Building the Bioscience Pipeline

Analysis and Recommendations

Arizona's Bioscience Roadmap Education Committee

September 2007

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Purpose and Study Approach

Arizona's Bioscience Roadmap Education Committee was formed in the Fall of 2006. Its goal — to identify actions that will help encourage and prepare high school students to explore and pursue bioscience careers. This focus recognizes the important link that high schools have with post-secondary institutions and their role in shaping career preparation. High school requirements also influence those of middle school and earlier grades in advancing specific academic skills.

Education Committee activities are being conducted under the auspices of Arizona's Bioscience Roadmap Steering Committee, and are consistent with the Governor's P-20 Council recommendations. The Education Committee has benefited from analysis and key policy directions emerging from P-20 Council deliberations, including drawing upon P-20 Council members to chair the Education Committee. At the same time, the Education Committee brings a more in-depth focus on high school education needs from the perspective of the bioscience industry, and the Education Committee's insights and recommendations are being shared with the P-20 Council. Committee members are drawn from Arizona high schools, post-secondary education community, and business leadership.

To identify key actions, the Education Committee has undertaken basic analysis and assessment, including:

- An environmental scan of academic performance in Arizona and the challenges ahead.
- A situational analysis of bioscience activities in high schools, including a survey of high schools done specifically for this project.
- A benchmarking analysis of best practices and approaches of leading bioscience high school initiatives from across the nation.

Definition of Terms

Before we delve into the details of this report, it is important to define terms:

- The biosciences involve the study and application of knowledge of how humans, animals, and plants function. From an industry perspective, the biosciences represent a diverse group of industries and activities that are constantly evolving to incorporate the latest research and scientific discoveries. Today, bioscience industries focus on five key areas: (1) drugs and pharmaceuticals, (2) hospitals and healthcare, (3) medical devices and instruments, (4) organic and agricultural chemicals, and (5) research, testing, and laboratories.

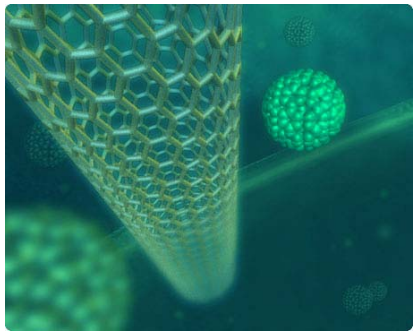
- **High school bioscience education programs** comprise any combination of curricular offerings involving **scientific principles** and **applied laboratory techniques** together with **experiential learning** and **career awareness activities** understood to be preparation for continued study towards advancing a career in the biosciences.

Case for Change

Four key themes, emerging from the basic analysis and assessment, guide the Education Committee's recommendations:

1. **Bioscience careers in Arizona are growing**, and nearly all jobs in the growing bioscience sector require post-secondary education.
2. To meet the demand, **Arizona faces key challenges in generating a home-grown biosciences workforce.** Beyond the shortfalls in trained workers for clinical care occupations, there is also a significant shortfall in trained workers for laboratory sciences occupations, particularly at the technician level.

3. Benchmarking of other leading states advancing high school bioscience education programs demonstrates that the **traditional silos between academic and technical education worlds are giving way to more integrated career education opportunities** that embrace and demonstrate the relevancy of science, technology, engineering, and math (STEM) education with rigorous career-oriented courses and activities.
4. To meet the demand in the near term, **advancing career and technical education (CTE) is most critical** with an emphasis on scientific principles, applied laboratory techniques, and project-focused activities.



Vision for High School Bioscience Education in Arizona

All interested high school students in Arizona will have the opportunity to develop competency in bioscience knowledge and skills through a program of study including scientific principles, applied laboratory techniques, and project-focused activities.

Goals for High School Bioscience Education in Arizona

To achieve the vision, the Education Committee recognizes that Arizona must aggressively address these three key objectives:

1. Improve the knowledge, training, availability, and retention of bioscience high school teachers in Arizona. Even existing high school bioscience education programs are finding the ability to attract, develop, and retain qualified bioscience teachers to be a significant challenge. Arizona must create, fund, and sustain ongoing education and professional development for bioscience teachers that produce confident, competent practitioners trained in state-of-the-art applications. The P-20 Council has identified STEM skills as critical to the state's education focus, and is strongly endorsed by the Education Committee.
2. Expand the opportunities for bioscience programs in Arizona's high school CTE offerings. Arizona's existing CTE programs are limited in the biosciences and do not align well with the challenging requirements of today's bioscience careers, in fields such as clinical care and laboratory sciences.
3. Advance a more seamless education system focused on developing bioscience career opportunities across high school and post-secondary education. Nearly all bioscience careers require post-secondary education that combine scientific principles, applied laboratory techniques, and project-focused activities. High school bioscience education programs are best viewed as a first step in a structured path to bioscience careers, based on industry standards and closely aligned with post-secondary education offerings.

Education Committee recommendations for "Building the Bioscience Pipeline"

Across each key goals, the Education Committee has developed a strategic action framework setting out strategies, associated actions, and organizational responsibilities required, along with an overview of current efforts underway and key issues to be addressed. Recommendations summarized on pages 5-7.

Goals (What Education Committee is trying to achieve)	Strategies (How will the objectives be achieved)	Current Situation & Key Issues to be addressed by Education Committee	Long Term Approach (An action that addresses the problem on a statewide scale and will take several years to accomplish)	Immediate Tactics (What corresponding actions are needed in the next 12 months to execute the strategy considering the key issues)	Key Partners
1. Expand the opportunities for bioscience programs in Arizona's CTE offerings.	A. Align CTE with growing opportunities for careers in biosciences.	• Models emerging across the state (e.g., Arizona Agribusiness & Equine Charter School, EVIT new Allied Health Career Programs, Mesa BioTech Academy; Paradise Valley Biotechnology Signature Program; Tucson High Magnet School; and Wildcat Charter School). • Leverage reforms in Perkins Act that promote career opportunities. • Address restrictive teacher certification requirements. • Address difficulty of accessing lab equipment and supplies.	• Promote adoption of new bioscience research and development CTE track across the state.	• Work with Arizona Department of Education CTE staff to establish the requirements and framework for a new bioscience curriculum.	Lead Organization: • Department of Education CTE program Partnering Organizations: • ABOR • AzHHA • P-20 Council • Universities Education Committee Role: • Facilitate
	B. Breakdown traditional silos between academic and technical education programs.	• P-20 Council effort is promoting STEM education across academic and technical education programs. • Ensure that there is a shared consensus on rigor for high school math and science requirements across academic and technical education.	• Establish an Arizona Students of Technology Achieving Results initiative providing summer and after-school experiential and project-focused learning targeted to students with an aptitude for science and math.	• Ensure ongoing discussions on math and science standards are coordinated across academic and technical education world.	Lead Organization: • P-20 Council Partnering Organizations: • ABOR • AzHHA • State Department of Education • Universities Education Committee Role: • Facilitate and champion

Education Committee recommendations for "Building the Bioscience Pipeline" (continued)

Goals	Strategies	Current Situation & Key Issues to be addressed by Education Committee	Long Term Approach	Immediate Tactics	Key Partners
2. Advance a more seamless education system focused on developing bioscience career-related skills across high schools, community colleges, and universities.	A. Promote career education programs in the biosciences across high school and post-secondary education in Arizona.	• Limited efforts to date. Minimal articulation across programs at either high school to community college or community college to four year degree programs. • Concern that any effort will become highly fragmented and ad hoc. Explore how to create replicable career programs in the biosciences.	• Have a portfolio of statewide career degrees approved for the biosciences by relevant oversight agencies that can be easily replicated by combinations of high school districts, community colleges, and universities. • Train high school counselors to advise students about bioscience career options.	• Support efforts, with ABOR involvement, to create a bioscience career program at ASU Polytechnic with Mesa Community College and high school districts (e.g., Mesa, Chandler). • Promote dual and concurrent enrollment as a means for advancing the goals of seamless education programs in the biosciences. • Build upon programs, such as MESA (Mathematics, Engineering, Science Achievement) and GEAR-UP (Gaining Early Awareness and Readiness for Undergraduate Programs), to attract more underrepresented students to bioscience education.	Lead Organization: • ABOR Partnering Organizations: • GPL • P-20 Council • State Department of Education • Universities Education Committee Role: • Facilitate and champion
	B. Universities outreach to high school or community college classrooms with on-site bioscience programs, and promote extended learning through high school student research internships.	• Range of existing efforts underway, which offer models to build upon. • Need exists to reach more high school teachers and schools.	• Build high school, community college, and university resources and materials to sustain and expand courses teaching laboratory skills.	• Consider advancing initiatives such as a bioscience bus and expanding summer bioscience research internships to reach more students and teachers.	Lead Organization: • Universities and non-profit research institutes Partnering Organizations: • Community colleges • GPL • P-20 Council • State Department of Education Education Committee Role: • Facilitate and identify funding

Education Committee recommendations for "Building the Bioscience Pipeline" (continued)

Goals	Strategies	Current Situation & Key Issues to be addressed by Education Committee	Long Term Approach	Immediate Tactics	Key Partners
3. Improve the skills and availability of bioscience high school teachers in Arizona.	A. Broaden the availability and depth of professional development efforts for existing bioscience teachers in Arizona.	• Growing number of efforts in professional development, led by universities, including ASU's CRESMET, NAU's Center for Science Teaching and Learning, and UA's BIO5 and AZSTART. • Current professional development efforts in the biosciences are fragmented and uncoordinated. • Existing efforts also lack scope to have major impact on existing number of bioscience high school teachers across the state.	• Embed professional development of bioscience teachers as part of a statewide STEM Center with dedicated state funding. • Make use of online Master's level courses with 1 to 2 week residency programs in summer for lab instruction.	• Develop a comprehensive statewide plan for addressing professional development needs of bioscience teachers.	Lead Organization: • State Department of Education Partnering Organizations: • ABOR • GPL • P-20 Council • Universities Education Committee Role: • Support efforts of P-20 Council
	B. Upgrade and promote college-level teacher preparation programs in the biosciences.	• Limited efforts: NAU's teacher preparation program for science majors and UTeach initiative as well as ongoing and new efforts at ASU and UA [TBD]. • Need for problem-based learning approach for science/math teaching. • Teacher certification requirements. • Availability of high schools sites for teacher training. • Incentives for student participation.	• Establish an Arizona initiative based on the UTeach model of attracting outstanding college students into K-12 teaching careers in science and math.	• Investigate establishing an Arizona-wide approach, similar to UTeach, that integrates science or math major with teaching certification, financial assistance, and early teaching experiences. • Build upon current programs that expand the number of highly skilled science and math teachers. • Promote alternative teacher certification approaches for science/math professionals.	Lead Organization: • ABOR Partnering Organizations: • ABOR • GPL • P-20 Council • Universities Education Committee Role: • Support efforts of P-20 Council

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Appendices

Appendix A: Assessment of Strengths, Weaknesses, Opportunities, and Threats

An analysis of the strengths, weaknesses, opportunities, and threats provides a strategic understanding of Arizona's position as it seeks to advance career-oriented bioscience education programs at the high school level.

Strengths

- **Growing number of professional development initiatives targeted on the biosciences and bringing new collaborations of university resources to assist high school bioscience education.** For instance, the University of Arizona offers a growing range of support services to high school biology teachers, such as teacher internships in genomics, a Master's program in General Biology, the BIOTECH project to provide technical support for Arizona classroom teachers conducting molecular genetics experiments, and grants to university students who work with high school teachers. Northern Arizona University, meanwhile, has an Improving Teacher Quality Grant from the Arizona Board of Regents to assist 25 high school biology teachers obtain their Master's and provides professional development in their classrooms with the goal of creating teachers that serve as bioscience leaders for their entire school districts. Arizona State University's Biodesign Institute and Polytechnic Campus (along with Maricopa Community Colleges) play an active role in the Mesa BioTech Academy.

- **An existing base of high school bioscience-related programs across Arizona.** A recent survey identified 90 such programs (out of 221 schools completing the survey) with 80% of these programs focusing on preparing students for college and 64% existing for over five years.

- **Availability of dual and concurrent enrollment courses in Arizona** to engage high school students in college-level bioscience courses.

Weaknesses

- **Lack of ability to attract, retain, or develop bioscience teachers.** A limiting factor noted in the survey of high school bioscience programs in Arizona was having teachers with advanced training in the biosciences. This perspective is shared by professional development providers to high school biology teachers at state universities. The number of teachers qualified to instruct in hands-on molecular biology techniques is limited.

- **Access to laboratory equipment and supplies is a key limiting factor for biosciences programs.** Support for program expenses and laboratory supplies is another top need identified by the survey of high school bioscience programs. Not only is initial equipment expensive to fit-out student labs ($80,000 to $200,000), there is an ongoing cost for supplies and overtime need for upgrading equipment.

- **Lack of coordinated state effort for career development in the biosciences.** The survey of high school bioscience programs found little familiarity by high schools with the state's bioscience community or initiatives. There is also little statewide coordination of innovative bioscience high school efforts.

Opportunities

- **Expand the opportunities for bioscience programs in Arizona's career and technical education efforts.** Arizona's existing Career and Technical Education (CTE) Program is an important asset for expanding opportunities for high school bioscience technical education. The P-20 Council's Pathways Committee endorses increasing the participation of students in CTE programs. For the biosciences, only limited approved programs in allied health and agriculture exist. Interest exists in pursuing a new Biomedical Genomics track for CTE. For current CTE bioscience programs, there are issues holding back broader efforts, including credentialing of teachers.

- **Better link high school bioscience programs with post-secondary bioscience technical programs.** In Arizona, community colleges are turning towards developing biotechnology programs. These programs, however, are not strongly linked to existing high school programs and lack a clear articulation to four-year degree programs.

- **Utilize Arizona's Joint Technological Education Districts (JTEDs) to increase the bioscience offerings for college-preparatory bioscience career-oriented education programs.** A unique resource in Arizona is the opportunity to establish JTEDs to spur innovative career preparation programs. The biosciences can be a key signature area where JTEDs can (1) create blended bioscience programs that focus on hands-on laboratory skills with access to specialized facilities and (2) promote more STEM skills development, including increasing the availability of dual enrollment courses through advancing teacher training and professional development.

Threats

- **The development of robust bioscience programs in Arizona might be held back by traditional silos found between academic and technical education worlds.** A robust bioscience career education program must blend STEM skills with more technical education and recognize that bioscience careers require post-secondary education. However, high schools organize their staff separately between academic and technical education, and it is difficult to create blended, integrated programs.

- **Broader cultural issues hold back the development and participation in rigorous bioscience career education initiatives.** Arizona continues to suffer from low expectations on behalf of students, counselors, parents, and schools. A concern expressed by Education Committee members is the lack of passion in Arizona for education reform.

Appendix B: Benchmarking Case Studies and Best Practice Lessons

This benchmarking analysis identifies best practices and key success factors in high school bioscience education and career development programs. The following four programs from across the nation were selected by the Education Committee for detailed case studies. They're not the only opportunities for duplication, but they are effective.

- Connecticut Career Choices, an initiative of the Connecticut Office for Workforce Competitiveness, engages high school students in technology-related career development. CCC builds upon basic courses in STEM with more applied courses in STEM fields focused on critical thinking, problem-solving and experiential learning activities. A module of bioscience courses has been developed and is being used by 12 high schools involved from across the state with 605 students attending courses.

- North Carolina New Schools Project is changing the fundamental high school structure with (1) full conversion of existing schools and new schools to smaller, more rigorous university-prep and (2) Early College schools based on college campuses (dual enrollment). To date, eight Health and Life Science/Biotechnology themed high schools are being formed, but many more may come online in the future.

- Seattle area high schools and the Northwest Biotech Education & Careers Consortium (NWBECC) bring together Puget Sound area educators, companies, and organized labor in a collaborative effort to prepare people for employment in the field. The program is designed under the federal-supported career and technical education framework for the region. Biotech courses and experiential learning are offered, based on industry skill standards, to over 50 students annually, with linkage to community college system.

- San Diego High Tech High brings an overall emphasis on liberal arts and general college preparation, integrating technical and academic programs and STEM orientation for minorities and the disadvantaged. Presently, biotechnology is one course that students can take, which was developed in consultation with industry and is aligned to certification requirements of the state-supported Regional Occupational Program (ROP). Students also participate in internship and capstone projects, many of which are in the biosciences. HTH is opening a new campus in San Marcos for the 2007-08 academic year. Plans are for the new school to have a thematic "life sciences" focus.

Five key questions were posed in developing the case studies:

- What is the focus of your bioscience education and career development program?
- What are the specific activities undertaken?
- How is industry involved in your program?
- Is your program structured to get to broader scale than an individual school or school district?
- What are your program's success metrics, key success factors, and barriers to success?

Key Lessons Learned

Benchmarking of other leading states advancing bioscience career development at the high school level demonstrates that the traditional silos between academic and technical education worlds are giving way to more integrated career education opportunities that embrace STEM education and demonstrates their relevancy to students through hands-on, project-based learning. However, programmatic aspects of successful programs do vary.

As revealed in Figure 1, none of the benchmarks fully incorporate all aspects of STEM-related career and technical education across use of skills-standard curriculum, close linkage to STEM courses, teacher professional development, emphasis on experiential learning, and extent of articulation.

Figure 1: Comparison of Benchmark Programs Across Key Program Features

	• Use of Skills-Standard Curriculum	• Linkage to STEM courses	• Teacher Professional Training	• Emphasis on Experiential & Extracurricular Activities	
• Connecticut Career Choices	◔	◑	○	○	◕
• NC New Schools Project	◑	◑	◔	◑	◑
• San Diego High Tech High	◑	○	◑	○	◑
• Seattle NW Biotech Education and Careers Consortium	○	◔	◕	◑	○

○ • Extensive
● • Not In Place

A key differentiator across benchmarks is their ability to reach scale. Programs based more on a CTE focus, rather than a high school reform focus, have an easier time reaching scale.

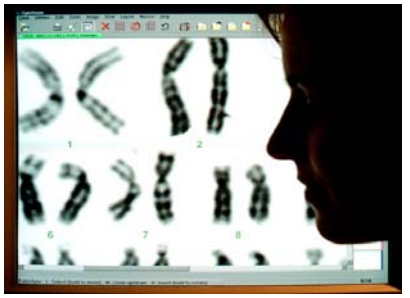


Figure 2: Comparison of Benchmark Programs Ability and Approach to Reaching Scale

	Year Initiated	# of Courses	# of Schools	# of Students	Approaches to Reach Scale
• Connecticut Career Choices	2004	3	12 in 2006-07	605 in 2006-07	• Use of on-line curriculum and collaboration tools • Statewide competition
• NC New Schools Project	2005	N/A	8 in 2006-07	N/A	• Initial round of new schools (2005) aggressively targeted Health & Life Sciences and Biotech
• San Diego High Tech High	2000	1	1 in 2006-07 (but new Life Sciences HS to be opened next year)	45-55 in 2006-07	• Expect new "Life Sciences" campus in San Marcos to enable outreach to other high schools and expand course offerings
• Seattle NW Biotech Education and Careers Consortium	1997	3 - 4	2 in 2006-07	55-110 in 2006-07	• Open classes to all eight districts in region – travel to school to access courses

Many different approaches to funding bioscience education programs emerge. The benchmarks do not utilize similar approaches to funding their program activities. The range of approaches include: foundation support, use of federal Perkins monies, education support for magnet schools, and line-item program support. Often, the benchmarks use more than one funding source or leverage other funding sources.

- Connecticut Career Choices Funding Approach: Line item appropriation for Connecticut Career Choices, with some leveraging of federal Perkins Act funding, but on a competitive basis from the state department of education.
- North Carolina New Schools Project: Gates Foundation recipient, with direct state funding to match Gates funds.
- Seattle NWBECC: Funded by school district's allocation of federal Perkins Act career and technical education.
- San Diego High Tech High: Gates Foundation recipient as well as direct state funding support. Also taps into Regional Occupation Program driven by federal Perkins Act and State of California, and funding from local companies.

Implications for Arizona

Two distinct paths seem to emerge from the benchmark case studies, which are not mutually exclusive. One is to develop bioscience programs in the context of overall high school reform and the other is to pursue bioscience programs as part of career and technical education offerings. Several of the benchmark programs are trying to create some vehicles for integration (San Diego High Tech High by linkage to the Regional Occupational Program and Connecticut Career Choices by collaboration with Magnet Schools) by programs that are grounded in either more academic or more CTE worlds.

There is not one right way, but clear advantages and disadvantages emerge:

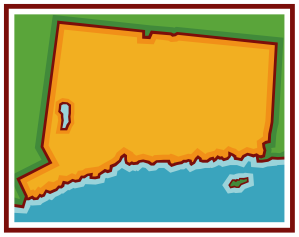
High School Reform Orientation

- Advantages: Closer links with basic STEM. Ability to raise foundation support.
- Disadvantages: Reaching scale is not easy given focus on individual schools.

Career & Technical Orientation

- Advantages: Scalability is enhanced through ease of replication as part of broader CTE efforts found across schools. Close links to industry skill standards and industry engagement. Can tap into existing funding source of federal Perkins Act.
- Disadvantages: Assumes basic STEM courses are in place. Not always able to change or leverage statewide CTE approaches.

Case Study #1: Connecticut Career Choices



Connecticut Career Choices (CCC) is an initiative to engage P-20 students in technology-related career development. CCC provides a context and a resource for advancing STEM skills to enable these students to pursue post-secondary education seamlessly in technology fields and emerge with the skills required to work effectively in the state's Knowledge Economy.

CCC is an outgrowth of the Connecticut's Information Technology Workforce Development Strategy, which the General Assembly initially required the Connecticut Employment and Training Commission (CETC) to produce through the OWC under P.A. 00-187. CCC was developed as the next generation from the school to work activities, which were seen as too divorced from the education process. The General Assembly then enacted the strategy presented by CETC through a set of pilot initiatives under P.A. 01-193, which CCC was one key component, and then it received a permanent line item appropriation as part of the 2005-2007 biennium budget of $800,000 yearly.

CCC builds off basic STEM courses (e.g., biology, math, and other sciences) and demonstrates their relevancy to students, linking to mastering critical thinking, problem-solving, and experiential learning. CCC involves innovative curriculum, online learning tools, professional development for teachers, experiential learning, and complementary extra-curricular programs.

The signature event for CCC is the Governor's High School Innovation Challenge, in which student teams are "challenged" to incorporate advanced technologies to develop a "mock" company and author a white paper that describes innovative applications of technologies and services.

CCC began with courses in information technology — an Information Technology Research and Development course and a E-Commerce and Entrepreneurship course — given its roots in growing out of the state's Information Technology Workforce Strategy.

Bioscience was added because of the concern about persistent workforce shortages in healthcare professions — particularly nursing and allied health — and the state's focus on its pharmaceutical and biotechnology-related industries, which are among a handful of targeted industry sectors for economic development. Not surprisingly, the current bioscience curriculum ranges across the spectrum of healthcare to biotechnology, including courses in Foundations of Health Science and Technology, Biotechnology Research and Development, and Medical Science and Technology.

Specific Activities in the Biosciences. The cross-cutting building blocks of CCC include:

- Innovative curriculum development in strategic technology fields for Connecticut of IT and biotechnology/health care, engaging students in problem-solving, team building, and project focused activities.
- Successfully utilizing online content and applications offered on Connecticut Education Network (CEN) with all CCC technology curriculum hosted online, broad use of electronic student portfolios, and access to facilitated web-based collaboration and communication tools.
- Professional development for teachers in use of web-based tools, training in CCC technology curriculum and understanding of industry education, and training needs and requirements through teacher externships.
- Cross-cutting experiential learning activities involving industry speakers tied to specific aspects of the CCC technology curriculum, teacher externships in support of professional development, and industry mentoring of student teams for developing business concepts for the Innovation Challenge.

- Continuing extra-curricular programs supporting proven extra-curricular programs broadening student's interests in pursuing careers in technology fields, including CWEALF's Girls in Technology outreach program; AHEC's Youth Health Service Corps Program and its high school chapters of the Health Occupation Students of America; and NFTE urban school entrepreneurship.

The culminating activity of CCC is the Governor's High School Innovation Challenge, which is tied into the CCC curriculum. Student teams, along with their teachers, interact with each other and with business mentors from around the state both online and face-to-face. They meet at least twice on a Connecticut community college or university campus to attend seminars and workshops. They develop valuable creative thinking, problem solving, and project management skills that will help them succeed in school and 21st century careers.

More on CCC Health and Medical Related Curriculum. The goal of the CCC Health and Medical (HMC) Curriculum initiative is the implementation of an HMC standards-based (www.nchste.org) sequence that builds a path for students from middle/high school to post-secondary education (both community and four-year colleges). This curriculum sequence builds on a foundation of employability and technical competencies that all students can use to acquire more advanced technical skills or the transferring of their skills to any 21st century technology or emerging career opportunity.

- Foundations of Health Science and Technology. This course is an introduction to National Health Care Cluster foundation standards that serve as a foundation for health care occupations and skills across the health service industry. The standards include academics in health care, communications, systems, legal responsibilities, ethics, teamwork, employability skills, health maintenance and safety practices, and information technology application. The course provides an overview of the healthcare system (past, present, and future) and the impact technology has on service quality. Students explore the various health professions that service, diagnose, and treat a range of health conditions and diseases in hospitals, clinics, private offices, schools, colleges, and universities as well as other health service agencies. Students investigate the medical needs of a culturally diverse society as well as the ethical and legal responsibilities of a healthcare provider. Students examine and demonstrate their understanding of universal precautions, safety principles and techniques crucial to healthcare employees and patients. The course requires students to develop a research project to be included in a health careers portfolio.

- Biotechnology Research and Development. The Biotechnology course is designed to develop student academic, communication, and scientific inquiry skills through in-depth investigations into the products created in the biosciences through manipulation of an organism's DNA. These investigations include the bioscience of the human body, the environment, and agriculture. The course includes both in-school labs and online simulations. Students recognize how the application of bioscience affects the quality of life along with the ethical and social impacts of this cutting edge technology.

- Medical Science and Technology. The Medical Science and Technology course is designed to develop a students academic, communication, and scientific inquiry skills through the completion of a comprehensive investigation into current 21st century medical and healthcare practices and the innovative technology that accompanies these practices. Emphasis is placed on research, communication, safety, computer literacy, problem solving, decision making, and the ethical and social impacts of 21st century medical technology. The course is designed to give students hands-on experience with fascinating medical techniques and exposure to careers associated with the techniques.

Area Health Education Center Extracurricular Activities. Closely aligned with in-school "co-curriculum" activities under the CCC bioscience efforts is the Area Health Education Center's extracurricular activities including (1) Health Occupation Students of America (HOSA) clubs that offer monthly programs, meetings, and student competitions and (2) Youth Health Service Corps at schools to train students to volunteer at healthcare settings. In 2005-2006, six high schools hosted HOSA chapters involving 100 students and ten high schools and nearly 200 students were involved in training for the Youth Health Service Corps.

Status. A total of 12 high schools are implementing the CCC Biosciences curriculum for the 2006-2007 school year, encompassing 605 students. This includes: six schools implementing Biotechnology course with 310 students; three schools implementing Foundations course with 180 students; and six schools implementing Medical Science Research course with 115 students. Several schools offer more than one curricula.

Another key milestone for CCC is that the state department of education has approved the CCC bioscience course sequence as meeting career and technical education requirements, which has enabled the program to be easily adopted by high schools.

Case Study #2: North Carolina New Schools Project

North Carolina is in the middle stages of an ambitious effort to reshape the structure and focus of high school education. The North Carolina New Schools Project (NCNSP) is taking a unique approach to high school redesign in addition to opening new schools. The Project began in 2003 as a cooperative effort between the Education Cabinet, the Office of the Governor, and the Public School Forum of North Carolina with support from the Bill and Melinda Gates Foundation. NCNSP operates as an independent not-for-profit corporation and works aggressively to pursue a three-part strategy of:

- Creating innovative, highly effective high schools across the state.
- Building statewide consensus for significant change.
- Advancing policies that promote innovation, higher standards and improved performance.

NCNSP is well on its way toward an ambitious goal of creating more than 100 new and redesigned North Carolina high schools by 2008. Each "new school" seeks to change the fundamental high school structure offering small class sizes, and all students a rigorous college-prep curriculum, setting high expectations for both post-secondary and career success. Curriculum puts students on a college-prep track by default, with students forced to opt out if they do not want to pursue collegiate studies.

Redesigned schools in the NCNSP have a particular economic development technology focus intended to make learning more relevant and interesting for students. The first cohort of 11 schools opened in Fall 2005 and included eight "Health and Life Science" focused schools (one of which has an explicit "biotechnology" theme). In addition to the HLS-focused schools, NCNSP has other economic development themes including: engineering, computer technology, coastal studies, IT, STEM international studies, ecology, and more.

The intent of the thematic focus is generally not for specific career preparation, but rather is used to bring relevance to the classroom and to allow teachers to plan interdisciplinary units of study around the focus.

NCNSP has a two-stage method for funding and designing its schools that spans a six-year relationship:

- Planning Grant: Schools receive a modest, one-year grant and a planning "coach" to design and propose the new school.
- Implementation Grant: Schools successful in the planning stage receive a five-year implementation grant that continues to fund its coach, professional development, and full operations.

NCNSP works with school districts and higher education partners to create two types of schools:

- Redesigned High Schools: Converting existing schools into new, autonomous, focused, and academically rigorous schools that operate on an existing high school campus. The schools are smaller (maximum 400 total students, 100 each grade) and adopt a focused curriculum that allows for interdisciplinary cooperation among teachers in order to make connections between courses and the world of work. They emphasize a general STEM curriculum in addition to their technology focus.
- Learn and Earn Early College High Schools: Situated on campuses of two- and four-year community colleges and universities, L&E schools are rigorous examples of dual enrollment — ensuring that all students graduate not only with a diploma, but with two years of transferable credit or an Associate's degree. L&E school students operate on a five-year academic plan.

Background and origins of high school education reform. Education policy and general reform efforts in North Carolina have a deep history. Former four-term Governor Jim Hunt established a strong focus and foundation in state education policy and a precedent for future governors of the state with respect to education as a top priority.

Today, Governor Mike Easley continues this tradition, playing an active, hands-on role in affecting positive change in schools. The Governor's Education Cabinet and the Public School Forum of North Carolina are working with Governor Easley to focus resources to change high school education.

Despite strong executive and legislative support for education in the state, and continued performance gains at lower grades levels, the performance of high school students (or lack thereof) has been alarming. North Carolina ranks 45th nationally in the share of ninth graders who graduate four years later. It is estimated that only 60 to 69% of North Carolina's ninth grade students graduate within four years. Minority students experience even lower graduation rates, with an estimated rate for African-American and Hispanic ninth graders of 55 and 54%, respectively. Even among those who do graduate, preparation for post-secondary pursuits is often lacking, for example:

- About one-fifth of recent high school grads in community colleges are enrolled in a developmental reading course.
- Among recent high school grads attending a community college or a UNC system school, 16% had to enroll in a remedial or developmental math course.

The Public School Forum of North Carolina ("Forum") is a well established, major education policy think tank that brings together state business, education, and government leaders. The Forum opened in 1986 and has been a primary advocate and administrator for several education programs and legislation within the state including the Teaching Fellows Program; passage of the 1989 School Improvement and Accountability Act; proposing major school funding changes that have redirected funds to lower income and smaller schools; establishing the North Carolina School Technology Fund; and creating the Institute for Educational Policymakers.

Before 2003, the Forum had little to no focus on high school education. At that time, the Gates Foundation was performing its due diligence with respect to potential state entities with which to partner in its aggressive new plans for national high school reform. The Foundation, acknowledging the Forum's long-standing work and expertise in the state, approached the Forum about partnering in this role. Ultimately, the Forum received the initial Gates funding for what would become the New Schools Project.

Using Gates Foundation funding, the Forum hosted the NCNSP for just over two years. An advisory council was established bringing together key stakeholders from business, education, and government and initial grants were awarded. After growing the NSP through its initial stages, the Forum handed off the project in January 2006 to the newly formed independent not-for-profit corporation that oversees the project today.

The Forum has worked to open the eyes of state legislators to the widening gap the U.S. faces with respect to STEM education at the international level. The Forum's legislative influence has been bolstered by hosting trips to seven foreign countries thus far in order to visit and study school systems abroad. Several of these trips focused on high schools including technology "themed" schools in Japan that are somewhat similar to those in the New Schools Project. The Forum's Executive Director, John Dornan, was particularly impressed with high school education in Denmark, citing innovative practices and broad curriculum.

Today, the Forum and Mr. Dornan continue to be active in the New Schools Project Advisory Council. In addition, the trips overseas play a role in the NSP as the Forum continues to pursue international best practices with respect to high school education.

Specific Activities in the Biosciences. For this case study three of the eight original Health and Life Science/Biotechnology themed schools were interviewed and their curriculum and structure analyzed. The high schools include The School of Inquiry and Life Sciences at Asheville (SILSA); Newton-Conover Health Science High School (Newton, NC); and Atkins School of Biotechnology (Winston-Salem, NC).

Atkins School of Biotechnology has the most detailed, varied, and advanced biotech courses of the three schools thus far, and is CTE certified with a career-driven curriculum. It offers two major elective paths or "strands" for students—biomedical or biotech. The biomedical strand prepares students for potential careers in healthcare in advanced technical or support positions in medical facilities. The biotech strand is more research based study.

At Atkins, both applied bioscience strands include a general "Biomedical Technology" course that introduces students to current healthcare and research tools and practices. Topics include biomedical technology, the language of medicine, new and evolving biomedical specialties, ethics, and health career development. Following this introductory course, students in the biomedical strand complete three additional courses titled: Medical Sciences I and II, and Health Science Advanced Studies. Students in the biotech strand take Biotechnology I and II, and also take Health Science Advanced Studies.

The School of Inquiry and Life Sciences at Asheville (SILSA) utilizes the life science theme for projects that incorporate several disciplines and are overseen by multiple teachers. Unlike Atkins, SILSA does not have a CTE focus, nor does it offer specific "biotech" courses. When it opened last year, the school only had 9th graders so it was difficult to incorporate advanced and applied science programs. SILSA did offer an elective "Life Sciences Seminar" course that proved to be too advanced for 9th grade. The school plans to re-implement this course again next year when it will have its first 11th grade class.

Newton-Conover Health Science High School operates much like SILSA in its full focus on a project-based, interdisciplinary approach to learning. The school "clusters" class time to combine social studies and science for example, or science with history. The disciplines are connected through projects such as traditional medical care versus alternative medicine; nutritional units that study fast food; ethical units studying stem cells, cloning, or euthanasia; and a market analysis of cosmetics or organic foods. Upon opening, the school made a conscious decision not to emphasize career (CTE) or occupational education with respect to the health sciences. Similar to most NCNSP schools, Newton-Conover is primarily focused on making sure every child is college ready.

Experiential Learning. Students in the biomedical strand at Atkins School of Biotechnology spend 45 or more hours in a formal mentoring relationship with a healthcare professional. Atkins is also preparing its summer internship program for students heading into their senior year.

SILSA and Newton-Conover are in the early stages of planning experiential learning opportunities and requirements as they gain students in the older grades. SILSA will begin to require internships in two years and now hosts guest speakers from industry and job shadowing through Junior Achievement.

Status. At present, there are 58 schools in the Implementation phase — 25 are redesigned and 33 are Learn and Earn Early College. Of the 58 schools, 24 have opened either in Fall 2005 or Fall 2006 and currently serve 3,000 high school students (adding one or two grades each year). Once fully operational, all 58 schools will serve about 7,000 students. In the next year or two, NCNSP plans to serve up to 7-8% of the entire state high school population in its new schools.

Ten schools in the planning phase are part of a specific STEM initiative and have an explicit STEM focus. Several of these have a "New Tech" model that is patterned after the project-based learning that goes on at schools in California like New Tech High in Napa Valley and High Tech High in San Diego.

Early Analysis Reveals Promise. While the 24 redesigned and Learn and Earn early college schools now open only have one or two years of operation to draw from, some initial results are encouraging. The majority of these schools are meeting testing goals and many are already outperforming the comparable comprehensive high schools in their district. As a whole, the 24 schools have experienced higher attendance rates than comparable schools. Additionally, early data reveals students at the new schools have been disciplined less frequently (including school suspensions). The 2006 Teacher Working Conditions Survey in North Carolina shows teachers in the new schools are much more positive about working conditions than their counterparts in other, traditional schools.. The NCNSP has commissioned on a new "return on investment" study to analyze costs and benefits associated with the new approaches to high schools.

Funding. The New Schools Project began with an initial challenge grant from the Gates Foundation of $11 million in 2003. A second Gates Foundation grant invested an additional $10.4 million in the Project, $9 million of which went toward the redesigned schools program and the remaining $1.4 million toward the Learn and Earn Early College program. In order to receive the additional $9 million for the redesigned schools, North Carolina was asked to match these funds with their own $9 million contribution.

Gates funding for the New Schools Project is only assigned to fund professional development activities. The Gates funds do not support physical structures such as buildings or furniture or laboratory equipment for the biosciences. At least one school in this case study receives Perkins Act funding. Atkins School of Biotechnology in Winston-Salem is CTE certified and utilizes a $2.1 million magnet school grant to equip its biotech and medical labs.

Case Study #3: High Tech High, San Diego, California

High Tech High (HTH) in San Diego, CA opened in 2000 as a single charter high school. Since then, it has grown into a group of seven total schools — four high schools, two middle, and one elementary all on the same campus. Reflecting this growth, HTH has a broad role as a school development organization attempting to "replicate" its success in order to create a national network of similar schools. In 2006, HTH became the first California charter school to receive state approval to open up to ten new campuses without having to gain local district permission.

HTH grew out of meetings in the late 1990s among business leaders (Economic Development Corporation and Business Roundtable) concerned with supplying qualified individuals for the high-tech workforce. Of particular concern were gaps or divides that had developed among women and minorities with respect to success in STEM. Each school has a technology-centered theme that places some focus on an area of advanced or emerging technologies.

While the mission and goals of HTH include broad aspects such as graduating "thoughtful, engaged citizens," and an overall emphasis on liberal arts and general college preparation, some of the goals are specific to technology and lend the program its name:

- Integrate technical and academic education to prepare students for post-secondary education in high-tech and liberal arts.
- Increase the number of educationally disadvantaged students in math and engineering who succeed in high school and post-secondary education.

The schools and programs distinguish themselves in their technology focus through several avenues. Experiential learning opportunities abound for students. Outside of school, Juniors are required to complete a one semester internship with a local business or agency. Seniors develop applicable, "real world" projects in the community. Job shadowing, community service, and "power lunches" for 7th through 10th graders all enable students to connect with working adults in various fields. Buildings are designed to provide a "business" feel and facilitate hands-on learning with labs, conference rooms, full wireless access, and displays of artwork and prototypes.

HTH is opening a new campus in San Marcos, CA for the 2007-08 academic year. Plans are for the new school to have a thematic "life sciences" focus. Like other schools in the HTH program, this new school will primarily focus on its liberal arts/prep program with a core college curriculum (90%), but will have a "90-10" split with a significant focus on the life sciences (10%). The San Marcos campus will begin with about 150 freshmen, and then add grades to ultimately reach about 500 total students.

The following details HTH's Biotechnology Services (Introduction to Biotechnology) course offered to 11th graders by Dr. Jay Vavra. The course is designed to not only cover required State curriculum, but also to prepare students for careers with a Regional Occupational Program (ROP) certificate awarded upon successful completion.

Specific Activities in the Biosciences. The 11th grade ROP Biotechnology course taught by Dr. Vavra has an ambitious set of curricula and project-based learning activities. The course not only covers the California State Biology Standards but goes much further to meet extensive biotechnology competencies so that students receive a certificate from ROP. Fulfillment of ROP requirements triggers student eligibility for a paid summer internship with a local bioscience company.

Research projects in the course begin with fundamental introductions to the scientific method and finish the year with genetic engineering. Throughout the course, students learn core laboratory techniques and industry-standard skills that provide for a strong transition to post-secondary schooling and potentially a career. Specific techniques include gene splicing, tissue culture, solution preparation, and sterile technique. Specialty labs on campus provide this access to students not only in biotechnology, but also in mechanical engineering, and graphic design. Exposure to advanced topics and techniques benefit students no matter their future field of study or career path.

Biotechnology curricula are continuously under scrutiny and changing to reflect the advances in science and industry. Dr. Vavra meets quarterly with an industry "Advisory Council" in order to keep course design up to date.

Experiential Learning. Biotechnology students participate in scientific field research. Dr. Vavra leads students in conducting comprehensive studies of the San Diego Bay that have ultimately been published as a Field Guide (www.sdbayguide.com). Another hands-on project is focused on forensic conservation biology where HTH students collaborate with geneticists from the San Diego Zoo and learn to isolate DNA sequences in order to determine the species of butchered meat. The conservation-type study addresses issues of wild game hunting in Africa and works to end illegal hunting of endangered species.

Additional opportunities in experiential biotech learning include concurrent opportunities for these 11th grade students during their required semester-long internship. HTH students have participated in numerous internships with a bioscience or biotechnology focus for example: the Salk Institute, Invitrogen, VA Hospital, UCSD School of Medicine, SDSU Bioinformatics, BIOCOM, and Scripps Institute of Oceanography have all hosted HTH student interns.

The National Oceanic and Atmospheric Administration (NOAA) recently announced a partnership with HTH. NOAA offers workshops on building undersea robots for use in ocean exploration and research.

Status. High Tech High currently offers only one year-long course in biotechnology. The course is offered to 11th graders who have completed biology and chemistry and have strong computational and computer skills. About 45-55 students take the course each year.

Administrators and faculty would like to see similar additional bioscience courses added, but resources and talented biotechnology teachers are limited. The opening of the "Life Sciences" school in San Marcos should provide a strong mechanism for expanding the Biotechnology/Bioscience program offerings within the HTH system. While the school is planned to have an overall liberal arts/college preparatory focus like all of HTH, significant resources will be allocated to life sciences curricula, projects, and experiential learning opportunities.

Articulation. Dr. Vavra's Biotechnology course meets the requirements for articulation with a local community college. The course is articulated with "Introduction to Biotechnology" at Miramar Community College. Students can receive credit for the college course if they receive an "A" or "B" and pass an exam at the end of the course.

Funding. In general, HTH has a creative and varied funding approach. Its status as a charter school enables a flexible approach, but has its challenges. The full HTH system has received funding from the Gates Foundation, the State of California, San Diego Unified School District, and direct funding from companies.

The Biotechnology Services course and other HTH courses in engineering, digital arts, and multimedia are funded by the Regional Occupational Program (ROP). ROP is run by the California Association of Regional Occupational Centers and Programs (CAROCP) and provides unique occupational type classes to high school students and even to adults. Regional Occupational Centers and Programs (ROCPs) are primarily state funded.

In 2005-06, there were 74 ROCPs in California that serve about 520,000 high school students and adults annually. There are over 300 different ROP career and technical education courses offered in IT, business, healthcare, construction, culinary arts, and more. Businesses serve as ROCP partners across the state (53,000 companies), offering internships, and serving on local Advisory Committees to ensure ROCP curriculum meets current labor market demands.

Specifically, the Biotechnology Services course incorporates core competencies in health careers with job specific didactic, laboratory, and clinical competencies for an array of occupations related to biotech professions. Those completing this course are prepared for work as lab professionals in biotech R&D. Employment possibilities stemming from this course include:

- Research laboratory assistant/aide
- Media/glassware technician
- Chemical technician/aide
- Bio-manufacturing assistant
- Bioreactor technician/aide
- Clinical manufacturing technician

Case Study #4: Seattle/Puget Sound Region High School Bioscience Initiatives

The Northwest Biotechnology/Biomedical Education and Careers Consortium (NWBECC) has brought together Puget Sound area educators, companies, and organized labor in a collaborative effort to prepare individuals for employment in the biosciences. The Consortium carries out its mission through a variety of activities including:

- Providing information on biotechnology/biomedical careers.
- Providing information on biotechnology/biomedical education/training.
- Aligning program learning outcomes with industry skill standards.
- Articulating educational skill standards between educational programs in the Puget Sound Region.
- Providing resources for faculty to start new or supplement existing biotechnology/biomedical programs.

Key high school educators in the Seattle/Puget Sound region, working through the Northwest Consortium, have been successful not only in creating and sustaining biotechnology courses in their high schools, but also in using the Consortium and its collaborative component to develop real bioscience skill standards. Mary Glodowski of Juanita High School in Kirkland and Connie Kelly of Shorewood High School in Shoreline worked to gather industry, university, and community college input and have successful articulation and program linkages in place to post-secondary education.

These high school educators in the region have been partnering for close to ten years since opening their biotechnology/bioscience classes in Kirkland and Shoreline. Since the late-1990s, each school has offered one or two biotech courses each year. The courses are designed under the Career and Technical Education (CTE) framework to focus on career-based outcomes in the sciences and to access national funding under the federal Perkins Act. In order to provide region-wide access to these courses, each school allows all high school students grades 10-12 in the NEVAC (Northeast Vocational Area Cooperative) region to participate (eight districts in total).

The focus and goals of the bioscience courses are generally threefold:

- Make students science literate.
- Develop laboratory and science skills that fulfill industry standards.
- Strengthen student's foundational science understanding.

Specific Activities in the Biosciences. The biotechnology courses offered at both Juanita and Shorewood high schools have innovative curricula designed to not only achieve strong foundations in science, but also to prepare students for careers in advanced biotechnology occupations. The year-long courses have been developed with a strong partnership between teachers/schools in addition to curricula and standards developed through the NWBECC.

The classes are structured in the CTE framework and thus have a strong career/vocational focus. The occupational credit requirement drives curriculum and overall design. The course targets college-bound students and/or those interested in laboratory or other scientific careers.

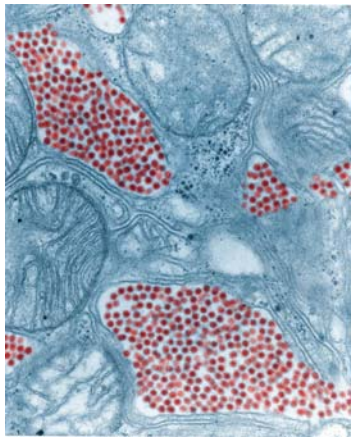
Cutting-edge and industry-specific curriculum includes course units in Bioethics, research integrity, the Human Genome Project, ag-biotech, cloning, Proteomics, FDA and drug development processes, and PCR techniques. Dozens of other topics and skills are covered in the course, most with real laboratory and research applications.

Experiential Learning. Unique student experiences include participating in the Human Genome Project, visits to laboratories, guest speakers from industry and universities, and career readiness activities. Both teachers collaborate closely with educational outreach programs that facilitate experiential learning, including: University of Washington Genome Sciences Department, Fred Hutchinson Cancer Research Center, Seattle Biomedical Research Institute, Northwest Association for Biomedical Research, and Amgen.

The biotechnology class at Shorewood has strong collaboration with the University of Washington through an ongoing research project. The Genome Sciences Department is using high school students to design behavioral research questionnaires for 300 study participants. This involves real statistical validation learning and participation in advanced research techniques.

Students showcase their learning and hands-on projects at the annual Student Biotech Expo, held each March in metro Seattle. Each student enters a project and competes with others across the region. The Expo supports student access to the regional scientific community as a local scientist partners with each student to guide their work.

Professional Development. While professional development opportunities have been limited for those teaching biotech courses in the region, this has not stopped them from developing new materials to further other's professional advancement. The teachers have developed, for example, a manual/guide for site visits to the Seattle Biomedical Research Institute for hands-on learning at one of the world's largest infectious disease research institutes. In addition, they have given seminars on best practices and their experiences in high school biotech education to national groups.



Status. Currently, two regional high schools offer three to four year-long Biotech courses with a range of 55 to 110 students (primarily 12th grade with some 11th) taking courses each year. Juanita High School's program has been in place since 1997 and was the first CTE Biotech program in the region. Shorewood soon followed, and now others are just beginning.

The Northwest Biotech/Biomedical Education and Careers Consortium continues its activities involving academic-industry collaboration in the biosciences. The skill standards developed through the Consortium have been used across the U.S. in developing new programs and achieving articulation with post-secondary institutions.

Articulation. The biotechnology courses at both Juanita and Shoreline high schools are articulated with Shoreline Community College (three transferable credits) and recently, a strong precedent has been set in articulation with the University of Washington.

Funding. Juanita and Shoreline are public high schools. They receive standard funding from their school districts and the State of Washington. Biotech programs are designated as CTE and receive funds allocated to their district under the federal Perkins Act that specifically help to pay for the biotechnology laboratories and classes. This additional Perkins money usually funds "consumables" in the lab and various lab kits and lab equipment.

Appendix C: Key Findings on Demand for Bioscience Workforce in Arizona

Recent occupation and industry data show that the bioscience workforce is growing significantly in Arizona. State job growth in major bioscience-related occupations outpaces the U.S. and is generally at a higher rate than the strong overall occupational growth that Arizona has established since 2001 (see table 1).

Table 1: Arizona Employment by Selected Major Bioscience-related Occupations, 2001-2006

Occupation	Employment, 2001	Employment, May 2006	AZ Change	AZ % Change	U.S. % Change
All Occupations	2,230,610	2,574,150	343,540	15%	4%
• Life, physical, & social science	13,560	17,590	4,030	30%	15%
• Healthcare practitioners & technical	90,840	107,110	16,270	18%	10%
• Healthcare support	52,030	58,410	6,380	12%	12%

Source: U.S. Bureau of Labor Statistics, Occupational Employment Statistics.

Similarly, the major bioscience industries in Arizona are adding jobs at a rapid rate, up 16% overall since 2001 compared with the national sector's 6.5% increase (table 2). The largest Arizona subsectors — hospitals and healthcare; research, testing, and medical labs; and medical devices — have all achieved employment growth rates well above those for the U.S. From both an occupational and industry perspective, it is clear that the state bioscience sector is exhibiting strong labor demand.

Table 2: Arizona Bioscience Industry Employment, 2001-2005

Bioscience Industry Subsector	Employment, 2001	Employment, 2005	AZ % Change	U.S. % Change
Total Biosciences	66,546	77,267	16.1%	6.5%
• Hospitals	55,695	64,602	16.0%	7.3%
• Research, Testing, & Medical Labs	5,007	6,627	32.3%	12.5%
• Medical Devices & Equipment	4,007	4,502	12.4%	-2.5%

Source: Battelle analysis of BLS, QCEW data from IMPLAN.

A more in-depth assessment of Arizona's bioscience workforce needs was sponsored by a coalition of education and government leaders back in 2003, led by Maricopa Community Colleges in collaboration with the Arizona Department of Commerce, Pima Community College, Yavapai College, and Flinn Foundation. This study found that substantial new hiring in the biosciences is expected for Arizona. The survey of bioscience employers showed that expected new hires in the next two years will reach 1,202 workers among those responding, a healthy 20% of current employment levels (Table 3).

Table 3: Survey Results for Job Categories

Job Categories	Number of Existing Workers	New Hires Last Year	Current Vacancies	Expected Hires, 2003-05	% of Expected Hiring to Existing Workers
Research	727	89	38	166	23%
Laboratory Technicians	1,681	364	148	535	32%
Production-related	2,083	188	78	309	15%
Management Support	1,599	232	81	192	12%

A surprising result from the survey of bioscience employers is that many are seeking workers with at least a bachelor's degree (Table 4). While this is not surprising for research scientists or engineers, it is surprising how frequently employers are seeking a bachelor's or higher degree for research lab technicians, engineering technicians, and management support occupations involving marketing/sales, quality assurance, and technical support.

Table 4: Frequency Distribution of Employer Interest in Educational Requirements by Job Function

Job Function	No Post-Secondary Required	2-Year Degree Required	BA Required	Advanced Degree Required	Hire Direct from Education
Product R&D Engineer		7%	67%	53%	53%
Research Scientist		0.03%	48%	79%	62%
Medical Lab Technician	76%	74%	64%	29%	98%
Research Technician	29%	41%	82%	29%	88%
Forensics	77%	77%	15%	8%	23%
Manufacturing & Production	94%	39%	28%	6%	100%
Engineering Technician	77%	80%	53%	7%	90%
Process Development Engineer		10%	80%	10%	70%
Marketing & Sales	33%	45%	64%	7%	50%
Technical Support/Documentation	66%	56%	91%	7%	90%
Quality Assurance/Validation	20%	43%	78%	35%	53%
Regulatory Affairs		34%	75%	53%	44%
Health/Bioinformatics	57%	67%	71%	19%	95%

Despite the promising signs of job gains in the biosciences, Arizona has some key challenges in aligning supply with demand. Examples of specific areas of mismatch include the following:

- Laboratory sciences. A significant and growing bioscience occupational area for Arizona is found in laboratory sciences, spanning both health care and research environments. Yet, few educational programs today address this need, and existing programs (especially in the health care laboratory) suffer from low enrollments. Interviews with postsecondary faculty and administrators suggest that not only are students unprepared to handle college-level scientific courses, but high school teachers are not trained to instruct students in the fundamentals of molecular biology and other key preparatory biology-related courses.

- Large generation of biology students lacking employable laboratory skills. Arizona stands out in the growth of its biology degrees, particularly at the undergraduate level, growing by 15% compared to just 1% nationally. The number of biology-related majors now stands at nearly 900 annually in Arizona. However, these biology students are generally poorly prepared to under-take the hands-on laboratory work required in healthcare and research settings. And the trend is to fewer laboratory instructional experiences for students in Arizona.

- Lack of educational and training curricula in regulatory affairs and quality assurance for medical devices. Beyond the fact that medical devices are Arizona's largest non-clinical bioscience industry and production workers the largest occupational grouping employed by bioscience employers, there is no active effort to provide training for workers entering that highly regulated environment with specific quality standards.

- Graduate degree programs in the biosciences are falling just as the demand for postdoctoral scientists in Arizona is soaring. Arizona has recorded a sharp decline in Ph.D. and master's graduates in the biosciences in recent years. Yet, a strong demand for research scientists is expected in Arizona in the next several years, with most of the positions to be filled by recent advanced degree graduates.

Underpinning these demand and supply mismatches in Arizona are deeper issues that must be addressed, including the following:

- The disconnect between bioscience employers and educational institutions in sharing information, setting priorities, developing needed programs, and addressing curriculum.
- Lack of capacity in the biosciences across the educational system, especially for specialized programs and advanced degrees.

- Limited awareness by Arizona residents — particularly school-age youth and those seeking new careers — of the opportunities to pursue bioscience careers, and a need for proactive steps to increase access to these career opportunities, especially among minority populations.

At the same time, as the economic priorities of Arizona are placing a clear emphasis on the bioscience sector, opportunities exist for Arizona to make workforce development a key driver and contributor to an overall bioscience economic development strategy for the state. Work-force development can provide both a resource for emerging and start-up bioscience ventures in Arizona and an advantage to attract investments and operations from existing bioscience companies, particularly from the West Coast.

Where do we go from here?

The Education Committee of Arizona's Biosciences Roadmap understands that if Arizona is to realize its dream of competing as a significant player in the emerging bioscience marketplace, it will need to maximize the potential of its education system. Policymakers cannot count on in-migration to produce future bioscience workforce alone, because other states and nations offer attractive alternatives in the bioscience arena. We need to build our own bioscience workforce.

The Education Committee has set out a bold, but realistic vision with specific recommendations to ensure that all interested high school students in Arizona have the opportunity to develop competency in bioscience knowledge and skills. Three key strategic goals must aggressively be pursued to reach this vision:

- Expand opportunities for high school biosciences education programs within Arizona's high school career and technical education offerings.
- Advance a more seamless education system focused on career opportunities across high school and post-secondary education.
- Improve the knowledge, training, availability, and retention of bioscience teachers in Arizona.

To achieve the vision and strategic goals outlined in this report, Education Committee members and advisors will champion, facilitate, and promote critical bioscience-specific issues in close coordination with the Governor's P-20 Council. Key organizations to carry out recommended activities will be our high schools, State Department of Education, community colleges, and universities, among others.

The Flinn Foundation wishes to thank SRP for the loan of
Senior Community Outreach Representative Darrell Sheppard, author of the first report,
“Building the Bioscience Pipeline: A Snapshot of Arizona High School Bioscience Education, 2006-2007.”
It and this report are available online at www.flinn.org