CHAPTER 4 – CHANGES IN THE ENTRY AND EXIT POINTS TO THE CHEMISTRY WORKFORCE

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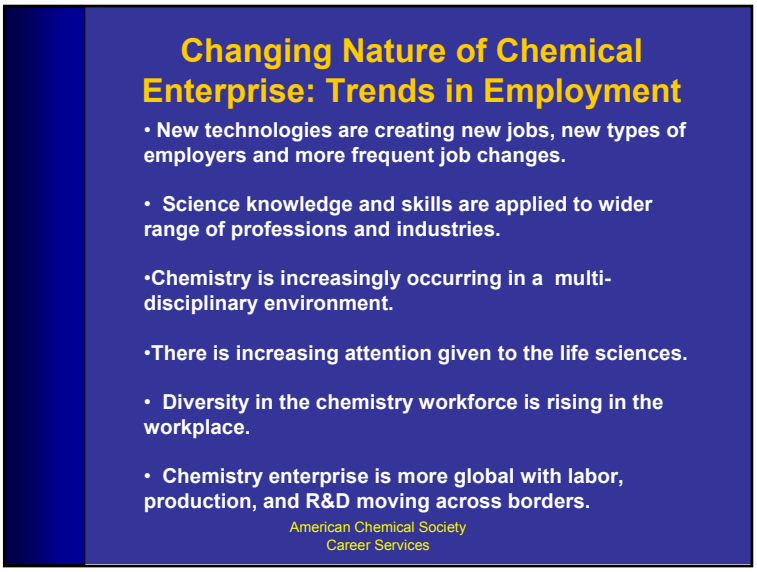
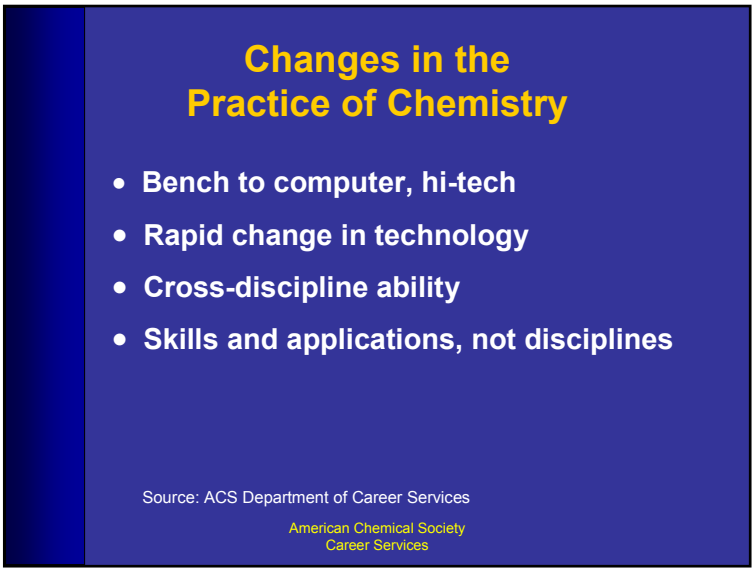
This presentation will discuss research from two American Chemical Society (ACS) studies: one called the Early Careers of Chemists and one called the Mature Careers of Chemists. It will also refer to an article called the *Changing Face of Chemistry*, which examines changes in chemistry degrees in relationship to subdisciplines, etc.

There are several general changes in the chemical enterprise that impact employment and trends in employment. For example, new technologies are creating new jobs, new types of employers, and more frequent job changes. Science knowledge and skills are applied to a wider range of professions and industries.



Chemistry is increasingly occurring in a multidisciplinary environment. There are specific ways that plays out when we look at those that are entering the chemical workforce and those that are exiting it.

Increasing attention has been given to the life sciences. It is not surprising to find chemists doing work that is related to the life sciences in industries that are related to the life sciences. Diversity in the chemistry workforce is also rising in the workplace, and finally, the chemistry enterprise is more global, with labor, production and research and development (R&D) moving across borders.

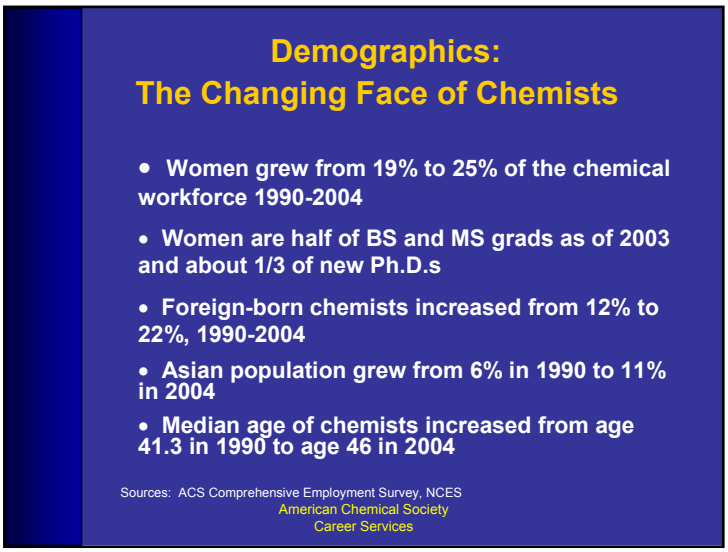


There also have been changes in the practice of chemistry. A lot of these are related to industry, although we certainly see changes in academia as well. So, for example, there has been a shift from bench to computer and high-tech. By this we mean that a chemist starting a career might not necessarily by doing what we would call wet bench chemistry. They are more likely to interact with high technology.

Also, there have been rapid changes in technology, such as nanotechnology and biotech. These are technologies that are changing the way the science is practiced, and by definition, the workforce. There

is also an emphasis on cross-discipline ability. This is also related to the last point, which is skills and applications, not disciplines. Someone might get a chemistry degree, be it a bachelor's degree or a PhD, but they are also taking skills with them that can be applied across disciplines. Especially in industry, employers are looking for things like that. So that does not just change the culture or the environment of the workforce, that changes how people approach jobs, where they are going to work, etc.

Focusing on demographics, we have what we are referring to as the changing face of chemistry. Women grew from 19 to 25 percent of the chemistry workforce from 1990 to 2004. Looking at degrees, women earn half of the bachelor's and master's degrees as of 2003, and about a third of the new PhDs, although if we look at subdisciplines across chemistry there is some variation by gender.

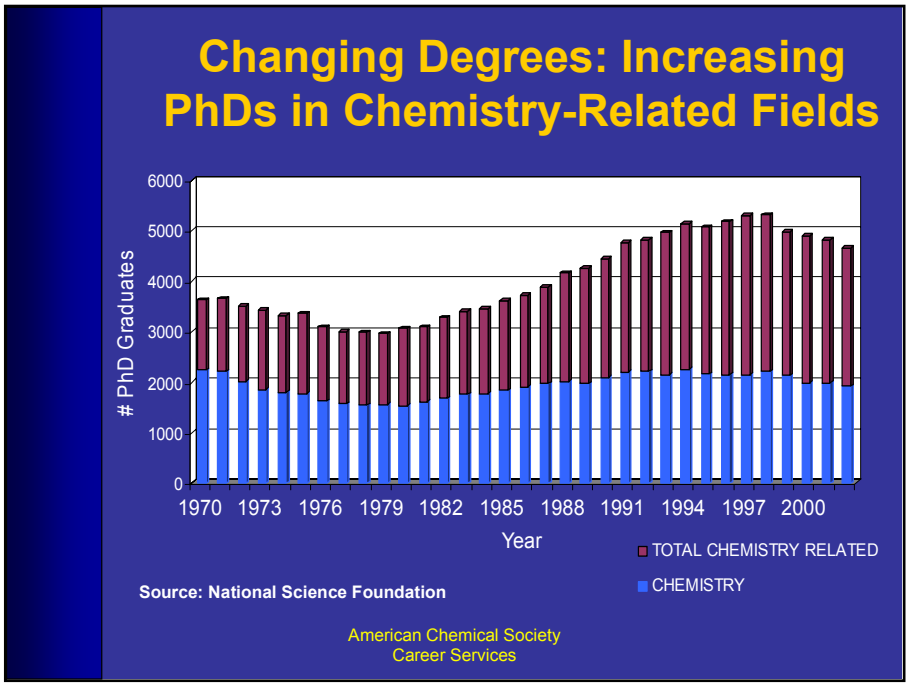


Given the increasingly global science and engineering community and workforce, it is not surprising that we would see foreign-born chemists increase from 12 percent to 22 percent from 1990 to 2004.

Just a side note about mobility: In our new graduate survey for the class of 2003, 20 percent of bachelor's degree graduates indicated that they had studied abroad in their undergraduate career. That was up by a few percentage points, and it is increasingly going up.

The Asian population in chemistry grew from 6 percent in 1990 to 11 percent in 2004. And finally, the median age of chemists increased from 41.3 in 1990 to 46 in 2004, so we see an aging workforce.

This chart to the right looks at changing degrees, and shows an increase in PhDs in chemistry-related fields. "Classic chemistry" PhDs have declined, but the number of graduates in chemistry-related areas has doubled. If we were just looking at a strict definition of chemistry for 1970 to 2002, we would think that chemistry was in trouble because degrees have flattened out, but once we pull in chemistry-related fields—which here include atomic and molecular physics, atmospheric physics and chemistry, geochemistry, biochemistry,



molecular biology, soil science, chemical engineering and material science—we would actually see quite a bit of growth.

One of the things that people talk about is the lengthening of the median time to PhD. So, we wanted to take a look at that and see how that looked for chemists, and also what that could tell us about the workforce. The median time from the bachelor's degree to the PhD was six years in 1960-64. It increased to a high point of seven years in 1990-94, and then back down to six years in 2002.

We saw a similar trend for the median registered time, where it started at five years from 1960-64, jumped up to six years in 1990-94, and then leveled off at six years in 2002.

Ph.D.s, Postdoctoral Positions, and Employment Trends

- **The median time from B.A./B.S. to Ph.D. was 6 years in 1960-64, 7 year in 1990-94 and 6 years in 2002.**
- **The median registered time followed similar trends; 5 years in 1960-64, 6 in 1990-94 and 6 years in 2002.**
- **The median age in 1965-69 was 28. It steadily increased reaching a peak of 30 from 1990-94 and has slightly decreased to 29 in 2002.**
- **In 2003, the proportion of Ph.D.s taking postdoctoral positions increased from 40.4 percent in 2002 to 50.6 percent.**

Source: NSF, Survey of Earned Doctorates and ACS Starting Salary Survey

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We have also seen an increase in the median age of chemistry PhD recipients. From 1965-69 it was 28. It increased to a peak of 30 from 1990-94, and then decreased to 29 in 2002.

There was something going on for chemists and a lot of other PhDs in the science and engineering workforce in the early 1990s—the job market was not very good. The last five years of that decade, things started to get better and looked really, really good in fact. And then in 2000 and 2001 we saw a softening of the job market, and that has continued. The proportion of new PhDs taking postdoctoral positions increased from 40.4 percent in 2002 to 50.6 percent, as of October 1, 2003. That was a 10 percentage point increase. And, according to ACS' new graduate survey, 43 percent of those who took postdocs in 2003 said that they took the position because full-time permanent employment was not available to them. That tells us again that there has been a softening of the job market. It will be interesting to see what happens next year.

Another way we can think about the entrance into the job market for younger chemists is how they got their job. For PhDs this is not surprising at all. The most successful way was through informal channels, i.e. colleagues and friends, as seen in the

How Starting Chemists Got Their Jobs (All Methods for Ph.D.)

HOW NEW CLASSES OF 1996 THRU 2001 GRADUATES FOUND FULL-TIME EMPLOYMENT BY OCTOBER						
THE SINGLE MOST SUCCESSFUL METHOD USED	2001	2000	1999	1998	1997	1996
FACULTY ADVISOR	12%	8%	12%	15%	13%	17%
INFORMAL CHANNELS, EG.COLLEAGUES OR FRIENDS	22	35	19	23	24	25
NEWS ADS	1	4	6	5	3	6
NEWSLETTERS/MAGAZINES/JOURNALS	12	13	17	12	17	16
PLACEMENT SERVICES (CAMPUS CONFERENCES, NECHS, ETC)	22	12	18	18	18	13
EMPLOYMENT AGENCIES	2	3	2	3	4	2
THRU FORMER JOB	3	3	5	4	3	5
SENT UNSOLICITED RESUMES	4	8	4	7	5	10
RECEIVED UNSOLICITED OFFER	1	0	1	1	2	1
ELECTRONIC RESOURCE/SEARCH	14	6	9	7	5	5
OTHER METHOD	6	7	7	5	5	1
TOTAL %	100%	100%	100%	100%	100%	100%
TOTAL NUMBER	207	89	262	364	297	216

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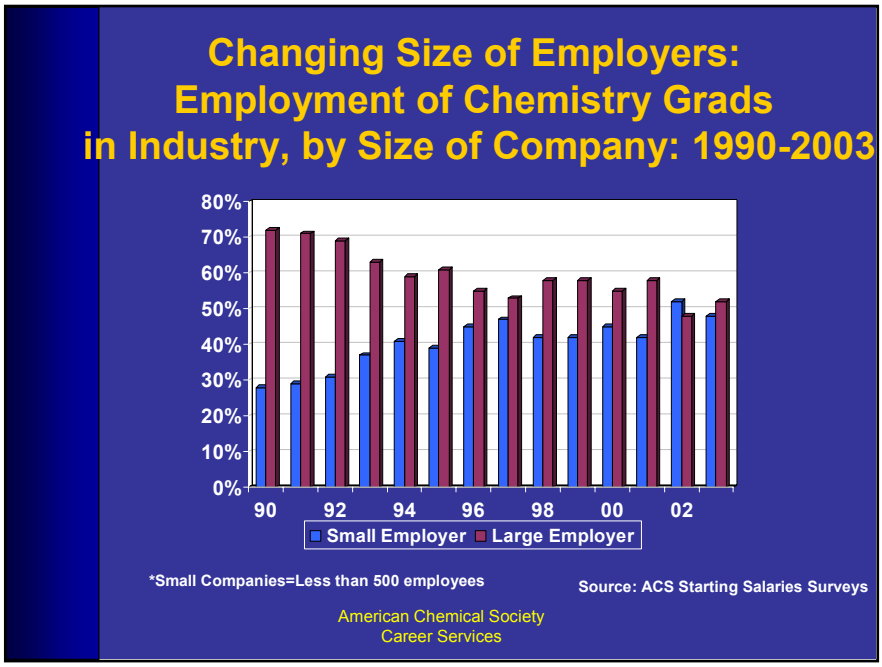
accompanying table. This is something that the ACS Department of Career Services frequently advises people—that your informal networks are the best sources for employment. Of course, faculty advisers, placement services, newsletters and journals all played a part.

I did not include tables for how master's or bachelor's degreed chemists found employment, but it looks different, especially for the bachelor's degreed chemists, where the top way that they successfully find jobs is through electronic means, and that has increased dramatically from 1996 to 2002. Twenty-six percent of new bachelor's graduates in 2003 indicated that that was the way that they found their job.

Another significant change we have seen is in the size of employer. I think that chemistry is distinct from some of the other physical sciences in that there has always been a strong link with industry. It varies by age, but industrial employers have always been a strong source of employment for chemists.

As illustrated in the chart to the right, large companies in 2002 and 2003 are still a strong source of employment for chemists, but small employers, meaning those with fewer than 500 employees, are increasingly a source of employment for new chemists of all degree levels.



The types of employers are also changing, as seen in the table to the right. This table breaks out the under 40 and over 40 age groups, looking at 1990, 2000 and 2004. It shows that industrial manufacturing is still a significant source of employment for chemists. Academia is also a significant source of employment for chemists, as well as non-manufacturing. There are differences for the over 40 and under 40 age groups, with the under 40 more likely to find employment in industry.

Changing Types of Employers
Full-time ACS Chemists, 1990-2004

	1990 -40	1990 40+	2000 -40	2000 40+	2004 -40	2004 40+
All manufacturing	**60.1**	**47.1**	**62.1**	**51.8**	**60.0**	**53.9**
Chemical & related	24.1	21.6	18.0	17.8	14.7	17.8
Pharmaceutical & related	16.9	8.9	29.9	17.1	32.6	19.1
Other manufacturing	19.1	16.6	14.3	17.0	12.7	17.0
Academia	**14.8**	**29.0**	**19.7**	**26.7**	**21.4**	**24.9**
Nonmanufacturing/nonacademic	**25.0**	**24.0**	**18.3**	**21.5**	**18.7**	**21.2**
Analytical/research services	---	---	6.6	4.2	11.9	8.0
Government	7.6	10.0	4.8	8.9	4.5	8.6
Self-employed	2.0	3.4	0.5	2.1	0.2	1.3
Other	---	---	6.4	6.3	2.0	3.3

Sources: ACS Comprehensive Salary & Employment Status Surveys

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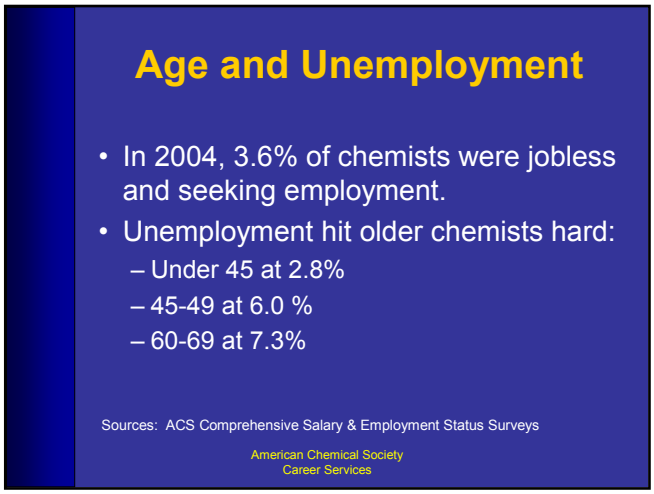
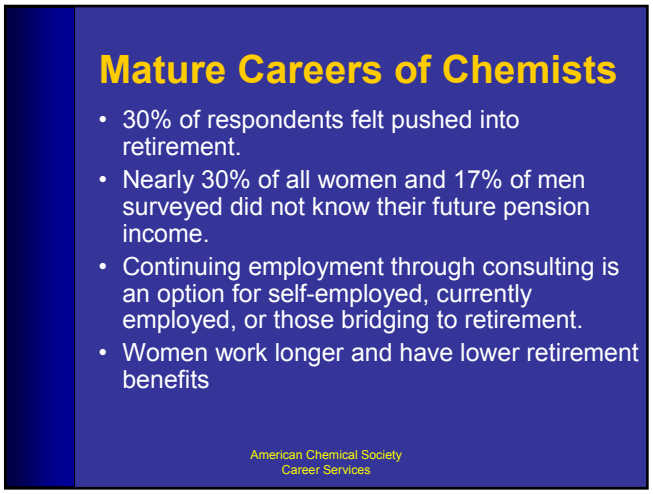
And then it matters what type of industry. In the last couple of years, the pharmaceutical industry has been the source of almost all newly created jobs for chemists. And that occurred sooner for chemists who were under 40. Even before 1990 it was already a significant source, but it continues to be, and you can see the transitioning of that age group throughout the last decade.

In the last three years the ACS Comprehensive Salary Survey of ACS members has measured record unemployment rates for chemists. In 2004 2.6 percent of chemists were jobless and seeking employment. Unemployment did not impact chemists similarly across age groups. For those who were under 45, it was only at 2.8 percent. For those who were 45 to 49, unemployment was at 6 percent, and for those who were 60 to 69 it was 7.3 percent. So the older you were, the harder you were hit.



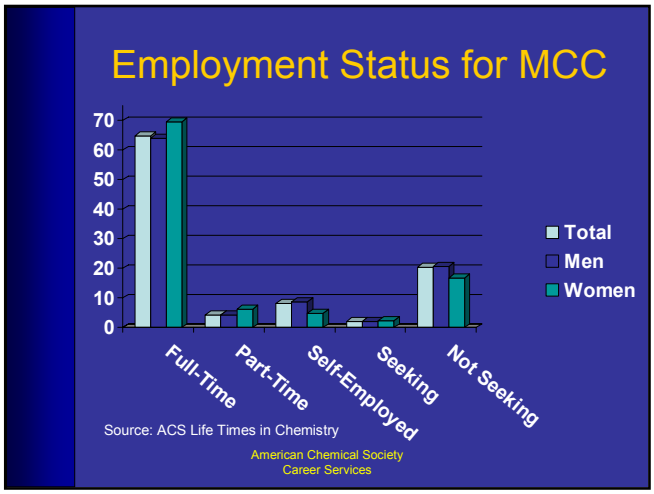
ACS conducted a special study on careers of mature chemists. These were, of course, individuals who were at the tail end of their career. Thirty percent of the respondents felt that they were being pushed into retirement. Nearly 30 percent of all women and 17 percent of men surveyed did not know what their future pension income would be, which lets us know that maybe their financial future was a little unstable. A portion of respondents knew exactly how much they were going to be making, and were confident that they were going to be able to meet their financial needs, but about 30 percent of the respondents did not.



Continuing employment through consulting is an option for individuals who were self-employed, currently employed, or those bridging into retirement. It is interesting to look at the way that consulting is conceptualized for chemists as a career option bridging to retirement. Some of them take the option, and some of them say that they intend to. It is certainly something that people think about.

The last point—again, this is not surprising—is that women work longer and have lower retirement benefits.

The next chart looks at the employment status for the respondents in the Mature Careers of Chemists survey. The survey covered chemists ages 50 to 69. A significant proportion of them—just under 70 percent for both men and women—

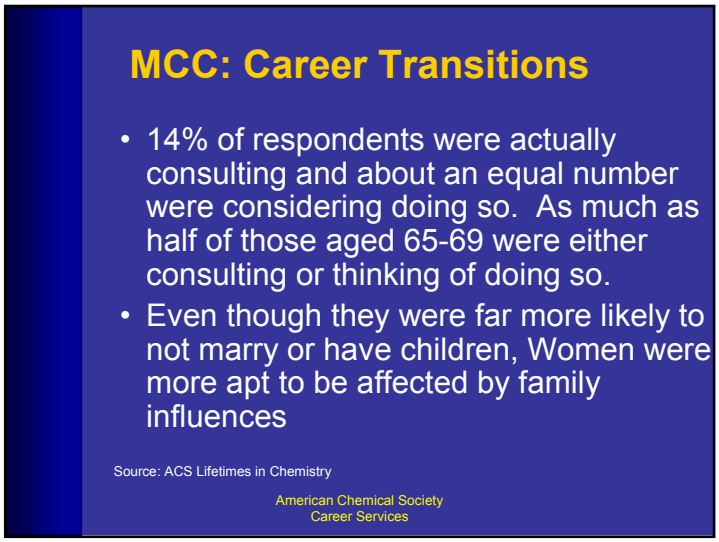


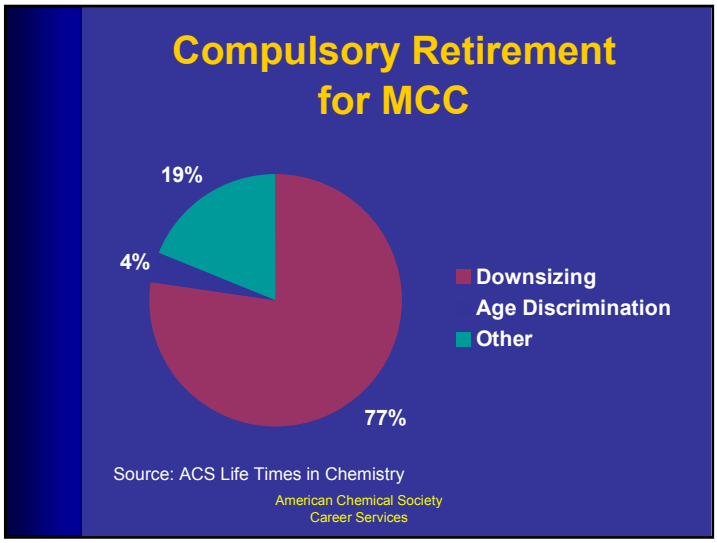
continued to work full time. The remainder were employed part-time, were self-employed, were seeking employment or were not seeking employment. Those in the last category are the people who are retired. We want to keep that in mind because I am going to break that down a little bit more, and talk about why they are not seeking.

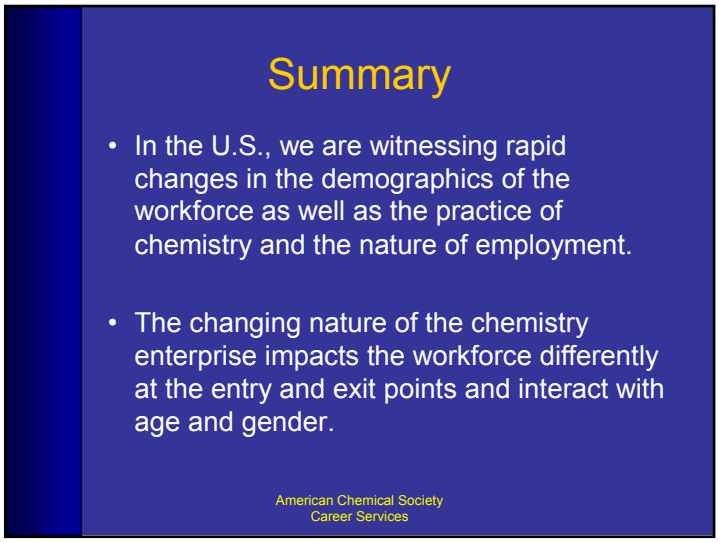
Some 14 percent of respondents were actually consulting, and an equal number were considering doing so. As many as half of those ages 65 to 69 were either consulting or thinking of it. Even though they were far more likely to not marry or have children, women were more apt to be affected by family influences. That tells us, again, that gender matters when we are looking at the careers of chemists at both the entry points and at the exit points, although I think that age intersects there too.

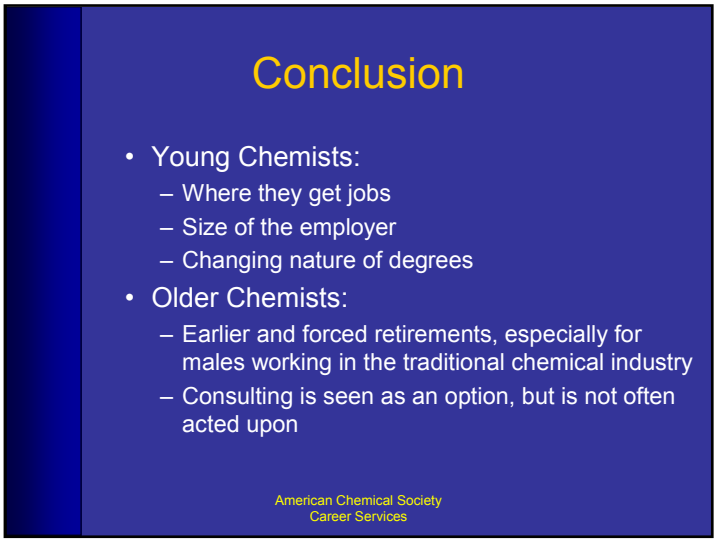
When we looked at the compulsory retirement for chemists for the proportion that said they did not voluntarily leave their position—I think that was 30 percent of those that had retired—19 percent said it was for other reasons. Four percent said it was for age discrimination, and a full 77 percent said it was because of downsizing. So that tells us something when we are looking at the unemployment numbers for recent years. When it is those particular age groups that are the hardest hit, you have to ask yourself why exactly are they unemployed and what else is going on with our economy that is related to that.

In summary, in the U.S., we are witnessing rapid changes in the demographics of the workforce as well as in the practice of chemistry and the nature of chemistry. The changing nature of the chemical enterprise impacts the workforce differently at the entry and exit points and interact with age and gender.









Specifically for young chemists this impacts where they get their job, and that is increasingly in life sciences-related industries, such as pharmaceuticals, etc. In terms of the size of the employer, younger chemists are working for smaller employers. The nature of degrees is also changing, meaning that chemistry is no longer in this tight little box—there are much more fluid definitions of chemistry.

For older chemists there are earlier and forced retirements, and this is especially true for males working in the traditional chemical industry. Also, consulting is seen as an option, but it is not often acted upon. Interestingly, in one of the earlier slides we saw 14 percent that were consulting and the same proportion intending to consult. So it is seen as an option for them although not everybody acts upon it.

Audience Comments/Questions:

- Alan Rapoport, National Science Foundation – The chemistry-related degrees you mentioned were more than 50 percent when you compared with the chemistry degrees. Do those people who get "chemistry-related degrees" think they are related to chemistry? Do you have a lot of them who are members of the American Chemical Society?

- Mary Jordan, American Chemical Society – Absolutely. About 20 percent of our workforce members are in the biochemistry area. NSF calls them biologists and we call them chemists. We have molecular biologists. We have physicists that call themselves chemists. We are very multidisciplinary. And we do ask them what their highest degree is in and what they consider themselves now.

- Joan Aron, Science Communication Studies – In following up on that interdisciplinary aspect of these other chemistry careers, do you know if these individuals are also a member of another professional society?

- Mary Jordan, American Chemical Society – Absolutely. We are just doing a huge study right now on that.

- Derek Hill, National Science Foundation – On your point about women, do you mean that women who are married without children have different career paths?

  Response – Yes. They indicated to us that family influences had affected their career. That does not mean that we necessarily know in particular what family influences they were. But in general—and I do not think this is just specific to women working in science and engineering—even if you do not have children, there are still a number of family influences that might affect your career. Increasingly, women of particular age groups are responsible for taking care of aging parents, and if you also have children, then you are juggling a number of balls at the same time.

- Jill Karsten, American Geophysical Union – I would guess that it is also true, because it is certainly true across most of the sciences, that women scientists tend to marry—if they are going to marry—someone else in the field, and so you often have the two career couple constraints, which definitely can dictate where you can and cannot work.

  Response – That is true in chemistry. Women chemists are more likely to marry another chemist than male chemists.

- Mark Regets, National Science Foundation – The postdoc jump was very large. Do both data points come from your survey, or are you comparing with the SED?

  Response – Neither data point is from the SED. The one on age discrimination was from a specific special study on mature careers of chemists, so it focused on those that were ages 50 to 69. The one on postdocs was taken from our new graduate study.

- Mark Regets, National Science Foundation – The age discrimination question is interesting. You see very different things by different fields, whether there seems to be a lot of age discrimination, at least anecdotally, in industry, and usually the story is something about the level of skill obsolescence and how that can differ. Have you done anything looking at different branches of chemistry in industry to see whether there are different types of reports of forced retirement?

  Response – No. And that particular question was the respondents indicating that they felt that they had faced age discrimination or the perception of it, so that was the way that that was measured.

- Michael Beals, Rutgers University – Back to that postdoc jump, which I thought was rather striking, were the number of postdoc positions actually increasing, or were the number of postdoc positions constant and the number of PhD recipients going down, or was it a combination?

- Mary Jordan, American Chemical Society – I would say it was a combination.

  Response – I think it is difficult sometimes to measure that. As we all know, we want more information about postdocs in any way we can get.

- Roberta Spalter-Roth, American Sociological Association – I wanted to go back to the family thing. We did a research brief called *The Best Time to Have a Baby.* We have been tracking a cohort of PhDs. The report got 1,000 hits right away. It is the most popular thing we ever did. Yet family issues, while more important for women than for men, are not the major reasons that people say they leave jobs—they move to new places. While it is important for women, it is not necessarily that they should be defined by this, so one has to be a bit careful.

- Adam Fagen, the National Academies – It just seems sort of unbelievable that there was a 10 percent increase in the space of a year. Did anything change with either the methodology or the membership structure of the ACS that might bias a sample population?

  Response – Nothing changed in the methodology of the survey. It is based on new graduates from ACS approved programs, which are all of the PhD granting institutions, and a huge proportion of departments that grant degrees in chemistry at all levels. Those lists include ACS members and non-members. Chemists are as likely to go into postdocs as those in other sciences. It is not seen as

necessarily part of your career path. A large proportion have always gone into postdocs, but not the majority like in the life sciences. But for the last five years, there has been a steady increase.

- Audience Question – On the demographics of the American Chemical Society membership, perhaps you have gotten more biological chemists these days since they are so favorable. I do not know if that has been an issue that has come up.

  Response – I would say we have gotten more. I think that our official member statistics have not always been very good at knowing exactly what they do and what field that they are in. But one of the things we can look at is our more comprehensive salary survey, which is a sample of all of our working members.

- Alan Rapoport, National Science Foundation – You said that 43 percent of the PhDs who took postdocs in 2003 did so because full-time permanent employment was not available. Did you have a similar question in the previous survey? And what was the percentage in the survey the year before?

- Mary Jordan, American Chemical Society – It was lower. We take this very much as an indicator that for the PhDs—because their actual unemployment rate did not change that much—the big change was in the postdocs and the decline in those that got full-time employment.

  Response – Related to that—and this was not brought up in the presentation—more of the PhD chemists went to work in academia than in industry. Overall we saw a decline in their salaries when we lumped everybody together, and wondered what was going on with that. So, we broke it down by industry, academia and government, and there were more people in academia this year than in industry, whereas more chemists have always gone into industry than into academia. I think that that is also another indication that the job market for PhD chemists is not as good or as strong as we would like to see it. I think there are definitely some red flags being raised based on the information we have been collecting.