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The QB3 Model

Fostering Innovative Workforce Development

Summary of Findings

by the

Bay Area Science and Innovation Consortium

BASIC

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CALIFORNIA SPACE AUTHORITY

California Innovation Corridor

The QB3 Model

Fostering Innovative Workforce Development

Introduction

In this century's emerging global marketplace, a skilled workforce is a foundation of competitiveness. To achieve and sustain continuing regional prosperity, the Bay Area must be able to focus public and private sector action within systems that are successful in generating the ideas and people to sustain profitable commercial innovation. Central to this task is ensuring that the local workforce keeps pace with the technology and broader skillsets necessary for commercialization of invention.

This workforce development issue was at the heart of an investigative project conducted by the Bay Area Science and Innovation Consortium (BASIC), a regional collaboration dedicated to advancing the Bay Area's leadership in science, technology and innovation in the increasingly competitive national and international R&D environment.

The Bay Area Council Economic Institute and BASIC were contracted to examine the innovation economy and its workforce as part of the U.S. Department of Labor WIRED (Workforce Innovation for Regional Economic Development) initiative within the California Innovation Corridor, managed by the California Space Authority. As part of this project, the Economic Institute and BASIC developed a model for innovation-driven economic development and explored the specific challenges of maintaining global leadership in the life sciences field and sustaining the competitiveness of its workforce.

The recipe for innovation success includes four major ingredients: expertise, interaction, diversity, and application. When these four factors interact successfully, innovation occurs. In focusing its examination on life sciences R&D and industries in California, BASIC found the innovation ingredients at work in a vibrant mix that has generated thousands of jobs and billions of dollars in revenue and has made the state a

global leader in the life sciences field. However, the examination also revealed a range of trends that could portend challenges in workforce quality in the life sciences over the next decade and beyond. There was significant evidence of difficulties in matching the rapidly evolving cutting-edge needs of industry and government employers to the curriculum for and practical experience of university-level and postgraduate science students.

Based on its findings, BASIC concluded that it would be important to identify and analyze "model projects" that are effectively pursuing innovation-driven strategies for 21st century economic development while simultaneously expanding the skills of the science and technology workforce. A San Francisco Bay Area entity that has proven to be such a model is the California Institute for Quantitative Biosciences (QB3).

Biology, Biotechnology, Biosciences, or Life Sciences?

A range of names is given to the industry and to scientific activities related to work with living organisms specifically for the improvement of human health and other applications, such as agriculture or energy.

Biology is the name for the overarching academic discipline. With the growth of commercial developments in the field, particularly resulting from genetic research, *biotechnology* or *biotech* came to be used more widely as a name for this emerging industry. The term *biosciences* is also used, often implying a broader scope than biotech.

More recently, the growth of commercial activities beyond healthcare and agriculture into energy, the environment, and homeland security—together with greater use of chemistry, physics, information technology, and other fields—has brought into vogue an even broader term: life sciences.

QB3 typically uses the term biosciences (as appears in its name). For this report, we frequently use the term *life sciences*, though we use other terms to reflect the words used by QB3.

QB3 Overview

QB3 is a joint venture between UC Berkeley, UC San Francisco and UC Santa Cruz to drive the next life sciences revolution through the application of quantitative science methodologies. The Institute's website notes that it builds on strengths in the engineering and physical sciences at UC Berkeley, the engineering and mathematical sciences at UC Santa Cruz, the medical sciences at UC San Francisco, and the strong biology programs at the three campuses.

Now officially known as the California Institute for Quantitative Biosciences, the QB3 moniker derives from the venture's original name: the Center for Quantitative Biology, Biochemistry and Bioengineering. As stated in its website, QB3 harnesses the quantitative sciences to integrate our understanding of biological systems at all levels of complexity—from atoms and protein molecules to cells, tissues, organs and the entire organism. This long-sought integration allows scientists to attack problems that have been simply unapproachable before, setting the stage for fundamental new discoveries, new products and new technologies for the benefit of human health.

The venture consists of managerial, academic and research representatives of the three institutions, along with private researchers and entrepreneurs—including 184 affiliated faculty members and dozens of research fellows. All are involved with the life sciences, and all share ideas and discoveries with one another to advance the field. Many of these individuals have demonstrated significant commercial skill. As the QB3 website points out, the UC scientists involved have founded one in three biotechnology companies in California, including five of the industry's ten largest companies (Amgen, Applied Biosystems, Chiron, Genentech, and Idec Pharmaceuticals).

QB3 Infrastructure

QB3 has facilities at all three affiliated campuses that provide its research and development community with access to top-tier research equipment, laboratory space, and office space. But it is QB3's main facility at the UCSF Mission Bay campus that demonstrates its most exciting and advanced infrastructure model, built around principles of innovation clustering, sustainable community, and expansion needs.

Mission Bay embodies an important life sciences park concept that is central to a broader view of workforce development, encompassing expansion planning, avoidance of urban sprawl, support for quality of life, opportunities for walking or bicycle commutes, and other measures outside of training.

Mission Bay has 43 acres devoted to university use, 250 acres for residential and commercial development, and 14 acres for a hospital. The hospital alone is a $1.5 billion project, the biggest construction project in California at the moment.

All of this infrastructure is specifically intended to create a life sciences business community where scientists and their families can live, work, think and create. Unlike the typical business park concept that undertakes commercial development and business clustering without a strong connection to pedestrian-friendly residential development, this new type of urban park is designed to create a small community that interacts and exchanges ideas at work and in personal time as well. Scientists can raise families, engage in social activities and have virtually no commute, because everything essential in their lives can be available in a small urban center that is also convenient to all the cultural, travel, lifestyle, research, and business amenities of San Francisco and the rest of the Bay Area.

Mission Bay is a direct example of how to move toward today's evolved imperative: "*think locally and act globally*." Foreign governments are also pursuing such innovation parks. As QB3 director Reg Kelly says, "We need to become small, local, sustainable communities that compete and interact with other communities/industries on a global scale."

Focusing on the Practical Outcome

QB3's work breaks roughly into three major areas: (1) research, (2) applied coursework and experiential learning, and (3) commercialization activities. What makes QB3's activities of particular note for the economic and workforce development communities is the effect of the institute's charter. All activities are directly linked by the need to make progress measured against a particular outcome—positive societal and economic impacts from the quantitative biosciences—and a mandate to speed commercial development of technologies.

Over 180 researchers utilize quantitative tools to explore how biological systems work, from atoms and molecules to cells, organs, and entire organisms. There are nine affiliated research programs. Individual scientists determine the research, but there is a common thread at QB3: to explore how the life sciences can benefit society in the future. This basic charter makes even QB3's pure research meet a test of potential practicality.

The Institute's research is described at the QB3 website:

> *Using advanced imaging, modeling, and computational tools, these scientists decipher the complex systems involved in living systems, and discover ground-breaking applications for that basic knowledge. [QB3's scientists and engineers] develop devices, drugs, and therapies that save human lives, as well as technologies to prevent or mitigate environmental damage and improve energy production and use. Research areas include bioengineering and biotechnology, bioinformatics and computational biology, structural and chemical biology, experimental genomics, proteomics, and biochemistry.*

Educational Activities to Establish Interdisciplinary and Applied Skillsets

A major issue in workforce development, particularly within scientific disciplines, has been how to establish interdisciplinary and applied skillsets. QB3 specifically undertakes educational activities that go beyond core research and academic work to deliver to students applied or experiential programs that directly translate into critical skills desired by employers.

- **Specialized Coursework**

  QB3 offers extensive coursework on business and entrepreneurship that is further described in the commercialization section, below. Besides these business classes, however, QB3 offers specific applied or interdisciplinary study opportunities for undergraduates, graduate students and postdoctoral fellows including the intensive hands-on QB3/GE Bioprocessing Seminars, the specialized QB3 Microarray Course, and a Summer Undergraduate Research Fellowship in Information Technology known as SURF-IT. This last item is a summer program for women, minority or disadvantaged undergraduate students, focusing on computer engineering, computer science, or electrical engineering.

- **Undergraduate Internships**

  QB3 has combined with UC Berkeley to create a biotech internship program for undergraduate students. This program places undergraduate students in ten-

week summer positions as full-time paid employees, at Bay Area biotech companies, to gain real-world work and research experience. This program is supported by faculty mentors, utilizes advanced laboratory facilities, and allows students to explore career paths and graduate study options.

▲ **Graduate Group in Computational and Genomic Biology**

This program combines genetics with the quantitative sciences. The goal of this group is to "orient students, systematize graduate training, catalyze research collaboration, and enhance an intellectual community which transcends traditional departmental boundaries." This group is for PhD students and, upon completion of the program, awards them with an added degree of designated emphasis (equivalent to a minor). This is an interdisciplinary educational track and is associated with UC Berkeley.

▲ **Malaysia Program**

During personal interviews of business executives conducted by BASIC in the spring of 2008, some employers expressed concerns about shortcomings in employees' abilities to understand foreign and cross-border industry trends, as well as to work within multi-country teams. This program, which focuses on Malaysian doctoral students and post doctorates, is an example of how QB3 works on cross-border opportunities. The program is a collaboration with the Malaysian Biotechnology Corporation, a government agency created to nurture growth of Malaysian biotech companies. Students, or fellows, come from Malaysia to study "neglected diseases" that receive inadequate attention by U.S. pharmaceutical researchers because of high development costs. These diseases mainly affect developing countries, and in an emerging biotech market like Malaysia, it is possible to develop pharmaceuticals profitably for such diseases. The program researches these diseases, trains scientists in biotechnologies and entrepreneurship, builds teams, and networks them with the UC research community. The visiting scientists ultimately return to Malaysia with the tools and connections to begin biotech companies. California industry benefits from the applied cross-border commercial teaming opportunities afforded local students and the active involvement in development of drugs that may represent an enormous foreign market.

▲ **Symposiums**

QB3 hosts 6–10 symposiums a year to share knowledge and networking on emerging life sciences innovation. These presentations, unlike the majority of symposiums, are free and open to all QB3 scientists, as well as members of the UC community. They explicitly enable industry to interact directly with the academic community on evolving topics, and speakers represent a wide range of perspectives, including industry, academia, government, and foreign scientists.

▲ **Anti-Med School**

This small but important program runs for 12–13 weeks per year. Life science researchers spend time in hospitals with practicing doctors and real patients. Instead of learning how to diagnose and cure illnesses, students focus on questioning doctors directly about missing knowledge that could improve medicine if explored. This helps drive innovation by defining medical problems in practical terms and inspiring students to develop exciting and much needed research proposals.

Experiential Education and Focus on Commercialization

Many of the foregoing activities are unique in their scope, cross-disciplinary aspects, or applied purpose. However, what takes QB3 to a new level in economic and workforce development terms is its focus on activities that engage students, entrepreneurs, capital, and large employers in the direct commercialization of technologies developed from QB3 research.

▲ **Business Classes**

Employers interviewed by BASIC expressed concern about lack of business understanding by employees at all educational levels. Industry observers generally fear loss of commercial opportunity to foreign competition by failure to support entrepreneurial development of innovative technologies here. QB3 offers a number of business classes to foster business-minded and business-skilled scientists. Two of the most significant include a Global Bio-entrepreneurship Course, and an Idea to IPO Course for entrepreneurial scientists. Information on advertising, marketing trends, commercialization and investment is available to participants in the class.

▲ **Innovation Toolkit**

Driving commercial activity and involving students in the experience goes far beyond coursework in the QB3 approach. The *Innovation Toolkit* is what QB3 calls its capacity to network scientists, entrepreneurs, venture capitalists, and corporate partners. There is a full-time staff devoted to counseling scientists in their attempts to bring laboratory discoveries into the marketplace, along with the seminars, networking opportunities, and guidance from mentors described elsewhere in this section. A clinical advisory board helps researchers determine the practical applications and potential of an invention. Part of the success of this "toolkit" stems from in-depth private sector input.

▲ **Discovery to Health (D2H) Program**

D2H is essentially the Innovation Toolkit described above, but with a specific emphasis on helping both existing firms and faculty entrepreneurs with what is known in the industry as "translational medicine" or "bench-to-bedside." The idea is to translate research advances as swiftly as possible into therapies that advance human health. For existing firms, QB3 provides knowledge brokering to locate research expertise and foster collaboration, access to QB3's core facilities, and master agreements to lower research costs by establishing intellectual property and contractual arrangements. For faculty entrepreneurs, QB3 offers pre-commercial funding (see the Rogers program below), expert mentoring, networking events, and the QB3 Garage (described below).

▲ **Venture Capital Development**

QB3 utilizes to the fullest the spirit of risk-taking and capitalism in the Bay Area. QB3 invites venture capitalists to be part of the research programs and projects that are being worked on. By bringing potential investors into the research process early on, QB3 can utilize their market expertise to help design projects that are ultimately successful and economically viable. It also connects these investors directly to scientists, improving understanding of the science and building personal rapport, thereby increasing the likelihood of investment support. This connection also allows QB3 to stay close to investment trends and respond effectively.

▲ **Drug Development**

Along with the specific commercial startup activities in connection with the QB3 Garage described below, QB3 undertakes commercial product development. For

instance, one of QB3's industrial partners is PharmaSTART, a consortium of research organizations led by SRI International, that offers translational drug development services to help bring drug discoveries into the marketplace. PharmaSTART acts as a knowledge broker to QB3 scientists by offering drug consulting, networking, and other development services such as lead development, GLP toxicology,[1] analytical and regulatory services and cGMP[2] manufacturing.

- **Synthetic Biology**

  As explained by QB3, synthetic biology involves creating and engineering microorganisms to deliver "major new advances in preventing and treating disease, generating new energy sources, and preventing and mitigating environmental threats." Leading development of this evolving field, which directly requires intensive application of quantitative sciences, is a priority for QB3. The Berkeley campus launched the Synthetic Biology Engineering Research Center (SynBERC) in the summer of 2006. The center was funded by a $16 million grant from the National Science Foundation (NSF), with a total five-year commitment of $20 million, counting matching funds from industry and university partners (UCSF, MIT, Harvard, and Prairie View A&M University).

Pre-Commercial Funding: Rogers Bridging the Gap Award

In describing QB3's work with the Rogers Bridging the Gap Award, *The Journal of Life Sciences* describes the problem of pre-commercial funding:

> *Today, there is a growing gap between the basic research funded by the NIH and applied research devoted to producing commercial products. As the biotech industry has matured, investors have become increasingly skeptical about funding the development of technology for which commercial viability is unproven. Some scientists describe this divide between projects that are too far along to qualify for NIH funding, but not sufficiently developed to attract venture or corporate money, as the "valley of death."*[3]

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[1] GLP stands for the regulatory standard known as "Good Laboratory Practice."

[2] The U.S. Food and Drug Administration's "current Good Manufacturing Practices" standard.

[3] The Journal of Life Sciences. The smiling heretic. May 16, 2008. http://www.tjols.com/article-617-4.html

The Rogers Bridging the Gap Award is a fund set up by the Rogers Family Foundation and administered by QB3 that awards funding to fill the gap between federal funding and either capital investment or profits from commercializing. Three awards of up to $100,000 each go to teams, led by QB3 faculty members, that can deliver research yielding novel, practical benefits in the commercial marketplace within a reasonable timeframe. Matching grants and gifts in kind are encouraged, as is collaboration with other QB3 scientists, clinicians, engineers, computer scientists, or industry scientists. The stated ideal outcome of the support is the filing of an intellectual property patent, the creation of a new company, or the equivalent. The program specifically recommends project management support from QB3 knowledge brokers and use of concepts in the Innovation Toolkit.

With this program, QB3 hopes to inspire creation of a sustainable "evergreen" fund to continue pre-commercial funding opportunities after the existing fund is expended.

Starting Out from the Garage

A notable QB3 program to commercialize technology is the business incubator space known as the QB3 Garage—a name evoking the garage in which tech pioneers Bill Hewlett and David Packard launched their company. The Garage enables entrepreneurs to engage in startup activities around QB3-developed or supported technologies.

Earlier this year, QB3 associate executive director Douglas Crawford succinctly commented on the scope of the Garage to the industry periodical *Biotech Transfer Week*:

> *The goal of the state when creating QB3 was to drive the creation of new industries. Towards this end we make three efforts. First, we promote creative science by encouraging cross-campus and cross-discipline collaborations. Second, we promote collaborations between industry and the university. Third, we try to stimulate university spinouts.*[4]

[4] Ben Butkus. Biotech Transfer Week. Affymetrix's $25M true materials buy is most recent graduate of QB3 Garage incubator. July 30, 2008. http://www.biotechtransferweek.com/issues/2_30/features/148509-1.html

The Garage is the first such business incubator in the UC system that specifically works to spin off companies from university innovation. QB3 and the Garage have not taken equity positions in the companies in the Garage, though they would not be prohibited from doing so. The Garage rents small spaces to tenant companies at market rates in a commercial real estate environment in which most brokers generally seek clients desiring more than 2,500 square feet of space. By offering small, shared space at a major research facility, the Garage cuts down on the very high cost of office and laboratory facilities while providing access to QB3 researchers who can mentor academic entrepreneurs and young companies. As reported in a *San Francisco Business Times* article in December 2007:

> *QB3 rents space in chunks of about 200 square feet at market rates—with annual Mission Bay rates in the $60 per square foot range—and doesn't offer traditional incubator niceties like administrative support. What it does provide is access to some of the keenest biotech minds and other up-and-coming entrepreneurs.*[5]

The Garage can help identify potential markets, assess intellectual property issues, open doors to QB3's rich network of connections and knowledge, generate opportunities for student experience and employment, and meet the Institute's goal to support successful market entry of new technologies.

As of the writing of this report, nine small companies were using the QB3 Garage. Of the companies using the Garage since its inception, four have graduated out of the Garage as commercially successful enterprises, including one that was acquired for $25 million. One company left the Garage due to lack of capital, but it is still in the process of developing the technology and funding. The remaining companies are in various stages of development.

As reported in the *Biotech Transfer Week* article, graduates of the Garage include True Materials, an entrepreneurial venture tied to analysis of genetic information; Fluxion Biosciences, a UC-Berkeley/QB3 spin-off developing assays and instrumentation for

[5] Ron Leuty. San Francisco Business Times. Bios born in garage. December 21, 2007. http://www.bizjournals.com/sanfrancisco/stories/2007/12/24/story2.html

single-cell analysis; drug developer Bay Therapeutics; and Satoris, a Stanford University spin-off developing a diagnostic for Alzheimer's disease.[6]

True Materials was the company acquired. Each of the other companies closed a significant financing round in 2008 and moved out of the QB3 Garage to other laboratory and office space in the Bay area.

To provide a better sense of companies in the Garage, we looked more closely at two of them.

QB3 Garage Graduate Case Studies

Satoris, Inc.

Satoris works in the field of molecular neuro-diagnostics. The company created a blood test that, with 95% accuracy, can identify if a patient has the terrible dementia known as Alzheimer's disease. The test uses a biomarker that has been identified with Alzheimer's. Previously, the disease diagnosis included spinal cord fluid analysis, an extremely invasive procedure. With Satoris' new technology, all that is required is a blood sample.

Garage linkage and role: Satoris was a spin-off from work at Stanford University and UCSF. The early team working on this technology included Tony Wyss-Corey and Sandip Ray, associated with Stanford University School of Medicine, and Bruce Miller at the UCSF Memory and Aging Center.

Funding: $5.2 million in a Series B financing round from a biomarker testing laboratory called Rules-Based Medicine, Inc. and the non-profit investment organizations Life Science Angels and the Brain Trust Accelerator Fund, LP that focuses on early stage investments to address diagnosis and treatment of brain-related diseases.

Current Status: Expanded operations in Redwood City. Conducting validation studies with the Mayo Clinic.

[6] *Ibid.*

True Materials

True Materials was the fourth company to graduate from the Garage, and it did so upon being acquired by Bay Area biotech leader Affymetrix in June 2008. At the time of its acquisition, True Materials had developed new technology to support microarrays, a specific approach to analysis of genetic material. This technology represents a combination of information technology, massive amounts of genetic data, and manufacturing—ultimately involving creation of types of genetic databases stored on specialty microprocessors called microarrays. More specifically, True Materials had developed digitally encoded microparticle technology for improving nucleic acid and protein analysis—technology of direct application in Affymetrix's core business.

Garage linkage and role: True Materials was the result of close personal ties and collaboration between its founder, Randy True, and researchers at QB3, including Joe DeRisi. The space offered by the Garage enabled the company to keep down cash flow demands, allowed growth of the space one individual at a time, and enabled access to essential assets and collaborators. This allowed much faster commercialization of the technology than would otherwise have been possible—enabling it to go from concept to $25 million acquisition in just two years. As Crawford commented to *Biotech Transfer Week*, "I think Randy would have been hard-pressed to keep cash flow under control and to gain the kind of intellectual power he could by working so closely with university investigators."

Funding: Raised $1.2 million from angels and spent $600,000.

Current Status: Acquired by Affymetrix for $25 million two years after moving into the QB3 Garage.

Anticipating Workforce Needs

Workforce development and educational officials find it difficult to anticipate the types of workers and training that should be produced to support the life sciences and other rapidly evolving science-driven fields. In BASIC's life sciences roundtable earlier this year, one proposed concept was to follow the direction of federal funding and the work of research institutions to develop at least a three- to five-year view of demand for workers with experience in certain types of new technologies.

Because of this, we investigated the decision-making process at QB3, and whether it might afford such medium-term visibility into technology evolution and, thus, into potential future hiring needs. The answer is mixed.

QB3 does seek out projects that are deemed to be the most promising, based on scientific merit, the availability of funding, and match with the Institute mission. There is a general step-by-step process that ultimately can span a few years:

1. Research idea
2. Research proposal
3. Government funding
4. Results promising
5. Nurture promising projects
6. Additional research
7. Start companies

Steps one and two are based solely on merit and the competition of ideas among scientists at the three QB3 partner universities. QB3 does not specifically guide the nature of research proposals. However, proposals should be generally consistent with QB3's mission and vision, and the Institute's management and acquisition of equipment affects the feasible types and direction of research.

The government funding process appears to be the first juncture at which medium-term predictions about the actual direction of technology evolution could reasonably occur. Though QB3 and UCSF have a policy of not requesting earmarks on policy/legislation, there is a positive feedback loop that establishes trends and a modicum of stability around funding priorities in a given time period. Scientific advisory boards ultimately guide government decisions on what research to fund. The advisory boards are composed of the highest qualified and most respected scientists in the country, who may include, or at least be influenced by, scientists involved in QB3 priority areas.

Up until step four, the ultimate viability of the research to yield a beneficial societal result is unknown. So although government funding priorities are an early indicator of potential workforce demand, such indicators should be tempered by research results that may be known twelve to twenty-four months or more later.

QB3 nurtures projects that can demonstrably serve a need in society. There are 5 scientist "knowledge brokers" at QB3 who meet with UC scientists, screen funding

requests, and arrange focused workshops. Decisions on continuing with research factor in societal needs and considerations voiced by the business and governmental agents working with QB3. The nurturing aspect in step five includes the various commercialization activities described previously, along with "proof of concept" funding. Proof of concept funding is a type of pre-commercial funding—taking place between the purely scientific research, largely funded by government, and commercial start-up capital. Such funding furthers research once a concept or a discovery has been made and proven true. Then, if the project can gain financial support, it moves into the QB3 Garage where QB3 helps find initial phase commercial funding from private and public sources, along with the necessary equipment for development. Ultimately, the success or failure of commercialization activities hinges upon free-market demand and the capabilities of the project team.

This entire process can take three to five years. Since large scale commercial activity may take another two to five years or more to ramp up—even longer if regulatory approvals encounter hurdles—there is some amount of planning time available for workforce needs assessment.

Based on this process, we would conclude that it is theoretically feasible to identify potential workforce needs over a five- to ten-year time horizon. However, this would require the broader educational and workforce community to be more intimately engaged with QB3 to construct and continuously update workforce planning based on the development cycle described.

How does the QB3 Model Address Workforce Education Challenges?

Earlier this year, BASIC investigated the current and future problems of the Bay Area's life sciences workforce.[7] Those findings informed this report by defining the specific areas in our workforce training systems that are failing to meet employer expectations.

In the life sciences, there is a fundamental challenge in training technicians, scientists, and managers. It is impossible to project beyond three years what the field will look like—and therefore what employers specifically need. Consider the True Materials case study above: the technology went from concept to commercialization in under three years.

While addressing this and other systemic issues requires concerted effort, certain QB3 approaches directly tackle four identified workforce problems in the life sciences.

1. The complex lab-to-market cycle impedes accurate training and hiring.

Problem: Laboratory discoveries face a range of commercialization hurdles that generate delay and uncertainty. This generates hesitation around hiring decisions, as well as difficulty for employers and the education/workforce community in predicting needs (as noted above).

QB3 approach: By integrating core innovation with the expertise and resources required for commercialization, QB3 not only reduces time-to-market, but also generates experienced talent while enjoying a clear view of issues such as capital development and regulatory approvals, as well as the future market potential (and thus potential hiring needs). These are specific effects of the QB3 Innovation Toolkit and the Garage.

2. There is a shortage of qualified geneticists.

Problem: Life sciences industry leaders predict a serious shortage of geneticists, including certified laboratory directors and technicians with strong backgrounds in genetic analysis. This is due to the rapid growth of genetic analysis for a range

[7] Paul V. Oliva / Bay Area Science and Innovation Consortium. 21st Century Workforce Preparedness in the Life Sciences: Summary of Findings. August 2008. See www.bayareabasic.org.

of activities from disease diagnosis and new therapy development to core research into new bioscience applications.

QB3 approach: The Graduate Group in Computational and Genomic Biology is a program generating not only more geneticists, but better trained geneticists. There are opportunities for direct work experience in conjunction with QB3's other offerings and commercialization activities.

3. **All scientists, technical workers, and managers require significant ongoing education to stay familiar with the rapid evolution of the field.**

Problem: Other than attending seminars and conferences or reading scholarly papers, there is no effective way for life sciences employees to stay familiar with innovations that may be essential to know but are outside their direct day-to-day experience.

QB3 approach: QB3's most important contribution toward addressing this problem is the development of a vibrant, close-knit, physically proximate community that mutually supports and engages in work, with individuals responsible for monitoring developments and brokering useful connections. With direct involvement in supporting commercial activity, QB3's extensive laboratory space and top-of-the-line research facilities represent a direct asset to the entire community that helps keep scientists and students familiar with all of the latest technology available. QB3's research and commercialization mandate ensures that its efforts to train new scientists will always incorporate the latest technology and thinking. Beyond the training of new scientists, QB3 is pushing for a continuing education requirement for people in the biotech industry, similar to the requirement for medical doctors to refresh and advance their skills every two years. This would ensure that scientists in extended industry stay on top of developments, and would create demand for continuing education infrastructure.

4. **There is a need for greater interdisciplinary skills in the life sciences.**

Problem: Many employers express concern that scientists, technicians, and managers lack a broad set of skills beyond their core area of academic study. This concern is particularly held in the life sciences industry, although WIRED surveys of other employers uncovered this concern in varying degrees as well. Some of

the concerns relate to business skills, such as understanding how to formulate the business case for a new product or how to deal with the regulatory process. Others relate to interpersonal skills, such as managing a multi-country team. There were even serious concerns directly within the biological sciences, such as a lack of database management, quantitative analysis, and information technology experience directly applied to genetic analysis on both the research and development sides of the industry.

QB3 approach: QB3 itself is a recognition of the need for skillset development in these three areas. As detailed above, QB3 offers coursework, experiential learning, and professional development opportunities that produce people who are top-quality scientists with business knowledge, practical project management experience, and rigorous, interdisciplinary training in quantitative sciences.

What Else Can Be Done?

QB3 is an important model that offers promising approaches to specific workforce development challenges in the life sciences and perhaps other disciplines as well. Of special significance is its ability to stimulate research, support commercialization, and broker a vibrant knowledge and funding network. It should also be noted that QB3 is one of four important California institutes, including CITRIS (Center for Information Technology Research in the Interest of Society) in the Bay Area and two institutes in Southern California—CNSI (California Nanosystems Institute) and Calit2 (California Institute for Telecommunications and Information Technology).

BASIC has focused on QB3 in this paper in order to provide an in-depth analysis of what is being achieved at one entity and what could be possible. Based on the findings and as a follow-up action, the BASIC Board of Directors will build on the QB3 model in developing specific workforce development strategies. Its special focus will be on developing targeted policy recommendations and determining services that BASIC could provide to future graduates and the current workforce to assist them in obtaining the expanded skills required in today's globally competitive environment.

Appendix A

QB3 as a Model for Innovation-Driven Development

Under its WIRED contract, the Bay Area Council Economic Institute launched an "innovation-driven economic development model." This model is a new way to undertake economic development that supports growth of innovative industry in the face of global competition and opportunity.

The focus of the model is the development and success of regional clusters of innovation rather than any single company or city. Silicon Valley, which evolved around the entrepreneurs, technologists, and venture capital community of Santa Clara County, is the quintessential example of such a regional cluster. To drive such an innovation cluster, economic development work must center around actions that cultivate the network of researchers, entrepreneurs, business administrators, venture capitalists, marketers, visionaries, and government and educational administrators to produce innovation and innovative products.

What follows is a cursory examination of QB3's ability to serve as a replicable, real-world example of the innovation-driven model in the life sciences.

1. Innovation entails four ingredient factors.

The model: The recipe for innovation success includes four ingredients: expertise, interaction, diversity, and application. When these four factors interact successfully, innovation occurs.

QB3 approach: QB3 applies the four factors of innovation quite well, supporting an amazing environment where the innovative process can flourish. Expertise is clearly in no short supply. The participation of the three universities (UCSF, UC Berkeley and UC Santa Cruz) gives QB3 a collection of minds that are at the top of their field. Diversity is brought to QB3 in different ways, including fellowships to foreign students, attraction of international scientists yielding unique perspectives and ideas and, most importantly, the interdisciplinary approach that

is central to QB3's founding and which actively integrates a variety of science and business disciplines. Interaction is clearly a foundation of the QB3 approach, through lectures, symposiums, internships, projects, shared laboratory space, and mentorship. As is detailed in the descriptions of the Innovation Toolkit, the Garage, and the symposiums, QB3 brokers interaction between private and public sector researchers as well as between members of business, academia, and government. Application of innovation happens throughout QB3, but the Institute's Garage is the clearest example of intentionally brokering and applying research-generated ideas to practical commercial execution within a support network.

2. Innovation requires knowledge brokers.

The model: To form an economic network and enable it to succeed requires knowledge brokers. Knowledge brokers—whether an organization or disparate individuals—connect the players necessary for innovation to take place. They are the glue bonding the different sectors of innovation.

QB3 approach: QB3 is acting as a knowledge broker for the life sciences in the San Francisco Bay Area. QB3's Innovation Toolkit is a systematic approach to match investors with scientists, and industry with academia and researchers. Beyond the toolkit, QB3's leaders are individuals whose leadership skills, visionary attitude, personal connections, and scientific knowledge help them connect people and ideas. QB3's executive management constantly examines the potential of the science, of the innovations around them, and of the application of these innovations to societal problems. In this way, QB3's leaders and managers can broker connections and deals essential for commercial success of technology—and have demonstrated their effectiveness in doing so.

3. Physical proximity fosters innovation.

The model: Innovation happens most easily when there is a geographic locality where it can take place—a locus for focused interaction and exchange of ideas, information, and visions between individuals and organizations.

QB3 approach: By design, the Mission Bay campus and its programs provide a central, physically convenient and compact space for regular face-to-face interactions among people across disciplines and sectors of society. Ideas flow

freely. The Mission Bay campus has an enormous amount of additional space for development, and the labs, offices, lecture halls, and open natural spaces give QB3 a forum for innovation unique among other campuses.

Appendix B

In-Person Interviews on QB3 Mission and Operation

QB3 Interview Participants

- **Douglas Crawford**
  Associate Executive Director
  QB3

- **Regis Kelly**
  Director
  QB3

- **Barry Klein**
  Vice Chancellor of Research
  University of California, Davis

- **Sarah Nelson**
  QB3 Scientific Director
  University of California, San Francisco

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