be researching the impacts of IT on society, or will it actually be involved in the creation of the technology, or both?

Bajcsy

Absolutely both. The engineering faculty is developing this technology independent of CITRIS. And this is in some ways the hard job for CITRIS as an organization, because typically, the reward system in academia is for individual achievements. One or two professors and graduate students—that's the model.

This involves new interdisciplinary measures. It's calling for a different way of conducting research. CITRIS really tries to address the large scale, what they call societal scale, to ask how these individual technologies interact.

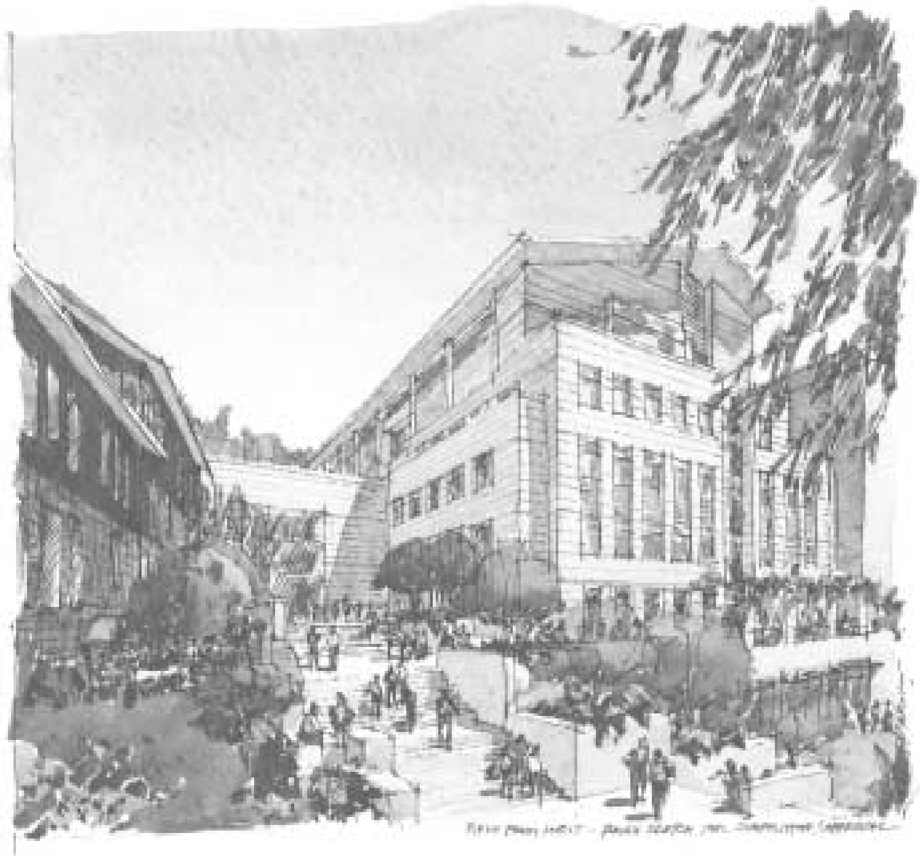
We are trying to set up these test beds using technology, but with full consideration of how this will interface with people. We also work with social scientists who are interested in what the impact is on people. So last year, from our small discretionary funds, we supported six or seven Masters and Ph.D. students in social science, economics, and political science, and business people who are non-engineers.
Now we are building a test bed with energy applications, for example, using 300 MOTES (small integrated systems of sensor computers and radio), and distributing them in every hall corridor (15 on each floor) on six floors of a building. We connected them to a network to monitor temperature and occupancy, and this information will be put on a secure website where people can analyze it and eventually use it as a feedback system for controlling air

conditioning and heat consumption.

Activity is underway in many areas, some with more intensity than others, depending on the funding. Energy and education are the most advanced. We are beginning a strong effort in disaster management. There's a professor in civil engineering who has tried these MOTES for earthquake monitoring. In transportation, we have a separate institute, which monitors congestion. And in education, we have a considerable effort using IT understanding for different subjects.

Question

If you look forward, what kind of challenges do you see for CITRIS to meet its full potential?



Bajcsy

Funding. The construction of the building is going full-speed. Where I feel we don't have enough funding is in providing serious investment for collaborative projects, computing, storage, networking and facilitating, and video conferencing. That is state funding, private funding, and Federal. Also, if CITRIS is to make the impact that was promised in the proposal, you have to change this academic culture, which is based in individual achievements.

Question

And there is no state budget for operations? It has to come from the private sector?

Bajcsy

That's correct. I'm really concerned that we will lose momentum, and that would be a very big mistake. The objective of CITRIS is noble and important for the economy. If we really want to energize customers we have to give them something new, because the current applications have exhausted the number of customers. People don't want to replace an old PC with a new one. It serves existing applications, but if you give them other possibilities, people will realize they need more processing power, more memory. All that technology is CITRIS' agenda.

Question

So CITRIS is breaking new ground?

Bajcsy

Absolutely, it's breaking new ground! And again, I don't expect the entire faculty to be jumping on the bandwagon. I do hope that if we have funding there will be a sufficient number that we can show that this can work. I'll give you one example. The high-energy physics community got together not because they loved each other, but because the science predicated such expensive facilities that they realized no individual could afford it. I think the scale of problems is also changing the engineering community. The computer science community will have to come to the same realization.

In high-energy physics, the driver was the science; they wanted to understand what particles are out there. For engineers and computer scientists, it's science, but also the business opportunities that this new approach will create. If you can say to a businessman that if I spread these sensors in my house they will work 24 hours a day, 7 days a week, without batteries, and if I push a button I can get a reading about how much energy I'm using and how much it will cost me, and because of that I can control my expenses, that's a business opportunity. Think of how many people would buy that. Another example. Today people are sending jpeg images to families back and forth. If videoconferencing would be easy, I'll bet you that 15 or 20% of the population would have much bigger Thanksgiving dinners, because all the extended family who couldn't come to the dinner would be on that screen. Those are also business opportunities.

Bio-X

Dr. Matthew P. Scott

Professor of Developmental Biology and Genetics, Stanford University and Investigator,
Howard Hughes Medical Institute

Bio-X really began with a collaboration between Steve Chu, who is a Nobel Prize winning Physicist, and Jim Spudich, who is a renowned molecular biologist. Jim was studying proteins that act like little motors, the sorts of proteins that make our muscles work, and Steve was developing new methods for manipulating molecules. They found out that by working together they could do types of manipulation of individual proteins that had never been possible before. Out of the recognition of the usefulness of that kind of collaboration, Jim, Steve and later others joined to push the idea that there are tremendous opportunities in bringing together physics, chemistry, and various types of engineering, including computer science, with biology and medicine.

There are many examples at Stanford and elsewhere, where such collaboration has been very fruitful. The invention of the cell sorter was a nice example of collaboration between engineers and immunologists. In general, what happens is that the biologists have only a limited understanding of the new tools and new ideas coming out of engineering, physics, and in some cases, chemistry, whereas the engineers often have only partial knowledge of what is happening in biology that might be approached using methods they are developing.

The goal of the Bio-X program is to bring these people together much more effectively and more often to work together on multi-disciplinary teams, and to provide students with new educational opportunities so that they are prepared in multiple fields: perhaps computer science and cell biology for example, or genetics and engineering. At its heart, this is an educational program, but it's educating not only students but also the faculty in fields in which they don't normally work. To do that, we are bringing together a community of something in the order of 50 faculty labs, who are doing work in this interface between biology and the other disciplines.

> *"What happens is that the biologists have only a limited understanding of the new tools and new ideas coming out of engineering, physics, and in some cases, chemistry, whereas the engineers often have only partial knowledge of what is happening in biology that might be approached using methods they are developing. The goal of the Bio-X program is to bring these people together."*

A new building, the Clark Center, will be a focal point for the program. The building will hold only 40 of those faculty, but will also have shared spaces where people can do projects that involve people from industry or people from other labs around campus, or other labs from other universities. And we have a grants program that provides internal seed money to stimulate new teams to form up. Basically, by dangling the bait of grants we can encourage people to think about new projects they might not have done otherwise. That's happening a lot already and will happen even more in the future.

Some of the grant funds have been donated and others are internal University funds. The hope is that more will come from donations. We're very dependent on that, and I think that from the standpoint of potential donors those grant programs are an especially exciting opportunity. The reason is that in most cases when you give money, you give money for instruments, or facilities and buildings, which is very exciting but it doesn't really change much. The nice thing about this is that if you give money it's constantly refreshed, whenever projects and new ideas and new young people come in. So, it's a living gift in a way that some others are not. I'm very excited about the prospects for this.

Question

And the design of the building itself is set up to facilitate that kind of interdisciplinary team building and project integration?

Scott

Yes, that's important to talk about. Sir Norman Foster, the famous British architect who designed this building, was highly aware of the programmatic goals of Bio-X from the beginning. The building has been designed masterfully to help reach those goals. The laboratories are large open laboratories with enormous flexibility in their designs, so all of the benches and desks are on wheels; we can move everything around and rearrange the labs as necessary to make room for new projects and new types of instruments. The laboratories are designed so that we can intermingle lab groups, and people get to know each other across disciplines much more. There are bridges and balconies that allow people to quickly get back and forth between their labs and other labs. No one in the building is far from anyone else.

There are many shared facilities in the building: small animal imaging facilities, microscope facilities, two super computers and all sorts of fantastic resources for the whole Stanford community, and of course, their collaborators from elsewhere. In addition, the building has a large coffee bar and restaurant, and all of these facilities are designed to lure people in, so that they will circulate and get to know each other and start projects together.

Question

Are there any major hurdles or issues that Bio-X faces as you look forward to finishing the development, or once it's up and running? In other words, you're building a building; you're building a concept. What else do you need, if anything, to make this come together and work?

Scott

The most important way to make this work is having students and post-doctoral fellows come together and talk beyond the superficial level about what they do, and to have that communication occurring with great clarity, so that people can really understand the needs, interests and goals of other people and start to work together. So you need a lot of contact between groups that are presently scattered about the campus all doing very interesting work, but not communicating much with each other. The hardest thing, because people are so busy, is to get them together to have a substantial conversation. I think the way to do that is to make it irresistible to spend time together with various sorts of opportunities, at symposiums, at laboratory group meetings, in the process of teaching courses, eating—we'll put bait out in the form of food—and bring people in that way. There's also web-based communication so that people can easily find out what other people are doing, which has not been done here as well as it could be. And also, seed grants.

There's also hotel space in the Clark Center, which will help with transient occupancy, where people can come in and do a project for a while, in cycles, and then somebody else has a turn. But I think the social experiment side of this is in fact the hardest part. Stanford is a great place to do it because everyone is on one campus. All the different schools, all the different areas of science and technology and medicine, are near each other. So when there is an opportunity to invent a new type of medical device, or to develop new software for diagnostics and medicine, both the doctors and computer scientist and engineers will be here. There's a chance to develop a new type of material science for example, based on biological molecules. We'll have both experts in protein structure and folding, and engineers who can think about how to apply those materials to important problems, all in one place. We have a huge advantage, I think, over the model where medical schools, undergraduate schools, and graduate schools are separated onto different campuses.

Question

It's interesting, talking with CITRIS and QB3, that everybody seems to have the same idea of creating a medium where you have structured interdisciplinary cooperation. I also have the impression from talking with CITRIS, that it is funding to some degree that brings people together, and it's a cultural hurdle that everybody has to get over for people to get out of their departments and discreet projects, and actually work together across disciplines.

Scott

The most expensive kinds of things that people often need for their research, large instruments, synchrotrons, things like this, are not the kind of things that Bio-X, at least, is likely to be providing. What's needed now are much smaller amounts of money for promoting these programmatic links between people. And as I said, I think those are some of the biggest bang-for-the-buck kinds of donations or partnerships with industrial affiliates, because for a relatively small amount of money you can have a huge impact on what kind of research gets done. I've experienced this myself working with engineers. I'm in developmental genetics. People in engineering are excited about biology and medicine and things we care about, and we're having so much fun seeing the amazing things that they can do. This is not something that takes an enormous sum of money to initiate, and if it works, as it often does, it starts to produce valuable findings and then usually it's possible to attract external funding to keep it going.

> *"we are bringing together a community of something in the order of 50 faculty labs, who are doing work in this interface between biology and the other disciplines."*

Now there are some facilities that we absolutely do need; there are some people with computationally intense problems, and we've already been getting substantial support in computers. The other expensive area is microscopes, so there's certainly some instrumentation needs. But I think the absolutely critical thing is money to provide incentives for people to do new projects and new lines of work. We're not talking about huge sums, and moreover, I think they're kind of loss leaders in the sense that when these things take off, they generate so much in the way of intellectual property and opportunities to spin off companies. Looking at it from the standpoint of the Bay Area, this is a bargain.

Question

What is the framework for interaction with industry? I gather you have a structured program that provides for joint research and research funding by the private sector. How does that work?

Scott

This is a very young program; we're thinking of several kinds of initiatives. There are a few specific research initiatives that we would like to do in partnership with certain companies that have appropriate expertise. We're in the process now of building an industrial affiliates program so that we can involve a fair amount of contact between companies and people in the Bio-X program. The contact medium could be small group meetings, it could be symposia, or it could be someone from a company working at Stanford for some period of time in one of the laboratories on some specific project. All of those models are possible; it's quite flexible.

Question

You mentioned commercialization and spin-offs. Given Bio-X's focus, what kind of impacts do you expect to see in how the research here eventually shows up in the economy, in healthcare or in technology?

Scott

We haven't talked too much about the specific areas of science that are now strong in Bio-X. Areas that at present are particularly strong here are chemical biology, regenerative medicine, neuroscience, imaging of various kinds, biophysics, computational science, and bioinformatics. We have started a new Department of Bioengineering. Biomechanical simulation and other areas of modeling using computational science, for example to look at movements of muscles and body parts, is very important for designing better therapies for people who have difficulties in moving normally for either genetic or environmental reasons. Modeling the cardiovascular system is critical to understanding better how blood flow happens, and how plaque accumulates at certain points in your cardiovascular system, and what it means to you in terms of medical problems. Our Biodesign group is expert at inventing medical and other devices. And then, there are a lot of areas that are just starting out that are less heavily represented in the program, but will be very exciting in the future.

So, in all of these areas we see potential for fairly short-term benefit. Take imaging, as one example. There is tremendous strength in the program in imaging tissues and cells. This imaging of tissues, medical scanning, interpretation of the images, and the acquisition of more and more informative images will have very direct impacts in the short-term on medicine.

Take another area, protein folding, where Bio-X is very strong. Protein folding is necessary to understand how the genome is translated into the working little machines that we call proteins, and to be able to predict how those proteins fold up. What shapes they take on, and what they're capable of means you can design new ones. So, there's a potential here for designing new materials, a whole new biological materials science. It's going along very nicely, but it's still in its infancy.

These opportunities will lead to all sorts of new materials that are useful to people. For example, by designing new enzymes, there are very clear short-term benefits. In chemical biology there are many opportunities for devising new kinds of drugs. There are many down-to-earth, easily anticipated benefits from this work, but we don't want to focus completely on those sorts of applications because, of course, we're also very interested in discovery science, finding things that no one has ever seen before. And where that will take us, we don't know. We want this process to go on, not knowing. So that's the other side of it.

> *"There are many down-to-earth, easily anticipated benefits from this work, but we don't want to focus completely on those sorts of applications because, of course, we're also very interested in discovery science, finding things that no one has ever seen before. And where that will take us, we don't know. We want this process to go on, not knowing."*

The Molecular Foundry, Lawrence Berkeley National Laboratory

Dr. Paul Alivisatos
Director, the Molecular Foundry

The newest research facility being developed in the Bay Area is Lawrence Berkeley National Laboratory's Molecular Foundry, an international user facility for the design, synthesis and characterization of nanoscale materials. This is one of five new centers for nanotechnology research established by the Department of Energy. Collaborations with users from around the world in materials, physics, chemistry, and biological science will focus on fabricated nanostructures and their integration into complex assemblies.

As a user facility, the Foundry will provide free-of-charge, state-of-the-art instruments and specialized staff. Investigators from academic, government, and industrial laboratories will be invited to submit proposals. The idea behind The Molecular Foundry is to give everybody in the nanoresearch community the tools to make new molecules and nano-sized objects.

Groundbreaking will take place in early 2004 for the six-story, 95,000 square foot facility, which will house cleanrooms for nanofabrication, state-of-the art imaging tools, and laboratories and equipment for visiting and resident scientists. While a significant amount of nanoresearch is already underway at Berkeley Lab, full-scale operations are expected to begin when the building is completed in 2006.

Question

What kind of research is underway at the Foundry now, and what kind of social and economic impacts do you see coming from it?

Alivisatos

A major thrust of the research already underway focuses on nanotubes, which are hollow elongated molecules that form cylinders with a typical diameter 100,000 times narrower than the diameter of a human hair. Nanotubes conduct heat better than any other known material, plus they're about a hundred times stronger than steel and more durable than diamonds. Their potential as building blocks for nanotechnology, particularly when mass-produced with tailored properties, is nothing short of mind-boggling.

As one example, Dr. Alex Zettl, a physicist with Berkeley Lab's Materials Sciences Division, and his research group have made an assortment of amazing new nanotube structures including what may be the world's smallest human-made bearings and mechanical switches, the world's smallest room temperature diodes, and the first insulated nanowires.

Nanotubes are by no means the only macromolecules with important impacts. Also high on the list are a class of polymerized macromolecules, called dendrimers, that have the potential to provide the most exquisitely tailored forms and functions ever realized outside of nature. A class of dendrimers has already been developed by Jean Fréchet, who heads the Organic and Macromolecular Facility at The Foundry, that can be used as transportation vessels for shuttling proteins into cells, with tremendous potential for delivering vaccine antigens. This technique skirts the disadvantages of today's injectable vaccines, which employ deactivated viruses to ferry antigens into the cell interior.

So nanotechnology has the potential for profound societal impacts, from communications to energy use and health care, and the Molecular Foundry will help put Berkeley Lab and the Bay Area at the forefront of the field.

BAY AREA COUNCIL

BAY AREA ECONOMIC FORUM

A Partnership of the Association of Bay Area Governments and the Bay Area Council

Association of Bay Area Governments

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(415) 981-7117

Chairman Mr. Lenny Mendonca
McKinsey & Company
President Dr. R. Sean Randolph

FAX: (415) 981-6408
E-MAIL: info@bayeconfor.org
WEBSITE: www.bayeconfor.org

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