
**EDUCATING THE NEXT GENERATION OF CALIFORNIANS
IN A RESEARCH UNIVERSITY CONTEXT:**
University of California Graduate and Undergraduate Enrollment
Planning Through 2010

Appendix 2

***WORKFORCE PROJECTIONS AND JOB MARKET TRENDS
FOR GRADUATE AND PROFESSIONAL DEGREE RECIPIENTS***

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EXECUTIVE SUMMARY

Under the California Master Plan for Higher Education, the University of California has a responsibility to prepare graduate and professional degree recipients to help meet California's and the nation's workforce needs. Workforce needs, therefore, are an important criterion in planning UC's graduate and professional enrollments. As part of the analysis for the University's long-range enrollment planning through the year 2010, currently in progress, this background report analyzes recent labor market trends and projected workforce needs for doctoral, professional, and masters degree recipients – where possible, by occupation and disciplinary field.

Projecting future workforce needs for graduate and professional degree recipients is a challenging task for several reasons. We cannot assume that future workforce needs in six or more years (when students now beginning doctoral study will enter the labor market) will mirror today's needs. Moreover, projecting needs even a few years in the future for professionals in fields closely tied to the economy, such as business and law, is difficult. Current job market conditions, as well as our own projections about future needs, influence the decisions that students, educators, and policy makers make about graduate study, thereby altering the supply of individuals entering the workforce. The labor market outlook also varies substantially by field. Finally, graduate and professional degree recipients not only fill existing workforce needs but shape the workforce, creating new demand and new opportunities for economic growth and social benefits through the jobs they take.

Indeed, a review of major national Ph.D. workforce studies and projections developed over the past decade indicates that different analyses have reached sometimes conflicting conclusions regarding future Ph.D. demand and supply, with some analyses projecting large Ph.D. shortages and others projecting large Ph.D. surpluses. The most recent projections present a somewhat more optimistic outlook than do those developed during the economic recession of the early 1990s.

Despite the difficulty in projecting workforce needs, we believe they are too important not to consider in UC's enrollment planning. We therefore have tried to summarize and evaluate available information and to provide our best guesses on needs for UC graduate and professional degree recipients, but we recognize that our ability to project the future accurately is limited. Consequently, workforce analysis will require continuous environmental monitoring and student and employer feedback, and planning assumptions will have to be revisited regularly, as new information becomes available.

In providing our best guesses about future workforce needs, it is important to note two points. First, *California's economic, social, demographic, and environmental needs and outlook will differ from the nation as a whole.* Although UC prepares graduate students who will meet not just state but national and international labor market needs, many UC graduates (especially those from professional programs) remain in California. Over the next decade, according to economic analysts, the California economy, especially that related to high-tech industries, is expected to be stronger than that for the U.S. as a whole, and college enrollments will grow at a faster rate. California is expected to outpace the nation in jobs, income, and population growth.

Second, *demand for graduates of UC's graduate and professional programs may be greater than that for advanced degree holders nationally, because of the quality and focus of UC's programs.* UC graduate and professional degree recipients generally have had good placement records, even when the job market has been relatively weak, and UC Ph.D.'s overall have better placement records than do Ph.D.'s nationally, especially in engineering/computer sciences and physical sciences/mathematics.

Given the information available at this time regarding job market trends, workforce projections, and continuing uncertainties, as well as the distinctive needs of California and the success of UC graduates, our best guesses about future workforce needs over the next decade for graduate and professional degree recipients from the University of California are as follows:

- *Ph.D. recipients:* We expect that UC will need to increase the number of doctoral students it prepares, to fill three main types of positions: (1) college and university faculty, to meet demand due to enrollment growth and faculty replacement needs, (2) private-sector scientists and engineers, especially in high-tech areas, and (3) nontraditional and alternative Ph.D. careers, to fill and create fields and occupations that are just now emerging, for example, in new interdisciplinary fields and new applications to existing fields. Based on information currently available, we expect that needs will be strongest in fields such as computer sciences, engineering, public administration, and some applied psychology areas. Private-sector demand for Ph.D.'s in chemistry and the biological sciences, as well as in computer sciences and engineering, is expected to increase significantly, especially in growing high-tech industries; this demand likely will be even stronger in California. Conversely, supply may continue to outpace demand in mathematics and in a number of humanities and social science fields. Nevertheless, within each of these disciplines, there will likely be demand in particular areas of specialization.
- *Professional and masters degree recipients:* Professional enrollments are closely tied to California's needs, since most UC-educated professionals remain in the state. To meet California's expanding and changing economic and social service needs, the numbers of UC professional and masters degree enrollments will need to increase, especially in computer science and engineering fields linked to high-tech industries. Demand for K-12 teachers with the kind of strong academic training that UC can provide will also be high. While demand for business executives and lawyers is expected to grow, it is unclear whether supply will outpace demand. Finally, there may be significant needs for new types of professionals with an interdisciplinary masters-level training that builds on UC's research base, especially in emerging technology-oriented fields (e.g., digital arts) or in areas of growing social concern, such as environmental studies.

INTRODUCTION¹

Under the California Master Plan for Higher Education, the University of California has a responsibility to prepare graduate and professional degree recipients capable of meeting not just current but changing workforce needs for California and the nation. Workforce needs, therefore, are an important criterion in planning UC's graduate and professional enrollments.

As part of the analysis for the University's long-range enrollment planning through the year 2010, currently in progress, this background report analyzes recent labor market trends and projected workforce needs for doctoral, professional, and masters degree recipients in California and the U.S. – where possible, by occupation and disciplinary field. We hope that the report, especially information by specific occupations and disciplinary fields, will also be useful to campuses and programs in their enrollment planning. However, determining the numbers of individuals the workforce will need as well as the numbers that UC and other institutions will enroll over the next decade is a challenging task. Consequently, workforce analysis will require continuous environmental monitoring and student and employer feedback, and enrollment planning will require institutional flexibility in thinking about how best to meet these needs.

The report is organized as follows:

- Section I presents a brief overview of the challenges inherent in projecting future workforce needs.
- Section II focuses on the labor market outlook for Ph.D. recipients.² This section first reviews recent data and studies that can inform our understanding of broad job market trends, broad workforce projections for doctoral recipients, and changing workforce conditions. Since job trends and outlooks for doctoral recipients vary widely by discipline, we then examine job market trends and projections for a number of specific disciplines for which information was available.
- Section III analyzes job market trends and projected workforce needs for professional and masters degree recipients in a number of fields.
- Finally, Section IV summarizes our “best guesses” about future workforce needs for graduate and professional degree recipients, focusing specifically on the role that we expect UC programs to play in meeting these needs.

¹ This analysis builds upon earlier analyses developed by the Office of Planning and Analysis in the University of California Office of the President, as well as upon a chapter by Ami Zusman, “Issues Facing Higher Education in the Twenty-First Century,” in Philip G. Altbach, Robert O. Berdahl, and Patricia J. Gumpert, eds., *American Higher Education in the Twenty-first Century: Social, Political, and Economic Challenges* (Baltimore: The Johns Hopkins University Press, 1999).

² The term “Ph.D.” in this report also includes other academic doctorates (e.g., Ed.D., D. Engin.).

I. DIFFICULTIES IN PROJECTING FUTURE WORKFORCE NEEDS

Determining future workforce needs for graduate and professional degree recipients is a challenging task for several reasons.

- *We cannot assume that future workforce needs will mirror today's needs.* For example, the employment outlook for Ph.D.'s in six or more years (when students now beginning doctoral study will enter the job market) may be far different than it is now. For college faculty, we may need to project at least eight years into the future. Most life science and physical science Ph.D. recipients complete their degrees in about six years but then complete two or more years of postdoctoral work before they are hired as faculty. In the social sciences and humanities, Ph.D. students typically take seven to eight years to complete their degrees but then generally move directly into faculty positions.
- *Given recent economic volatility, projecting needs even a few years in the future for professionals in fields closely tied to the economy, such as business and law, is difficult.* In addition, as always, there will be shifts in demand for professionals that cannot be fully anticipated.
- *The narrower the focus (i.e., specific disciplines or subfields), the greater the chance that projections based on current employment conditions will err.* Fluctuations in demand for individual disciplines are even greater than that for the overall Ph.D. market or for broad fields. Yet to plan graduate enrollments and programs, we need information by discipline.
- *Current job market conditions, as well as the projections we make about future workforce needs, influence individuals' decisions, thereby altering the future demand/supply ratio.* As Richard Freeman noted as far back as the 1970s, a "boom and bust" cycle exists in the academic labor market for Ph.D.'s: When current Ph.D. jobs appear plentiful, growing numbers of individuals apply to graduate programs, but fewer apply when jobs are in short supply. In addition, our own projections of future demand influence student decisions about whether or not to enter doctoral programs and institutional and governmental decisions about whether or not to expand and support them; in so doing, these decisions may invalidate the projections. Because a lag exists between job market needs and Ph.D. production, job shortages are inevitably followed by surpluses and surpluses by shortages.³

Demand for graduates of UC's graduate and professional degree programs may differ from national prospects.

- *California's economic, social, demographic, and environmental needs and outlook will differ from the nation as a whole.* Although UC prepares graduate students who will meet not just state but national and international labor market needs, many UC graduates remain in California. This is especially true of graduates of UC's professional programs, the great majority of whom work in California; but many Ph.D. recipients, especially in engineering

³ Richard Freeman, *The Overeducated American* (New York: Academic Press, 1976).

and the physical sciences, take jobs in California as well.⁴ Over the next decade, according to economic analysts, the California economy, especially that related to high-tech industries, is expected to be stronger than that for the U.S. as a whole, and college enrollments will grow at a faster rate. California is expected to outpace the nation in jobs, income, and population growth.⁵

- *Demand for graduate and professional degree recipients from UC may be greater than that for advanced degree holders nationally because of the quality and focus of UC's programs. UC graduate and professional degree recipients generally have had good placement records, even during periods of a relatively weak job market. (See Section IV.)*

Graduate and professional degree recipients themselves shape workforce needs and requirements.

- *Graduate and professional degree recipients not only fill existing workforce needs but shape the workforce, creating new demand and new opportunities for economic growth and social benefits through the jobs they take. Masters and Ph.D. recipients in nontraditional careers that might once have been considered "out-of-field" or inappropriate have transformed those positions by bringing their skills and knowledge to bear on these positions, so that now holding the advanced degree is a job requirement. For example, those entering public-sector policy analysis are now often required to hold an advanced degree, although this was not true 15-20 years ago. Experience with the skillful analysis advanced degree holders provide has increased the profession's expectations for the kind of analyses that will be carried out and for the kinds of skills that incumbents will bring to their tasks.*

Given these and other challenges in projecting future graduate and professional demand and supply, some analysts have concluded that it is not now possible, and may never be possible, to forecast future workforce needs for doctoral and other advanced degree recipients with accuracy sufficient for planning, and that we therefore should not attempt to do so.⁶ Rather, such observers would base graduate-level enrollments on criteria such as student and program quality, avoid sharp enrollment increases or decreases, and modify graduate programs to provide greater breadth and flexibility, better career guidance, and financial support mechanisms that encourage

⁴ For example, among recent UC engineering doctorates, over 72 percent sought immediate employment (rather than postdoctoral appointments) after graduating; of these, nearly 60 percent obtained jobs in California upon graduating. Nearly 50 percent of physics Ph.D.'s seeking immediate employment and over 40 percent of chemistry Ph.D.'s seeking employment obtained jobs in California (National Research Council, Survey of Earned Doctorates, 1995, UC data files). Many Ph.D.'s who accept postdoctoral appointments ultimately will take career positions in California colleges, industry, or other sectors.

⁵ Center for Continuing Study of the California Economy (CCSCE), *California Economic Growth, 1998 Edition* (Palo Alto, CA: CCSCE, 1998).

⁶ Ad Hoc Working Group on the Supply of Science, Engineering, and Mathematics (SEM) Professionals, Federal Coordinating Council for Science, Engineering, and Technology, *Report* (September 9, 1993); National Science Foundation, Division of Science Resources Studies, *Who Is Unemployed? Factors Affecting Unemployment Among Individuals with Doctoral Degrees in Science and Engineering*, Special Report, NSF 97-336, By Carolyn F. Shettle (Arlington, VA: NSF, 1997).

student flexibility in meeting employment demands.⁷ High quality must, of course, be a prerequisite for all UC graduate programs and enrollments, and flexibility and responsiveness are essential. However, despite the difficulty in projecting workforce needs, we believe they are too important not to consider in UC's enrollment planning. We therefore have tried to evaluate the best information available, but we recognize that planning assumptions will have to be revisited regularly, as new information becomes available.

⁷ Committee on Science, Engineering, and Public Policy (COSEPUP) of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine, *Reshaping the Graduate Education of Scientists and Engineers* (Washington, D.C.: National Academy Press, 1995). Henceforth, we refer to this report as the COSEPUP report.

II. PH.D. WORKFORCE NEEDS

This section first reviews recent data and studies that can inform our understanding of broad job market trends, broad workforce projections for doctoral recipients, and changing workforce conditions. Since job trends and outlooks for doctoral recipients vary widely by discipline, we then examine job market trends and projections for a number of specific disciplines for which information was available.

A. Broad Job Market Trends and Projections for Ph.D. Recipients

Overview of Ph.D. Job Market Trends in the 1990s

In the early 1990s, the Ph.D. job market dropped to a 20-year low point, a fact that generated widespread concerns about Ph.D. employment and the size of graduate programs.

In the first half of the 1990s, the job market for most U.S. Ph.D. recipients was worse than it had been for at least two decades. This was true not only for Ph.D.'s in the humanities and social sciences, many of whom have long faced lengthy job searches after graduating, but for new engineering and physical science Ph.D.'s as well.

The poor job market for Ph.D.'s (as well as for many professionals) was due to a number of unanticipated changes, including perhaps most importantly the economic recession of the early 1990s. As a result both of the recession and of shifts in state tax dollars toward growing demand for services in areas such as health, corrections, and K-12 education, funding for public higher education in California and in many other states was constrained and cut, sometimes severely, and public colleges hired fewer new faculty than they had earlier expected. In addition, the end of the Cold War brought about "downsizing" in the defense industry, which employs many doctoral scientists and engineers. Other reductions in private-sector research and development (R&D) in business and industry and in government employment also hurt job prospects for new Ph.D.'s. At the same time, partly in response to earlier predictions of Ph.D. job shortages, doctoral production (which had been expected to remain level) increased more than 30 percent between 1986 and 1996.⁸

Nationally, nearly half of all physical scientists and over 70 percent of biological science doctorates now seek postdoctoral scholar appointments after graduating, rather than immediate

⁸ U.S. Department of Education, National Center for Education Statistics (NCES), *Projections of Education Statistics to 2008*, NCES 98-016, by Debra E. Gerald and William J. Hussar (Washington, D.C.: U.S. Government Printing Office, 1998).

employment,⁹ and the number of years they spend in postdoctoral positions appears to be lengthening. These increases reflect the emergence of a period of mentored postdoctoral research and study as an expected part of the preparation of scientists, but the extended number of years that new Ph.D.'s are spending in such appointments is also a response in part to a weaker job market in the sciences.¹⁰ Part-time, out-of-field, or temporary employment among new Ph.D.'s rose in the early 1990s, as well. In the humanities, 14 percent of 1988-92 Ph.D.'s were involuntarily working part-time or outside their fields in April 1993, and 11 percent were in temporary positions.¹¹

Even during weak job markets, however, unemployment among Ph.D.'s has been considerably below that of the labor force as a whole.

Even during the difficult years in the early 1990s, most Ph.D.'s, in both science and non-science fields, eventually found jobs, and unemployment for Ph.D.'s remained considerably lower than that for the U.S. civilian labor force as a whole. For instance, in 1993, the overall U.S. unemployment rate was 6.8 percent. By contrast, the overall unemployment rate in 1993 for recent science, engineering, and social science Ph.D.'s (that is, Ph.D.'s who had received their degrees one to three years earlier) was 1.7 percent, and it was 3.3 percent for recent humanities Ph.D.'s. In 1995, overall unemployment for recent science, engineering, and social science Ph.D.'s was 1.9 percent, ranging from 0.5 percent in psychology to 4.3 percent in chemical engineering, and it was 3.0 percent in the humanities.¹²

In recent years the job market for Ph.D.'s in most fields has begun to improve, especially for jobs in the industrial sector.

Some industries have created new opportunities for Ph.D. holders in recent years. Most U.S. science and engineering Ph.D.'s and nearly half of all social science doctorates no longer work in four-year colleges or universities, the traditional employer of Ph.D.'s. Rather, by 1991, business and industry had become the largest single employment sector for both engineering and physical science Ph.D.'s. As the recent "COSEPUP" report concluded, "PhDs are increasingly finding employment outside universities and more and more are in types of positions that they had not expected to occupy."¹³

⁹ National Research Council, *Summary Report: Doctoral Recipients from United States Universities, 1996*, by Peter H. Henderson, Julie E. Clarke, and Cynthia Woods (Washington, D.C.: National Academy Press, 1998). Physical science figure includes mathematics but excludes computer sciences (which UC classifies with engineering/computer sciences). Even higher proportions of UC Ph.D.'s in the physical sciences (as well as in engineering) seek postdoctoral scholar appointments as a step toward career positions – 57 percent of physical science/mathematics Ph.D.'s, and 27 percent of Ph.D.'s in engineering/computer sciences.

¹⁰ Commission on Professionals in Science and Technology (CPST), *Postdocs and Career Prospects: A Status Report* (Washington, D.C.: American Association for the Advancement of Science, 1997).

¹¹ National Science Board, *Science & Engineering Indicators—1996* (Washington, D.C.: U.S. Government Printing Office, 1996).

¹² Ibid.; Mark Regets, "What's Happening in the Labor Market for Recent Science and Engineering Ph.D. Recipients?," National Science Foundation *Issue Brief*, NSF 97-321 (Washington, D.C.: NSF, September 23, 1997); National Research Council, *Humanities Doctorates in the United States: 1995 Profile*, by Linda Ingram and Prudence Brown (Washington, D.C., National Academy Press, 1997).

¹³ COSEPUP, *Reshaping the Graduate Education of Scientists and Engineers*.

Moreover, as noted further below, recent surveys by a number of professional associations, including chemistry, history, languages and literature, mathematics, and physics, conclude that the Ph.D. job market for new Ph.D.'s (i.e., those graduating within the previous year) is improving, especially in the industrial sector. In addition, a survey of a sample of new 1996-97 doctorates in 13 science, social science, and engineering fields found that unemployment as of mid-October 1997 ranged from 0.6 percent in psychology to 4.6 percent in chemistry.¹⁴ Since unemployment levels are usually highest in the first few months after Ph.D.'s graduate, when they are first seeking positions, we would expect that unemployment rates for these individuals have dropped still further since October 1997.

Nevertheless, job market difficulties for Ph.D.'s in some fields remain.

Despite evidence of an improved job market, several cautions should be kept in mind. First, these are improvements over what in many cases had been the worst job market in two decades. In a number of fields, including mathematics, English, and history, the supply of new Ph.D.'s continues to outpace demand, and many new Ph.D.'s in these fields are still having difficulty finding jobs in their fields, especially potentially permanent positions. For example, a 1997 report by the Modern Language Association concluded that new English and foreign language Ph.D.'s continue to face a crisis in the academic job market (where most such Ph.D.'s are employed) because the number of Ph.D.'s awarded annually in these fields continues to rise faster than full-time faculty openings.¹⁵ Second, in some cases, faculty hires are coming from a backlog of Ph.D. recipients who had been in temporary positions, while new Ph.D.'s continue to enter the job market. For example, although the number of newly hired assistant professors in history rose substantially between 1996 and 1997, over a third of them had received their degrees more than three years earlier.¹⁶

Third, as noted, larger numbers of Ph.D.'s in the sciences are spending longer periods of time in temporary postdoctoral appointments. According to surveys by a number of professional associations, many postdocs, especially those in fields like chemistry, earth sciences, mathematics, and physics, say they are taking such temporary positions because they were unable to find permanent jobs.¹⁷ Finally, in fields such as political science, mathematics,

¹⁴ CPST, *Employment of Recent Doctoral Graduates in S&E: Results of Professional Society Surveys* (Washington, D.C.: CPST, 1998). Percentages in this report should be viewed with some caution, because of low sample size in some fields, low response rates (ranging from 34 percent in engineering to 73 percent in physiology), exclusion of those with foreign addresses in physics, and other problems that may bias the responses. (The CPST report includes a fourteenth field, political science, with seven percent unemployment; however, CPST advises interpreting this rate cautiously, because of the particularly small sample size.)

¹⁵ Modern Language Association of America, "MLA Committee on Professional Employment, Final Report" (Sandra Gilbert, Chair) (MLA: December 1997).

¹⁶ Robert B. Townsend, "Academic Job Opportunities Better than Expected in 1997," *American Historical Association, Perspectives* (October 1997): 9, 11-13.

¹⁷ CPST, *Postdocs and Career Prospects*; CPST, *Employment of Recent Doctoral Graduates in S&E*. By contrast, taking a postdoctoral position has become an expected career step in some fields, especially in the biological sciences.

sociology/anthropology, and the humanities, many employed Ph.D.'s continue to be involuntarily employed part-time or outside their fields.¹⁸

Multi-Field Projections of Future Ph.D. Workforce Needs

National Ph.D. workforce projections paint a mixed picture, with differences not only by field but among different labor force analysts. The most recent projections present a somewhat more optimistic outlook than do those developed during the economic recession of the early 1990s.

In spite of the difficulties associated with producing projections, several labor force economists and other scholars, governmental agencies, and professional associations have attempted in recent years to assess the nation's future workforce needs for doctoral recipients. A number of these analyses are broad-based studies that cut across a range of fields. These studies provide important sources of information regarding overall Ph.D. labor market needs, and several have had a significant influence on public discussions about future Ph.D. needs. Therefore, it is important both to note their conclusions and to understand their methods and assumptions.

There is no clear consensus among these studies about future workforce needs for doctoral recipients, however. Indeed, these analyses disagree not only about the scope and nature of such future workforce needs but whether there will be shortages or surpluses. Rather, their conclusions appear to be influenced by the assumptions and methodologies used, as well as by the conditions existing at the time in which they were developed. For example, those developed in the late 1980s, prior to the economic recession and the end of the Cold War, projected substantial shortages of Ph.D.'s in many fields, while those developed in the midst of the recession made more pessimistic assumptions. Each study has significant limitations and, in hindsight, did not anticipate important recent developments. Yet, they remain our best source of information about future Ph.D. workforce needs – as well as underscoring the difficulties inherent in attempting to project the future and, thus, the need to ensure that we continue to monitor employment conditions and to maintain flexibility to adapt programs and enrollments to changing needs.

We summarize briefly below, in chronological order, the major studies of projected Ph.D. workforce needs that have been conducted over the past decade.

1. William G. Bowen and Julie Ann Sosa, *Prospects for Faculty in the Arts and Sciences: A Study of Factors Affecting Demand and Supply, 1987 to 2012* (Princeton, N.J.: Princeton University Press, 1989). (Focus: arts and sciences faculty for four-year colleges.)

In what remains the most recent comprehensive set of labor market projections for college faculty in arts and sciences fields, Bowen and Sosa projected serious faculty shortages after 1997 across the arts and sciences, with particularly severe shortages in the humanities and social sciences during the 1997-2007 period. Basing their analysis on conditions and trends present in

¹⁸ Mark Regets, "What's Happening in the Labor Market for Recent Science and Engineering Ph.D. Recipients?"; National Science Board, *Science and Engineering Indicators-1996*. Data on involuntary out-of-field or part-time employment date from 1995 or earlier; the stronger economy in the past three years may have reduced these numbers.

the mid-1980s, Bowen and Sosa projected substantial faculty shortages as a result of several expected outcomes: large numbers of faculty would retire and need to be replaced after 1997, as faculty hired in the 1960s and 1970s reached retirement age; college enrollments would increase; and the number of new doctorates seeking academic careers would decline, falling well short of demand between 1997 and 2007. They also assumed that the arts and sciences student-faculty ratio at four-year colleges in the mid-1980s (then at what may have been an all-time low) would be maintained or even decline further and that the time the typical graduate student took to complete the doctorate would continue to increase. Although the authors presented four alternative models of faculty demand, the highest and lowest of these projections differed by only eight percent.

To date, these projections of serious faculty shortages have not come to pass and seem unlikely at least in the next few years. New doctorates soared 30 percent between 1986 and 1996, rather than declining. In addition, because colleges and universities suffered sharp budgetary cutbacks in the 1990s, they hired fewer new faculty than anticipated. In the humanities and in some of the physical sciences, a reserve pool of recent Ph.D.'s in temporary positions are eager to assume faculty positions. Moreover, the authors' assumption that the low student-faculty ratio would be maintained or decline even further seems unrealistic for the foreseeable future. A crude calculation of full-time student-faculty ratios (for all fields) in four-year institutions nationally suggests that at best they have not changed in recent years; in California, they have risen. Moreover, even though the total number of college faculty grew nearly 13 percent between 1991 and 1995 (with higher growth rates in two-year colleges), the number of *full-time* faculty increased less than three percent, and the number of *newly hired* full-time faculty declined nearly eight percent.¹⁹ However, because faculty retirements are likely to grow in the coming years, there may be greater numbers of new hires in the future. Nevertheless, from the vantage point of 1999, Bowen and Sosa's projections of future Ph.D. supply to 2007 seem too low by far, while their projections of future faculty demand seem overly optimistic, even at a time of anticipated enrollment increases, faculty retirements, and improved economic conditions.

2. Richard C. Atkinson, "Supply and Demand for Scientists and Engineers: A National Crisis in the Making," *Science*, 248 (27 April 1990): pp. 425-432. (Focus: natural science and engineering Ph.D.'s.)

Based on data from a draft National Science Foundation study, Atkinson, then president of the American Association for the Advancement of Science and chancellor of UC San Diego, projected a critical shortfall of Ph.D. scientists and engineers for both academic and private-sector positions by the early years of the 21st century. He calculated that an annual shortfall of several thousand doctoral scientists and engineers would develop over the next several years and would persist well into the 21st century. Three factors in particular were expected to increase demand for Ph.D. scientists and engineers: increasing faculty retirements, which would require faculty replacements, growth in college enrollments, and anticipated growth in federal and private R&D investments, resulting in industry need for additional Ph.D. scientists and engineers. Like the Bowen and Sosa study, the NSF study projected that supply would fall short of demand. The NSF study projected that the number of new Ph.D.'s would peak in 1993 and

¹⁹ U.S. Department of Education, NCES, *E.D. TABS: Fall Staff in Postsecondary Institutions, 1995*, NCES 98-228, by Stephen Roey and Rebecca Rak (Washington, D.C.: U.S. Government Printing Office, 1998).

then decline nearly 17 percent by 2003, before subsequently beginning to recover. In the early 1990s, the unpublished NSF study was widely cited as evidence for the need to intervene to increase the number of individuals pursuing Ph.D.'s in the sciences and engineering.

The NSF study appears to have underestimated the numbers of students already in the doctoral pipeline in 1990. In addition, calls to increase the number of Ph.D.'s further may have been successful. By 1993, the number of new science and engineering doctorates awarded was 26 percent higher than projected and, rather than declining after 1993, the number of new science and engineering Ph.D.'s increased another eight percent between 1993 and 1996. This increase, together with the unanticipated economic recession and the defense downsizing, has meant that the projected shortfall has not materialized to date. On the other hand, perhaps in response to widespread reports about a weaker doctoral job market, applications to graduate programs nationally began to decline in a number of fields beginning in 1993, leading to enrollment declines.²⁰ In particular, first-time graduate enrollments in the physical sciences and engineering declined by 15 and 20 percent, respectively, between 1991 and 1996; only in 1997 did these numbers level off or increase slightly.²¹ If new graduate enrollments remain at these lower levels or continue to decline, the number of new Ph.D.'s in these fields may decline in the next few years. Nevertheless, in retrospect this study, too, appears to have overestimated projected shortages at least for the next few years, although current graduate enrollment patterns and an improving R&D environment could produce Ph.D. shortages further down the road.²²

3. Committee on Science, Engineering, and Public Policy (COSEPUP) of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine, *Reshaping the Graduate Education of Scientists and Engineers* (Washington, D.C.: National Academy Press, 1995). (Focus: Ph.D.'s in the physical sciences, life sciences, social sciences, and engineering.)

The COSEPUP report found that, while new Ph.D.'s in the sciences, social sciences, and engineering were facing increasing difficulties in obtaining positions during the weak doctoral job market of the early 1990s, most eventually did obtain jobs. The report concluded that the overall demand for Ph.D. scientists and engineers remains strong but that the types of positions for which these Ph.D.'s will be needed are changing. In general, the COSEPUP report expected slowed growth in academic positions and reduced demand for traditional basic researchers in some fields (both within and outside academe) but a relatively good market for those seeking *applied* R&D positions in business and industry, as well as non-research positions, especially for those who are adaptable and can bring diverse skills: "Over the long term, demand for graduate

²⁰ Peter D. Syverson, "Early Returns of 1997 CGS/GRE Survey Reveal Second Year of Graduate Enrollment Decreases," *CGS Communicator* (Newsletter of the Council of Graduate Schools), XXXI (November/December 1998): pp. 7-9.

²¹ National Science Foundation, *Graduate Students and Postdoctorates in Science and Engineering: Fall 1997 Supplemental Tables*. Data are for full-time students in both masters and doctoral programs; it is not known what proportion of the decline is at the doctoral (rather than masters) level. It should also be noted that first-time graduate enrollments in many fields, as well as first-time undergraduate enrollments, declined in the early 1990s.

²² The UC situation with regard to applications to and enrollments in graduate engineering and computer science programs differs somewhat from the national one. While applications to such UC programs declined from 1993 through 1995, they rose four percent in 1996 and another six percent between 1996 and 1997. These UC programs have now increased their admissions in response to needs, and new enrollments have increased as well, returning the enrollment level for new students to that of the early 1990s.

scientists and engineers in business and industry is increasing; more employment options are available to graduate scientists and engineers who have multiple disciplines, minor degrees, personal communication skills, and entrepreneurial initiative" (p. 2-17).

The report did not make specific workforce projections, arguing that current supply-demand models could not adequately predict undersupply or oversupply of scientists and engineers, in part because students, faculty, policy makers and others alter their behavior on the basis of employment projections, thereby altering labor supply outcomes. However, the report found no convincing arguments to limit the number of graduate enrollments. Rather, it suggested that universities broaden graduate training to prepare individuals for a wider range of prospective careers. Critics have argued that the report is overly optimistic because it discounts individuals who may be employed but may not be in permanent career positions appropriate to their training.

4. William F. Massy and Charles A. Goldman, *The Production and Utilization of Science and Engineering Doctorates in the United States* (Stanford, CA: Stanford Institute for Higher Education Research Discussion Paper, May 1995, with August 1995 revisions). (Focus: Ph.D.'s in the physical sciences, life sciences, social sciences, and engineering.)

Using econometric model simulations of supply and demand, Massy and Goldman projected employment gaps in 12 fields – physics/astronomy, chemistry, bioscience, geological sciences, mathematics, economics, psychology, computer science, and four engineering fields. Massy and Goldman concluded that, given conditions prevailing in the early 1990s, about 22 percent of science and engineering doctorates in the U.S. could fail to find suitable employment, with wide variations among fields. For example, they projected labor surpluses ranging from a 44 percent surplus in mechanical engineering to no or negligible surpluses in chemistry, psychology, and computer science.

Many higher education experts have argued that the study's assumptions and methodology, and therefore its conclusions, are flawed.²³ For example, the model ignored differences among fields in industrial demand and in retirement rates; engineering fields were projected to have high labor surpluses, in part because the model failed to consider the higher rates of industry demand for engineering Ph.D.'s. The model also is based on several questionable assumptions, for example, assumptions of a steady-state in employment demand and supply, steady-state undergraduate enrollments, and assumptions about the proportions of foreign students who will remain in the U.S. Nor did the model account for major changes in the National Research Council's definitions of field of study and employment, which resulted in some cases in a narrow definition of "appropriate" field of employment; for example, medical science positions are excluded from the workforce demand for bioscience Ph.D.'s. Among the model's surprising conclusions are an estimated labor shortage in chemistry (five percent) and large labor surpluses in electrical engineering (41 percent) and bioscience (28 percent) – contrary to conclusions drawn by most professional association surveys and other studies. Nevertheless, the report received wide attention from both policy makers and the media. Our evaluation of the study is that, while it is an impressive effort to model complex variables, the measures used in the simulations do not

²³ See, for example, Peter D. Syverson, "When Simulation Becomes Reality: Press Reaction to Massy/Goldman Study Creates Erroneous Message," *CGS Communicator* (Newsletter of the Council of Graduate Schools) (August 1995): 8-10; Charlotte Kuh, "Is There a Ph.D. Glut? Is that the Right Question?," *CGS Communicator* (August/September 1996): 1, 3-4.

reflect reality, as a comparison between the model's projections and actual situations shows. Consequently, we have not found the study helpful in projecting future Ph.D. demand and supply.

5. Robert C. Dauffenbach, mid-growth scenario for supply and demand of scientists and engineers (1994 to 2005), unpublished tabulations, cited by the National Science Board, *Science and Engineering Indicators—1996* (Washington, D.C.: U.S. Government Printing Office, 1996), Chapter 3. (Focus: scientists and engineers, all degree levels.)

Under a mid-growth scenario in a model developed by Robert C. Dauffenbach, supply and demand for scientists and engineers (not separated by degree level) will remain more or less in balance between 1994 and 2005. Labor shortages are projected in a few areas (especially for computer and mathematics specialists and, to a smaller extent, engineers), and slight labor surpluses are projected in other areas, such as for physical scientists. Much of the growth in demand is not projected to occur until after 2002.

It is important to emphasize that Dauffenbach's model does not distinguish between demand or supply at different degree levels (baccalaureate, masters, and doctoral) and that only about five percent of the science and engineering workforce has doctoral degrees. The National Science Board notes that it does not endorse this or other models but presents it as one possible approach worthy of examination.

6. U.S. Bureau of Labor Statistics, *1998-99 Occupational Outlook Handbook* (Washington, D.C.: U.S. Government Printing Office, 1998); George T. Silvestri, "Occupational Employment Projections to 2006," U.S. Bureau of Labor Statistics, *Monthly Labor Review*, 120 (November 1997): pp. 58-83; George T. Silvestri, "Occupational Employment to 2005," U.S. Bureau of Labor Statistics, *Monthly Labor Review*, 118 (November 1995): pp. 60-84. (Focus: two- and four-year college faculty, all fields; also doctoral degree recipients, all fields.)

College and university faculty: The most recent U.S. Bureau of Labor Statistics (BLS) projections for college faculty demand and supply, which provide projections for the period from 1996 through 2006, are more optimistic than previous reports. The *Occupational Outlook Handbook* projects that there will be many openings for college faculty (at two- or four-year institutions) during the 10-year projection period, as large numbers of faculty members retire, beginning in the late 1990s. In addition to replacements, the total numbers of college faculty will increase "about as fast as the average for all occupations" (i.e., a 10 to 20 percent increase), as college enrollments increase. Faculty prospects will continue to be better in certain fields (such as business, engineering, health science, and computer science) where applicants also have attractive job opportunities outside academe. On an annual basis, the BLS's November 1997 projections of total job openings for college faculty through 2006 (including both growth in jobs and replacements) are nearly 15 percent higher than November 1995 projections through 2005. (In fact, however, the BLS notes that job openings are expected to be greater in the later years than in the earlier years.) However, the *Handbook* predicts "keen competition" for *full-time* college faculty positions, as growing numbers of new Ph.D.'s compete for what is expected to be a decreasing number of such full-time positions. In addition, even though demand may increase, in some fields the supply of Ph.D.'s will increase faster than demand. In terms of projecting needs for doctoral recipients, one shortcoming of the BLS projections is that they combine job

openings for faculty in four-year institutions (where most faculty have doctorates) with those in two-year institutions (where only a small proportion of faculty currently hold doctorates).

Doctoral degree recipients: According to BLS projections, total job openings between 1996 and 2006, as a proportion of 1996 employment, will be greater for doctoral degree recipients (45 percent) than for all occupations (38 percent). (Job openings for bachelors recipients will be 46 percent of 1996 employment, while those for first-professional (law and health professions) and masters degree recipients will be 34 percent and 31 percent, respectively.)

In summary, these various national projections of Ph.D. workforce demand and supply provide us some, but limited, guidance in assessing the workforce component of UC doctoral enrollment planning. Projections of both large Ph.D. shortages (for example, the Bowen and Sosa and Atkinson studies) and large surpluses (for example, the Massy and Goldman study) seem less likely to be realized than do projections of moderate growth in demand. The most recent projections suggest that much of the growth in such demand, where it occurs, is not likely for several years. Since entry of Ph.D.'s into the workforce generally takes six years or more from the start of doctoral study, this time frame fits with our enrollment planning, but it means that many Ph.D.'s currently in the pipeline may continue to face a somewhat difficult job market. As detailed in Section IIB below, it is important to emphasize that Ph.D. demand and supply *will vary greatly by discipline*. But year-to-year fluctuations in demand for Ph.D.'s in particular disciplines are even greater than those in the overall Ph.D. market or in broad fields, and unanticipated events (for example, economic recession or substantially increased federal investment in research and development) could radically alter demand and supply. This again points to the need for constant monitoring and flexibility.²⁴

Changing Conditions

If economic conditions remain strong, overall demand for Ph.D.'s will likely increase. Less certain is whether Ph.D. supply (the numbers of new Ph.D.'s awarded nationally) will match, fall short, or exceed demand.

While the workforce projections published to date help guide our thinking, we must pay special attention, in planning future UC graduate enrollments, to several important and changing conditions that will affect Ph.D. workforce needs. Some of these changing conditions will likely increase workforce needs for doctoral recipients; others will likely constrain them. These factors will impact individual disciplines differently.

²⁴ Additional studies now underway should provide further information in the next year or two on the Ph.D. labor market and our ability to project it. For example, the National Academy of Sciences has established a Committee on Methods of Forecasting Demand and Supply of Doctoral Scientists and Engineers, to examine additional forecasting methodologies and recommend improvements in the way that forecasts are presented. A national study on "Ph.D.'s – Ten Years Later," being conducted by Maresi Nerad and Joseph Cerny of UC Berkeley, will provide better understanding of long-term Ph.D. career patterns in six representative disciplines, and a special substudy of Ph.D.'s from the nine UC campuses will provide specific information on how UC Ph.D. recipients have fared.

- *Enrollment growth:* California college enrollments are expected to increase significantly over the next decade, as “Tidal Wave II” (the large numbers of students now in the secondary school system) enters college in the early years of the 21st century. In the next seven years alone, UC’s preliminary planning estimates project an increase of about 15 percent between 1998-99 and 2005-06 – from 153,600 to about 176,000; and CSU enrollments are projected to increase over 23 percent – from 350,900 to 432,000, according to 1998 Department of Finance projections.²⁵ Although debate continues regarding the specifics of different enrollment projections, there is no question that enrollments in California’s public four-year institutions will increase significantly.²⁶ If, as expected, enrollments in CSU and UC grow by approximately 104,000 over the next seven years, roughly 5,200 to 5,550 new faculty could be required, with still more faculty needed as enrollments continue to grow beyond 2005.²⁷

Nationally, enrollments in four-year institutions are projected to increase more slowly but still substantially during this seven-year period – an eight percent increase from 8.9 million to 9.6 million students, with faster enrollment growth after 2005.²⁸ This enrollment growth will require colleges and universities to hire more Ph.D. faculty, although the fields in which new faculty will be in heaviest demand are not fully certain. (We address this question in more detail below.) In addition, if more working adults return to school for advanced education, new opportunities for faculty hiring may open.

- *Faculty retirements:* Large numbers of faculty, both in California and in the U.S., were hired in the 1960s to teach the “baby boom” generation, which not only enrolled in college in large numbers but also enrolled in higher proportions than their predecessors. As many of these faculty reach retirement age in the next decade, colleges will be hiring new faculty to replace them. Nationally, nearly half (44 percent) of all full-time faculty in the U.S. were aged 50 or older as of 1992. At the California State University, which has nearly 11,000 full-time faculty, 58 percent of full-time faculty were 50 years or older in 1997; 16 percent were 60 years or older. At UC, 45 percent of tenure-track faculty were 50 years or older in 1997. Consequently, colleges and universities may be looking to replace close to half of their current faculties in the next 10 to 15 years.²⁹
- *The level of faculty hiring:* Even though enrollments will increase and large numbers of faculty will retire over the next decade, it is possible that colleges and universities will not

²⁵ UC figures are based on year-average headcount enrollments and preliminary projections. CSU figures are projected Fall headcount enrollments, as projected by the California Department of Finance, Demographic Research Unit in its “California Public Postsecondary Enrollment Projections, 1998 Series.”

²⁶ We limited our analysis of state and national enrollment projections to four-year colleges and universities, because the great majority of faculty in these institutions has Ph.D. degrees. By contrast, only about 17 percent of full-time two-year college faculty in the U.S. (or roughly three to four percent of all full-time faculty) hold doctoral degrees.

²⁷ This assumes student-faculty ratios no lower than 18.7:1 or higher than 20:1.

²⁸ U.S. Department of Education, NCES, *Projections of Education Statistics to 2008*. Middle alternative projections for enrollments in 4-year institutions.

²⁹ U.S. Department of Education, NCES, *Digest of Education Statistics - 1997* (Washington, D.C.: U.S. Government Printing Office, 1997); CSU, Faculty and staff data, Fall 1997; UC, Academic Personnel Report 9, October 1997.

hire new faculty in the numbers once expected. A number of factors could affect faculty hiring levels. Institutions might further raise their student-faculty ratios if there are continuing or recurring constraints on public funding, along with constraints on tuition increases. Indeed, between 1991 and 1995, many of the positions vacated by retiring faculty in a number of science and engineering fields, including the social sciences, mathematics, physical sciences, and psychology, were not filled by new faculty; and overall numbers of faculty declined. It is too soon to know whether this is a long-term shift in faculty hiring patterns or a temporary one, in response to the economic recession of the early 1990s and the decline in overall college enrollments.³⁰ There has also been speculation that greater use of distance-learning and other instructional technology delivery systems could reduce the number of regular faculty that institutions hire. In addition, if college access and affordability decline, college-going rates may be lower than now projected. Also, the traditional college-age population will grow more slowly after about 2010. Finally, if many older faculty choose to stay on beyond traditional retirement age, if Ph.D.'s now in temporary positions succeed in finding permanent positions, or if there is an influx of immigrant scientists and engineers, there could be fewer openings for new doctorates.

- *Industry opportunities:* The resurgent California and U.S. economies will likely require growing numbers of Ph.D.'s and other advanced degree recipients, especially in engineering and the sciences, to meet industry R&D needs. The private sector, primarily industry, now employs well over half of all engineering and physical science Ph.D.'s in the U.S., and the proportion of life science Ph.D.'s employed in industry is growing, especially in areas such as biotechnology and pharmaceuticals.³¹ If another recession should occur, industry R&D could go through another round of downsizing, similar to that which occurred in the late 1980s and early 1990s. On the other hand, if the economy remains strong, as most forecasters expect, industrial demand for Ph.D. scientists and engineers is expected to increase significantly, especially in areas such as electronics, biotechnology, and other high-tech areas, but with more of these opportunities in development and applied research work.
- *Ph.D. supply:* Whether there will be too many or too few Ph.D.'s to meet workforce needs also depends on the number of new doctorates awarded. Universities around the country have been responding to many of the same trends affecting California, including declines or stagnation in state government support, anticipation until recently of significant cuts in federal research support for graduate research assistantships, and concerns about a weak job market. As has occurred at UC, other institutions have reduced graduate admissions in some departments in order to ensure that those students who do enroll have adequate financial support and in response to concerns about the job market. Prospective graduate students also have responded to combined concerns about the job market and the adequacy of financial support, including rising debt burdens, by choosing not to enroll. Between 1992 and 1997, first-time full-time graduate enrollments in the sciences, social sciences, and engineering

³⁰ Rolf F. Lehming, "What is Happening to Academic Employment of Scientists and Engineers?," National Science Foundation *Issue Brief*, NSF 98-312 (Washington, D.C.: NSF, June 19, 1998).

³¹ Keith Wilkinson, "Number of Doctoral Scientists and Engineers Grows by 6 Percent between 1993 and 1995," National Science Foundation *Data Brief*, NSF 97-305 (Washington, D.C.: NSF, March 13, 1997, as revised October 16, 1997).

declined by 12 percent; total graduate enrollment in these fields in research universities (which prepare most U.S. Ph.D.'s) declined by seven percent during this period.³²

The National Center for Education Statistics (NCES) projects an increase in Ph.D. degrees of 10 percent between 1996 and 2006, a figure lower than its projected increase in enrollments in four-year institutions, as well as the more than 30 percent increase in Ph.D. degrees that occurred between 1986 and 1996.³³ In the 1980s, similar NCES projections of slow Ph.D. growth contributed to the belief that there would be severe Ph.D. shortages in the 1990s and consequently helped lead to actions that ultimately increased Ph.D. awards by 30 percent. However, in the late 1990s the reluctance of policy makers in many states to fund increases in expensive doctoral education in the face of competing demands, as well as strong job markets for bachelor's recipients and the resulting recent declines in new graduate enrollments, make it much less likely that a similar large increase in Ph.D. awards will occur in the next decade. Therefore, it is possible that if national opportunities for faculty and non-academic researchers expand, the supply of Ph.D.'s could fall short of demand.

- *Possible impacts of renewed federal support:* In the early and mid-1990s, there was much speculation that federal support for research might decline as lawmakers in Washington, D.C. struggled to balance the federal budget. However, with a healthy national economy, an expected budget surplus for fiscal year 1999, and strong bipartisan support for research funding, Congress and the President have given continued high priority and support to higher education in general and to basic and applied research both within and outside of academia. The 1998-99 omnibus budget bill included increases both for student financial aid to expand the college-going population and for support for research, which provides graduate students crucial support through research assistantships. According to an analysis by the American Association for the Advancement of Science, federal funding for basic research has been exceptionally good, with an overall increase in fiscal year 1999 of more than 11 percent over the previous year and significant funding increases for basic research to every major R&D funding agency. The National Institutes of Health (NIH), the largest funder of university research, received an increase of over 14 percent, and the National Science Foundation (NSF) received a 10 percent increase in basic research funding.³⁴ The President's proposed budget for fiscal year 2000 would give NSF continued increases in basic research funding and a modest increase to NIH.

Nevertheless, given budgetary constraints on discretionary funding (which provides most university R&D support), the reliance of the President's proposed budget on passage of a substantial (and controversial) new tobacco tax, and continuing political differences in how expected budget surpluses will be allocated, the *long-term* picture for federal R&D funding remains encouraging but still uncertain. In turn, federal research support for Ph.D. study and demand for federally funded doctoral researchers (in government, academe, and the private

³² National Science Foundation, *Graduate Students and Postdoctorates in Science and Engineering: Fall 1997 Supplemental Tables*. Research universities are those defined as Research I and II in the Carnegie classification.

³³ U.S. Department of Education, NCES, *Projections of Education Statistics to 2008*.

³⁴ American Association for the Advancement of Science, "A Preview Report for *Congressional Action on Research and Development in the FY 1999 Budget*" (AAAS R&D Funding Update, November 3, 1998): <http://www.aaas.org>.

sector) remains uncertain. If federal investment in the academic research enterprise does continue to increase, this could result in more job opportunities for Ph.D.'s, particularly in the sciences and engineering.

In summary, if economic conditions remain strong for the immediate future, as most forecasters expect, overall demand for Ph.D.'s will likely increase in response to such key factors as expected enrollment growth, faculty retirements, industry opportunities, and renewed federal funding. Less certain is the extent of such demand, the disciplines in which demand will be strongest, and whether Ph.D. supply will match, fall short, or exceed demand. The next section seeks to examine some of these factors more closely.

B. Ph.D. Employment Trends and Outlooks, By Discipline

Current employment trends and long-term outlooks for new Ph.D.'s vary significantly among disciplines and often among subfields within disciplines.

Ph.D. employment outlooks appear strongest in computer sciences, high-tech-related engineering areas, public administration, some applied psychology areas, and industrial positions in chemistry. The job market may be more difficult for new Ph.D.'s in several humanities and social science fields (such as anthropology, English, some foreign languages, history, philosophy, political science, and sociology) and in mathematics and physics.

Most of the available data on Ph.D. employment by discipline is collected by individual professional associations. These data have several shortcomings and thus should be viewed with caution: Few provide placement information beyond the first six months to a year following receipt of the doctoral degree (and thus beyond the postdoctoral period in the sciences); few try to project future demand; survey response rates are sometimes low and may therefore be biased; and data from different professional associations often are not comparable with one another (for example, some survey new doctoral recipients, while others use job listings in professional journals as a measure of demand).

In addition to professional associations, two other sources provide relevant employment data by discipline: (1) the National Science Foundation/National Research Council's Survey of Doctoral Recipients, which samples doctoral recipients throughout their career lifetimes; however, because of small sample size, the ability to disaggregate survey data is limited; and (2) the U.S. Bureau of Labor Statistics (BLS), *Occupational Outlook Handbook*, which projects employment outlook by field for the next decade; but the *Handbook* generally does not distinguish between needs for those with doctoral degrees and those with baccalaureate or masters degrees.

We summarize below available information on the Ph.D. labor market for specific disciplines, first examining current job market trends and then assessing the longer-term employment outlook for new Ph.D.'s. In addition, Table 1 (on page 34, at the end of Section IIB) summarizes

three recent analyses that do provide cross-disciplinary comparisons for Ph.D.'s in science, social science, and engineering fields.

Engineering and Computer Sciences

1. Computer sciences

Job trends: The current labor market for computer scientists at all degree levels appears to be very strong, for both industry and academic employment, according to the U.S. Bureau of Labor Statistics and other sources. California's high-technology driven economy has resulted in even higher needs and greater job opportunities for computer scientists than the national average.

Employment outlook: The job outlook through 2006 for computer scientists (all degree levels) is expected to remain quite strong, as workforce demand continues to be high. According to the BLS, "Employment of computing professionals is expected to increase much faster than average as technology becomes more sophisticated and organizations continue to adopt and integrate these technologies, making for plentiful job openings. . . . Individuals with an advanced degree in computer science, management information systems (MIS) [or] computer engineering . . . should enjoy very favorable employment prospects." Colleges and universities seeking computer science Ph.D.'s for faculty positions may find a tight supply, both because such Ph.D.'s will have attractive job opportunities outside academe and because institutions will need to hire larger numbers of computer science faculty if undergraduate computer science enrollments continue to increase in response to job opportunities at the bachelors level.³⁵ (Table 1 on page 34 provides additional Ph.D. projections. The employment outlook for masters-level computer scientists and systems analysts, including the especially strong outlook for California, is discussed in Section III.)

2. Engineering (overall)

Job trends: The engineering job market, at all degree levels, has witnessed considerable volatility over the past several decades, with employment in some fields rising and falling with changes in defense spending, aerospace demand, and other large-scale trends. However, after a difficult market in the early 1990s, the job market for engineering Ph.D.'s – especially in electrical engineering, biotechnology, and other high-technology areas – appears strong, particularly in industry. Because the majority of Ph.D. recipients in engineering are employed in the private sector, industry trends are especially important.

Employment outlook: The job market for engineers should remain strong over the next decade, especially in high-tech oriented engineering fields, according to projections by the Bureau of Labor Statistics and Dauffenbach, among others. (These projections do not distinguish Ph.D.-

³⁵ U.S. Bureau of Labor Statistics, *1998-99 Occupational Outlook Handbook* (Washington, D.C.: U.S. Government Printing Office, 1998). A survey by the Computing Research Association found that bachelor-level enrollments in computer science and computer engineering at U.S. Ph.D.-granting departments increased 46 percent in 1996 (U.S. Department of Commerce, Office of Technology Policy, "Update: America's New Deficit," January 1998).

level engineers from those with baccalaureate or masters degrees.)³⁶ Moreover, if current trends continue, the future supply of graduate engineers may drop, further strengthening the engineering job market but possibly intensifying employers' difficulties in meeting workforce needs. First-time graduate enrollments in engineering declined five straight years between 1991 and 1996, a drop of over 20 percent. Although it is not known what proportion of these enrollment declines were at the doctoral (rather than masters) level, and although first-time enrollments increased five percent in 1997,³⁷ a continuation of these trends may result in a reduced supply of doctoral-level engineers in the future. In addition, because engineering Ph.D.'s are expected to have good job opportunities outside academe, institutions seeking to hire engineering faculty will have to compete with attractive industry positions. These projections of a strong job market differ from those in the Massy and Goldman study, which projects high labor surpluses for Ph.D.'s in four engineering fields, ranging from 26 percent in chemical engineering to 44 percent in mechanical engineering.³⁸ Again, however, the difference between the Massy-Goldman projections and those by others appears due in part to Massy and Goldman's lack of modeling of demand in the industrial sector, where the majority of engineering Ph.D.'s are employed. (The employment outlook for masters-level engineers, including the California outlook, is discussed in Section III.)

3. *Chemical engineering*

Job trends: The job market for chemical engineering Ph.D.'s has rebounded strongly, after a difficult period in the early 1990s, when many pharmaceutical and other chemical companies downsized. Indeed, in 1998 the job market for chemists and chemical engineers was "the best on record for the 1990s." New chemical engineers with Ph.D. degrees had better placement records than did those with bachelors or masters degrees and slightly better placement records than new Ph.D.'s in chemistry. A survey of 1996-97 Ph.D. recipients in chemical engineering found that 74 percent had secured full-time employment and another 22 percent had accepted postdoctoral appointments within a few months after completing their degrees; only 3.2 percent were unemployed but seeking employment. The American Chemical Society (ACS) expects that in 1999, the overall job market for chemists and chemical engineers (looking at all degree levels combined) could be as good as it was in 1998, although it cautions that companies could reduce their hiring plans if economic problems continue in Asia and elsewhere. Nevertheless, ACS finds an optimistic outlook for both industrial and academic hiring of chemical engineers and chemists (all degree levels combined) in the immediate future.³⁹

Employment outlook: The *longer-term* outlook for Ph.D.'s in chemical engineering is somewhat less certain, although demand in California may be stronger than is true nationally. Based on

³⁶ U.S. Bureau of Labor Statistics, *1998-99 Occupational Outlook Handbook*.; Robert C. Dauffenbach, mid-growth scenario for supply and demand of scientists and engineers (1994 to 2005).

³⁷ National Science Foundation, *Graduate Students and Postdoctorates in Science and Engineering: Fall 1997 Supplemental Tables*.

³⁸ William F. Massy and Charles A. Goldman, *The Production and Utilization of Science and Engineering Doctorates in the United States*.

³⁹ Mairin B. Brennan, "Employment Outlook: Demand," *Chemical and Engineering News*, American Chemical Society (November 2, 1998). The report often does not distinguish between chemists and chemical engineers or among degree levels.

1996 information, the BLS projects that chemical engineers nationally “may face competition for jobs” in the 1996-2006 period, because the number of job openings is projected to be lower than the supply of new graduates. Again, these projections do not distinguish Ph.D. demand and supply from that for masters and bachelors degree recipients; however, Ph.D. supply has grown substantially over the past decade. Between 1986 and 1996, the number of chemical engineering Ph.D.’s increased more than 50 percent, according to ACS figures; between 1990 and 1996, it increased 19 percent. Moreover, unlike several other engineering fields, where first-time graduate enrollments declined substantially during the 1990s, first-time graduate enrollments in chemical engineering remained essentially stable.⁴⁰ On the other hand, demand is increasing for expertise in several fields, including biochemical engineering and agricultural biotechnology. In California, expected continued growth in the state’s pharmaceutical industries, driven by California’s dominant position in biotech R&D, may provide many job opportunities for doctoral engineers and other doctoral scientists; overall, jobs in California pharmaceutical firms are expected to increase 36 percent between 1997 and 2005.⁴¹

4. *Civil engineering*

Job trends: Most civil engineering Ph.D. recipients are employed in the private sector, and unemployment among them is very low. In 1995, only 1.3 percent of recent civil engineering doctorates were unemployed one-to-three years after receiving their doctorates. One percent were involuntarily employed out-of-field or part-time.⁴²

Employment outlook: According to the BLS, civil engineers (not separated by degree level) should find favorable employment opportunities through 2006, spurred both by replacement needs and by needs for additional engineers to develop, repair, or replace transportation systems, water and sewage systems, buildings, and bridges. Civil engineers’ employment opportunities are linked to local economic conditions, especially the strength of the construction industry.⁴³ Future supply may decline, however. First-time graduate enrollments (masters and doctoral) declined 11 percent between 1991 and 1997.⁴⁴

5. *Electrical engineering*

Job trends: Electrical engineers (all degree levels) comprise more than one-fourth of all engineers in the U.S. Both nationally and in California, the current labor market for electrical engineers at all degree levels appears to be very strong, for both industry and academic employment, according to the U.S. Bureau of Labor Statistics and other sources.

⁴⁰ National Science Foundation, *Graduate Students and Postdoctorates in Science and Engineering: Fall 1997 Supplemental Tables*.

⁴¹ CCSCE, *California Economic Growth, 1998 Edition*. It is unknown what proportion of these new jobs will require doctoral engineers or scientists. Also, because California firms recruit nationally for doctoral-level researchers, not all of those hired will be drawn from California.

⁴² Mark Regets, “What’s Happening in the Labor Market for Recent Science and Engineering Ph.D. Recipients?”

⁴³ U.S. Bureau of Labor Statistics, *1998-99 Occupational Outlook Handbook*.

⁴⁴ National Science Foundation, *Graduate Students and Postdoctorates in Science and Engineering: Fall 1997 Supplemental Tables*.

Employment outlook: The job outlook through 2006 for electrical and electronics engineers at all degree levels is expected to remain strong, both nationally and in California. According to the BLS, job openings for electrical and electronics engineers will increase substantially, with much of the growth due to increased demand for improved computers and communications equipment.⁴⁵ At the same time, supply of new Ph.D.'s in electrical engineering may dip in the coming years. First-time graduate enrollments dropped 12 percent between 1991 and 1997, although 1997 numbers were substantially higher than the previous year and may portend a turnaround in enrollments. (Again, we cannot determine what proportion of the change is at the doctoral level.)⁴⁶ In California, job openings for electrical and electronic engineers are projected to grow by 60 percent between 1993 and 2005, based on 1993 data, slightly faster than the average for all occupations but not as fast as the extremely high growth projected for computer engineers and systems analysts.⁴⁷ The California Employment Development Department concludes that California employers are finding it more difficult or costly to fill demand for information technology professionals, and it expects these difficulties to increase.⁴⁸

6. *Mechanical engineering*

Job trends: Although the current job market for Ph.D.'s in mechanical engineering is not as good as in some other engineering fields, it is still relatively solid. In 1995, 2.8 percent of recent mechanical engineering doctorates were unemployed one-to-three years after receiving their doctorates. Five percent were involuntarily employed out-of-field or part-time; this is a decrease from 8.3 percent in 1993.⁴⁹

Employment outlook: According to the BLS, mechanical engineers (not disaggregated by degree level) should find favorable employment opportunities through 2006, resulting from both employment growth and the need to replace those who will leave the occupation. Even though overall employment in manufacturing is expected to decline, manufacturing jobs for mechanical engineers should increase, as the result of increased demand for improved machinery and as industrial machinery and processes become more complex.⁵⁰ Moreover, first-time graduate enrollments (masters and doctoral) dropped more sharply in mechanical engineering (a 25 percent decline between 1991 and 1997) than in most other engineering or science fields, suggesting that fewer new Ph.D.'s may enter the job market in the future.⁵¹

⁴⁵ U.S. Bureau of Labor Statistics, *1998-99 Occupational Outlook Handbook*.

⁴⁶ National Science Foundation, *Graduate Students and Postdoctorates in Science and Engineering: Fall 1997 Supplemental Tables*.

⁴⁷ Richard Holden, California Employment Development Department, Labor Market Information Division, "Labor Market Analysis of the Labor Supply in Information Technology Occupations," Testimony to the Joint Hearing of the [California] Senate Select Committee on Economic Development and [California] Assembly Committee on Consumer Protection, Governmental Efficiency and Economic Development, March 25, 1998. The 1993 data are the most recent available.

⁴⁸ *Ibid.*

⁴⁹ Mark Regets, "What's Happening in the Labor Market for Recent Science and Engineering Ph.D. Recipients?"

⁵⁰ U.S. Bureau of Labor Statistics, *1998-99 Occupational Outlook Handbook*.

⁵¹ National Science Foundation, *Graduate Students and Postdoctorates in Science and Engineering: Fall 1997 Supplemental Tables*.

Life Sciences

1. Biomedical/other biological sciences

Job trends: Unemployment among Ph.D.'s in the biomedical and other biological sciences (both total and recent Ph.D.'s) remains very low, generally around one to two percent. However, significant changes in the job market for such Ph.D.'s are occurring. For example, R&D jobs in industry, especially in the pharmaceutical and biotechnology industries, have grown enormously in the past 15 years; in the future, such jobs may surpass academic jobs as the largest employment sector for these Ph.D.'s, just as they have in a number of physical science disciplines. By contrast, the number of tenure-track faculty positions in these fields has remained relatively steady.⁵² Moreover, a new report by the life sciences commission of the National Research Council finds that growth in industrial jobs has slowed nationally since 1989, while the number of new life science Ph.D.'s has grown over 40 percent in the past decade. Consequently, the report concludes that new biomedical and other biological science Ph.D.'s are spending longer periods in temporary postdoctoral appointments or other non-permanent positions, with no guarantee of ultimately obtaining a permanent position in their field. In 1995, nearly one-third of biomedical science Ph.D.'s who had received doctorates three to four years earlier still held temporary postdoctoral appointments (compared to one-quarter in 1991), and about 15 percent of those who had received doctorates five to six years earlier still such appointments.⁵³

Employment outlook: Employment projections for life science Ph.D.'s are mixed, although opportunities will be best for those seeking high-tech industry positions. The NRC report concludes that, if the number of new life science Ph.D.'s continues to rise (and graduate students already in the pipeline suggest that it will continue to grow for at least the next several years), a shrinking proportion of them will obtain the kinds of permanent research positions in academia, industry, or government to which these graduates have generally aspired.⁵⁴ In addition, the BLS projects that, even in industry, employment growth will slow between 1996 and 2006, as increases in the number of new biotechnology firms slow; and, as the academic job market becomes more competitive, the industrial market will also become more difficult.⁵⁵ This already appears to be happening.

On the other hand, the NRC report suggests that some expansion of life science Ph.D. enrollments might be warranted if it is directed at specific needs, such as increasing the number of minority students in certain areas or providing trained researchers for emerging new fields,

⁵² Federation of American Societies for Experimental Biology, *Graduate Education: Consensus Conference Report* (July 1997).

⁵³ National Research Council, Commission on Life Sciences, *Trends in the Early Careers of Life Scientists* (Washington, D.C.: National Academy Press, 1998).

⁵⁴ *Ibid.*; National Science Foundation, *Graduate Students and Postdoctorates in Science and Engineering: Fall 1997 Supplemental Tables*.

⁵⁵ U.S. Bureau of Labor Statistics, *1998-99 Occupational Outlook Handbook*.

such as neuroscience, gene therapy, bioinformatics, and environmental sciences, among others. Moreover, Ph.D.'s from the University of California should have better job prospects than Ph.D.'s nationally, for at least two reasons. First, the NRC report found that Ph.D.'s from top-ranked university departments were much more likely than others to obtain faculty positions in Ph.D.-granting universities (although overall employment rates for both groups were similar). Second, the projected growth in California's biotechnology and pharmaceutical industries should provide good employment opportunities, especially given the strong linkages between UC campuses and many biotech firms, many of which were developed by UC faculty or alumni.⁵⁶ Many of these positions will differ from those that Ph.D.'s filled in the past; in particular, they will be devoted to applied research and to product development in clinical, agricultural, forensic, and other applications of biological research.⁵⁷ The strength of the future job market, both academic and non-academic, will also depend in good part on the level of federal support for the biomedical sciences, which currently appears much stronger than it did two years ago.⁵⁸

Physical Sciences and Mathematics

I. Chemistry

Job trends: The American Chemical Society (ACS) concludes that, following several years of "some tough times," the current job market for Ph.D. chemists, in both industry and academe, is better than it has been at any time during the 1990s. While some job market weakness remains (for example, it took 1996-97 Ph.D. recipients six months on average to find a job or postdoctoral appointment, and 4.5 percent were still unemployed and seeking work in mid-October 1997), ACS found a strong job market in 1998 for chemists and expects a similar good market in 1999. Industry recruiting of new chemists (not identified by degree level) is robust, as biotechnology and pharmaceutical firms hire chemists, and ACS predicts that the academic job market for Ph.D.'s "will continue to gather steam as retirements, relocations, promotions, and department expansions open up slots." Although ACS raises cautions regarding both industry and academic hiring – companies could reduce their hiring plans if the global economy falters, and the high start-up costs needed to recruit faculty members could result in unfilled positions – nevertheless, it expects an optimistic job outlook in the near future. Demand for chemists in some fields, such as synthetic organic chemistry, is especially high.⁵⁹

⁵⁶ According to the UC Biotechnology Program, 85 percent of California biotech companies employ UC alumni with graduate degrees (University of California Biotechnology Program, "When it comes to Biotechnology, UC means Business," September 1996).

⁵⁷ Federation of American Societies for Experimental Biology, *Graduate Education: Consensus Conference Report*; Gregg Van Ryzin, Stephen Dietz, Jill Weiner, and David Wright, *The Employment Outlook in the Microbiological Sciences* (American Society for Microbiology, 1996).

⁵⁸ These projections (even those in the NRC report) are more positive than those developed by Massy and Goldman. Again, this appears to be due in part to the authors' lack of modeling of demand in the industrial sector, as well as use of a narrow definition of appropriate employment that excludes employment in health science occupations, where large numbers of biological science Ph.D.'s are employed (William F. Massy and Charles A. Goldman, *The Production and Utilization of Science and Engineering Doctorates in the United States*).

⁵⁹ Mairin B. Brennan, "Employment Outlook: Demand," *Chemical and Engineering News*, ACS (November 2, 1998).

Employment outlook: The longer-term job market outlook for Ph.D. chemists appears reasonably good although, as ACS notes, changes in the global economy and other uncertainties potentially could reduce demand. The Bureau of Labor Statistics projects that employment of chemists (not separated by degree level) will grow “about as fast as the average for all occupations” (i.e., 10 to 20 percent) between 1996 and 2006. Within the chemical industry, job opportunities will be most plentiful in pharmaceutical and biotechnology firms. Again, California’s strong position in biotech R&D may provide many job opportunities within California for Ph.D. chemists. Firms that provide research, development, and testing services for drug manufacturing and environmental cleanup, among others, will also be the source of many job opportunities.⁶⁰

2. *Mathematics*

Job trends: The U.S. job market for new Ph.D.’s in mathematics improved for the second year in 1997, especially for jobs in business or industry, according to a recent survey by the American Mathematical Society, the Institute for Mathematics Society, and the Mathematical Association of America. Unemployment among new 1996-97 math Ph.D.’s, surveyed in October 1997, was 3.8 percent, a substantial decline from the previous year’s final unemployment figure of 8.1 percent and the lowest reported unemployment rate since Fall 1990. Significant shifts in the job market for mathematicians are occurring. For example, large numbers of new math Ph.D.’s are taking temporary positions following graduation. Of those responding to the survey question, 45 percent of those employed in the U.S. were in temporary positions (the majority in postdoctoral appointments), and a majority of those in temporary positions said they took them because suitable permanent positions were unavailable. More mathematicians are taking nonacademic positions as well. For 1996-97 Ph.D.’s employed in the U.S., 36 percent took positions in business/industry or government (with over three-fourths of these in business or industry); this is a 23 percent increase over the previous year and more than double the figures reported in the late 1980s.⁶¹

Employment outlook: Despite recent improvements, the outlook for new math Ph.D.’s suggests continuing job market difficulties, although if graduate enrollments continue to drop sharply, there could eventually be a shortage of math Ph.D.’s. For academic positions (where most mathematics Ph.D.’s continue to seek employment), current supply and demand projections suggest a very substantial oversupply of new Ph.D.’s for tenure-track positions in Ph.D.-granting institutions.⁶² Moreover, according to the BLS, employment of mathematicians (not separated by degree level) is expected to increase more slowly than the average for all occupations through the year 2006. Many firms engaged in civilian R&D that use mathematicians are not planning to expand their research departments much, and, in some cases, may reduce them, and reductions in defense-related research and development may also affect mathematicians’ employment.⁶³ On

⁶⁰ U.S. Bureau of Labor Statistics, *1998-99 Occupational Outlook Handbook*.

⁶¹ Paul W. Davis, James W. Maxwell, and Kinda M. Remick, "1997 AMS-IMS-MAA Annual Survey" (second report), *Notices of the American Mathematical Society*, 45 (October 1998), pp. 1158-1171.

⁶² Frank DeMeyer, "Finding Employment in a Ph.D.-Granting Institution," *Employment Information in the Mathematical Sciences*, 143 (December 1995).

⁶³ U.S. Bureau of Labor Statistics, *1998-99 Occupational Outlook Handbook*.

the other hand, first-year graduate enrollments in mathematics declined 26 percent between 1992 and 1997; enrollments by U.S. citizens dropped even more than did those of international students.⁶⁴ If these enrollment declines continue, there could be a shortage of math Ph.D.'s further down the road. Thus, the supply and demand situation will need to be monitored closely.

3. *Physics*

Job trends: The employment situation for new and recent physics Ph.D.'s also improved in the past year, according to surveys by the American Institute of Physics (AIP). AIP found that only about two percent of 1996-97 Ph.D. recipients were unemployed approximately six months after the end of the academic year, compared to four percent for the previous two Ph.D. classes and six percent for 1993 and 1994 Ph.D.'s. Also, major shifts have occurred in employment patterns among new physics Ph.D.'s, which the AIP report suggests may reflect both the strong industrial market in 1997 and new Ph.D.'s reduced expectations for obtaining an academic position. For example, over the past few years, a higher proportion of new Ph.D.'s have begun accepting potentially permanent positions (rather than postdoctoral appointments), and an increasing proportion of these are working for industrial employers. Nearly half (48 percent) of 1996-97 physics Ph.D.'s surveyed had accepted potentially permanent jobs, compared to only 20-30 percent in the early 1990s. A majority (57 percent) of these newly employed Ph.D.'s took jobs outside physics, primarily in engineering and computer software, with 10 percent taking jobs entirely outside of science and technology fields (especially in business and finance).⁶⁵ By contrast, the success of new Ph.D.'s in obtaining academic, tenure-track positions in Ph.D.-granting departments has remained low, with supply far higher than academic openings and many of those openings being filled not by new Ph.D.'s but by experienced physicists moving from industrial labs or other physics departments.⁶⁶

Employment outlook: The employment outlook for new physics Ph.D.'s remains less than optimal, even though, as in mathematics, first-time graduate enrollments have declined sharply in recent years. First-time graduate enrollments in physics fell 25 percent between 1992 and 1997; and the number of bachelors degrees has dropped steadily as well, falling in 1996-97 to their lowest point in nearly four decades.⁶⁷ It seems likely, therefore, that the number of new U.S. physics Ph.D.'s will drop significantly over the next several years. (Similar declines are occurring in astronomy.) Future demand for physics Ph.D.'s, however, may decline slightly, and new Ph.D.'s will be competing with those already in the labor pool. The BLS expects that continued defense cutbacks will reduce job opportunities in the national labs, the second largest employment sector for physicists engaged in physics; together with expected continued slowing

⁶⁴ National Science Foundation, *Graduate Students and Postdoctorates in Science and Engineering: Fall 1997 Supplemental Tables*; Paul W. Davis, James W. Maxwell, and Kinda M. Remick, "1997 AMS-IMS-MAA Annual Survey."

⁶⁵ Patrick J. Mulvey, "1998 Initial Employment Report Preliminary Findings: Follow-Up of the 1997 Physics Doctorate Recipients," American Institute of Physics: <http://www.aip.org/statistics/trends/highlite/emp98/emphigh.htm> (1998).

⁶⁶ James Glanz, "Young Physicists Despair of Tenured Jobs," *Science*, 279 (20 February 1998): p. 1128.

⁶⁷ National Science Foundation, *Graduate Students and Postdoctorates in Science and Engineering: Fall 1997 Supplemental Tables*; Patrick J. Mulvey and Starr Nicholson, "1997 Bachelor's Degree Recipients Report," *American Institute of Physics Report R-211.29* (AIP: September 1998).

of civilian physics-related research, the BLS projects a small decline in employment of physicists through 2006. And, although faculty openings are expected to increase to replace retirements, the academic job market is expected to remain tight, at least in the near future. Moreover, the overall supply of physicists will be affected by the large pool of postdocs seeking permanent positions, as well as by any decision by Congress to reopen discussions on increasing immigration quotas for Ph.D. scientists and engineers. Nevertheless, the industrial market for physicists in applied or manufacturing research and product and software development may be among the most promising,⁶⁸ and recent trends show that physicists are both willing and able to apply their expertise to fields outside physics.

Social Sciences and Psychology

I. Anthropology

Job trends: The job market for anthropologists remains weak, although almost all eventually find jobs. At the time they complete their doctoral degree, approximately 60 percent of new anthropology Ph.D.'s seeking employment have obtained or are negotiating for a position or are continuing jobs begun before they completed their degree.⁶⁹ However, in 1995, only 3.2 percent of sociology/anthropology Ph.D.'s were still unemployed one-to-three years after completing the Ph.D.; 9.1 percent were involuntarily employed outside their field or in part-time positions.⁷⁰ According to surveys by the American Anthropological Association (AAA), an estimated 60 percent of those seeking jobs in anthropology in 1997 (including both new Ph.D.'s and those who had not yet completed their doctorates) found jobs *in anthropology* within a year after subscribing to AAA's placement service. A second AAA survey suggests that 71 percent of new 1996-97 Ph.D.'s who found employment took academic jobs and 29 percent took nonacademic jobs (i.e., jobs outside of traditional academic departments and campus centers, such as jobs in museums, physical anthropology labs or field archaeology). Although the proportion taking academic jobs has been increasing since 1990 (after dropping from the high point of 88 percent in 1972), AAA concludes that there currently are more *nonacademic* career opportunities available to Ph.D.'s in anthropology than there are academic jobs. One indicator of the continuing weak academic job market is the number of academic job listings; in 1996, the number of academic job listings was less than two-thirds the number of new Ph.D.'s available to fill them.⁷¹

⁶⁸ U.S. Bureau of Labor Statistics, *1998-99 Occupational Outlook Handbook*.

⁶⁹ National Research Council, Survey of Earned Doctorates for 1993-94, 1994-95, and 1995-96 U.S. doctorate recipients, special data analysis by the National Opinion Research Center.

⁷⁰ Mark Regets, "What's Happening in the Labor Market for Recent Science and Engineering Ph.D. Recipients?" Data for anthropology Ph.D.'s are not separated from those for sociology Ph.D.'s.

⁷¹ David B. Givens, Patsy Evans, and Timothy Jablonski, "1997 AAA Survey of Anthropology PhDs," American Anthropological Association, *Anthropology Newsletter* (1998): <http://www.ameranthassn.org/97survey.htm>. Because response rates to the surveys were low and overall employment data were based on those seeking AAA placement services, some bias may exist.

Employment outlook: The employment outlook for Ph.D.'s in anthropology suggests continuing job market difficulties. Through the year 2006, the U.S. Bureau of Labor Statistics projects that U.S. job growth for anthropologists will be slower than the average for all occupations. Competition for academic positions will be especially stiff.⁷²

2. Economics

Job trends: Several sources suggest that the job market for economics Ph.D.'s has been relatively good. For example, a survey conducted by the American Economic Association in conjunction with the Commission on Professionals in Science and Technology (CPST) found that only 2.3 percent of 1996-97 economics Ph.D.'s were unemployed and seeking employment as of October 1997, and 80 percent of those employed had obtained permanent positions, although it took new Ph.D.'s five months on average to find a job.⁷³ In addition, job listings published in AEA's newsletter have been increasing.⁷⁴ Even during the recession of the early 1990s, economics Ph.D.'s had low unemployment rates. For example, unemployment among recent Ph.D.'s in economics (one to three years after receiving the degree) was 2.1 percent in 1993 and 1.4 percent in 1995, and involuntarily out-of-field employment was 4.1 percent in 1993 and 2.7 percent in 1995. Especially for 1995, these rates were better than the majority of other science, social science, and engineering fields.⁷⁵

Employment outlook: If current conditions continue, the employment outlook for new economics Ph.D.'s should be satisfactory, since demand for economists is expected to grow while the supply of new advanced degree holders (masters and doctorates) will decline for at least the next several years. According to the U.S. Bureau of Labor Statistics, employment of economists and marketing research analysts (not separated by degree level) is expected to grow about as fast as the average for all occupations through the year 2006. While Ph.D. recipients who seek college and university faculty positions are expected to face strong competition, opportunities for economists with advanced degrees are expected to be best in private industry, especially in research, testing, and consulting firms. In addition, those who also have strong skills in quantitative techniques and their application to economic modeling and forecasting, together with good communication skills, will have the best job opportunities.⁷⁶ At the same time, fewer new Ph.D.'s may enter the job market in coming years, since first-time graduate enrollments in economics declined 21 percent between 1992 and 1997.⁷⁷ However, what portions of future demand and recent enrollment declines are at the doctoral level is unclear; a

⁷² U.S. Bureau of Labor Statistics, *1998-99 Occupational Outlook Handbook*.

⁷³ CPST, *Employment of Recent Doctoral Graduates in S&E: Results of Professional Society Surveys*. As noted earlier, percentages from these surveys should be viewed with some caution because of uncertainty regarding response bias. In economics, 66 percent of those surveyed responded, a relatively high response rate.

⁷⁴ D.W. Miller, "Survey Indicates an Improving Job Market for New Ph.D.'s in Economics," *Chronicle of Higher Education*, daily news bulletin, January 5, 1999.

⁷⁵ Mark Regets, "What's Happening in the Labor Market for Recent Science and Engineering Ph.D. Recipients?"

⁷⁶ U.S. Bureau of Labor Statistics, *1998-99 Occupational Outlook Handbook*.

⁷⁷ National Science Foundation, *Graduate Students and Postdoctorates in Science and Engineering: Fall 1997 Supplemental Tables*.

good part of both may be at the masters level, and, in fact, the BLS suggests that masters degree recipients may have better employment prospects than either bachelors or doctoral recipients.

3. *History*

Job trends: According to the American Historical Association (AHA), academic job opportunities for new and recent history Ph.D.'s in 1998 improved slightly over 1997, due mostly to a growing number of senior faculty retirements and institutions' renewed ability to fill faculty vacancies, as college budgets have risen. The number of jobs listed in AHA's professional newsletter during Fall 1998 was 13 percent over that in Fall 1997 and was the highest since the early 1990s. Despite this improvement, however, the gap between the pool of applicants and the number of junior faculty positions "remains very large." According to AHA, "for the fifth year in a row, more than three history PhDs were conferred for every two junior jobs advertised, and there is no indication that PhD production will ease significantly in the near future."⁷⁸ Moreover, as noted earlier, many of the faculty hires are coming from a backlog of Ph.D. recipients who had been in temporary positions, while new Ph.D.'s continue to enter the job market.

Employment outlook: History Ph.D.'s who graduate in six to ten years from now will likely find a continued soft labor market, especially in academe, but it may well be better than today's market. For 1997, new graduate-student admissions to Ph.D. programs in history were 27 percent below the peak admissions year in 1991.⁷⁹ Thus, supply and demand a decade from now may be in somewhat better balance by the time students now beginning their doctoral studies receive their degrees – *if* new enrollments continue to decline or at least remain steady and if job openings remain at today's levels or increase as senior faculty retire. However, several concerns remain. Job openings are not necessarily for full-time positions; indeed, the proportion of part-time faculty positions has continued to grow, although precise numbers are unavailable. Also, job prospects will depend on the match between the areas of specialization in demand and those that candidates bring. Currently, for example, demand for junior faculty in European history is higher than the number of new Ph.D.'s with this specialization, and demand has risen strongly for candidates with expertise in world history and Latin American history; by contrast, there is an oversupply of those with a specialization in U.S. history. Finally, relatively little information is available about employment trends or prospects for Ph.D.'s employed outside academia – now a quarter of all history Ph.D.'s.⁸⁰

4. *Political Science*

Job trends: Although new 1997 political science Ph.D.'s were slightly more successful than their 1996 counterparts in obtaining jobs within several months after completing their doctoral program (81 percent to 77 percent), the Ph.D. job market remains difficult, according to surveys of Ph.D. departments by the American Political Science Association. In addition, much of the

⁷⁸ Robert Townsend, "1998 Job Market Report: Retirements Create More Opportunities but Job Gap Remains," American Historical Association, *Perspectives* (January 1999).

⁷⁹ *Ibid.*

⁸⁰ *Ibid.*; National Research Council, *Humanities Doctorates in the United States: 1995 Profile*.

1997 increase may be due to a rise in temporary positions (one-third of all placements), nor is there an evident trend in placement rates, which have fluctuated between 77 and 85 percent over the past decade. Perhaps anticipating a weak job market, many Ph.D. students began job searches before completing their degrees (42 percent of 1997 job seekers), and nearly half of all 1997 job seekers had sought jobs the previous year. Placement success differed substantially by specialization area. For example, 80 percent of all jobs seekers in public policy and 76 percent in public administration were successful. Since these numbers include both Ph.D.'s and those who had not yet completed their degrees, and since Ph.D.'s consistently have higher job placement success, placement of Ph.D.'s in these two areas is undoubtedly higher. By comparison, only 43 percent of 1997 job seekers in methodology were placed. About 15 percent of political science job seekers who were hired took positions outside academia, a proportion that has slowly but steadily increased over the past decade.⁸¹ It is likely that those with public policy or public administration specializations take many of these non-academic positions, perhaps contributing to their strong placement records.

Employment outlook: The outlook for new Ph.D.'s in political science remains problematic, especially because it remains so heavily dependent on the academic labor market. Despite increases in job listings in the discipline's main professional newsletter for the past two years and a decline of 22 percent in first-time graduate enrollments between 1992 and 1997,⁸² supply appears likely to continue to exceed demand, especially for faculty positions. The U.S. Bureau of Labor Statistics projects that U.S. job growth for political scientists (not separated by degree level) will be slower than the average for all occupations through the year 2006.⁸³ However, although non-faculty employment remains a small part of the job market for political science Ph.D.'s, the modest increase in such placements and the success of those with expertise in public administration and policy analysis suggest better prospects outside academe for those with relevant expertise.

5. *Psychology*

Job trends: Compared to many other fields, especially in the social sciences, the job market for psychology doctorates (both Ph.D.'s and clinical Psy.D.'s) is good. According to a survey conducted by the American Psychological Association (APA) in conjunction with the Commission on Professionals in Science and Technology, only 0.6 percent of 1996-97 psychology doctorates were unemployed and seeking employment as of October 1997 – the lowest unemployment rate of the 14 fields in the CPST study. It took new doctorates four months on average to find a job (with many beginning their search and taking jobs before completing their degree programs). However, weaknesses exist. Nearly a quarter of those employed were in part-time positions.⁸⁴ Although many of these may deliberately have chosen

⁸¹ Jun Yin, "Placement Report: Political Science Ph.D.s and ABDs on the Job Market in 1997," American Political Science Association, *PS: Political Science & Politics* (December 1998): 818-825.

⁸² *Ibid.*; National Science Foundation, *Graduate Students and Postdoctorates in Science and Engineering: Fall 1997 Supplemental Tables*.

⁸³ U.S. Bureau of Labor Statistics, *1998-99 Occupational Outlook Handbook*.

⁸⁴ CPST, *Employment of Recent Doctoral Graduates in S&E: Results of Professional Society Surveys*. Survey response rate for psychology doctorates was 51 percent.

to hold two or more part-time jobs, for example, a university position and simultaneous work in a practice setting, earlier APA surveys confirm a steady decline in the proportion of new doctorates employed full-time (from 82 percent in 1986 to 70 percent in 1995), along with an increasing proportion taking postdoctoral positions (from 6 percent in 1986 to 14 percent in 1995).⁸⁵

Employment outlook: The outlook for doctorates in psychology appears relatively good, especially for those seeking clinical/practice positions, those in particular specializations, and those from top-ranked programs. Although the BLS projects that employment of psychologists through the year 2006 will grow more slowly than the average for all occupations, it notes that “opportunities for people holding doctorates from leading universities in areas with an applied emphasis, such as clinical, counseling, health, and educational psychology, should have particularly good prospects.” Because of the growing use of computer-based analysis in evaluation, research, and other activities in which psychologists are engaged, those who also have extensive training in quantitative research methods and in computer science may have a competitive edge over other applicants. On the other hand, academic positions will be more problematic: social scientists, including psychologists, will face “stiff competition” for faculty positions in colleges and universities.⁸⁶

6. *Sociology*

Job trends: The job market for new Ph.D.’s in sociology remains relatively weak, although a recent survey suggests it may have improved a bit. Even though the number of positions advertised in the American Sociological Association’s employment bulletin has been rising since the early 1990s, the ratio between the number of positions open and the number of new Ph.D.’s to fill them remains low and continues to decline, as the number of new Ph.D.’s awarded annually continues to rise. Nevertheless, a survey conducted by the American Sociological Association in conjunction with CPST found that only 1.9 percent of 1996-97 sociology Ph.D.’s were unemployed and seeking employment as of October 1997, but it took new Ph.D.’s six months on average to find a job, and 35 percent of those employed were in temporary positions.⁸⁷

Employment outlook: The job market for sociologists is expected to remain weak for the foreseeable future (i.e., through the middle of the next decade). The BLS projects that U.S. job growth for sociologists will be slower than the average for all occupations through the year 2006 and that competition for academic positions (where most Ph.D.’s in sociology are employed) will be especially stiff.⁸⁸

⁸⁵ Marlene Wicherski and Jessica Kohout, *1995 Doctorate Employment Survey* (Washington, D.C.: American Psychological Association, July 1997).

⁸⁶ U.S. Bureau of Labor Statistics, *1998-99 Occupational Outlook Handbook*.

⁸⁷ CPST, *Employment of Recent Doctoral Graduates in S&E: Results of Professional Society Surveys*. Sociology data are preliminary: ASA is attempting to increase the response rate from 62 percent to 70 percent.

⁸⁸ *Ibid.*

Humanities and Arts

1. English

Job trends: Nearly three-fourths of all Ph.D.'s in English (as well as in foreign languages) are employed as college and university faculty. Over the past 25 years, except for a relatively brief period in the late 1980s, "qualified candidates seeking academic careers in tenure-track positions have far outnumbered available positions," according to a 1997 report by the Modern Language Association (MLA). In the early 1990s, sharp declines in faculty hiring in these fields, together with increasing numbers of new Ph.D.'s, led to the worst job market in over two decades, with large numbers of new Ph.D.'s accepting "stopgap part-time or full-time lectureships."⁸⁹ By Fall 1997, only one-third of new 1996-97 English Ph.D.'s had obtained tenure-track faculty positions (down from 46 percent for new Ph.D.'s surveyed just three years earlier, during the economic recession). By contrast, 39 percent had accepted full- or part-time non-tenure track positions (up from 33 percent three years earlier), and eight percent were still seeking employment.⁹⁰ But it is possible that the job market is now improving: The number of jobs for English Ph.D.'s in MLA's October 1998 job listings was 28 percent greater than the number listed a year earlier, and the majority of these were full-time, tenure-track positions. MLA representatives caution, however, that the increase could be a one-year "blip." In any case, MLA concludes that new Ph.D.'s continue to face a crisis in the academic job market because the number of Ph.D.'s awarded annually continues to outpace "decent jobs" in academe.⁹¹

Employment outlook: Despite the increase in job openings in 1998, the long-term employment outlook for English Ph.D.'s continues to look bleak, especially in academe, where most Ph.D.'s continue to seek employment. If present employment patterns continue, fewer than half, and perhaps as few as one-third, of the Ph.D.'s awarded in English between 1996 and 2000 can expect to obtain full-time tenure-track positions within a year of receiving their degrees. Although the 1997 MLA report concludes that across-the-board enrollment reductions are not appropriate, it suggests that the poor job market (for both English and foreign language Ph.D.'s) may improve if self-study leads some departments to reduce their graduate enrollments, if graduate training is revised to give more attention to teaching, and if departments help their graduates find careers outside the academy.⁹²

⁸⁹ Modern Language Association of America, "MLA Committee on Professional Employment, Final Report."

⁹⁰ MLA, "Data on the Job Market: Findings from the MLA Surveys of PhD Placement, 1977 to 1997" (1998): http://www.mla.org/JILData_98.htm.

⁹¹ Denise K. Magner, "MLA Reports 28% Increase in Job Openings for Ph.D.'s in English," *Chronicle of Higher Education*, daily news bulletin, December 9, 1998.

⁹² MLA, "MLA Committee on Professional Employment, Final Report." In addition, the Woodrow Wilson National Fellowship Foundation has established several grant programs to encourage private-sector and non-profit employers to consider employing humanities Ph.D.'s, and to give humanities doctoral students experiences that prepare them for meaningful careers beyond the academy, for example in publishing, media, and technology companies and in non-profit foundations. Such efforts, if successful, could both open up new employment avenues for Ph.D.'s and significantly expand the talent and creativity of the broader U.S. workforce.

2. *Foreign languages and literature*

Job trends: The situation for Ph.D.'s in foreign languages is very similar to that for English Ph.D.'s, although graduates in some areas (such as Spanish) are in stronger positions than are those in others (such as German). In general, however, tenure-track academic positions have been difficult for most to obtain. Among new 1996-97 foreign language Ph.D.'s (all languages), 40 percent had obtained tenure-track faculty positions by Fall 1997, while 36 percent had accepted full- or part-time non-tenure track positions, and eight percent were still seeking employment.⁹³ Unlike English, the number of jobs for foreign language Ph.D.'s in MLA's October 1998 job listings declined two percent from that a year earlier. As in English, the number of Ph.D.'s awarded annually continues to outpace good full-time jobs in academe.⁹⁴

Employment outlook: The overall employment outlook for foreign language Ph.D.'s continues to look poor, especially in academe, where most Ph.D.'s continue to seek employment, although it may be better in some language areas. If present employment patterns continue, fewer than half, and perhaps as few as one-third, of the Ph.D.'s awarded in foreign languages between 1996 and 2000 can expect to obtain full-time tenure-track positions within a year of receiving their degrees. However, employment prospects appear to be a little stronger in Spanish, where undergraduate enrollments have increased, than in languages such as German and French, where undergraduate enrollments have declined.

3. *Philosophy*

Job trends: The great majority of philosophy Ph.D.'s are employed as college and university faculty. The job market for philosophy Ph.D.'s has long been difficult, although their employment situation appears to be slightly better than that for most other humanities Ph.D.'s. Among recent philosophy Ph.D.'s (1990-94 graduates), 89 percent were employed full-time, and eight percent were employed part-time in 1995.⁹⁵ A 15-year analysis by the American Philosophical Association (APA) of candidates per job advertised through the association found an increasing number of candidates vying for a declining number of advertised jobs during the 1990s, peaking in 1995-96 at 2.6 candidates for each position. Job prospects improved slightly in 1996-97. However, many of those who were hired had been in the labor market for several years: a 1996 survey of hiring academic departments found that 27 percent of those hired had held the Ph.D. for three or more years.⁹⁶

Employment outlook: Based on current job market patterns and continued growth in the number of Ph.D.'s, the employment outlook for philosophy Ph.D.'s continues to look poor. For a number of years, the APA recommended that philosophy departments send a memo to prospective graduate students noting difficult employment prospects in the profession. In 1996,

⁹³ MLA, "Data on the Job Market: Findings from the MLA Surveys of PhD Placement, 1977 to 1997."

⁹⁴ Denise K. Magner, "MLA Reports 28% Increase in Job Openings for Ph.D.'s in English."

⁹⁵ National Research Council, *Humanities Doctorates in the United States: 1995 Profile*.

⁹⁶ American Philosophical Association, information provided on the association's website (<http://www.udel.edu>); "Special Report of the APA Committee on Career Opportunities," *Proceedings and Addresses of the American Philosophical Association*, 70 (May 1997).

the APA decided to discontinue this policy, stating that the realities of the academic job market are now well known and that prospective students should receive counsel directly from philosophy teachers who know the individual students.

4. *Fine and applied arts*

Job trends: Obtaining information on employment trends among those with graduate degrees in arts fields is difficult because most associations do not collect placement information. Media reports and comments by arts faculty, however, suggest that graduates in these fields typically face highly uncertain career prospects. This may be borne out by data in National Research Council surveys of humanities Ph.D.'s, which include data for two arts fields, art history and music. According to the most recent survey, a smaller proportion of recent Ph.D.'s (1990-1994) in these two fields were employed full-time in 1995 (76 percent in music and 83 percent in art history) than in any other field classified as a humanities field by the NRC.⁹⁷ Between 1984-85 and 1994-95, doctoral recipients in visual and performing arts fields increased by 48 percent, compared to an increase of 35 percent for Ph.D.'s overall.⁹⁸

Employment outlook: No job market projections specifically for Ph.D.'s in fine or applied arts are available, but indications are that the job market will be highly competitive. For example, the U.S. Bureau of Labor Statistics' projections to 2006 for visual artists, most of whom have bachelor's or masters (M.F.A.) degrees, may have relevance for Ph.D.'s as well. Even though demand for visual artists is expected to increase, especially for graphic artists, the BLS projects keen competition for both salaried jobs and freelance work in the visual arts – because the glamorous image of the graphic and fine arts fields is expected to attract a supply of aspiring artists larger than the number of job openings.⁹⁹ Informal conversations with faculty and college arts association personnel suggest that the same is likely true at the Ph.D. level: demand will increase but supply will increase faster. (By contrast, demand and job prospects appear much stronger for those entering the new field of digital arts, where educational requirements are primarily at the masters degree level. The employment outlook in the digital arts, one of several emerging interdisciplinary, technology-oriented fields, is noted briefly in Section III.)

⁹⁷ National Research Council, National Research Council, *Humanities Doctorates in the United States: 1995 Profile*.

⁹⁸ U.S. Department of Education, NCEs, *Digest of Education Statistics - 1997*.

⁹⁹ U.S. Bureau of Labor Statistics, *1998-99 Occupational Outlook Handbook*.

Table 1
Recent Employment Trends and Projections for Ph.D. Scientists and Engineers,
By Discipline, Selected Sources*

Discipline	Employment Status of Recent U.S. Ph.D.'s (1-3 Yrs after Degree), as of 1995		Projected Labor Surplus (or Shortage)** (for Ph.D.'s or for All Degree Recipients)	
	(1) Regets (1997)		(2) Massy & Goldman (1995) (Ph.D.'s)	(3) Dauffenbach (1996) (all degree recipients)
	Unemployment Rates	Involuntarily Out-of-Field/Part-time Rates***	Long-Term Outlook, Percent Labor Surplus	Est. Supply/Demand Differentials, 2005
Life Sciences	2.0%	2.6%		1%
Agriculture	1.1	2.2		
Biological Sci.	2.2	2.8	28%	
Health/Medical	1.3	2.2		
Phys. Sciences	2.4	5.3		2
Chemistry	2.1	4.1	-5	
Geosciences	1.7	6.8	23	
Physics	2.9	6.7	9	
Math/Computer Sci.	2.6	6.2		-7
Computer Science	1.1	2.7	4	
Mathematics	4.0	9.3	32	
Engineering	1.7	3.7		-4
Chem. Engin.	4.3	3.3	26	
Civil Engin.	1.3	1.0	33	
Elect. Engin.	0.9	3.0	41	
Mechan. Engin.	2.8	5.0	44	
Social Sci./Psych.	1.4	5.5		-2
Economics	1.4	2.7	23	
Political Science	2.5	11.2		
Psychology	0.5	3.8	4	
Sociol./Anthropol.	3.2	9.1		

*See Section IIA, pp. 6-11, for limitations of the different analyses.

**A projected labor shortage (i.e., demand greater than supply) is shown as a negative percentage.

***The definition of "involuntarily out-of-field" includes positions that the individuals surveyed did not consider to be "closely related" or "somewhat related" to their degree programs, as well as part-time positions in the field that individuals took because full-time work was unavailable.

SOURCES: (1) Mark Regets, "What's Happening in the Labor Market for Recent Science and Engineering Ph.D. Recipients?," National Science Foundation *Issue Brief*, NSF 97-321 (Washington, D.C.: NSF, September 23, 1997); based on NSF *Survey of Doctorate Recipients*. (2) William F. Massy and Charles A. Goldman, *The Production and Utilization of Science and Engineering Doctorates in the United States* (Stanford, CA: Stanford Institute for Higher Education Research Discussion Paper, May 1995, with August 1995 revisions). (3) Robert C. Dauffenbach, mid-growth scenario for supply and demand of scientists and engineers (1994 to 2005), unpublished tabulations, cited by the National Science Board, *Science and Engineering Indicators-1996* (Washington, D.C.: U.S. Government Printing Office, 1996).

III. WORKFORCE NEEDS FOR PROFESSIONAL AND MASTERS DEGREE RECIPIENTS¹⁰⁰

Workforce projections suggest that there will be opportunities for professional and masters degree recipients in some fields, especially high-tech oriented fields within engineering and computer sciences.

The great majority of UC and other California professional and masters degree recipients practice or take positions in California and thus contribute directly to the state's economic and social welfare. Because most seek employment in California, state workforce needs are particularly pertinent to enrollment planning for professional and masters degree recipients. Concurrently, because the state depends heavily on California-trained professionals and masters recipients in most fields, enrollment planning for these individuals is of special relevance to California.

Projecting workforce needs for those with advanced professional and masters degrees is perhaps even more difficult than projecting Ph.D. demand, since employment in professions such as law, management, architecture, and engineering is heavily dependent on economic ups and downs. In addition, projections by the U.S. Bureau of Labor Statistics (BLS), the California Employment Development Department (CEDD), and others generally do not distinguish between undergraduate and graduate degree requirements for employment demand in fields like business or engineering. Perhaps most importantly, the world of work is changing; it is difficult to estimate the numbers of jobs that will be needed in fields and occupations that do not yet even exist. Nevertheless, available trends and projections at least provide a sense of potential workforce need.

A. Engineering and Computer Scientists (Masters-Level)

1. Computer scientists and systems analysts (masters-level)

Employment outlook: Job opportunities for individuals with advanced degrees in computer science and related areas are expected to be very good over the next decade and will likely be even better in California, because of the state's emphasis on high-tech industries and services.

As a result of our transformation to a knowledge-based economy, the U.S. now faces a critical shortage of systems analysts and other information technology workers, according to the U.S. Department of Commerce and industry associations such as the Information Technology Association of America. Moreover, these organizations expect this shortage to get worse over the next decade.¹⁰¹ Consequently, job opportunities are expected to be plentiful through the year 2006 for those who enter these fields. Employment growth of computer scientists, computer

¹⁰⁰ This section does not address needs for health professionals (such as physicians, dentists, nurses, and veterinarians), since separate enrollment planning is being developed for the health professions.

¹⁰¹ U.S. Department of Commerce, Office of Technology Policy, "America's New Deficit: The Shortage of Information Technology Workers" (September 1997).

engineers, and systems analysts will be among the most rapid of all occupations, with computer engineers and scientists expected to grow by 114 percent and systems analysts by 103 percent. In addition, thousands of job openings will result annually from the need to replace workers – in part because of a very high turnover among these workers, as employees leave these fields or start their own businesses or as employers seek individuals with very specific and often narrowly defined skill sets. The Institute of Electrical and Electronics Engineers argues that, rather than a shortage of technology workers, there is a “mismatch” created by the difficulty of keeping workers’ skills up-to-date in a rapidly changing technological environment and that retraining current employees, rather than a major expansion of the workforce, should be emphasized. Nevertheless, individuals with an advanced degree in computer science, management information systems (MIS), computer engineering, or an M.B.A. with a concentration in information systems are expected to have very favorable employment prospects.¹⁰²

In California, workforce needs and job opportunities for computer scientists are expected to be especially strong. Jobs in computer services, which include many advanced degree holders, are expected to grow by more than 80 percent between 1997 and 2005. In addition, professional services (which includes computer services and engineering personnel, among others) and high-tech manufacturing are two of the four major sectors expected to propel California’s economic base forward to 2005.¹⁰³

2. *Engineers (masters-level)*

Employment outlook: Overall employment opportunities for masters-level engineers are expected to be good over the next decade, although opportunities will vary by subfield, with stronger prospects for electrical and electronics engineers.

The current job outlook for UC engineering graduates (at all degree levels) is good, according to UC engineering deans, and it is likely to remain strong. According to the U.S. Bureau of Labor Statistics, future employment prospects in engineering (all degree levels combined) “are expected to be good through the year 2006” because, although employment is expected to increase about as fast as average for all occupations, “the number of degrees granted in engineering may not increase as rapidly as employment.”¹⁰⁴ Although BLS projections do not distinguish employment outlook by degree required, masters-level engineers comprise a significant portion (about 30 percent) of new engineering degree recipients. Some professional engineering associations, such as the board of the American Society of Civil Engineers, have urged that the masters degree be established as the entry-level degree in engineering, a move that would increase engineering enrollments at the masters level.

¹⁰² Ibid.; U.S. Department of Commerce, Office of Technology Policy, “Update: America’s New Deficit” (January 1998); U.S. Bureau of Labor Statistics, *1998-99 Occupational Outlook Handbook*.

¹⁰³ Center for Continuing Study of the California Economy (CCSCE), *California Economic Growth, 1998 Edition*. The other two sectors are foreign trade, and tourism and entertainment. It is important to note that CCSCE’s projections are based on total growth by industry, not occupation, and that CCSCE concludes that increased productivity in high-tech manufacturing could result in relatively steady job levels in this sector.

¹⁰⁴ U.S. Bureau of Labor Statistics, *1998-99 Occupational Outlook Handbook*.

The job market will vary by subfield, however. For example, electrical and electronics engineers are expected to have good employment opportunities through 2006, while projections based on 1996 information suggest that chemical engineering graduates may face a competitive job market because the supply of new graduates is projected to be greater than the number of job openings. Defense-related/aerospace engineering jobs may suffer.¹⁰⁵ These trends will likely impact California even more strongly, with expected high demand in high-tech oriented specialties, such as electrical engineering and bioengineering.

B. Other Professionals

1. Business executives

Employment outlook: Because supply is expected to grow faster than demand and because demand is heavily dependent on the economy, the job outlook for future M.B.A.-educated business executives is uncertain. However, there will be better opportunities for those from strong programs and with specializations in areas of growing demand.

Demand for M.B.A.'s will depend, more than any other occupation, on the state of the economy. A strong economy will likely translate into more opportunities for M.B.A. graduates. In California, opportunities for business executives would appear good for those with the education and skills to work in what are expected to be high-growth industries, such as high-tech fields, trade with the Pacific Rim nations, and the entertainment and multimedia industries.¹⁰⁶ Job opportunities for M.B.A.'s will also depend, of course, on supply, and supply has been increasing significantly. Between 1990-91 and 1994-95, the number of M.B.A.'s awarded increased 20 percent nationally and 14 percent in California. Although UC awarded six percent fewer M.B.A.'s between 1990-91 and 1994-95, the number of UC M.B.A.'s has increased 15 percent in the past two years.¹⁰⁷ If supply continues to grow rapidly, new M.B.A.'s may find a more competitive job market, unless they bring exceptional skills in areas of growing demand, as well as private-sector experience. Nationally, the BLS projects that, despite projected rapid employment growth of management analysts and consultants (areas which sizeable proportions of UC M.B.A.'s enter), competition for jobs will be keen, because of the large pool of applicants. The BLS projects that job opportunities will be "best for those with a graduate degree, a talent for salesmanship and public relations and industry expertise."¹⁰⁸

¹⁰⁵ Ibid.

¹⁰⁶ Center for Continuing Study of the California Economy (CCSCE), *California Economic Growth, 1998 Edition*; UCLA Anderson School of Management, September 1998 Forecast.

¹⁰⁷ U.S. Department of Education, Integrated Postsecondary Education Data Survey (IPEDS) data, and UC Office of the President data.

¹⁰⁸ U.S. Bureau of Labor Statistics, *1998-99 Occupational Outlook Handbook*.

2. *K-12 teachers*

Employment outlook: Demand for teachers for California's public schools will be high.

In its 1995 projections (the most recent available), the California Employment Development Department (CEDD) projected that over a third of secondary school teachers will retire or otherwise leave the field between 1993 and 2005, and the secondary school teacher workforce will have to expand by nearly one-third more, to meet California's projected burgeoning school enrollments. In all, over 63,000 new secondary-school teachers will be needed by 2005.¹⁰⁹ Demand will be especially high for special education teachers and for teachers in areas of continuing shortage, such as mathematics, science, and English as a second language. Moreover, since 1995, the Governor and the Legislature have initiated legislation and funding to reduce classroom size in the elementary school grades, which will increase demand for elementary school teachers significantly. Including all grade levels, recent analyses estimate that California schools will need about 20,000 new teachers each year between now and 2004. Although CSU has primary responsibility for educating new teachers for California's schools, UC plays a role as well, by preparing classroom teachers with strong graduate-level academic training and by providing extensive professional development programs (both degree and non-degree) for California teachers.

3. *Lawyers*

Employment outlook: Because supply is expected to grow faster than demand, and because demand is tied to the economy, the job outlook for lawyers is uncertain. However, law school graduates from well-regarded programs (such as UC's) are expected to have good opportunities.

The field of law has been especially volatile in recent years as the profession has grown in popularity and as opportunities for employment have expanded. The U.S. Bureau of Labor Statistics projects that the supply of lawyers will exceed job openings over the next several years, despite increasing demand for lawyers as a result of population growth and expansion of business and legal activities. In fact, the BLS's most recent (1997) projections to 2006 estimate 14 percent fewer annual job openings than its 1995 projections. Nevertheless, the BLS does expect that "graduates with superior academic records from well-regarded law schools will continue to enjoy good opportunities."¹¹⁰

How will the outlook for lawyers in California compare to the national outlook? California relies on California-trained lawyers; three-fourths of those who pass the California bar exam are trained in California. According to career placement specialists at UC's three law schools, the current market for their graduates is good, with high demand particularly for lawyers specializing in certain subfields such as intellectual property, high-technology, and venture capital legal work, and those who can bring a scientific background to law. The Center for Continuing Study of the California Economy (CCSCE) projects that both the number of California lawyers and

¹⁰⁹ California Employment Development Department (CEDD), "Occupational Employment Projections, 1993-2005" (Sacramento: CEDD, 1995). Projections are based on data as of 1993.

¹¹⁰ George T. Silvestri, "Occupational Employment Projections to 2006"; U.S. Bureau of Labor Statistics, 1998-99 *Occupational Outlook Handbook*.

California's share of the nation's employment in legal services will rise slightly between 1997 and 2005, but it will rise less than will California's share of the nation's population.¹¹¹ As at the national level, however, the supply of new lawyers in California could grow faster than demand, especially given California's large number of independent law schools. Moreover, as UC's law placement officers noted, law opportunities are closely linked to economic conditions; future recessions, like that in the early 1990s, could result in fewer job openings. In short, the overall outlook is uncertain.

4. *Other professionals*

Employment outlook: The employment outlook in other fields in which UC educates professionals varies by field.

The 1995 CEDD projected above-average job growth for professionals in several fields, including (among others) architects, especially landscape architects, urban and regional planners, and social workers. Educational administrators are expected to grow slightly below the average for all California occupations. On the national level, the BLS projects better-than-average employment opportunities for social workers, while new architects may face competition if the number of individuals entering the profession continues at its current level.¹¹²

5. *New professionals and other masters degree recipients*

Employment outlook: Although it is impossible to assess the future job market in professions only now developing, demand for masters-level professionals in areas such as digital arts or environmental sciences will surely grow.

The economy of the 21st century will likely demand increasing numbers of individuals with professionally-oriented, interdisciplinary masters training, who can apply the research knowledge and methodologies of these various disciplines to needs and occupations that are only now emerging. For example, employment in California's entertainment industry is expected to increase sharply between now and the year 2010, surpassing employment in high-tech manufacturing by about 2005.¹¹³ Many of the individuals in the entertainment industry will need interdisciplinary skills, perhaps provided by new types of professionally-oriented masters programs, such as programs in the digital arts now being created at UC and some other institutions. The rapidly expanding multimedia industry is a prime example of an industry that will need highly skilled individuals able to blend art and computer skills to create a growing list of products and services; as a consequence, those trained in these new areas should be in high demand. Environmental sciences, urban studies, and applied anthropology are other areas where new types of professionals with interdisciplinary masters-level training will be needed. For example, CCSCE notes that professionals working in California firms provide environmental

¹¹¹ Center for Continuing Study of the California Economy (CCSCE), *California Economic Growth, 1998 Edition*.

¹¹² CEDD, "Occupational Employment Projections, 1993-2005"; U.S. Bureau of Labor Statistics, *1998-99 Occupational Outlook Handbook*.

¹¹³ UCLA Anderson School of Management, 1997 Forecast.

cleanup services to superfund sites,¹¹⁴ and growing attention to air and water quality and land-use policies will likely require more individuals who can combine scientific understanding, technical abilities, and policy analysis.

Historically, most UC masters students in arts and sciences fields, like those in other research universities, have been en route toward a doctoral degree. While this is likely to continue to be true for most such UC students, there has been growing attention to the need for those with masters-level education. In the physical sciences, Tobias and her colleagues suggest that "reinvented" masters degree programs that emphasize practical applications of emerging research areas and develop "practitioner-experts" for the nonacademic workplace could make valuable contributions to industry and other nonacademic sectors.¹¹⁵ Similarly, in biological and other life science areas, there may be increased demand for masters-level workers for the biotechnology industry and medical specializations, as well as for K-12 and community college teaching. The 1998 NRC report on the life sciences recommends greater emphasis on both focused masters programs to prepare individuals for applied science positions and K-12 and community college teaching careers and interdisciplinary masters programs that combine advanced life science training with preparation in fields such as management, public affairs, and engineering.¹¹⁶

¹¹⁴ Center for Continuing Study of the California Economy (CCSCE), *California Economic Growth, 1998 Edition*.

¹¹⁵ Sheila Tobias, Daryl E. Chubin, and Kevin Aylesworth, *Rethinking Science as a Career: Perceptions and Realities in the Physical Sciences* (Tucson, AZ: Research Corporation, 1995). See also Clifton F. Conrad, Jennifer Grant Haworth, and Susan Bolyard Millar, *A Silent Success: Master's Education in the United States* (Baltimore: The Johns Hopkins University Press, 1993).

¹¹⁶ National Research Council, Commission on Life Sciences, *Trends in the Early Careers of Life Scientists*.

IV. BEST GUESSES: WORKFORCE NEEDS FOR UC GRADUATE AND PROFESSIONAL DEGREE RECIPIENTS

Given these job market trends, workforce projections, and continuing uncertainties, we offer our best guesses about the future workforce needs for faculty, researchers, professionals, and others with advanced degrees from the University of California. In view of the potential for changing circumstances, we intend to revisit these expectations on a regular basis, so that campuses and programs can respond accordingly.

In providing our best guesses, it is important to reiterate the following points:

- *California's economic, social, and demographic needs and outlook will differ from the nation's as a whole.* Although UC prepares masters, professional, and doctoral students to meet national and international needs as well as state needs, many UC graduates, including the majority of professional degree recipients, remain in California. California's high-tech economy – including expanding computer, communications, pharmaceutical, biotech, and multimedia industries – will likely require substantial numbers of individuals with advanced degrees. In addition, California's internationally oriented economy and society, its great demographic diversity, and ongoing environmental concerns will present different workforce needs and opportunities than those that may be true nationally. Over the next decade, California is expected to outpace the nation “in jobs, income, household and population growth.”¹¹⁷
- *Demand for graduates of UC's graduate and professional degree programs may be greater than that for advanced degree recipients nationally, because of the quality and focus of UC programs.* UC advanced degree holders generally have had good placement records, even when the job market has been relatively weak. For example, UC Ph.D.'s overall have better placement records than do Ph.D.'s nationally, especially in engineering/computer sciences and physical sciences/mathematics.¹¹⁸ Placements of UC professional degree recipients in business, law, and other fields are also very high, according to program placement offices. For example, over 90 percent of the Class of 1997 M.B.A. graduates from UC business schools at Berkeley and Los Angeles had accepted job offers less than three months after graduating, and business schools at the other UC campuses also had strong placements. Recent graduates of UC's three law schools also have lower unemployment rates than the national average. In business, several campuses have recently initiated more systematic follow-up and monitoring of graduate alumni, in order to obtain further information on UC graduates, especially longer-term career patterns.¹¹⁹

¹¹⁷ Center for Continuing Study of the California Economy (CCSCE), *California Economic Growth, 1998 Edition*.

¹¹⁸ National Research Council, Survey of Earned Doctorates, 1994-1996 U.S. and UC doctorate recipients.

¹¹⁹ The UC substudy of the “Ph.D.'s – Ten Years Later” study, which is expected to be completed in the next one to two years, will shed additional light on long-term careers of UC doctoral recipients. More detail on placement of both Ph.D. and other advanced degree recipients is reported in UC's long-range enrollment plan, being developed concurrently.

An increase in the number of UC doctoral students will be needed, especially in computer science and engineering and in a number of science fields.

Ph.D. training will be needed for three main types of positions in the next decade: (1) college and university faculty for four-year institutions, (2) private-sector scientists and engineers, especially for industry, and (3) nontraditional and alternative careers, including for occupations and in industries only now being created.

- *College and university faculty:* We expect a moderate increase in demand for faculty in both California and the U.S. in the first decade of the 21st century, both to teach the projected surge in undergraduates expected to enter college in those years and to replace retiring faculty. Since UC Ph.D.'s currently comprise more than 20 percent of the faculties in both the UC and CSU systems (and no doubt a substantial proportion of faculty in California's private institutions), it seems likely that California institutions will turn to UC doctoral recipients to fill a significant proportion of future faculty positions in California institutions.

Although new faculty will be required across a range of fields, demand will vary among individual disciplines and among subareas within disciplines. Moreover, in some fields, while demand may increase, the supply of new Ph.D.'s may outpace that demand. Based on current information, we expect that needs for additional Ph.D.'s for faculty positions will be strongest in such fields as computer science, engineering, public administration, and some psychology areas, such as clinical psychology. By contrast, the supply of new Ph.D.'s for academe may continue to outpace demand in such disciplines as anthropology, English, philosophy, and some foreign languages, and in many areas of history, mathematics, physics, political science, and sociology. Nevertheless, within each of these disciplines, there will likely be demand in particular areas of specialization.

- *Private-sector scientists and engineers:* We expect that industrial demand for Ph.D.'s will increase significantly, especially in areas such as electronics, pharmaceuticals, biotechnology, and other high-tech areas, particularly if the economy remains strong, as most forecasters expect. This suggests increased private-sector demand for Ph.D.'s in targeted areas of engineering, computer sciences, chemistry, and the biosciences. Demand is likely to be even stronger in a high-technology state like California.
- *Nontraditional and alternative Ph.D. careers:* Based on recent experience, we can expect that some Ph.D.'s in the sciences, social sciences, and humanities will fill and create new types of positions in the economy and society – for example, those that cross disciplinary borders or apply knowledge to new settings or new industries. Because these positions are only now emerging or are yet to be developed, we cannot guess at the numbers of individuals who will be needed, but some will surely be needed.

Numbers of UC professional and masters degree enrollments will need to increase as well, especially in engineering/computer science fields and in emerging occupations.

Because the great majority of UC-educated professionals remain in California to serve the state's economic, social service, and labor market needs, demand for graduates of these programs is closely tied to California's economy and population. To meet the needs of California's growing and changing economy and population, we will need to prepare highly skilled graduate

professionals. UC-educated professionals, of course, also fill important roles in the nation and even internationally; this is especially true in business, where UC-trained international students who return home advance trade and other economic relationships that serve both their own countries and California.

- *Masters-level computer scientists and engineers:* We expect that there will be high demand for these individuals, especially in specialties most closely linked to high-technology industries, such as computer systems analysts, electrical engineering, and bioengineering. Moreover, because of the growth of high-tech industries in other states and other countries, California may be less able in the future to import engineers to help meet the State's needs. UC therefore will have a role to play in helping meet these needs.
- *Business executives:* If the economy remains strong (as most forecasters expect), so should demand for business executives. However, questions remain about whether supply will outpace demand. Where increased enrollments are projected, it may be important to target subfields with expected high demand (such as international business) and where UC can offer distinctive programs and skills, including, in many cases, building on the expertise of those who already have experience in the field.
- *K-12 teachers:* Demand for K-12 teachers, especially in areas of continuing shortage, such as special education, mathematics and science, will be high. UC has a role to play in preparing classroom teachers with strong graduate-level academic training and in providing ongoing professional development, through both degree and shorter non-degree programs.
- *Lawyers:* At this time, we believe that planning for future UC law enrollments should be relatively conservative, given expectations that supply will continue to outpace demand. Nevertheless, because the state relies on California-trained lawyers, because there will be some increased demand, and because UC graduates have strong records both in passing the bar and in securing legal positions, UC's existing law schools should at least maintain current levels of law school enrollments through the year 2005. Whether or not there should be increases after 2005 is not yet clear.
- *Other professionals:* Demand should be strong for architects, urban planners, and social workers, among others. Here too, however, questions remain about whether supply will outpace demand. Because these professional programs are generally no more than two years in length, it will be easier to adjust such UC enrollments, if labor market trends shift, than is true for Ph.D. programs.
- *New professionals and other masters degree recipients:* There is growing consensus that needs will increase for individuals with new types of professionally-oriented, interdisciplinary training that builds on the University's research base, especially in biotech and electronics fields, in emerging technology-oriented fields, such as digital arts, and in areas of growing social and political concern, such as environmental studies and new health-related specializations. Given California's high-tech economy and its diverse and changing demographic patterns and environmental challenges, workforce needs for such new professionals may be significant.