Preparing for the Next Silicon Valley

Opportunities and Choices

June 2002

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About This Paper

The Next Silicon Valley Initiative is working to shape both a *framework* for understanding and communicating what is happening in the Valley economy, and a *process* for engaging leaders in a regional discussion of our opportunities and choices for the next wave of innovation. The goal is to stimulate creative thinking about resource requirements and encourage regional leaders to collaborate on finding solutions that enable individuals, businesses and communities in Silicon Valley to benefit from this coming wave. Joint Venture: Silicon Valley Network has convened a Next Silicon Valley Leadership Group consisting of local industry and community leaders, CEOs, senior human resources executives, and advisors from government and education.

In December 2001, the Next Silicon Valley Leadership Group issued its white paper, *Riding the Waves of Innovation.* The paper provided a model for analyzing waves of innovation and communicating their impact on the local economy. It also identified the need to shape a resilient region and called for a commitment to social and technological innovation.

This paper, *Preparing for the Next Silicon Valley: Opportunities and Choices*, identifies the economic opportunities and risks associated with the evolving convergence of biotechnology, nanotechnology and information technology. Regional leaders have a choice in how they collaborate in meeting the challenges presented by this convergence. While the economic and strategic opportunities of this convergence are huge, so are the potential risks of missing it—if the Valley is underprepared. The purpose of this paper is to stimulate discussion and action in preparing for the next wave of social and technological innovation.

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Next Silicon Valley Leadership Group

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SUMMARY

Converging revolutions in bio-, info- and nanotechnology will create new industries and fundamentally transform a wide range of existing industries worldwide. This wave of innovation will also fundamentally transform Silicon Valley's economy and society.

We possess the assets that could help our region participate in—if not lead—this next wave of innovation. However, our success is far from guaranteed; we will have to compete with other regions that are aggressively pursuing this convergence.

Faced with this situation, Silicon Valley will move in one of three directions:

1. **We will wither as the wave passes us by (and other regions prove to be better locations).**

2. **We will become part of the wave, but it will roll over us—largely because as we import thousands of workers and development pressures build, our communities are disrupted.**

3. **Or we make the wave work for us as we invest in innovation and prepare our people and communities to benefit.**

This third future is possible, but only with business, government, education and community leaders working together. A future based on the convergence of bio-, info- and nanotechnology may be just right for Silicon Valley—one driven by innovation that creates a widening circle of prosperity without sacrificing our unique quality of life.

I. Overview

A new global wave of technological innovation could produce significant opportunities for the next Silicon Valley in the coming decade. Driving this wave are converging revolutions in bio-, info- and nanotechnology, which will likely create new industries and fundamentally transform a wide range of existing industries. This global wave of innovation could also transform the Silicon Valley economy and society, just as previous waves have done.

Silicon Valley possesses assets that could help the region participate in—if not lead—this next wave of innovation. The Silicon Valley habitat has traditional assets that remain critical to economic success, including entrepreneurial culture, capital and people. The region also has assets that are particularly important in this new wave of innovation, such as firms and research institutions working on bio-, info- and nanotechnologies and their applications.

However, Silicon Valley will have to compete with other regions that are aggressively investing in these same areas of innovation. Despite its strong assets, Silicon Valley's role in this new wave is not guaranteed. A diverse set of competitors is emerging, including San Diego, Boston, Washington D.C., Pennsylvania, Colorado and several regions internationally.

The coming wave of innovation will force Silicon Valley to make a choice. Depending on the choice we make, one of the following three things could happen:

> *1. The wave could miss us*. The wave of innovation could pass us by because leaders in other regions provide a better habitat for companies developing and applying bio-, info- and nanotechnologies to flourish. In the meantime, our economy would decline as innovative firms move out and other firms struggle to remain viable in established technologies and markets.
>
> *2. The wave could roll over us.* Like the Internet boom, the next wave of innovation could happen here, but with negative consequences. If our residents are not prepared to participate, we would be forced to import thousands of new workers. If our communities are unable to manage the influx of people and the development pressures effectively, they would experience significant disruption.
>
> *Or,* in the last scenario,
>
> *3. The wave could work for us*. This outcome is possible only if we understand and take the proper steps for what's coming, prepare our people and places for the next wave, and use it to create broadly shared prosperity and enhance our quality of life.

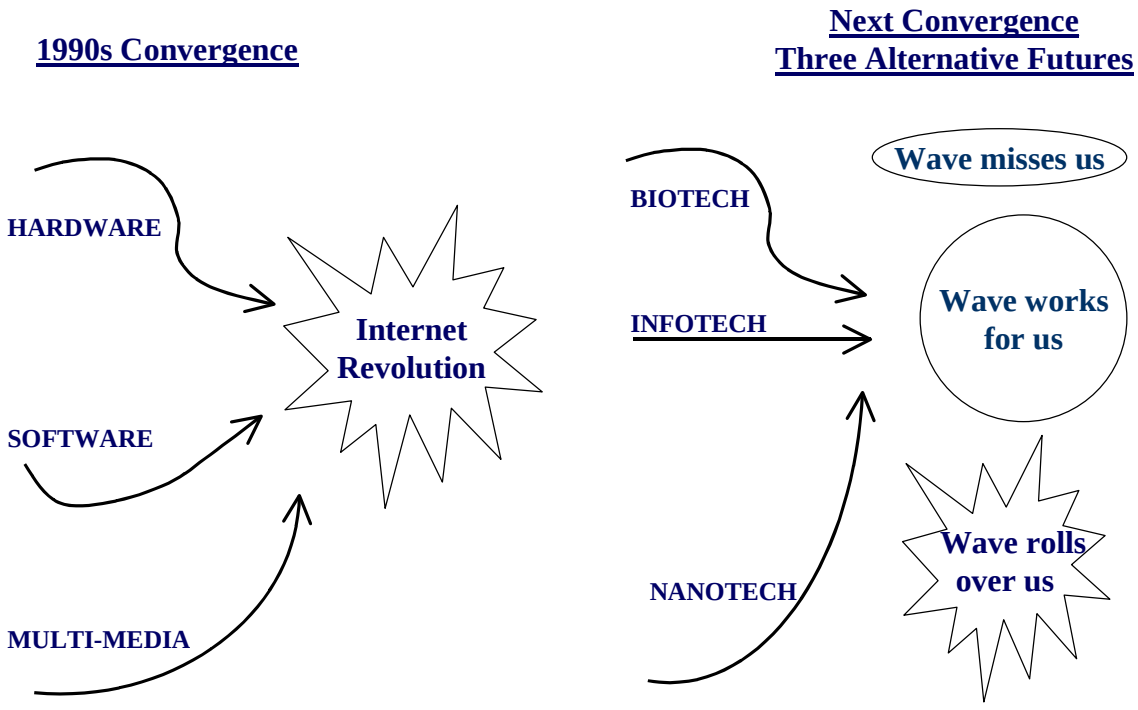
Now is the time for business, government, education and community leaders to try to put our region on the third path: preparing for the next wave of innovation and making it work for us, not against us. Our challenge is to harness the next economy to create the next community—one that is an exciting place to work and a wonderful place to live for all our residents.

There may be a fundamental difference between this wave and the previous waves. Prior waves were based on an industrial model that required more space and more people, and hence promoted

rapid quantitative growth spurts that placed major demands on our community infrastructure. The next wave may be different. We may have the opportunity for high-productivity growth based on a fundamentally different industrial model with fewer material inputs and less land required. The "small technologies" of the future may lead to different development and employment patterns in the next Silicon Valley.

A future based on a new convergence of bio-, info- and nanotechnologies creating a high-productivity, more sustainable habitat may be just right for our region. This could result in a future based on economic and social innovation that creates a widening circle of prosperity without sacrificing our unique quality of life.

Figure 1: The Coming Wave Is a New Convergence



Source: Collaborative Economics, Inc.

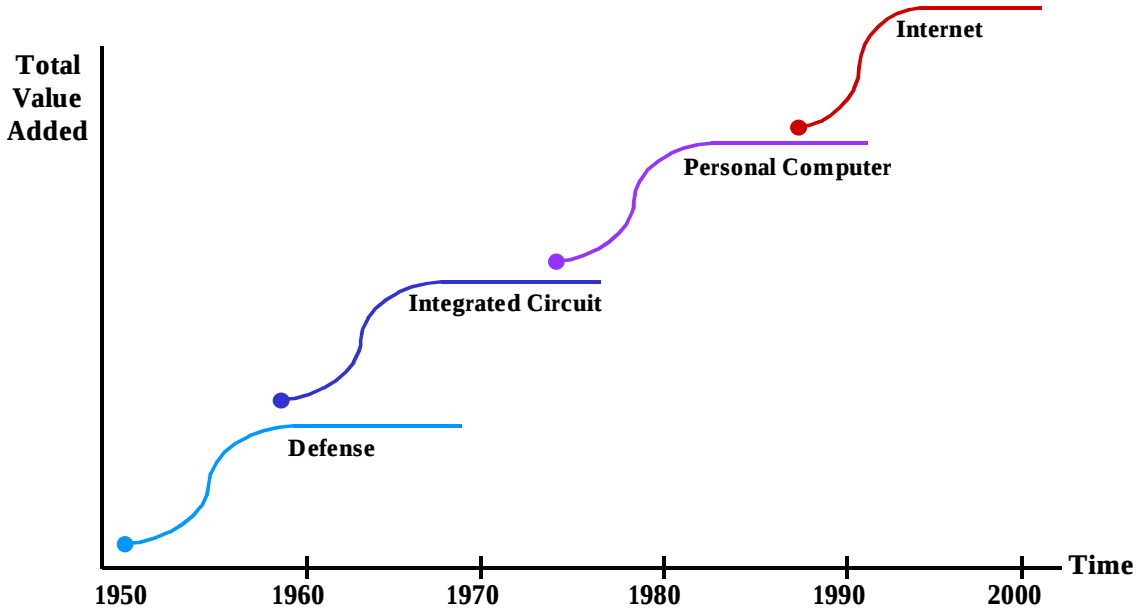
II. A Global Wave of Technological Innovation Will Shape Silicon Valley's Future

A global wave of technological innovation could produce a new regional wave of opportunities in Silicon Valley. Driving this wave are converging revolutions in bio-, info- and nanotechnology, which hold the promise to transform a wide range of products and processes within a decade. This wave of innovation could fundamentally transform the Silicon Valley economy and society, just as previous waves have done.

Silicon Valley has been shaped by past waves of innovation, including the commercialization of the integrated circuit (1960s–70s), the development of the microprocessor and personal computer (1980s), and the application of the Internet (1990s). Each time, these waves of innovation produced the "next" Silicon Valley economy and changed the structure and mix of industries in the region.

Each prior wave of innovation has created the foundation for the next wave. Each wave expands the networks of talent, suppliers, financial services providers and infrastructure, creating the habitat for innovation and entrepreneurship that helps make the next wave possible. For example, in the 1950s and 1960s, defense procurement—including second-source arrangements requiring major contractors to work with local suppliers—helped spread technological capabilities in the region. In this way, large firms helped create the foundation for smaller firms that later helped commercialize defense technologies such as wireless communications.

Figure 2: Evolution of Silicon Valley 1950-2000



Source: The Silicon Valley Edge: A Habitat for Innovation and Entrepreneurship (Stanford Univ. Press, 2000)

During the wave driven by integrated circuits in the 1960s-70s, key firms such as Fairchild Semiconductor helped spawn many offspring including Intel, Advanced Micro Devices and National Semiconductor, and created a strong foundation for the next wave driven by the microprocessor and the personal-computer revolutions of the 1980s. Again, key Silicon Valley computer technology firms such as Hewlett-Packard, Intel and Apple Computer helped stimulate the growth of a strong foundation of firms in software, high-speed workstations and other areas that led the next wave. During the 1990s, firms such as

Netscape, Cisco, 3Com, Sun Microsystems and Oracle helped set the stage for the next wave of information technology.

The next wave is likely to involve the deepening of information and communications technologies in our economy as well as the convergence of bio-, info- and nanotechnologies in ways that will transform existing firms and spawn new firms from our existing industry base. As we move toward "Internet everywhere" with the mobile Internet, as well as new productivity tools and social applications of embedded Internet tools, our existing anchor firms and new enterprises will both play an important role in the transformation of our region. We will continue to need both, because our region's innovation comes as much from existing firms and the talent within them as it does from our premier research institutions and universities.

Some industry followers see new opportunities ahead as these areas converge in new and more sophisticated ways. For example, Michael Malone, Editor of *Forbes ASAP*, says:

> Most of the world is hunkering down and still laying off people. The economic indicators are still pointing in every direction. Announcing another great era of prosperity is risky. But the fact is that all the signs of a turnaround are in place. It is across the board from chips to wireless to information technology...It is the first-born offspring of the Internet, only smarter and more agile and obedient than its predecessor. For now, let's call it Internet II. (From *Internet II: Rebooting America: Getting Real and Getting it Righ*t. *Forbes ASAP* Special Issue, September 10, 2001; pp. 44-49.)

Malone and other observers see two major barriers to achieving this vision: our current lack of *high-speed broadband Internet capacity* and a lack of a *public infrastructure* with security, confidentiality, integrity, and uniform encryption standards. While SBC Communications, Sprint Broadband, AT&T Broadband and other private telecommunications companies are now actively competing to build increased broadband capacity, the federal government will probably have to continue to play a key role in building a public infrastructure. An important question for the next Silicon Valley is whether the future of the Internet will be driven more by fixed connections using high-speed broadband or by wireless mobile devices.

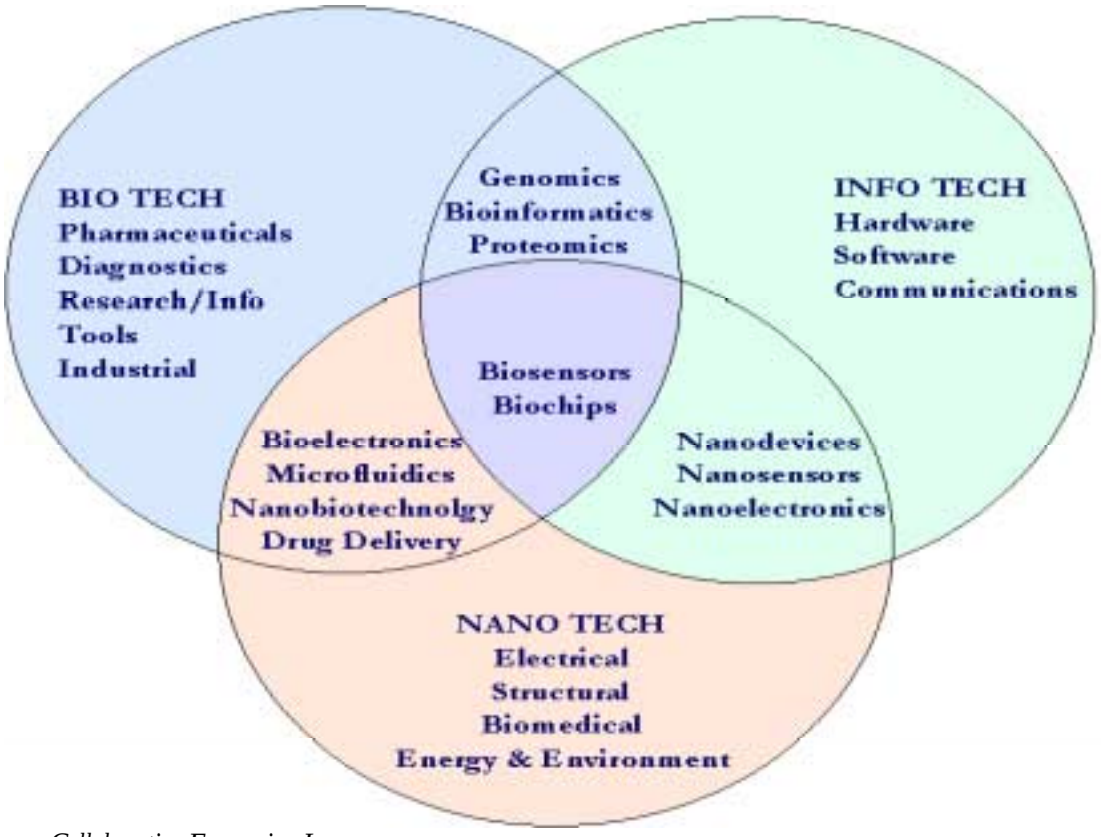
In the next wave, innovation is likely to occur near the intersection of disciplines. For example, we can expect major advances in biotechnology to converge with information technologies and create new opportunities in the emerging fields of bioinformatics, biomaterials and biochips. The commercialization of nanotechnology holds the potential to revolutionize chip and computer manufacturing while at the same time creating a new foundation for further developments in information and biotechnology.

The mapping of the human genome was an historical milestone that was partially enabled by the intersection of biotechnology and information technologies. The use of sophisticated computational methods has opened the door to entirely new medical products and services. Years of significant investments by the National Institutes of Health are now beginning to pay off in commercial applications. The market for biotechnology products was $16 billion in 1996 and is estimated to double to $32 billion by 2006. As Gary Zweiger, Director of Agilent Technologies, has observed in his book, *Transducing the Genome* (p.xi):

> The life sciences are now undergoing a dramatic shift from single-gene studies to experiments involving thousands of genes at a time, from small-scale academic studies to industrial-scale ones, from a molecular approach to life to one that is information-based and computer intensive…Biology is being reborn as an information science; a progeny of the Information Age.

At the same time, nanotechnologies are being recognized as a foundation for both advances in biotechnology and information technologies. "Nanotechnology" refers to the manipulation of matter at the atomic and molecular level (where the objects are 0.1 to 100 nanometers in size, hence the term). Nanotechnology is a multidisciplinary field that borrows from physics, engineering, molecular biology and chemistry. It has been pursued very actively in university, government and commercial laboratories worldwide for more than 15 years, and has yielded a set of building-block materials, tools and techniques that are being applied in a variety of industries, including bioscience (as tools for drug discovery and delivery), information technology (as a next generation to microprocessors and self-assembly) and materials (as new carbon fibers and high-performance composites).

Figure 3: Three Converging Revolutions



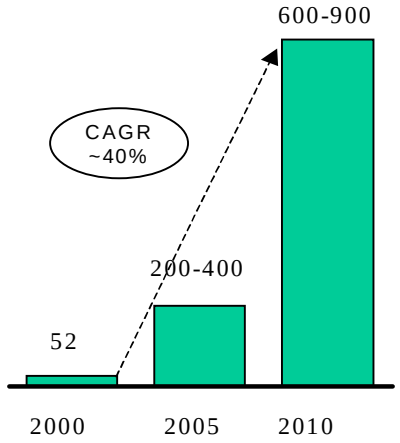
Source: Collaborative Economics, Inc.

The market potential of these converging technologies is substantial. Based on an analysis of existing estimates, McKinsey has shown that the cumulative market for converging bio-, info- and nanotechnologies could top $1 trillion in about a decade (see figure 4).

Figure 4: Huge Market Potential for Converging Technologies

Information Technology*

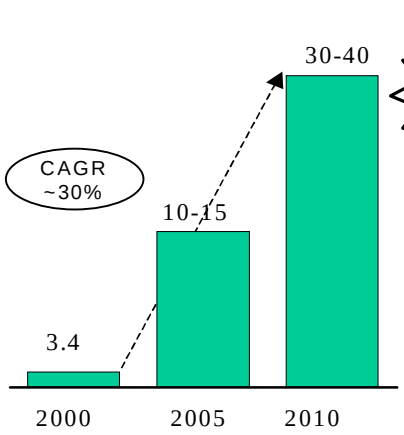
$ Billion



Includes worldwide wireless data based revenue (e.g. content/applications, gateway and middleware,), broadband B2C (US and Europe), PSCA applications

Bio-/High Technology

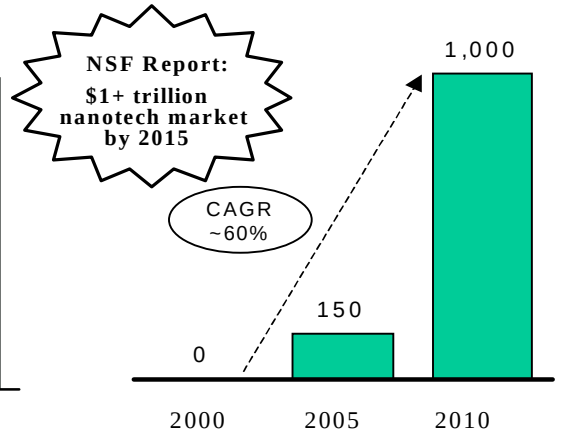
$ Billion



Includes the biochip, bioinformatics and biomaterial (e.g. drug delivery, tissue engineering) markets

Nanotechnology

$ Billion



Some overlap between biotechnology and nanotechnology markets, especially in the area of biomaterials

*Only includes a subset of potential applications.
Sources: McKinsey Analysis, IDC, Goldman Sachs Research, Dresdner KleinwortBenson Research, DLJ Research, Dataquest, National Science Foundation, Nanobusiness Alliance, MIG Report, PJB Publications.
CAGR (Cumulative Annual Growth Rate)

Why will the market potential of these converging technologies be so substantial? As Stan Williams of Hewlett-Packard Laboratories explained in a speech at The Next 20 Years technology conference in 2000, the convergence of these three technologies will drive a revolution in how people live and work:

> We are actually watching the birth of three great new technologies, all simultaneously. "Bio" is the utilization of chemistry in life to not only understand living organisms but to manufacture all types of things that we have in our environment. "Info" is the harvesting, storage, and transmission of information about our environment in all sorts of ways. And "nano" is the control of matter at the scale where basic material properties are determined.
>
> All three of these areas are completing the transition from applied science into technology right now. And during the next 20 years, all three of these are going to see exponential types of increases—many experts estimate these increases to be to a factor of 10,000—in the improvement of the capabilities of each.

Any one of these areas by itself would be classified as an industrial revolution. But having all three of them progressing simultaneously—sometimes competing with one another, but very often interacting and reinforcing one another—is going to be completely beyond anything we've ever experienced.

While this new world of global innovation holds much promise, it is also likely to be more volatile than anything we have known before. We must learn how to ride constant waves of innovation that cause "creative destruction" with major consequences for both organizations and people. The waves are speeding up as the world becomes even more interconnected. Understanding the cycles that drive the Valley and learning how to deal with them are critical for future success. What is happening now is not new. We have been here before. The only differences this time are the size of the waves; the magnitude of their impact on our region, the nation and the world; and how we choose to respond.

III. Silicon Valley Has Assets for Participating in This Global Wave of Innovation

Silicon Valley possesses many assets that could help the region participate in—if not lead—this next wave of innovation. The region has traditional assets that remain critical to economic success, like entrepreneurial culture, capital and people. It also has specific assets that are particularly important in this new wave of innovation, such as firms and research institutions working on bio-, info- and nanotechnologies and their applications.

The most important asset is Silicon Valley's a special habitat for innovation and entrepreneurship. This habitat consists of dense, flexible networks and relationships among entrepreneurs, venture capitalists, university researchers, lawyers, consultants, highly skilled employees and others who know how to translate ideas into new commercial products and services fast enough to stay on the edge of the innovation curve. These complex networks continually connect people to good ideas and test the changing market, always searching for the next innovation.

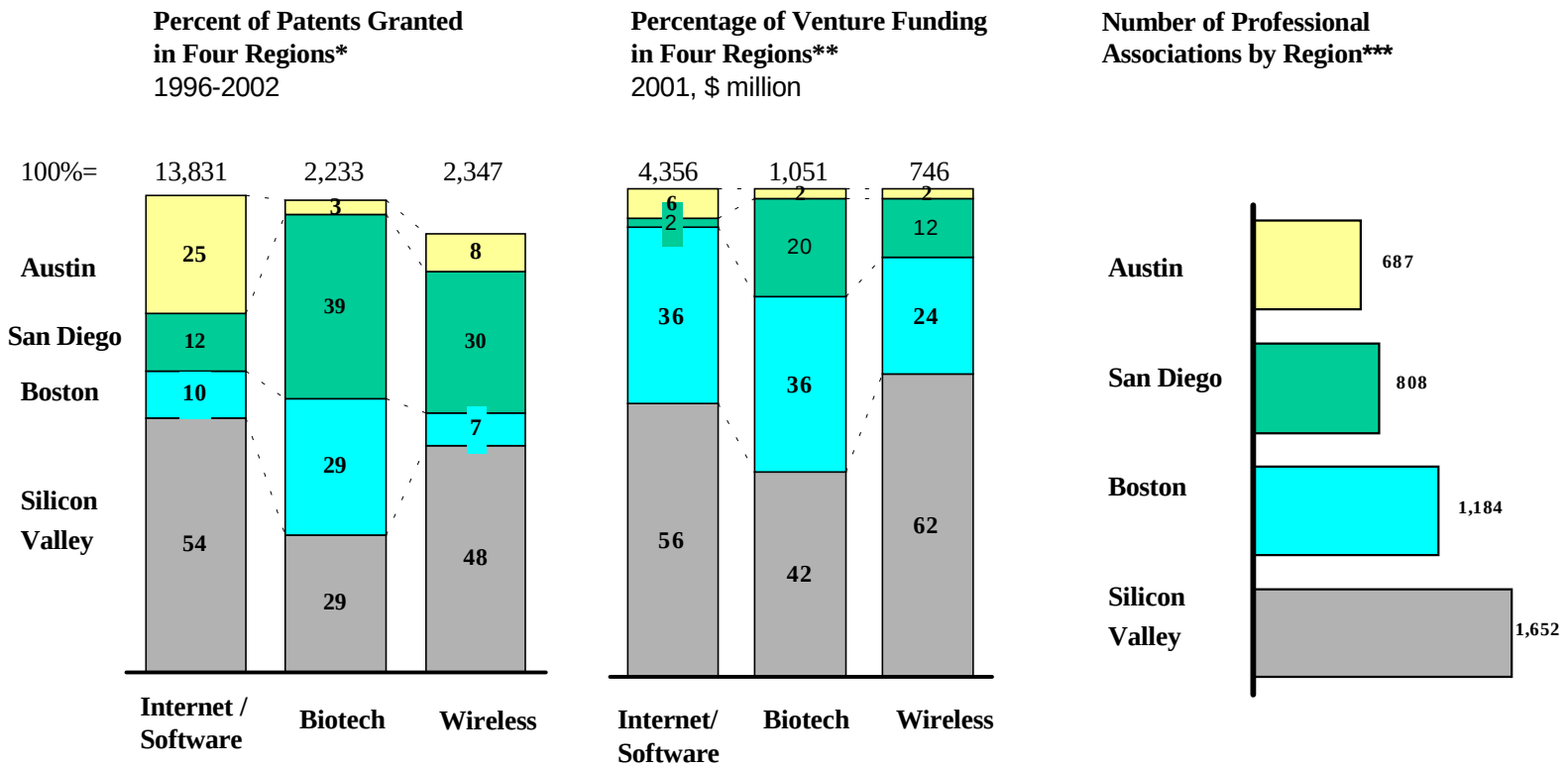
In fact, Silicon Valley has become known as much for its innovation and entrepreneurship as for any specific industry or technology. The region excels at applying and commercializing new inventions. Waves of innovation typically begin with scientists—including those in

other regions—producing technological breakthroughs. Entrepreneurs then innovate and bring new ideas to market, thereby amplifying the wave. In this respect, Silicon Valley's culture of tolerance for entrepreneurial trial-and-error is critical to the risk-taking required for innovation.

The Silicon Valley habitat for innovation and entrepreneurship has enabled the region to make repeated leaps with new technology waves over the last four decades, from leadership in integrated circuits in the 1960s to personal computers in the 1980s to the Internet in the 1990s. All of these innovative leaps occurred in the face of rising costs, growing competition and increasingly rapid diffusion of technology.

In addition to these traditional assets, Silicon Valley and the broader Bay Area possess assets that are particularly critical to this wave of innovation. An analysis of key areas of innovation by McKinsey shows that Silicon Valley is already an established leader compared to other regions (see figure 5).

Figure 5: Silicon Valley Has Been an Innovation Leader in Key Areas



*Number of patents by inventor regions calculated by using the Quick Search option in U.S. Patent and Trademark Office. Boston region defined as Boston and Cambridge; Silicon Valley defined as San Jose and Palo Alto.

**Regions defined using Venture Economics' Metro region definitions; industry definitions based on Venture Economics' Industry Sub-Groups.

***Regions defined by using telephone area codes: Silicon Valley – 650, 510, 408 (the total will be 1,860 if 415 is included); Boston – 617, 781; San Diego – 619, 760, 935; Austin – 512.

Sources: U.S. Patent and Trademark Office, Venture Economics, National Venture Capital Association, Encyclopedia of Associations, McKinsey analysis.

According to Ernst and Young, the broader region already has by far the largest concentration of public bioscience firms of any region in the U.S. (76 in 2001), almost double the number of firms in the next two regions combined (48 in New England and 31 in San Diego). With Silicon Valley's existing strength in information technologies and the broader Bay Area's strength in bioscience—including National Institute of Health (NIH)-funded bio research at UC-San Francisco, Stanford, UC-Berkeley and the national labs—the region is well positioned to participate in this next wave of innovation. According to the Bay Area Bioscience Center:

> Assuming 60,000 direct private and public sector jobs, and a multiplier of 2 to reflect employees of the area's financial institutions, venture capitalists, public relations, publishing, construction, legal, accounting, and management firms which provide services to the life sciences industry and research institutions, this results in an estimated 120,000 employees in Northern California alone.

The convergence of bio- and information technology will extend well beyond pharmaceuticals and medical devices to include biochips, bioinformatics and biomaterials. Both established and newer Valley companies are players in these emerging fields, as described below.

Biochips: The continued miniaturization of integrated circuits requires working at the molecular level. Palo Alto-based *Genencor* is teaming with Dow Chemical to build biochips, including biological optical switches using a new technique: silicon biotechnology. *Affymetrix* bought an old National Semiconductor manufacturing facility in Santa Clara to create biochips that place hybrid bits of DNA on computer chips instead of transistors. Affymetrix has emerged as a clear leader, with 60 percent of a growing $400 million biochip market. It serves as a leading example of a "bridge" company that connects Valley strengths in information technology and biotechnology.

Bioinformatics: The key tool for the commercial application of genomics is information technologies that speed up the process of discovery and product development. As venture capitalist Sam Colella has commented in *Fast Company* magazine, "Recent breakthroughs in genomics have unleashed an abundance of raw data. Those findings need to be crunched in order for drug companies to develop better leads for new types of medicine. We have moved beyond just identifying genes. The next phase can be personalized medicine." Foster City-based *Applied Biosystems* provided the computational tools for the private sector *Celera Genomics* team that help map the human genome. *Nanogen* is using bioinformatics to bridge the gap between research and clinical settings by enabling on-the-spot analysis of genetic samples. *Sun Microsystems* and *IBM* have teamed up with 40 life science organizations to form the "I3C," a consortium aiming to help accelerate the development of genomics and protein research. *Oracle* has launched a $185 million collaboration in bioscience projects with Hitachi and Myriad Genetics.

Biomaterials: Biotechnology holds the promise of creating new materials for applications in manufacturing and agriculture, including new fibers such as DuPont's

"3GT" fiber (which is based on bacteria), new polymers such as magneto-optics used and smart materials such as time-released seeds developed by *Landec*.

Established and emerging companies in Silicon Valley are also making significant commitments to innovation in nanotechnology. Nanotechnology should be viewed as an "enabling technology," or a set of tools that can transform existing industries in Silicon Valley (such as semiconductors and computing) as well as help spawn new industries (such as biochips and bioinformatics). The following examples are drawn from many sources, including the BASIC Task Force, Economic Development Alliance for Business, Bay Area Economic Forum, Bay Area Bioscience Center, NASA and JP Morgan.

- Computer companies with large research labs such as *IBM* and *Hewlett-Packard* have developed substantial nanotechnology programs. IBM researchers have already successfully created carbon nanotube transistors that substantially outperform advanced silicon devices.

- *Hewlett-Packard* researchers have patented a potential breakthrough in their quest to develop computer circuits made merely of individual molecules. HP plans to refine this process to create microchips as powerful as the next generation of silicon-based chips—but 1,000 times smaller and much less expensive. That advance and others in the burgeoning field of nanotechnology could result in computers that are small enough to be worn, embedded in materials or perhaps even injected.

- *Intel* recently announced a new chip-design breakthrough that will enable the development of cheaper and faster microprocessors based on nano-level technology with more than one billion transistors compared to "just" 42 million in Intel's latest Pentium 4 chip.

- *Applied Materials* is building "nanochips," tiny computer chips to power mobile devices. Applied expects that high-speed wireless networks will drive demand for such chips.

- *Nanogram* in Fremont is an example of a leading company developing the core process technology enabling the manufacture of nanoscale optical, electronic and energy-storage applications.

- *Nanosys* in Palo Alto is a small, venture-funded developer of nanotechnology-enabled systems that include applications of nanodots, rods and wires. These materials, which are literally wires or rods one-billionth of a meter in size, are used in optics and molecular-scale electronics.

- *Gilead Sciences* is a Foster City biotechnology firm that develops therapeutics for life threatening diseases including cancer. It is selling a drug delivery mechanism that uses lipid spheres of 100 nanometers in diameter that encase an anti-cancer drug While primarily a bio company, Gilead Sciences is an example of the emerging use of nanotechnology in the pursuit of bioscience breakthroughs.

The Bay Area seems well positioned to be a global leader in the emerging commercial field of nanotechnology. *Small Times* magazine has identified the region as having the highest concentration of research and industry capabilities in the nanotechnology field. This includes not only research strength at UC-Berkeley, Stanford, NASA Ames and Livermore Berkeley National Laboratory, but also at least 50 nanotechnology companies. *Small Times* also noted that "Silicon Valley has had four decades to develop a technology-focused infrastructure, academic agenda, talent pool, and culture of innovation."

New interdisciplinary research facilities are being established across the Bay Area to augment this existing research capacity:

- *Stanford Bio-X Center* connects the schools of Medicine, Sciences and Engineering around the use of computational tools in molecular, cellular, tissue and organ research. The catalyst for this work is the new Clark Center, a building designed by Norman Foster that will serve as the hub for 275 interdisciplinary researchers.

- *QB3 Institute for Quantitative Biomedical Research*, one of the California Institutes for Science and Innovation funded by Governor Gray Davis, will draw on the strengths of three UC campuses (San Francisco, Berkeley and Santa Cruz) in biology, computer science, physics, chemistry and engineering. The goal is to integrate our understanding of biological systems at all levels of complexity, from atoms and DNA to cells, tissues, organs and entire organisms. This will require advances in bioinformatics and bionanotechnology, and could lead to advances such as personalized medicines.

- *Center for Information Technology Research in the Interest of Society (CITRIS)*, the other California Institute in northern California, is a partnership between UC-Berkeley, Santa Cruz and Davis. Leading Silicon Valley companies (e.g. HP, Sun, Intel, Agilent) and private donors have pledged over $170 million to match the state's $100 million investment. The goal of CITRIS is to develop "societal-scale information systems" that can enhance our quality of life by boosting energy efficiency, reducing traffic congestion and improving our ability to respond to natural and man-made disasters.

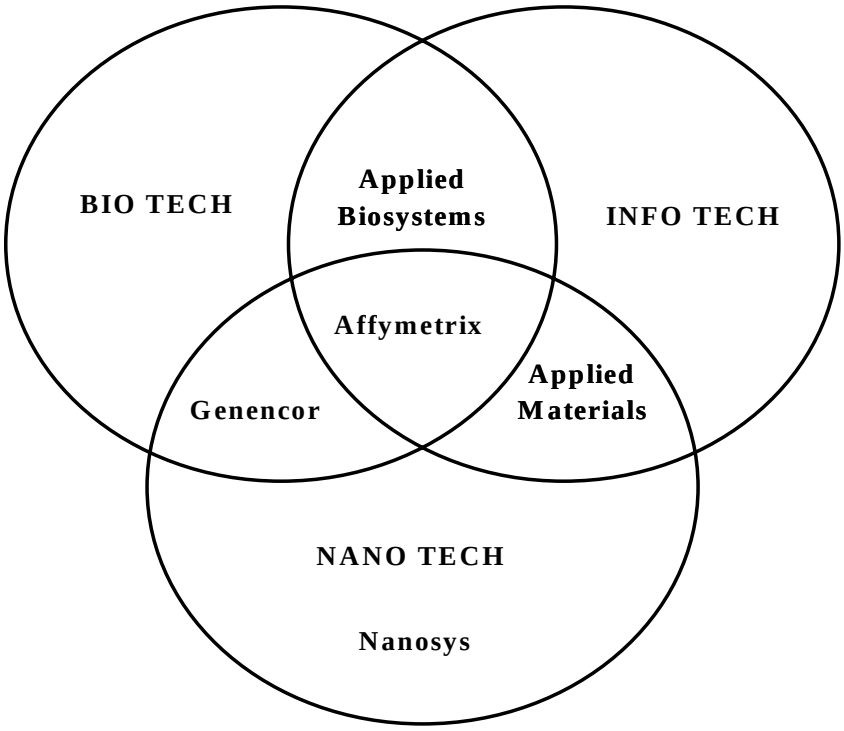
- *The Lawrence Berkeley National Laboratory (LBNL) and UC-Berkeley* both have created new nanotechnology initiatives. LBNL has received approval from the Department of Energy for the $85 million "Molecular Foundry," a national user facility that will provide researchers and Bay Area companies with the cutting-edge tools they need to explore the frontiers of nanotechnology. In addition, UC-Berkeley is launching a major initiative in nanoscience and

nanoengineering to develop a new multidisciplinary curriculum, recruit additional faculty and create shared facilities for nanoscale imaging and fabrication.

- *NASA Ames Research Center* is planning to expand significantly on its foundation of nanotechnology research activities, including carbon nanotubes (important to nanoelectronic devices, computers and sensors), computational nanotechnology (key to modeling and simulation) and biosensors (including collaboration with the National Cancer Institute to develop a nanoelectronic-based biopsy sampler).

It is clear that Silicon Valley is well positioned for the coming convergence, given its research assets and existing companies. Many of the leading companies in the "crossover" fields are already working in this region.

Figure 6: Examples of Convergence



Source: Collaborative Economics, Inc.

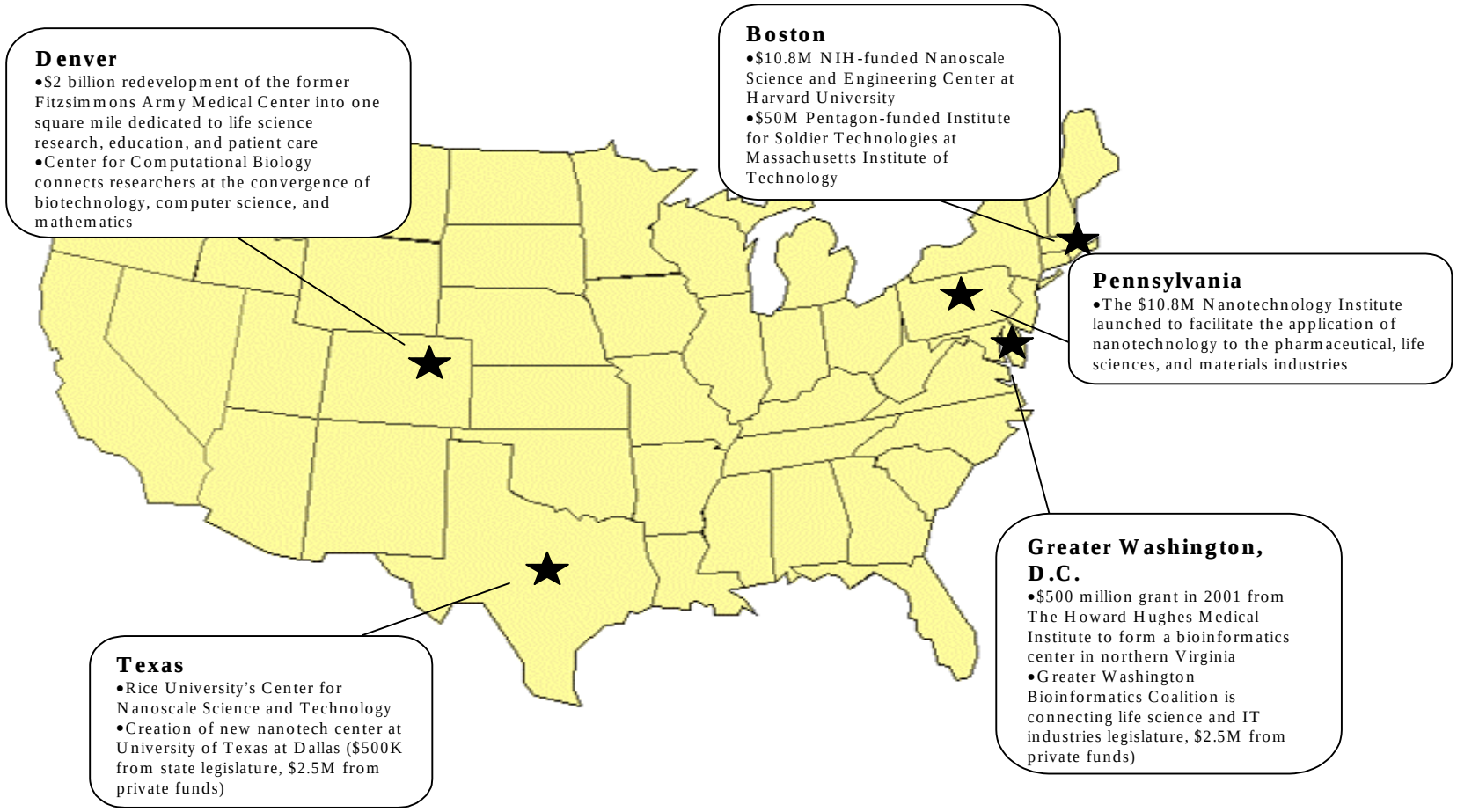
The challenge for Silicon Valley is how to "connect the dots" and leverage these substantial assets to take advantage of the next wave of innovation across the entire region.

IV. Silicon Valley Will Face Competition from Other Regions

Despite its strong assets, Silicon Valley will have to compete with other regions that are aggressively investing in this area of innovation. The region's role in this new wave is not guaranteed. A diverse set of competitors is emerging, including San Diego, Boston, Washington D.C., Pennsylvania, Colorado and several regions internationally.

In 2001, the National Science Foundation (NSF) announced awards estimated to total $65 million over five years to fund six major centers in nanoscale science and engineering—none of which are in the Bay Area. The awards are part of a series of NSF grants—totaling $150 million in fiscal year 2001 alone—for research in applying nanotechnology to information, medical, manufacturing and environmental technologies. The six centers will be located at Columbia University, Cornell University and Rensselaer Polytechnic Institute in New York; Harvard University in Massachusetts; Northwestern University in Illinois; and Rice University in Texas.

Figure 7: Nanotechnology Investments by Region



Source: Collaborative Economics, Inc.

Already a leader in the biosciences, the greater Boston region is also emerging as a pacesetter in nanotechnology. In 2001, the National Science Foundation (NSF) awarded Harvard University a $10.8 million grant to form a nanoscale science and engineering center. A big factor in winning the grant was the existence of Harvard's Center for Imaging and Mesoscale Systems (CIMS), which has facilities and equipment available to conduct nanoscale research (such as a clean room and electron microscopes). Close by, MIT has been working on nanotechnology for over 10 years. It recently announced two new initiatives: The Institute for Soldier Nanotechnologies (a $50 million Pentagon-funded laboratory to create nanotech gear for soldiers) and the NanoMechanical Technology Laboratory which opened in March 2002 with at least a dozen faculty from more than five departments at MIT who will be actively involved in the "NanoLab"

Several states are also making significant commitments to nanotechnology. The Nanotechnology Institute, a multistate initiative involving Pennsylvania, New Jersey, Delaware and Maryland, called was launched in 2000 to support the rapid application of nanotechnology to the pharmaceutical, life sciences and materials industries—already key strengths of the region. Funded by a $10.8 million grant from the Commonwealth of Pennsylvania, the Institute is supporting four interdisciplinary research teams spanning 47 faculty across nine universities and includes corporate partners, private investors and government agencies. The Initiative is focusing on education and workforce development and entrepreneurial support, and is in the process of forming international alliances with Japan, Italy, Germany and Great Britain.

Texas is home to Rice University's Center for Nanoscale Science and Technology, a pioneering institution that was the first U.S. laboratory dedicated to nanotechnology. Recently, the Texas legislature approved a $500,000 grant to help fund another nanotechnology research center at the University of Texas at Dallas. The grant is being matched by the University and a nanotechnology entrepreneur, Jim Von Ehr, who are each contributing $2.5 million for the creation of the Center. Von Ehr, founder of Zyvex, also helped found the Texas Nanotechnology Initiative, which is a consortium of participants from industry, universities, government and venture capital firms, all of whom are committed to supporting the development of nanotechnology enterprises in Texas.

The Greater Washington D.C. region is aggressively trying to become a leader in bioinformatics. In 2001, The Howard Hughes Medical Institute, the largest private biomedical research organization in the U.S., announced that it would invest $500 million to form a bioinformatics center in northern Virginia. Regional leaders have formed the Greater Washington Bioinformatics Coalition to build on the area's strengths—in particular, Virginia's information technology concentration and Maryland's bioscience concentration—to position the region as a leader in the converging technologies. The Coalition involves over 30 organizations, including educational institutions (George Mason University and George Washington University); economic development interests (Fairfax County Economic Development Authority and Virginia's Center for Innovative Technology); and private companies (Viaken Systems, the Adrenaline Group and Inova Health Systems).

Another aggressive competitor that has emerged in bioinformatics is the greater Denver region. Led by the University of Colorado and the UC Health Sciences Center, the Center for Computational Biology is a new initiative to connect researchers from different disciplines—particularly at

the convergence of biotechnology, computer science, and mathematics—and forge collaborations between academia and industry. The Center also plans to create new courses and programs in computational biology and introduce a Ph.D. program in bioinformatics. New infrastructure is also being created in the form of the $2 billion redevelopment of the former Fitzsimmons Army Medical Center into one square mile dedicated to life science research, education and patient care. According to Ernst & Young, the region's biotechnology sector is growing faster than those in other regions and could eventually rival Silicon Valley, Boston and North Carolina's Research Triangle in terms of venture capital investments, impact on the local economy, and research and development programs.

International competition in nanotechnology also seems assured. In fact, by some estimates, the U.S. makes up only 30 percent of global nanotechnology investment. The Asia-Pacific region, Germany, and Great Britain have significant nanotechnology efforts underway. In Great Britain, for example, plans are in place for a new £80 million (about $144 million U.S.) manufacturing complex for microsystems and nanotechnologies that will employ 10,000. The Japanese government has proposed investing $1 billion in nanotechnology—far more than the U.S. budget for the National Nanotechnology Initiative.

While these competitors vary widely in the quantity and quality of their assets for innovation, they share the same commitment to promoting collaboration across technologies, sectors and institutions. Each of these regions is already organizing itself to make the most of its existing assets, strengthen them, and add new capabilities. Past Silicon Valley advantages like specialized talent and entrepreneurial spirit are becoming more prevalent in other regions. Without a doubt, these regions—and many more—will move aggressively to be included in the next wave of global innovation in bio-, info- and nanotechnology. In view of this growing competition, Silicon Valley cannot "stand pat" and expect to remain a leader.

V. Silicon Valley Will Have to Make a Choice

While our region seems well positioned for the next wave of innovation, a positive future is not guaranteed. We clearly have a strong concentration of regional assets, but we also have a wide dispersion of those assets. While we can point to tangible examples of convergence in our region, we certainly have not reached critical mass. Are we really leveraging our assets and connecting them through collaborative projects and investments, or are they operating more as "silos of activity" and missing the opportunity for convergence? Many believe the latter to be the case. What we do know is that our competitors are aggressively moving forward, investing in and connecting their assets. Given these realities, one possible future is that:

- ***The wave could completely miss us.*** The new wave of innovation could pass us by because leaders in other regions provide a better habitat for companies' bio-, info- and nanotechnologies to flourish. In the meantime, our economy could decline as innovative firms move out and other firms struggle to remain viable in established technologies and markets. Our talented and entrepreneurial people could opt to migrate to regions that are leading the wave and providing better economic opportunity and quality of life.

While it may seem inconceivable that Silicon Valley has reached its historic peak, history teaches us that economic leaders in one technology era can lose their place in the wave of innovation that forms the next era. The Pittsburgh of 1900 was a lot like the Silicon Valley of 2000, riding high as the unrivalled technology leader of its day, and famous for its culture of entrepreneurship and for creating wealth at an astounding rate. Within 30 years, though, Pittsburgh plunged into a decades-long decline, losing an enormous number of jobs and residents. The lesson: When a region misses a wave, it compromises—or even destroys—its ability to catch subsequent waves, since each wave of innovation emerges from seeds sown in prior waves (e.g., talented people who leave large companies to create new entrepreneurial firms).

However, rather than accept decline, perhaps we will adequately leverage our assets and stimulate a new wave of innovation in the region. Still, inadequate planning could still see us falter nonetheless. In this future:

- ***The wave could roll over us.*** Like the Internet boom, the next wave of innovation could happen here, but with negative consequences. In failing to prepare our people to participate, we could be forced to import thousands of new workers. If we do not prepare our communities for the influx of people and the new development pressures, they could experience significant disruption. We would therefore ruin our quality of life and, in the process, compromise our ability to retain talented, entrepreneurial people.

The wave of new technologies developed commercially from the early 1990s triggered hope that a different kind of economy was emerging, one that offered the prospect of improved productivity, a rising standard of living and full employment. What we discovered was that the demands, speed and volatility of the economy created real challenges for people, companies and civic institutions.

The Silicon Valley habitat suffered damage as a result of the excesses of the Internet boom. The bursting of the Internet bubble and the resulting layoffs are hurting many people. The rapid growth of employment placed a strain on the labor force supply in the region, creating talent shortages and requiring significant migration to the region. This migration, in turn, placed pressure on the region's housing market and transportation systems. The price of housing skyrocketed, making it difficult to attract and retain workers. The decline in quality of life caused by congestion contributed to Silicon Valley's emerging reputation as a "bad" place to live. In addition, many found the demands of the workplace incompatible with responsibilities to family, community and personal health. And, in the end, the boom lifted only some boats producing very little change in the real income of the poorest or even the median-income households in the Valley.

Instead of accepting decline or replaying the past, perhaps we will choose a different future:

- ***The wave could work for us.*** In this scenario, we would understand what's coming, prepare our people and places for it and use the next wave to create a broadly shared prosperity that would not sacrifice our quality of life. We would

therefore be able to retain a talented, entrepreneurial workforce that leads us into a new era of prosperity.

Clearly, now is the time to try to put our region on the third path: preparing for the next wave of innovation and making it work <u>for</u> us, not against us. Our challenge is to harness the next economy to create the next community, an exciting place to work and a wonderful place to live for all our residents. Meeting this challenge will require strong leadership. Without leadership, the wave will either miss us or roll over us. Only corporate, government and other community leadership, working together, can shape how we meet this global wave of technological innovation.

In fact, a different type of innovation—social innovation—will be required to make technological and economic innovation work for us in the years ahead. Management guru Peter Drucker writes that "social innovation may be of greater importance and have much greater impact than any scientific or technical innovation."

We have practiced social innovation before, so we should be able to do it again. For example, Silicon Valley people and institutions pioneered less formal, less hierarchical workplaces and social orders, social innovations that helped spur technological and economic innovations, and made our region an attractive place to live and work. Recently, Santa Clara County became the first county in the nation to ensure health care for all children, a major social innovation that could help ensure long-term economic competitiveness. To shape the coming wave of innovation into a positive future for Silicon Valley, we will need to pioneer more new and effective approaches to preparing our people and communities for change.

The economic health of our region will depend on its underlying social health, including the quality of its education, the affordability of its housing, the efficiency of its infrastructure in getting people to and from work, and the upward mobility of its people. At its core, the high productivity of the region is based on both core assets—including its talent, technology, infrastructure and capital base—and the ability to reduce "transactions cost" through its networks and relationships. Anything that harms those assets or networks, in turn, hurts the Valley.

In particular, the younger generation of talented, entrepreneurial workers will need to lead the next wave of innovation. Those now aged 25 to 45 will be indispensable to our future prosperity, but this is the same group that is having enormous difficulty affording homes in Silicon Valley. In this way, housing affordability is an example of a long-standing regional issue that is given new urgency as a serious barrier to our future economic success and ultimately the quality of life of Silicon Valley.

Despite the challenges, we can choose a positive future for our region. We can recognize the next wave and prepare our people and places to participate positively in the next economy, making it work better for all of us this time. The potential community benefits if we proactively prepare are various:

- *Local residents* will benefit from new occupations and careers, higher living standards, less displacement, and more opportunities to become homeowners, especially among the younger generation.

- *Local cities and counties* will benefit from new public revenues, full use of existing space, more downtown development, less pressure for sprawl development and more opportunities to retain younger residents.

For local residents, there will be opportunities to participate in new prosperity. Those involved in the convergence of bio-, info- and nanotechnologies suggest that new kinds of skilled workers will be required. While some new Ph.D.s will be needed, much of the future workforce will likely require bachelor's degrees, associate degrees, professional certificates and other specialized training beyond high school. While there will be few opportunities for low-skilled workers, there will likely be opportunities accessible to a wide range of Silicon Valley residents, including youth now in elementary and high school, and adults who could make the transition from other occupations if given the appropriate post-secondary education and training.

- If, as a region, we are able to create the education and training programs to meet this coming demand, and current residents are able to prepare themselves, then the next wave of innovation could give the next generation—today's children—an opportunity both to remain in this region and to afford homes in the communities where they grew up.

- If, as a region, we are able to prepare residents from less advantaged backgrounds for a "step up" into entry-level occupations with career potential, then the next wave will be an inclusive wave of shared prosperity, lifting the living standards for everyone and limiting the displacement of these individuals and families.

- If, as a region, we are able to create a "super-flexible," high-trust work environment that benefits both employers and workers—one that supports fluid work arrangements and creates lasting bonds of trust—then we will be able to sustain a high level of innovation in the years ahead.

For local cities and counties, there will also be opportunities to participate in this new prosperity. Those involved in the convergence of bio, info, and nanotechnologies agree that new kinds of workplaces will be required. Our region may not be home to many new large biotechnology manufacturing operations; we are too costly and lack large tracts of land for new facilities. However, our region is likely to be a location for computer-based R&D and for smaller-scale customized and prototype manufacturing. Many existing facilities—those used by firms during earlier waves of innovation—could be reused during the next wave. Moreover, much of the convergence will not involve manufacturing at all, focusing instead on the creation and integration of information and knowledge. Firms doing this work can be located in existing office parks or downtown areas, or similar settings.

Preparing for the next wave of innovation will require entrepreneurial local government. Cities and counties will need to reach out to the private sector, work together to anticipate change and creatively find space for innovative firms despite the fiscal incentives now shaping land-use decisions (e.g., a public finance system that encourages large, sales-tax-generating retail over other kinds of development).

- If, as a region, we are able to anticipate and direct new businesses into existing facilities (e.g., Affymetrix's reuse of a National Semiconductor facility in Santa Clara) or into more desirable locations (e.g., infill locations in downtown areas), then the next wave of innovation can be fit into our communities with a minimum of disruption and sprawl.

- If, as a region, we are able to welcome new businesses into our communities on mutually beneficial terms, our cities and residents can enjoy the benefits of economic vitality, including increasing public revenues to pay for higher-quality community services and amenities (e.g., parks and community facilities).

- If, as a region, we are able to provide housing that is accessible to the younger generation and located so as to minimize traffic congestion, we can retain our talented, entrepreneurial workforce with a minimum of community disruption and sprawl.

The next wave of innovation (and the resulting new business vitality) can also be a source of new corporate involvement in the community. Working together with emerging businesses and their leaders, communities can help integrate businesses into the fabric of civic affairs and help cement their long-term commitment to the region. In this way, perhaps the region can produce more responsible corporate citizens and fewer disengaged firms that care little about their impact on the community.

There may be a fundamental difference between this wave and the last waves. Prior waves were based on an industrial model that required more space and more people, and hence promoted rapid quantitative growth spurts that placed major demands on our community infrastructure. This next wave may be different. We may have the opportunity for high productivity growth based on a fundamentally different industrial model with fewer material inputs and land required. The "small technologies" of the future may lead to different development and employment patterns in the next Silicon Valley.

A future based on economic and social innovation that creates a widening circle of prosperity without sacrificing our quality of life may be just right for our region. Perhaps we can imagine a world of high productivity and social innovation where, in the words of famed economist John Maynard Keynes, "The day is not far off when the economic problem will take the back seat where it belongs, and the arena of the heart and head will be occupied where it belongs . . . (with) the problems of life and human relations."

VI. How We Can Choose a Positive Future

To choose a positive future, as a region we must begin preparing today. No one knows exactly what this next wave of innovation will produce in terms of jobs, companies and the like. However, we can be proactive, rather than reactive, by asking ourselves the right questions and working together to move quickly as the answers become clearer over time.

We can proactively shape our future by taking following actions:

1. ***Develop a shared mindset about the future of Silicon Valley***. We need to communicate the possibilities of the coming wave of innovation and the opportunity to chose a future consistent with our region's values. Perhaps this vision could produce a shift in mindset that can help us think about a future of high productivity and social innovation that expands opportunity without destroying our community. Perhaps this vision could also help us communicate to those outside our region that Silicon Valley is preparing to be a leader in this new wave of innovation.

   Key Questions for Consideration: What is the compelling vision that can shift the region's mindset about the future and help us prepare our people and communities to participate? How can we best bring together the converging technologies and industries, and unite the broader community around a shared positive vision for the next Silicon Valley?

2. ***Fill the innovation pipeline of the next Silicon Valley economy.*** While we have many of the assets, we must ensure that our innovation "pipeline" is filled with interdisciplinary R&D funding, including investment from the federal government. The pipeline must also work effectively to translate R&D into new products and services. This means making investments to keep Silicon Valley at the forefront of R&D, while also making strong connections among technology areas and firms to capitalize on this R&D.

   Key Question for Consideration: How can we best build and leverage our assets on a Silicon Valley and broader Bay Area basis?

3. ***Increase the number of local "stakeholders" in the next Silicon Valley economy.*** Education and training institutions and local firms must begin planning now for occupations and careers that are emerging and will grow considerably in the future. This means new programs, changes in curriculum, better career awareness among youth, and better recruitment and support for lower-skilled workers so they can make the transition.

   Key Questions for Consideration: What are the careers of the next economy? What education and training do we have in place now? What do we have to add? How can we make sure we have broad participation, especially among those who traditionally have been left behind by past waves of innovation?

4. ***Encourage an engaged workforce with fluid employment options and pathways***. To ensure that the region's workforce can adapt to the new demands and volatility produced by the next wave of innovation, Silicon Valley must have a "super-flexible," high-trust work environment. Super-flexibility means addressing the needs of employers and workers for fluid work arrangements over time, such as regular full-time employment, regular reduced-time employment, self-employment, contracted work, temporary help and mixed models blending work and education or training. At the same time, a high-trust work environment is necessary for sustained high performance and innovation. With many disillusioned by the "dot-com bust" and the economic downturn, a new kind of employee/employer relationship may be required to carry Silicon Valley into the next wave of innovation.

   Key Questions for Consideration: How do we encourage widespread adoption of new models for super-flexible, high-trust employer/employee relationships? How do we encourage a shift from traditional, standardized careers and employer arrangements to customized careers and workforce arrangements?

5. ***Build the next Silicon Valley economy into our communities***. Cities and counties, the development community, the building trades, firms, and others must work together to anticipate the new workplaces required, and direct the next wave into existing facilities, downtown centers and other desirable locations.

   Key Questions for Consideration: How do we weave new firms and corporate leaders into the fabric of our communities in mutually beneficial ways? What incentives can we create to promote entrepreneurial investments by local government? What will the "next Silicon Valley" require in terms of land, facilities and resources?

6. ***Recognize that our long-standing quality-of-life issues are serious obstacles to creating the next Silicon Valley.*** Faced with growing competition from other regions for a place in this new wave of innovation, we must make more progress on issues such as affordable housing, transportation and K-12 education. Unless our region makes more significant progress on these issues, we face the undesirable prospect of either missing the wave or having it roll over us, thus further compromising our quality of life.

   Key Question for Consideration: How can we give new urgency to our long-standing quality-of-life issues so as to ensure that we participate positively in the next wave of innovation?

The bottom-line is leadership, and, more precisely, regional stewardship—leaders committed to the long-term future of this area. Will business, government, education and community leaders step up to the challenge? Will regional stewards build a future that blends technological, economic and social innovation to improve the quality of our lives and communities? The purpose of this discussion guide is to explore the opportunities, frame the choices to be made and issue a call to action to regional stewards across Silicon Valley, urging them to work together to create a bright future for our region.

ABOUT THE NEXT SILICON VALLEY INITIATIVE

The complete paper is available at http://www.jointventure.org/nsv/nsvchoices.pdf. There are many ways to be involved with the Next Silicon Valley Initiative. For more information about this Initiative, please visit www.jointventure.org/nsv or contact Kathy Klotz-Guest, Joint Venture: Silicon Valley Network, at (408) 271-7213 or k_guest@jointventure.org. For sponsorship opportunities, please contact Linda Holroyd, Director of Marketing & Business Development, at 408-938-1511.

ABOUT JOINT VENTURE

Joint Venture: Silicon Valley Network is a regional, neutral, non-partisan voice and a civic catalyst for creative solutions to problems that impact all sectors of the community. Joint Venture brings together established and emerging leaders from business, labor, government, education, and community organizations with the goal of creating benefits for people, businesses and communities. Visit www.jointventure.org for more information about Joint Venture: Silicon Valley Network, or call 408-271-7213.

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