Using Web Tools to Support Workers Transitioning into New Biotechnology Fields:

The Bio-Link Career Exploration Web Site Final Report

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By SRI International

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FOR

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Introduction

"This is the century of biology. Physics has had its good time, but now, it's going to be biology."

Harvard Biologist E.O. Wilson
2008

The Bio-Link National Advanced Technology Education Center of Excellencestands at the beginning of a scientific era of exploration that marshals the technological ingenuity of chemistry, physics, information sciences, and artificial intelligence toward the central goal of understanding the molecular systems and interactions that guide all life. The growth in this scientific field is already radically reshaping the technologies and systems of medicine, agriculture, energy, and engineering. As scientific discovery and innovation expand, so too will the need for workers to support these new industries.

Although these new jobs fall under the broad heading of "biotechnology," they represent a diverse range of disciplines and skills. The good news is that there is projected to be strong growth in work—not just for the scientists and researchers creating this new future, but also for the technicians who will work alongside them. That is the focus of this report and the mission of the Bio-LinkNational Center.

A key challenge facing American workers will be to find their place in this new employment landscape. At present, it is not easy to find one's way. Few students, parents, or guidance counselors know of the kinds of high-skill technician jobs in the biotechnology industry. Those studying biology in college rarely learn or hear about the hands-on, high-skill work going on in cutting edge biotechnology laboratories. Even the experienced lab technician may find it difficult to determine what new skills and tools are required to shift into emerging biotechnology fields, such as nanotechnology and bio-fuels.

To meet this need, Bio-Link seeks to develop a web-based set of tools and resources designed to track and disseminate information about technician jobs in the biotechnology field. Over the past year, Bio-Link has engaged SRI International to conduct a thorough review of the many career web sites focused on biotechnology careers. This review, documented in several previous presentations and reports(see the appendices of this report), revealed there is no one-stop place for connecting to and learning about jobs for the biotechnology technician. It also revealed 11 key features that are potentially helpful to serving the prospective audience for the Bio-Link web site. That audience comprises young job seekers in high school and early college, students near or at completion of a community college biotechnology certificate program, and mid-career workers seeking to transition into emerging biotechnology fields.

This report illustrates how web tools can support the particular information needs of these three types of prospective workers in biotechnology technician fields. It includes **narrative descriptions** of how these specific users might use the features of the proposed Bio-Link web site, tracing each user's distinct point of entry and information search paths. The report also highlights **survey results** from an online questionnaire sent to biotechnology deans. The summary provides updated information from deans of 62 community college biotechnology programs across the U.S. on the biotechnology certificates they offer, the employers hiring their students, and the professional organizations that serve as resources for their programs. The deans' survey was conducted in July-August 2010. The invitation was sent to 108 schools and 62 schools responded.

In addition to updating certificate data, the survey queried the deans to obtain specific content ideas to shape the part of the web site dedicated to younger students who are exploring possible biotechnology careers. Such students typically know only their broad, general interests and desire greater concrete information about work in specific workplaces. SRI offered a sampling of possible personal interest statements designed to serve as entry points for exploration by these students. The deans ranked these statements based on their perceptions of what draws students to their programs. These results provide the Bio-Link community with some ideas of how to catch students' interest in different biotechnology technician fields.

This report presents a **model of a skills matrix** that would provide the web site's underlying "search and match" architecture for the mid-career transition worker. The matrix draws from an analysisintegrating the deans' feedback on updated certificates with three other forms of information: (1) skill standards for the basic biology lab technician, (3) emerging standards on a new biotechnology field, and (3) dean's feedback on the local employers who hire their graduates.

Finally, the report provides a design process **outline** that lays out a general description of the next steps for Bio-Link to consider as it develops its expanded prototype career exploration web site. This section may be taken in conjunction with the Preliminary Resources Analysis Report (SRI International, August 31, 2010) to plan for the expanded career exploration features of the current Bio-Link web site.

Three Use Cases for the Bio-Link Career Exploration Web Site

Here are some examples of how users might interact with the expanded Bio-Link web site to explore careers.

Scenario 1: Younger Student Exploring Possible Careers in Biotechnology

Carlos

High school senior. 18 years old.

Goals: To learn about careers that match his interests in protecting the environment, and find education programs that could prepare him for such careers.

Desires: He'd like to stay in southern California, but would consider colleges across the state or west coast that have good programs and are affordable.

Technology level: Fair. Carlos uses social media Twitter, Facebook, and YouTube, and has used Microsoft Word to do homework.

Carlos will be graduating from high school in a few months. He's worried about the effects of global warming and pollution (having grown up in a smoggy suburb of LA) and has been talking to his biology teacher about careers in which he could help come up with solutions to environmental problems. His teacher suggests that they together explore career options on the Bio-Link.org web site, which the school guidance counselor recently brought to the teacher's attention.

They go together to the computer lab to check out the site. On the home page, Carlos follows a link to "find information about biotechnology careers". He's not sure what biotechnology is, but he does want career information. This brings him to the Explore Careers page, where he is presented with an option to browse and select personal interests from a list, or to select a set of skills that he has. Carlos looks at both lists, but he and his teacher decide that the list of interests is more at his level—he's not sure what most of the skills are, but he does identify with some of the personal interest questions.

One of the questions, "I want to protect the environment", reflects exactly what he wants to do! He selects this question from the list and clicks "Show Matching Careers". The next page presents a list of about 10 job titles related to this interest, including Environmental Technician, Environmental Specialist, Laboratory Specialist, Environmental Health Specialist, Sanitarian, and Industrial Pretreatment Program Specialist. He likes the sounds of "Environmental Specialist" so he clicks on this title. The next page briefly describes what this career involves, job growth projects and average salaries, and information on the kind of education that is needed. The page also links to related careers, and to a video of Mike, a person who

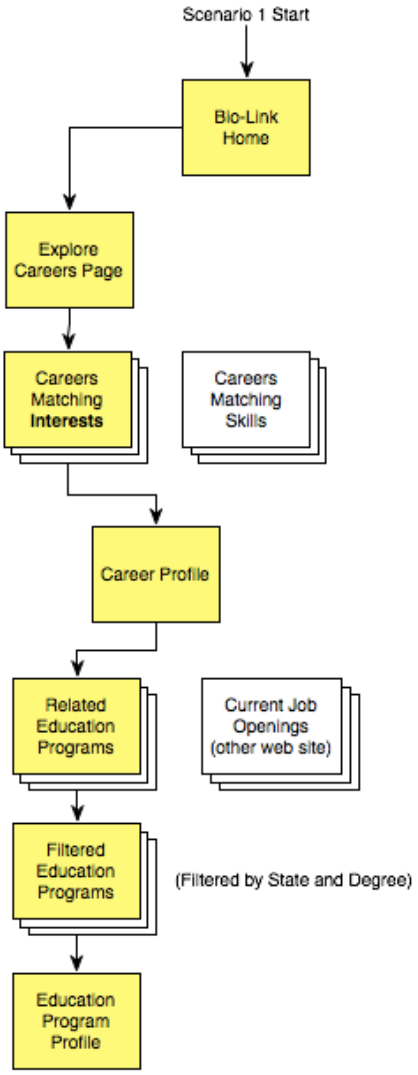
holds such a job. Carlos plays the video and learns about what Mike does in a typical day and how he works with different kind of equipment and other people in a team. He connects with Mike's enthusiasm for his job, and can imagine himself making a difference doing something like what Mike does.

A little farther down the page, Carlos sees a list of skills required for a job as an Environmental Specialist, and sees that the site lets him find educational programs that offer certificate or degree options to gain these skills. He clicks on the "Find Educational Programs" button. The next page presents a long list of programs around the country that provide programs in Environmental Science.

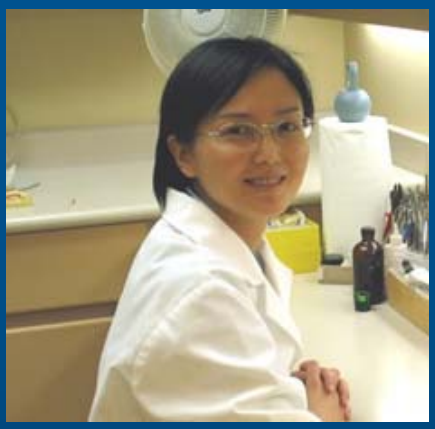
The list provides filtering options, including the option to filter the list by state. Carlos would like to stay in California, so he filters the list to show only colleges in California. This shortens the list to about 30 colleges. The list includes a mix of community colleges and universities. Carlos missed the application deadline for many of the universities on the list. He'd like to go to a university eventually, but will probably need to go to a community college for the first year or two. He filters the list to show programs that offer associate degrees (not bachelor or advanced degrees), which reduces the list to 4 colleges. Carlos and his teacher spend some time looking through the list. After some browsing, Fresno City College catches his eye. He goes to the college's web site to learn more about the program and how to apply.

Features highlighted in this scenario

Exploring careers by personal interest, video and descriptions of careers on career profile pages, finding educational institutions that prepare you for a given career, filtering program results by state and certificate level offered.



Scenario 2. Community College Student with Certificate



Hyeon

A lab assistant completing a certificate in nanotechnologyat a community college. 24 years old.

Goals: To find a career in the field of nanotechnology.

Desires:Significantly increase her salary, and find a career for which there is a good job market in her local community.

Technology level:High. Hyeon uses the Internet frequently, and has been trained on a variety of software and lab technologies in her job and classes.

Hyeon has just one more quarter to go to finish her certificate in nanotechnology. Taking evening classes while working part-time as a lab assistantduring the day has kept her incredibly busy, but she sees some light at the end of the tunnel. She has learned about several career options in the course of her studies and at career fairs sponsored by her college.

One evening after returning home from her nanofabricationclass, Hyeondecides to do a Google search to learn more about various nanotechnologycareer specialties and salaries. She enters “nanotechcareers salaries” in Google and clicks on some of the top results. One of the top results is the Bio-Link site, and the link takes her to a page titled “Explore Careers”. On this page, she notices that she can check off a set of skills and find matching careers. Given her coursework and position as a lab assistant, she checks off several skills, including “Maintain laboratory and equipment”, “Operate equipment”, “Order stock and supplies”, “Maintain biological stock cultures”, “Prepare biological and/or chemical materials”, and “Bottom-up and top-down fabrication”. She clicks “Show Matching Careers”.

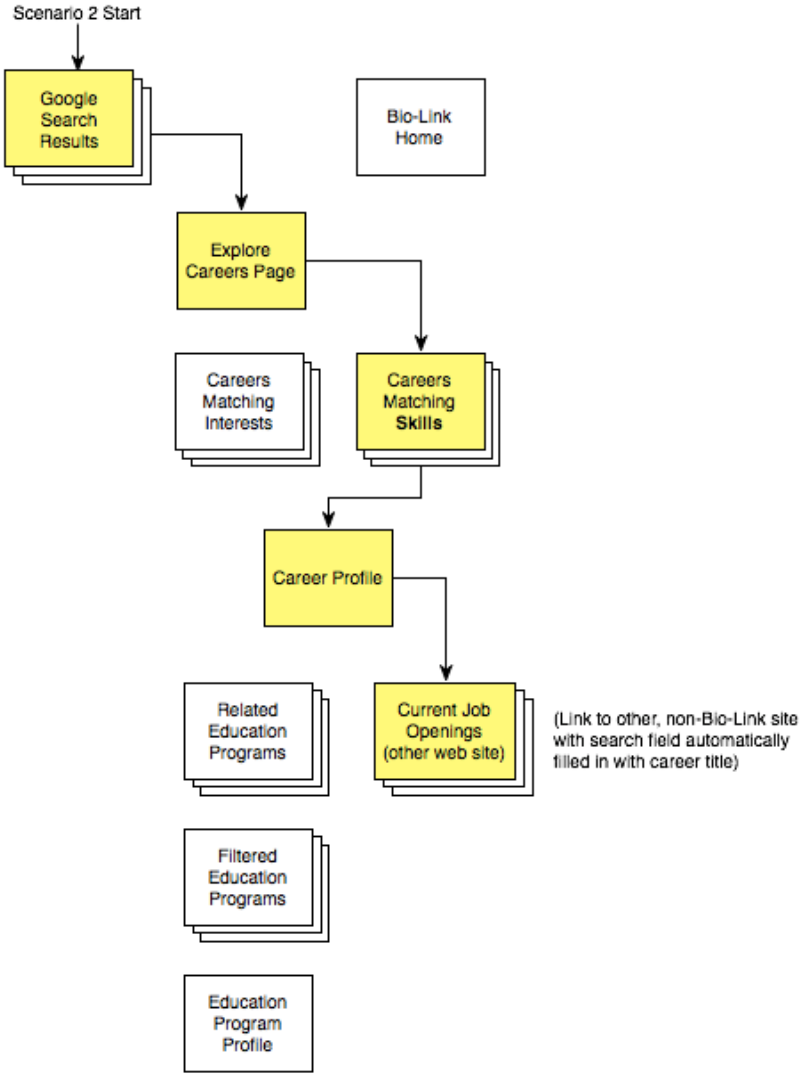
The next page presents a list of four job titles, including Nano Technician, Nano Technologist, Nanofabrication Engineer, and Nanomaterials Engineer. The first title grabs her attention, since she has enjoyed being a lab technician. She clicks on the job title and reads the description, job growth and salary profile.

Under salary information, Hyeon notices that nano technician salaries start around $50,000/year and average salaries are around $85,000. The description says that nanotechnicians often work with nanofabrication engineers and nanoscientists, and there are clear career advancement opportunities—she could work her way up to managing a lab or even becoming an engineer or scientist herself. Hyeon watches a video of Kim, a nanotechnician in the Bay Area, to learn more about the job.

On the page she also notices a link to “Search for nano technicianjob openings” and clicks it to get an idea of where the jobs are. The link takes her to a differentweb site that catalogs job openings. The term “nano technician” has been automatically entered in the search area for her, and the results are already filtered by the title. She wants a job close her where she lives, so she filters the results to positions within 20 miles of her address. The filtered list is still quite long—she is excited that there are many nearby job options related to her interests!

Features highlighted in this scenario

Exploring careers based on skill set, content on career profile pages, linking to a separate job search site andBio-Link automatically filling in the search criteria on the job search site through a URL parameter, browsing job openings, filtering job openings by distance from where she lives.



Scenario 3. Mid-Career Worker Transitioning into Emerging Biotechnology Field

Steve

A farmer in Iowa who raises crops for a local biofuels company. 36 years old.

Goals: To find a nearby education program that offers training in biofuels as an alternative energy technology.

Desires: Use his biofuels degree to produce energy for on-farm use and, possibly, off-site sales.

Technology level: Medium. He uses email and the internet frequently, and does his farm accounting in Intuit Quick Books.

Steve's soy crop yields the past year have been the highest ever thanks to a combination of good weather and technical assistance from biodiesel producers. Since he began participating in the BioIowa program 2 years ago, he has learned a lot from Josh, his liaison with the biofuels company, about different forms of biomass, how they are converted into fuel, and new biofuels under development. Steve decides that he'd like to look into nearby community college programs to learn more about renewable and sustainable resources, as well as specific skills needed to run his own small biofuels business. He was an agricultural major in college, but that was 14 years ago, and agribio has advanced a lot since then.

Steve asks Josh for advice about how he might proceed. Josh says he'll ask some colleagues for ideas and get back to him. The next day, Steve gets an email from Josh with several links to web sites where he can learn more about biofuel technology programs, including the Bio-Link.org web site. Steve visits Bio-Link and enters "biofuels" into the keyword search area on the site. The first result links to a page titled "Biofuels Technician Profile". Steve clicks on the profile and reads more about what the career involves, including job growth and salary prospects, and watches a video about a day-in-the-life of a biofuels technician.

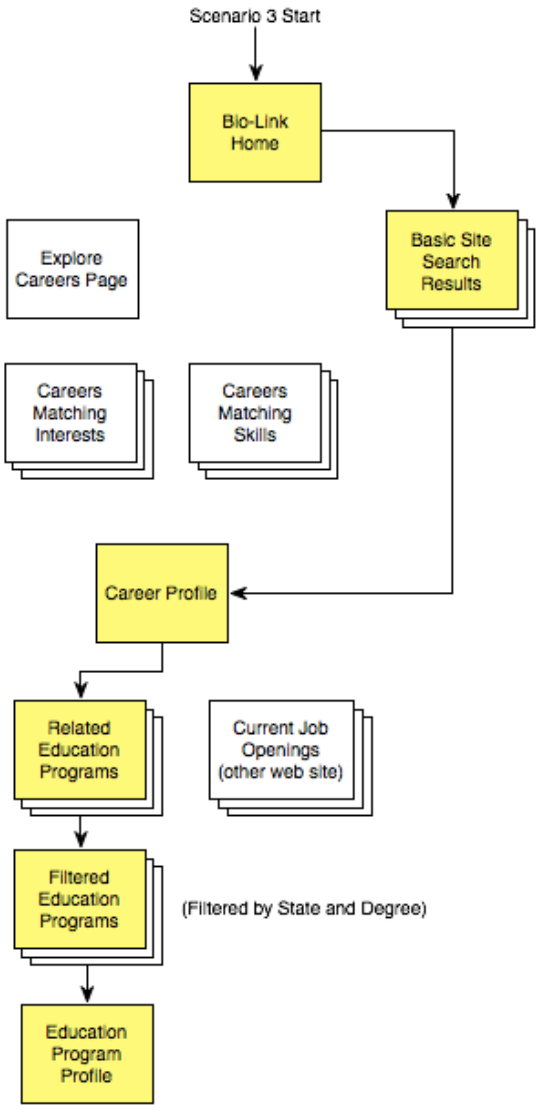
Down the page, Steve sees a list of skills required for the job, and notices that the site lets him find educational programs that offer certificate or degree options to gain these skills. He clicks on "Find Educational Programs" and the next page presents a list of programs around the country that provide programs in biofuels technology. What a difference from when he graduated college 14 years ago--now there are biofuels education programs all over the country! Some of the first few listed include Anoka-Ramsey Community College (MN), Central Carolina Community College (NC), Iowa Central College, Miles Community College (MT), and Richland Community College (IL).

Steve filters by state, and finds three good options in Iowa: Iowa Central College, Iowa State University, and Marharishi University of Management. He got his agriculture degree at Iowa State, but he already has a bachelor's degree, so he's looking for a shorter certificate program. In reading the school profiles, he learns that ICC offers a certificate, and many classes on evenings or weekends. ICC even offers some classes online. Steve thinks that taking some of the early, prerequisite math classes in math online would be really convenient, and since he took math in college,

he should be able to get through the early classes quickly. He follows the contact link to the Iowa Central College web site, and completes a form to request more information about the program.

Features highlighted in this scenario

Simple keyword text search, content on career profile page, finding educational institutions that prepare you for a given career, filtering program results by state, content on education program profile pages.



Community College Biotech Survey Results

SRI administered an online survey during August 2010 to collect career information related to biotechnology. This survey served multiple purposes, from gathering updated information on biotechnology certificates and employers hiring from community colleges nationwide to collecting ideas for appealing “hooks” for student interest in biotechnology fields. Before summarizing the results, the methods and procedure are briefly described.

Method, Questions, and Response Rate

Survey participants included deans from 108 community colleges across 35 states in the United States (see Table 1 for the geographical distribution of the community colleges) and 10 school contact people in case the deans did not respond. The survey included 3 questions about job titles, 2 questions about prospective biotechnology students’ personal interests, 1 question about professional societies, 1 question about certificates offered by the college, and 1 question about biotechnology employers for the college’s graduates (see Appendix A for the detailed questions and options). We estimate that the survey took approximately 10 to 15 minutes to complete. Participants were sent an email invitation that linked to the survey and were offered a $20 gift card for completing the survey. Among the 108 community colleges that we emailed,3 deans opted out from the survey, 1 email was bounced back, 62 deans completed the survey between July 26 and August 13, 2010 and the remaining 42 deans did not respond to the email invitation. So, overall, we have a response rate of 57% (62/108). The results summarized below were based upon responses of the 62 respondents.

Table 1.Geographical distribution of 104 community colleges that were sent the survey invitation.

State	Frequency		State	Frequency		State	Frequency
AL	1		KY	1		NY	5
AZ	4		LA	1		OH	3
CA	14		MA	8		OK	2
CO	3		MD	7		PA	4
CT	2		ME	1		RI	1
DE	2		MI	2		TN	2
FL	3		MN	2		TX	7
GA	3		MO	3		VA	2
IA	5		MS	1		WA	2
IL	1		NC	1		WI	1
IN	3		NJ	3		WY	1
KS	1		NM	2			
GRAND Total	104 community colleges (this total does not include the 3 colleges that opted out and 1 college for which we did not have a correct email contact address)						

Analysis and Results

What jobs do community college biotechnology programs prepare students to enter?

As shown in Table 2, among the 12 job titles listed from US Bureau of Labor Statistics, most biotechnology programs reported preparing students for the job of *biological technician*(56 out of 62 respondents confirmed that their institution prepares students to enter this job). The next most common job reported was *medical and clinical laboratory technician* (31 out of 62 respondents checked this title). Least commonly targeted were *medical equipment preparer* and *veterinary assistant and animal laboratory caretaker* (only 9 and 8 out of 62 respondents, respectively, said their institution prepares students for them).

The survey also provided a secondary list of 14 job titles called "other" for respondents to review. On this list, *research/development technician* was the most commonly targeted (39 out of 62 respondents answered, "yes, my institute prepares students to enter this job") while *environmental health & safety technician* and *facilities technician* were the two least targeted jobs (11 and 10 respectively out of 62 respondents answered yes).

Table 2.Job titles that students are prepared for by surveyed community colleges.

Job Titles from US Bureau of Labor Statistics	Total number of respondents who checked the job title	Percentage of all respondents (n = 62) who checked job title
Biological technician	56	90%
Medical and clinical laboratory technician	31	50%
Chemical technician	23	37%
Environmental science and protection technician	22	35%
Food science technician	20	32%
Medical and clinical laboratory technologist	17	27%
Veterinary technologist and technician	16	26%
Agricultural technician	15	24%
Industrial engineering technicians	14	23%
Medical equipment preparer	9	15%
Veterinary assistant and animal laboratory caretaker	8	13%
Other Common Job Titles		
Research/Development technician	39	63%
Research technician/associate/assistant	37	60%
Research and development technician	35	56%
Manufacturing technician	34	55%
Quality control technician/analyst	29	47%
Clinical lab technician	25	40%
Quality control technician (Chemistry)	24	39%
Forensic Science technician	21	34%
Instrumentation/Calibration technician	19	31%
Bioinformatics technician	14	23%
Animal technician	14	23%
Validation technician	13	21%

Environmental health & safety technician	11	18%
Facilities technician	10	16%

Besides the common job titles that we identified and included in the survey, the respondents listed additional job titles that their institutions prepare students for, including the following:

- Technical trainer
- Technical writer
- Clinical Research Coordinator
- Associate Degree Nursing
- Architectural Engineering Technician
- Automotive Technician
- Chemical Process Operator
- Computer engineering technician
- Criminal Justice
- Culinary Arts Education
- Electronics Technician
- HVAC Technician
- Fire Protection Engineering Technician
- Mechanical Engineering Technician
- Biotech Laboratory Technician
- Quality Assurance Technician
- Biotechnology technician
- Laboratory Assistant
- Laboratory Technician
- Nursing field
- LPN
- Respiratory Therapy Technician
- Phlebotomy technician
- Electrical engineering technician
- Advanced manufacturing technician
- Automotive technician

It's worth noting that two respondents expressed the idea that "the titles are pretty much endless" and "there are some more." This statement aligns with comments from Bio-Link fellows who noted the importance of skills instead of the titles of occupations. We have also found from O*Net (online.onetcenter.org) and CareerOneStop (www.careeronestop.org/) web sites that one occupation can have many alternative reported job titles. For example, the sample reported job titles for *Biological Technician* includes Biological Technician, Research Associate, Laboratory Technician, Biological Science Laboratory Technician, Research Specialist, Research Assistant, Research Technician, Environmental Technician, Resource Biologist, and Wildlife Biology Technician.

What biotechnology certificates are offered by community colleges?

Survey participants were asked to indicate which biotechnology certificates were offered by their community college. The survey provided a list of six possible certificates offered by the nine colleges in the Bio-Link programs (as shown in Table 3), and asked respondents to specify additional certificates offered by their institution. 11 colleges responded indicating that their institutions do not offer any certificates. Several of them stated that they only offer associate degrees, which require 2 full years of course work. Table 3 summarizes the responses from the remaining 51 responding colleges to each listed certificate.

Table 3.Summary of certificates offered by surveyed community colleges.

Certificate	Number of colleges offering a biotechnology certificate (n = 51)
Biotechnician / Biotechnology Bioscience certificate	34
Biomanufacturing Certificate	9
Stem Cell Research Certificate	9
Post Baccalaureate Certificate / Advanced Technical Certificate	8
Bioinformatics Certificate	7
Post-Baccalaureate Intensive Certificate Program	5

As an addition to the listing of certificates in the survey, several more certificates or training programs were provided in the responses, namely:

- Medical Device Manufacturing Certificate
- Flow Cytometry Certificate
- Tissue and Cell Culture Certificate
- A.A.S. in Biotechnology
- Lab Technician Certificate
- AAS Degree in Biotechnology
- Lab Specialist
- Biotechnology Lab Specialist certificate
- Biomedical Research technology
- Biotechnology certificate of completion
- A.S. Biological Technician

What employers hire graduates (and where are they located)?

SRI has compiled a list of biotech program locations (see Appendix B), but to further inform the job search function of the Bio-Link website, we asked participants to provide a list of industry companies that hire biotechnology graduates.We also asked them to provide names of companies on the college biotechnology industry advisory panel. The list of biotechnology companies and assorted research laboratories (state or federal, public, or private) provided by the survey respondents is summarized in the table below, by state.

Table 4.Biotechnology companies and assorted research laboratories reported by survey respondents, by state.

AL	Hudson-Alpha Institute for Biotechnology, Partnership for Biotechnology Research, ThermoFisher, EuroFins-Open Biosystems, Diatherix, CFDRC
AZ	Covance, TGen, TGEN, Genosensor, Capstone, Covance, Barrow Neurological, Intrinsic Bioprobes, Sausavion, USDA/ARS, T-GEN,
CA	Amgen, City of Hope, USC, CSU, UCLA, Grifols, Startup Biotech Companies, GenMark, Neumediciens, Ophidion, Oak Crest, Bayer, Genentech, Mendel Biotechnology, Novartis, BioRad, Pacific BioLabs, BayBioAnalytical Labs, USDA, Dole, Joint Genome Institute, BioMarin Pharmaceutical, UC Davis, Novartis, Bayer, Biorad, California Department of Health Services, Lawrence Berkeley National

	Laboratory, U.S. Department of Agriculture, Division of Food Safety and Inspection, California Department of Justice, Forensic Division, University of California, Berkeley and San Diego, CSU, UC, Inscent, Allergan, Beckman-Coulter, Genentech, Applied Biosystems, Genentech, Excelixis, Gilead, Novozymes, Agraquest, BloodSource, Calgene, Genentech, Johnson & Johnson, Sacramento State University (CSUS), Shriners Hospital, UC Davis, Los Rios CCD Prosetta, Genentech, Gladstone Institute, UCSF
CO	CU Health Sciences Center, National Jewish Research Center,
DE	QPS, Agilent, Gore, Siemanns, Delaware Biotechnology Institutive, Fraunhofer, Institute, DuPont Company, Ashland
FL	Banyan Biomarkers, Pasteuria Bioscience, RTI, Biologics, St Charles Pharmaceuticals, Medtronics, Mayo Clinic, RTI Biologics Inc, Pasteuria Biosciences, LLC Applied Food Technologies, Banyan Biomarkers, Florida Biologix, AGTC, Histology Tech Services, University of Florida
GA	Immucor, Ciba Vision, CDC, UGA, Aderans, Yerkes, Emory, Genesis Biosciences, MVA
IA	Pioneer Hi-Bred, Monsanto,Kemin Industries, USDA,Proliant Health &Biologicals,Heska Corporation New Link Genetics,Marzetti Foods, Midland Bio-Products Corp
IA	Wells Blue Bunny, Diamond Vogel, Valero, Hematech, Green Meadows, Poet, TransOva Genetics, Novartis, SIG International, Foundation Analytical
IN	Cook Medical, Cook Pharmica, Baxter, KPPT, BioConvergence, Valley Foods, Underwriters Laboratories, McCormick, Stan-Bio, Enzyme Research, Research Methods, Serim Research, University of Notre Dame and Indiana University.
LA	LSU Health Science Center, Red River Pharma, SteriFX, BioMedical Research Institute
MA	Abbott, Lonza, UMASS, Athena, Avectia, Genzyme, Biogen/Idec, Millenium, Pfizer, EMD/Serono, Millipore, Shire Human Genetics Therapies, PharmaLucent, Microbiology Associate, Argules, Microbia, MicroTest Laboratories, Genzyme, Pioneer Valley Life Science Center, Vertex
MD	Astra Zenica, Human Genome Sciences, SAIC, Paragon Bioservices, Athena, ES, University of Maryland Biotechnology Institute
MN	R&D Systems, Beckman Coulter, Medtronic, 3M, Lab Support, Kelly Scientific
MO	Sigma, Monsanto, Danforth Center
NJ	Campbell Soup, UMD-NJ, Thomas Jefferson University, DuPont BMS, Jansen, hospital med tech, J and J
NY	Trinity Biotech, Invitrogen, Cornell University
OK	Oklahoma State University Center for Health Sciences Research Labs
PA	Sanofi-Pasteur
TX	Ambion, stratagene, Lexicon Genetics, Molecular LogiX Inc., Synergos, INc, Sigma Genosys, Rigaku Americas Corp, Advisys, SkinMedica, Ut MD Anderson Cancer Center, Life Sciences, Cellz Direct, Cedra, Luminex, Bioo Scientific, Stratagene, University of Texas, LCRA, MD Anderson Cancer Research Center
UT	4Life Research, Inc., Advanced Clinical Research, Affiliated Genetics, Inc. Albion Laboratories, Inc., AlloCure Inc., Amalgamated Research, Inc., American Environmental Testing Lab, American West Analytical Lab, AmeriPath, AMT Labs Incorporated, Aral Biosynthetics, Inc.,AshniNaturaceuticals, Associates of Pathology, Axial Biotech, Inc.,Baicor, Inc., Bard Access Systems, Bio-West, Inc.,Biomicro Systems, Inc.,Biotraces, a division of Asarco,Biotron Labs, Inc.,Calorimetery Sciences Corp., Cephalon Inc., Chemtech-Ford Analytical Laboratory, CIMA Labs Inc., Manufacturing Cognetix, Inc. CornerStone

	Research & Development, Inc., Crantec Research,Cytozyme Laboratories, Inc., DataChem Laboratories, DeltagenDeseret Laboratories, Inc., E Excel International, Inc., Echelon Biosciences Inc. Fillco Custom Bottling,Fluoresentric, GeneTree,Hema Metrics, Heredilab, Inc., HUB Research & Development,HycloneLaboratories, Inc., Idaho Technology, Intech, One-Eighty Corporation, IOMED, Inc. Jean Brown Associates, Inc., K K Biomedical Corp., Kelatron Incorporated, Laboratory Corporation of America, Life Science Products Inc., LineaGen Research Corporation, LumitekkMacromed, Inc., Medical Discoveries, Inc., Mineral Resources International, Mountain States Analytical, Inc., Myriad Genetic Laboratories, Inc., Myriad Genetics, Inc., Myriad Pharmaceuticals, Inc., Nature's Systems, Nature's Way, Natures Sunshine Products, Nelson Laboratories, Inc., NeuroInsight, LLC, Neways International, NuSkin International, Nutraceutical, Nutraceutical International, Occupational Health Care, Inc., OmniLytics, Inc., Organa International, OVOS Natural Health Inc., Pathology Consulting Services, Phytokinetics, Inc., Plant Bioactives Research Institute, Pro Pac Labs, Q Therapeutics, Inc., Radiant Development, Relative Genetics, Ross Southern Labs, Salt Lake Utah Research Project, San Rafael Chemical Services, Inc., Science Applications International Corporation, Scytek Laboratories, Sentrx Animal Care Inc., Sorenson Genomics, Systemic Formulas, Tahitian Noni International, Taueret Laboratories, Timpview Analytical Laboratories, TJ Clark & Co., Trace Minerals Research, TwinLab (Utah Division), Unicity, USANA Health Sciences, Inc., Volu-sol, Inc., Wasatch Environmental, Inc., Weider Nutrition, Western Biological Laboratory, Young Living Essential Oils
VA	ATCC, HGS, Covance, Media Tech, HHMI-Janelia Farm, Acess Bio, BODE Technology, Rividium, Innovative Biologics, Bode Technology, American Type Culture Collection, MediaTech, Covance Laboratories, Rividium Inc, Howard Hughes Medical Institute - Janelia Farm, Access Bio, Human Genome Sciences
WA	Fred Hutch, Amgen, Berlex, Seattle Cancer Care Alliance, Xactagen, Children's Hospital, Dendreon, Pacific northwest National Laboratory, University of Washington, ZymoGenetics, Shoreline Community College, SNBL, USA Zymogenetics, Fred Hutchinson, U.S. Army Center for Health Promotion and Preventive Medicine, Madigan Army Medical Center, Weyerhaeuser PSC LLC, Sterling Reference Labs, Berlex/Bayer, Northwest Kinetics, Dept. of Health, Public Health Laboratories, Merck & Co. Inc, Pierce County Sheriff's Department, Environmental Management Training, LLC
WI	UW-Madison, Novagen, Nat'l Wildlife Health Labs, Epicentre Technologies, Gala, Harlan-Sprague-Dawley, Mirus, Hydrite Chemical Co, Platypus Technologies, Fotodyne, AGSTAT, AMOCO, Doskocil Foods, Gen Trac, Marschall Products/Rhone-Poulenc, Donaldson Co Inc, VA Hospital, WI Dept of Ag, Altagenetics, SciLog Inc, Scientific Protein Labs, Medical College of WI, PPD, Promega, Catalent, National Wildlife Laboratory, Platypus Technologies, Monsanto, Roche Nimblegen, Covance, PPD, UW Madison Biotech Center, USDA Dairy Forage Research Center, Wisconsin State Laboratory of Hygeine, UW Madison Sequencing Center, ABS global, Minitube, Promega, Scarab, ioGenetics, Deibel Labs, WiCell, Hologics, Covance, University of Wisconsin - Madison, Cell Line Genetics, Cellular Dynamics International, Lucigen, Morgridge Institute for Research, Atrium, Forest Laboratories, Scientific Protein Laboratories, ABS Global, Inc.

In addition to listing companies, some respondents mentioned resources for locating biotechnology employers, such as by the Massachusetts Biotechnology Council membership directory (http://www.massbio.org/membership/membership_directory). Members of the council include academic, hospital, industry (biotechnology and associated industries), research institute, and other non-profit organizations primarily located in MA and other states in New England. For instance, the members in Agricultural/Industrial Biotechnology category include 10 companies from MA and NH, namely, Agrivida, Inc., Aqua Bounty Technologies, Biocell Center Corporation, Joule Biotechnologies, Mascoma Corporation, Metabolix, Inc., Myriant Technologies LLC, PharmaSphere, LLC, Qteros Inc., and Stem Cell & Regenerative Medicine International.

Aside from the survey, based upon the web site review SRI conducted in earlier research, we identified BioSpace (http://www.biospace.com/company_index.aspx) as another site where biotech company profiles were maintained. For instance, there are profiles of 300 industrial, biotechnology companies. Besides, the site also listed companies in academic research, Agricultural Chemicals, Big Pharma,

Biopharmaceutical, Clinical Research, DevelopmentDiagnostics, Diversity, Educational Training, Government, Healthcare, Manufacturing, Medical Device, Non-Profit Organization, Pharmaceutical, Recruitment, Services, Suppliers, Technology, and Trade Association.

What personal interest questions could help lead a student to appropriate career paths?

Bio-Link's exploration section of its web site seeks to appeal to younger students based on their interests. This is a strategy modeled after the original OceanCareers web site (www.oceancareers.com) as well as some other web sites. SRI constructed a list of possible interest questions and asked the survey respondents to rank order them by their appeal. In order not to overwhelm the participants, we asked them to rank order only their top 5 choices, with a score of 1 being the highest ranking (i.e., most appealing) and 5 being the lowest ranking. Table 5 summarizes the responses from 62 respondents. The highest and lowest possibletotals for an item show the range of points that could be assigned to that item should each respondent who ranked that item score it a 1(highest ranking) or a 5 (lowest ranking). The total score shows the sum total number of points assigned by the respective respondents for each question item. The itemscore shows a weighted overall score for each question item based on all 62 respondents. This weighted item score was calculated by first assigning a respondent's un-ranked items a score of "6" (indicating they are not appealing enough to be ranked) and then computing the mean score for each item across the 62 respondents. For example, for the question item "I want to work on a team to solve health problems," 48 respondents assigned a ranking from 1-5 (total score of 108) and 14 respondents did not (14*6=84) resulting in a weighted mean score of 3.10. Recall that a lower weighted score indicates that the question item was more appealing.

Table 5.Summary of responses to personal interest questions.

Question Item	Number of respondents who ranked this question	Highest and lowest possible total score	Total score for the question	Item score(weighted score based on all 62 respondents)
I want to work on a team to solve health problems	48	48/240	108	3.10
I want to work with the latest tools, machines, and technology	44	44/220	127	3.79
I want to protect the environment	37	37/185	99	4.02
I want to work on investigations of crime scenes	35	35/175	93	4.11
I want to make sure things are being done correctly and products are safe to use	22	22/110	73	5.05
I want to manage the day-to-day operations or work in data collection or analysis	18	18/90	60	5.23
I want to interact with the public	14	14/70	45	5.37
I want to develop or improve food or beverage products	21	21/105	91	5.44
I want to work with plants, farms, and agriculture	13	13/65	44	5.45
I want to work outside	9	9/45	27	5.56
I want to work with finances and numbers	8	8/40	30	5.71

As we can see from Table 5, the two questions "I want to work on a team to solve health problems" and "I want to work with the latest tools, machines, and technology" were ranked among the top 5 by most respondents (weighted item scoreswere3.10, and 3.79, respectively), followed by "I want to protect the

environment" (weighted itemscore 4.02). Overall, the first four statements in Table 5 were ranked by a majority of the 62 respondents and those respondents who selected these statements tended to rank them high (i.e. ranked as 1-3). On the other end of the rankings table, most respondents did notidentifystatements such as "I want to work outside" (weighted itemscore 5.56), or "I want to work with finances and numbers" (weighted itemscore 5.71) among their top 5 choices. Of note is that the statement "I want to develop or improve food or beverage products" was ranked among the top 5 statements by 21 respondents and that these respondents tended to rank this statement lower (i.e., ranked as 3-5).

In addition to the questions we constructed, many respondents provided additional questions/statements that they believed could help lead a student into biotechnology career exploration. Here is a listing of additional questions/statements.

- Do I want a career that will always allow me to learn new things?
- I want to work in a lab
- I want to work in a lab as lab assistant
- I want to do research
- I want to work in medical research.
- I want to do cutting-edge research.
- I want to work in developing new medicines.
- I want to investigate diseases
- I want to find cures to diseases or disorders that affect humans.
- I want to work on developing new treatments for curing human diseases.
- I want to be a part of something bigger than me.
- I want to understand the bio-manufacturing industry to learn where I might best fit.
- I want to learn about working in a strictly regulated industry.
- I think I would prefer Research and Development over manufacturing.
- I want to work with my hands
- I want to work with science to protect the environment.
- I want to work on developing better ways for waste disposal and bio-degradation of toxic waste.
- I want to work within science to improve the agriculture process.
- I want to work in microbial biotechnology
- I want to solve problems in a lab setting using the most current techniques.
- I want to work in a field that is driven by innovation

Some respondents provided suggestions to improve the wording of the interest questions. For instance, regarding the question "I want to work on investigations of crime scenes," one respondent said "I would change the CSI question to work using DNA technology to solve crimes: crime scene investigation is another matter." One respondent pointed out that "Biotechnology encompasses far more than 'solving health problems'; it includes working in the fields of agriculture, public health, forensics (in its broadest interpretation). Many students list all of the above when desiring to complete a degree in biotechnology." Another respondent commented on the presentation of the questions at a higher level, saying, "I think some more GENERAL questions to get the big picture of where to direct students, rather than the specific (food, data, and finances) would narrow the field that could then be followed up with more specific questions as to the exact field of interest."

What are important industry groups and/or professional societies in the field of biotechnology?

Most survey participants listed examples in response to the question about industry groups and/or professional societies in the biotechnology field. There were some overlaps across different respondents' lists. Of note is that Biotechnology Industry Organization (BIO) and Bio-Link were the two most frequently cited organizations (See Table 6).

Table 6.Biotechnology industry groups and/or professional organizations reported on the survey.

AAAS	BioNJInc	Genencor	Promega
American Breeders Assoc	Biotech Institute	Genzyme	Regulatory Assurance Professional Society
American Chemical Society	Biotech X	International Society of Pharmaceutical Engineers	Sigma Xi
American Society for Microbiology	Biotechnology Industry Organization (BIO)*	Kendrick Labs	Silliker Labs
AOAC	BTCI	Lucigen	Society of Industrial Microbiology
ASBMB	Colorado Bioscience Association	Merck	Third Biotech
Council for Biotechnology Information	Covance	Monsanto	Third Wave
BioFlorida	Deibel Labs	Nature Genetics	Utah Technology Council
BioForward (Wisconsin)	Delaware BioScienceAssociation	NCBI	Virent
Biogen/Idec	FASEB	NEPDA	WI State Lab
Bio-Link*	Forest Products Lab	Parenteral Drug Association	Wisconsin Technology Network
American Society of Cell Biology	HI-TEC Society for industrial microbiology	WWABR	AWIS
International Biotechnology Industry Organization	Northeast Biomanufacturing Center and Collaborative	American Society for Plant Biology	

* Denotes most frequently cited organizations by respondents.

Other than listing the names of the organizations, one of the respondents provides a very helpful hyperlink http://www.medzilla.com/biotechassoc.html where 120 Biotechnology Associates are listed. Additionally, during our review process of web sites, we have noted that BioTech Career Center **Error! Hyperlink reference not valid.** provides a list of local biotechnology organizations, organized by states.

Skills Linkage Matrix

This section presents a model of a skills matrix that would support mid-career workers seeking to see how their skills align with typical requirements of skills for biotechnology jobs. The same matrix may also be used to link students who have completed biotechnology certificates to lists of employers who have hired students from biotechnology programs. This section represents an initial approach. This process would require multiple iterations across different pathways between biotechnology legacy and emerging jobs, and among multiple programs and their lists of employers.

For example, Table 7 shows the basic skills for a laboratory technician. Imagine that Teresa, a laboratory technician, has a basic skill set, a few years of work experience, and is interested in moving into nanotechnology. Teresa might review the skills required to become a nanotechnician (as shown in Table 8) and compare them with the skills she has acquired. As indicated in Table 8, Teresa notes that she has had good training on “safety, and environmental protection awareness” and decent experience in “equipment use and maintenance,” butshe still needs to learn “process design and control.” She has also gained some knowledge of electron microscopy, but has not been exposed to optical or scanning probe skills. Most importantly, she learns that she will need to gain foundational skills in pattern transfer and fabrication. Having identified the gap between the targeted job and her current skill set, she searches for community college programs that offer training on these missing skills.

Now that Teresa has identified the occupation (i.e. nano technician) she wants to pursue and the gap between the skills required by that occupation and her current skill set, she searches for a local community college that offers certificates on nano-related skills. Suppose she lives near Silicon Valley, and the nearest program is the one offered by Foothill Community College. She decides to enroll in the program, taking classes toward a nano technician certificate. Later, when she is close to graduating with the certificate, she wants to see what employers in the immediate region may hire someone with her new skill set. After conducting a search on the job title (“nano technician”) and her region, she sees a listing of potential employers as shown in Table 9.

Table 7. Technical skill set for a basic laboratory technician. Advanced skills that are congruent with those of a nanotechnician are shown in bold.

A1. Maintain Laboratory and equipment	Knowledge of equipment calibration
	Knowledge of equipment operation and troubleshooting/repair for equipment such as pipette-aid, pipettmen, micropipettes, pH meter, centrifuge, scale, autoclave or spectrophotometer, cleaning spatulas, stir bars and flow hoods
	Knowledge of equipment cleaning and PM (Preventive Maintenance) procedures
	Knowledge of laboratory procedures and systems
	Knowledge of cleaning agents and procedures
	Knowledge of hazardous material handling and disposal procedures and laws
	Knowledge of company policies, procedures, laws and regulations regarding Good Manufacturing Practices, Good Laboratory Practices and Good Clinical Practices
	Knowledge of Good Manufacturing Practices, Good Laboratory Practices and Good Clinical Practices training opportunities and requirements
A2. Order stock	
	Knowledge of laboratory requirements regarding stocks such as usage rates and laboratory

and supplies	schedules
	Knowledge of stock record storage locations and procedures
	Ability to identify expired materials
	Knowledge of discard and reprocessing procedures
	Knowledge of stock and supply inventory techniques and ordering procedures
	Knowledge of chemical classifications for proper storage
	Knowledge of chemical safety
	Knowledge of chemical/biological stocks inventory procedures
	Knowledge of logbook and database management procedures
	Knowledge of database security protocols
A3. Operate equipment	Knowledge of equipment operation training opportunities and requirements
	Knowledge of equipment operation and procedures for equipment such as pipette-aid, pipettmen, micropipettes, pH meter, centrifuge, scale, autoclave, or spectrophotometer, cleaning spatulas, stir bars and flow hoods
	Knowledge of equipment operation safety procedures and requirements
	Knowledge of and ability to use personal protective equipment
	Knowledge of company policies
	Knowledge of equipment cleaning procedures and ability to keep equipment in good operating condition
	Knowledge of procedures for equipment logbooks
	Ability to identify and document malfunction, calibration, cleaning, and preventive maintenance activities, and knowledge of associated terminology
	Knowledge of robotic liquid handlers
	Knowledge of microscopy, whole body imaging, fluorophores.
A4. Maintain biological stock cultures	Knowledge of culture labeling protocols
	Knowledge of care and feeding procedures for biological cultures to keep them healthy and viable
	Knowledge of aseptic techniques
	Knowledge of specific culture procedures and associated tools and equipment
	Knowledge of the requirements of laboratory personnel and the projects for which they are responsible with respect to biological stock cultures
	Knowledge of biological stock culture documentation procedures
	Knowledge of safety hazards for each culture
	Knowledge of basic microscopy
	Knowledge of biological culture disposal procedures and law/regulations
	Knowledge of basic bloodbornepathogens and biohazards
	Knowledge of logbook and database management procedures
	Knowledge of chemical/biological stocks inventory procedures
	Knowledge of stock record storage locations and procedures
	Knowledge of database security protocols.
A5. Clean and prepare items for lab	Knowledge of the requirements of laboratory personnel and the projects for which they are responsible with respect to lab ware
	Knowledge of lab ware washing, staging, and sterilization procedures
	Knowledge of lab ware storage locations and procedures
	Knowledge of laboratory project priorities and ability to prioritize special requests

	Knowledge of hazards, pathogen transfer, and safe handling practices
	Knowledge of properties of lab ware materials and proper handling
A6. Prepare biological and/or chemical materials	Knowledge of basic biology
	Knowledge of basic bloodborne pathogens and biohazards
	Knowledge of material preparation training opportunities and requirements
	Knowledge of material preparation procedures
	Knowledge of labeling protocols, and storage areas, and procedures for biological and chemical materials
	Knowledge of material handling procedures
	Knowledge of hazardous materials and disposal procedures
	Knowledge of basic chemistry, including buffers and pH.

Table8.Technical skill set for a nanotechnician, and the match between this skill set and our lab technician's current set of skills.

Technical skills required for nanotechnician job	Match to current skills
Safety and environmental protection awareness.	 Very good match
Foundation skills such as equipment use and maintenance as well process design and control.	 Good match
Foundation skills in pattern transfer including block co-polymer techniques and optical, e-beam, and ion beam lithography.	 Poor match
Fabrication skills including both bottom up (e.g., self-assembly, catalyzed nano-wire growth, colloidal chemistry) and top-down (e.g., etching, deposition, materials modification) processing.	 Poor match
Characterization skills (e.g., optical, scanning probe, and electron microscopy).	 Fair match

Table 9.Potential employers of nano technicians near Silicon Valley.

Aerotek	Pacific Biosciences	NeoPhotronics
Aixtron	Micrel	OpthUS
Aligent	Nanosolar	SRI International
CyberCoders	Nanometrics	Tyco Electronics
IBM	NanoOptronics	Western Digital
InnovaLight	Nanosys	
KLA-Tencor	Nanogram	

New and Emerging Biotechnician Occupations

New biotechnology technician occupations arise as new biotechnology fields emerge and go to scale in the U.S. economy. In the past two years, the U.S. Department of Labor has identified several new and emerging technician occupations related to biotechnology (Table 10). Many of these occupations are considered "green"; that is, they are occupations that have environmental and economic impact around reducing or eliminating green house gas emissions, dependence on fossil fuels, and non-recyclable waste. These types of technician jobs focus on developing new technologies and practices related to energy efficiency, renewable energy, and recycling.

Table 10.New and emerging biotechnician occupations identified by the U.S. Department of Labor's Occupational Information Network (O*NET).

Occupation	Descriptor	O*Net Address
Biofuels Processing Technician*	Calculate, measure, load, mix, and process refined feedstock with additives in fermentation or reaction process vessels and monitor production process. Perform, and keep records of plant maintenance, repairs, and safety inspections.	http://online.onetcenter.org/link/details/51-8099.01
Bioinformatics Technician	Apply principles and methods of bioinformatics to assist scientists in areas such as pharmaceuticals, medical technology, biotechnology, computational biology, proteomics, computer information science, biology and medical informatics. Apply bioinformatics tools to visualize, analyze, manipulate or interpret molecular data. May build and maintain databases for processing and analyzing genomic or other biological information.	http://online.onetcenter.org/link/summary/43-9111.01
Biomass Plant Technician*	Control and monitor biomass plant activities and perform maintenance as needed.	http://online.onetcenter.org/link/details/51-8099.03
Fuel Cell Technician*	Install, operate, and maintain integrated fuel cell systems in transportation, stationary, or portable applications.	http://online.onetcenter.org/link/details/17-3029.10
Nanotechnology Engineering Technician*	Implement production processes for nanoscale designs to produce and modify materials, devices, and systems of unique molecular or macromolecular composition. Operate advanced microscopy equipment to manipulate nanoscale objects. Work under the supervision of engineering staff.	http://online.onetcenter.org/link/details/17-3029.12

*Green new and emerging occupation.

Outline of Next Steps

The closing section provides an overview of best practices for site design and user testing. These practices are highly recommended as effective ways to proceed in developing the Bio-Link web site over the next several months.

Designof the Bio-Link Web Site

The design of new features for the Bio-Link web site should be done through a user-centered, participatory approach (Carroll, 1996; Schuler &Namioka, 1993, Farooq, Schank, Harris, Fusco &Schlager, 2007). User-centered design focuses on understanding the evolving needs of an audience and the impact of design on the audience during all phases of development, from initial conceptualization through design, implementation, and maintenance of a system (Kuniavsky, 2003; Nielson, 1993a, 1993b). While it may seem obvious that design should be desired and strongly influenced by the needs of the target audience, there are endless “good” web sites (e.g., with robust code and good visual design) that fail because they simply address the wrong problem or don’t satisfy the needs of the intended audience. Good user-centered design takes advantage of a collection of best practices—tools and methods that help designers and developers define the boundaries of their target users’ needs and abilities—to create solutions that effectively meet user needs.

The following are broadly recognized as core steps in user-centered web site design:

1. Understand your audience, including their goals, expectations, capabilities, and needs, often done by collecting and prioritizing issues through survey, interview, and focus-group methodologies.
2. Define the scope of the design space and keep the designers and stakeholders focused on user needs and contexts by creating a set of user profiles and user scenarios of how different types of users will interact with the system and expect things to work (as expressed in the User Scenarios earlier in the report) (Nielson, 1993; Kuniavsky, 2003; Rossen& Carroll, 2001).
3. Elaborate key anchor scenarios through paper and pencil sketches and screen designs to better understand and flesh out major requirements of the platform.
4. Get frequent feedback from target audience members in all steps of the process by presenting design artifacts to them; gathering their reactions, and using their feedback help iteratively refine the design.
5. Test the implementation with users to assess the appropriateness of the solution and reveal any problems that users encounter so that they can be addressed (see “User Testing the Bio-Link Web Site” below).

Although many organizations claim to be user-centered in their technology development, most concentrate their interactions with users at the beginning of the project when they are gathering requirements or at the end then they are evaluating their implementation. Prioritizing user input at every stage of the technology development with iteration and feedback as a core philosophy is a relatively new concept that results in a better product and reduces overall project cost because needs and misunderstandings are made evident early in the life cycle when it is easy to react to them. The cost of

making changes in software can increase exponentially the later they are made because of wasted development time and potential changes to the foundational design implemented in the software infrastructure (Ambler, 2004).

User profiles and scenarios are a lightweight user-centered design representations that keeps designers and stakeholders focused on the overall goal of a useful and usable system. A profile describes a prototypical user, her background, and any contextual factors that lead up to an episode described in the scenario. A scenario is a narrative story told from the perspective of an individual (the main actor), and takes the reader through the individual's experience over a period of time, describing what the actor is trying to accomplish and the expected outcomes from the activities. User profiles and scenario descriptions are both concrete and flexible, and as such, can be very useful in managing the tradeoffs and uncertainties of design work while also sharpening and strengthening design goals. They convey vivid images that different participants involved in the project can understand and react to, and can be revised quickly and easily based on feedback.

An earlier section in this report (see p.5) presented sample user profiles and scenarios for Bio-Link users who have a range backgrounds and biotechnology-related skills. We recommend that Bio-Link staff develop 3-5 additional user profiles and user scenarios that cover a range of intended Bio-Link target audience and focus on desired new functionality. These new scenarios, along with the scenarios already provided, could then be presented to various stakeholders for feedback. After a few iterations of editing to address stakeholder feedback, Bio-Link should converge on a prioritized set of key, refined anchor scenarios. These anchor scenarios can then be elaborated through paper and pencil sketches and screen mockups to flesh out the major requirements, user interactions, and functionality required to support key scenarios in Bio-Link.

Many individuals and business offer professional web site design and user testing services. For example, SRI has hired hotstudio.com to help us do user research, interaction design, and usability testing for our public web site. Baychi.org, a local society for human-computer interface professionals, has a consultant directory with a list of professionals in the Bay Area who incorporate user-centered principles into their work and provide user research, interaction design, and usability testing services. As you expand the Bio-Link site to provide additional services around career and education offerings, consider hiring design professionals such as those mentioned above to help you refine the interaction design of the web site and conduct user testing to ensure that the site is meeting user needs and provides a good user experience.

User Testing the Bio-Link Web Site

As the Bio-Link web site continues to evolve, consider hiring design and usability professionals through user experience design companies like hotstudio.com or baychi.org (mentioned above) to help you conduct iterative testing of the Bio-Link site. Such professionals can help to test the appropriateness and usability of the new content and features with members of your target audience and determine priorities for revision. Jacob Nielson's book on usability engineering (Nielson, 1993a) and his useit.com web site are also good resources for learning about how to plan and analyze results from a user test. Framing research questions for Bio-Link user testing might include:

- The first time that users encounter the design, how easy is it for them to accomplish basic tasks like finding a career profile that interests them and matches their skill set, or finding an education program that fits their needs?
- Once users have learned the design, how quickly can they complete such tasks?
- How many and what kind of errors do users make, and how easily can they recover from the errors?

- How satisfied are users with the design? Is it pleasant to use?

User testing is commonly conducted using structured interview and think-aloud protocol methods. During the test, representative users are typically asked to perform a set of relevant tasks (like find a career profile that suites them, post a resume, find job salary information) and to talk about what they are looking at, thinking, doing, and feeling as they do the task. As the users complete tasks with the site, observers will complete an observation protocol to document what users are doing and saying as well as problems that the user encounters. The usability and appropriateness of the site design can be measured through both qualitative and quantitative measures, such as time to complete tasks, how many errors users make, how severe the errors are and how easy users can recover, features or interactions that the user has trouble understanding or asks questions about, features and content the user can remember after the test (in debrief), and proportion of users statements that are positive versus critical both during the session and in a post-session satisfaction questionnaire.

To identify the most important usability problems on a site, at most five users is typically enough for each usability test (Nielson, 2000). Usability professionals recommend an iterative approach in which you run many usability tests, each with 3-5 users, and fix problems in the design between each test to progressively refine the design. Iterating through at least three versions of the interface is recommended, with redesign occurring between each test to fix the most obvious problems. Using this iterative design, test, redesign, test, etc. approach, researchers have found average improvement of 25% for each iteration and around 95% improvement from the first to the last version with 3 iterations (Nielson, 1993b).

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Appendix A. Questions from SRI's Bio-Link Survey of College Deans

Subject	Question stem	Options	Mapping to Topics on Other Sites	Relevant web site section
Job titles: please check the job titles in the list below that your institution prepares students to enter	Job titles from the US Bureau of Labor Statistics	Medical and clinical; laboratory technician; medical and clinical laboratory technologist; Medical equipment preparer; agricultural technician; food science technician; Veterinary technologist and technician; Veterinary assistant and animal laboratory caretaker; Industrial engineering technicians; Chemical technician; Environmental science and protection technician; Biological technician	Career Profiles	Exploration
	Other common job titles	Animal technician; Clinical lab technician; Manufacturing technician; Validation technician; Research/Development technician; Instrumentation/Calibration technician; Facilities technician; Quality control technician (chemistry); Quality control technician/analyst; Environmental health and safety technician; Research technician/associate/assistant; Bio-informatics technician;		

		Forensic Science technician		
	Additional job titles. Please write any additional titles not listed above that your institution prepares students to enter.			
Below is a starter list of "personal interest" questions that could help lead a student into career exploration.	Please check the questions on this list that you think would help LEAD students to appropriate career paths. Please rank order your top 5 choices by what you think will be most appealing to students. 1 being the most appealing.	I want to protect the environment; I want to work on a team to solve health problems; I want to manage the day-to-day operations or work in data collection or analysis; I want to work with the latest tools, machines, and technology; I want to work outside; I want to work with plants,farms, and agriculture; I want to make sure things are being done correctly and products are safe to use; I want to develop or improve food or beverage products; I want to work on investigations of crimescenes; I want to interact with the public; I want to work with finances and numbers	Career profiles	Exploration
	Additional Questions. Please write any additional questions not listed above (or better wordings of the questions above) that you think could help lead a student into biotechnology career exploration.			
Please name some industry groups and/or professional societies for the biotechnology field.			Job Search	Job Matching
Please check the certificates your college offers in biotechnology		Bioinformatics Certificate; Biomanufacturing Certificate; Biotechnician / Biotechnology Bioscience certificate; Post Baccalaureate Certificate / Advanced Technical Certificate;	Education	Exploration

		Post-Baccalaureate Intensive Certificate Program; Stem Cell Research Certificate		
	Other (please specify):			
List by name the employers or companies in your region who will hire your graduates and/or the employers or companies who serve on your college's biotechnology industry advisory panel.			Job Search	Job Matching

Appendix B. Biotech Program Locations

SRI reviewed types of employers by geographic location. Many national biotechnology portal websites list focus biotech regions to help people who are looking for a specific specialty or listing of positions in a metropolitan area, state or country. For example, as shown in Table 11, Biotech Work Portal includes several biotech regions and ranks them by employment opportunity.

Table 11.Biotech Work Portal regions.

Error! Hyperlink reference not valid.	Error! Hyperlink reference not valid.	Error! Hyperlink reference not valid.
Chicago, IL Chicago-Naperville-Michigan City, IL-IN-WI	30,193	532
Boston, MA Boston-Worcester-Manchester, MA-NH	15,105	362
Dallas-Fort Worth, TX Dallas-Fort Worth, TX	8,444	263
Houston, TX Houston-Baytown-Huntsville, TX	7,259	283
Raleigh-Durham, NC Raleigh-Durham-Cary, NC	5,862	47
Denver, CO Denver-Aurora-Boulder, CO	5,110	201
Cincinnati, OH Cincinnati-Middletown-Wilmington, OH-KY-IN	4,490	123
Detroit, MI Detroit-Warren-Flint, MI	3,821	192
Atlanta, GA Atlanta-Sandy Springs-Gainesville, GA-AL	3,425	222
New York-New Jersey New York-Newark-Bridgeport, NY-NJ-CT-PA New York-Northern New Jersey-Long Island, NY-NJ-PA	2,208	60
Kansas City Kansas City-Overland Park-Kansas City, MO-KS	2,167	128
Greater Washington DC Area Washington-Baltimore-Northern Virginia, DC-MD-VA-WV	1,833	110
Winston-Salem NC Greensboro--Winston-Salem--High Point, NC	193	55
Seattle, WA Seattle-Tacoma-Olympia, WA	34	13
San Juan, PR San Juan-Caguas-Fajardo, PR	n/a	04
Albuquerque, NM Albuquerque, NM	n/a	38

Another site, hireBio identifies the following biotech focus regions (http://www.hirebio.com/home/career/focusareas.asp):

Great Boston area: Boston, Massachusetts is a recognized world leader in biotech, pharmaceutical and genetic research. With US headquarters for Genzyme, Biogen, Millennium Pharmaceuticals, Novartis, Cubist and the MIT campus, the Boston metropolitan area is home to over 150 biotechnology firms.

Raleigh area: The Raleigh-Durham area is the leading center for biotechnology in the South. Raleigh-Durham attracted major investment from the federal government and from multinational pharmaceutical firms including Glaxo-Smith Kline and Burroughs Wellcome. A list of pharmaceutical and biotech companies in the Research Triangle Park area today reads like a Who's Who of the industry: Aventis, BASF, Bayer, Biogen, and the like.

WDC and Baltimore area: The Washington, DC, and Baltimore, MD, metropolitan area benefits from the region's wide array of research institutions, including Johns Hopkins University, located in Baltimore, and the National Institutes of Health (NIH), located in Montgomery County, Maryland. A large number of scientists and professionals have extensive experience in the industry, and Washington is home to the industry's principal trade association, BIO.

Philadelphia area: Philadelphia's manufacturing sector has a substantial basis in pharmaceuticals, medical devices, and biotechnology. Today, the sector represents more than 21,000 jobs in the region. According to a 2002 Brookings Institution study, 80 percent of the world's largest pharmaceutical companies have a presence in the metropolitan area, and employment in the industry is second only to the New York metropolitan area.

Chicago area: Chicago, Illinois has outstanding opportunities for life-science and healthcare professionals. With the University of Chicago Health System, large operations for Searle and Abbott Labs, Chicago is a leading metropolitan area for science and research.

San Francisco Bay area: With dozens of biotechnology companies based in the area, this area has significant opportunities for entry-level and experienced pharm and biotech professionals.There are also countless opportunities in healthcare with world-class hospitals and medical organizations.

San Diego area: The San Diego metropolitan area is a leader in biomedical research and development, with a significant concentration of research institutions and biotechnology firms -- such as Salk Institute, Scripps Research Institute, and the University of California San Diego. There are more than 1,400 life scientists working in the region, three biological institutions granting life science PhDs. One of these institutions is ranked among the top 20 nationally in life sciences research. The San Diego area has 33 publicly traded biotech companies and includes 31 firms with more than 100 employees. Sixty-one of these firms are members of the national Biotechnology Industry Association.