4. Postdoctoral Training: A Survey of Fellows

Introduction

To assess the effectiveness of the nation's investment in postdoctoral training and to help us understand the factors influencing a successful career in nuclear science, we conducted a web-based survey of postdoctoral fellows currently working in the field between February 15 and March 15, 2004. The survey included a comprehensive set of 104 questions addressing "Career Path and Demographic Background" (25 questions), "Evaluation of Doctoral Education and Experience" (20), "Usefulness of Your Doctoral Education" (8), "Family and Career" (12), and "Economic, Social, and Environmental Factors" (39). In addition, we asked eight open-ended questions concerning "Recommendations and Opinions."

We distributed the survey to 352 postdoctoral fellows, approximately 271 of whom registered as having begun the survey. Of those, 225 (64%) answered the entire survey (except the open-ended questions, which some did not answer). One hundred eighty-five respondents (53%) fully completed the survey and provided responses to the open-ended questions. The following sections discuss the main conclusions from each section of the survey.

Demographics and Career Paths

The gender and citizenship demographics, details of citizenship status, and ethnic background for those responding to the survey are shown in Tables 1–3.

Table 1: Gender and citizenship demographics for survey respondents.

Women	Men	US PhD	Non-US PhD	US Citizen	Non-US Citizen
14%	86%	47%	53%	29%	71%

Table 2: Citizenship status of survey respondents.

	All	Women	Men	US PhD	Non-US PhD	US Citizen	Non-US Citizen
US Citizen, Native Born	27%	28%	26%	60%	1%	92%	0%
US Citizen, Naturalized	2%	0%	3%	5%	0%	8%	0%
Permanent Resident (GC)	6%	6%	6%	5%	5%	0%	9%
Temporary Resident	59%	63%	58%	28%	84%	0%	82%
Non-US Resid. Outside US	5%	3%	6%	1%	9%	0%	8%
Other	1%	0%	1%	1%	1%	0%	1%

Table 3: Ethnic background survey respondents.

	All	Women	Men	US Citizen	Non-US Citizen
American Indian/Alaskan Native	1%	0%	1%	3%	0%
Asian or Pacific Islander	20%	28%	19%	5%	27%
Black	1%	0%	1%	0%	1%
Chicano or Latino	2%	0%	2%	0%	3%
White	76%	72%	77%	92%	69%

The age demographic for those responding to the survey is shown in Figure 1 for women and men. Table 4 provides the average ages at the time of the survey and at the time of the respondents' first postdoctoral position, for several subgroups of respondents.

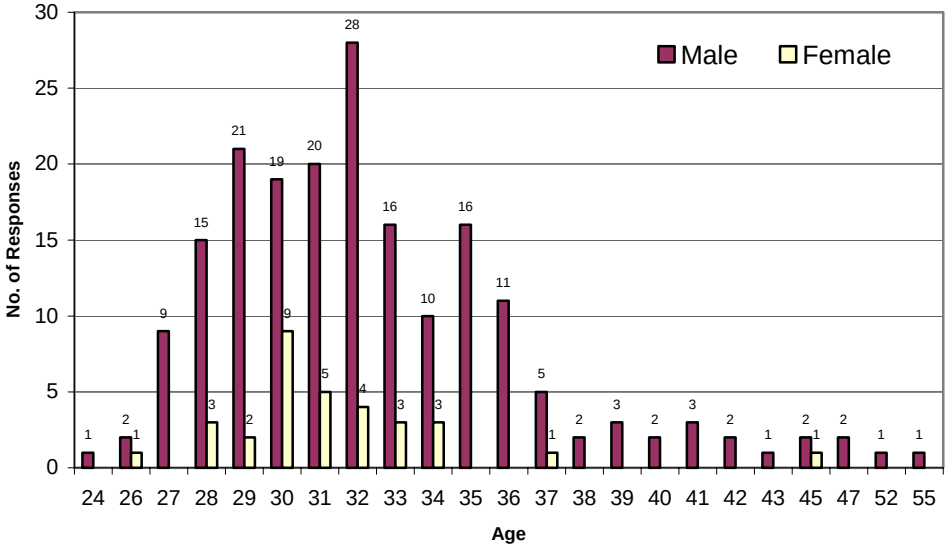

Figure 1: Age distributions for male and female survey respondents.

Table 4: The average age for several subpopulations of postdoctoral fellows.

	All	Female	Male	US PhD	Non-US PhD	US Citizen	Non-US Citizen
Average age	32.4	31.4	32.6	32.1	32.5	31.7	32.7
Average age at time of first post doc	29.5	29.2	29.6	29.6	29.4	29.1	29.7

The distribution of the number of postdoctoral positions that have been held is shown in Figure 2, and the average number of positions held for several subpopulations is indicated in Table 5.

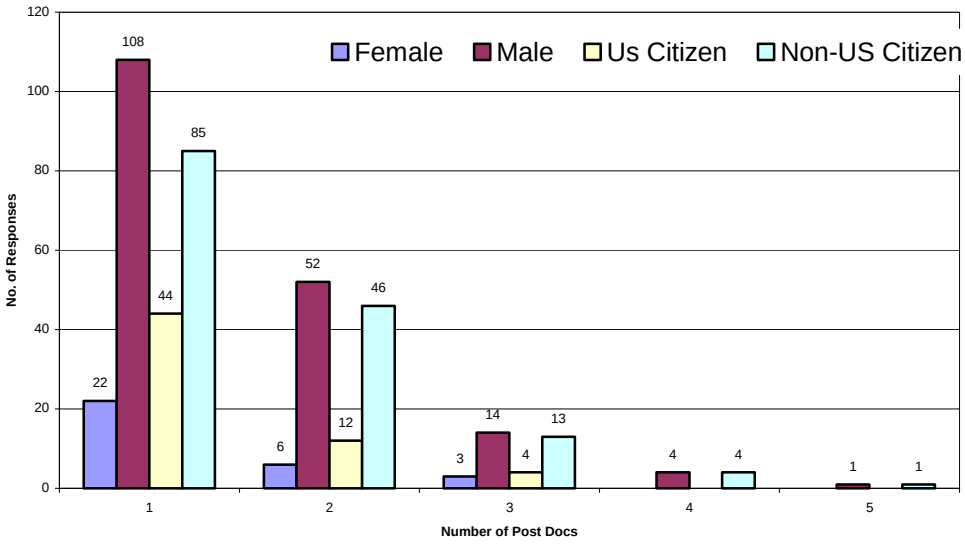

Figure 2: Distribution of the number of postdoctoral positions held for various sub-populations

Table 5: The average number of postdoctoral positions held by several subpopulations of fellows.

	All	Female	Male	US Citizen	Non-US Citizen
Average No. of Post Doctoral Positions Held	1.5	1.3	1.5	1.3	1.6

The above data show that the percentage of U.S. citizens in the present population is 29%. About 50% of the postdoctoral fellows received their PhDs in the U.S., suggesting that the opportunity for advanced training in nuclear science in the U.S. is competitive with educational programs in other countries. The percentage of women in the survey population is 14%, lower than the percentage of women in the total graduate student population (20%), but higher than the percentage of women who responded to the PhDs 5–10 Years Later Survey (12%). This suggests a hopeful trend toward a gradual increase in the number of women postdoctoral fellows in nuclear science. There is essentially no ethnic diversity in the U.S. postdoctoral population. The percentage of nonwhite fellows in the non-U.S. citizen population is significantly higher, owing to a sizable population of Asian postdoctoral fellows from Japan, India, China, and South Korea—in descending order of numbers of fellows.

The “age” and “number of positions held” demographics show that, on average, most respondents have held 1.5 postdoctoral fellowships. They began their first one about 2.6

years before responding to our survey. At the time they began their first postdoc, women were, on average, slightly younger than men, and U.S. citizens slightly younger than non-U.S. citizens. The age distribution for both men and women is approximately Gaussian below the age of 38, with an average age of about 32 years. It has a tail, accounting for about 10% of the total population, extending from the age of 38 to age 55. About 95% of these older postdoctoral fellows were male, and 90% of them were non-U.S. citizens.

The distribution of ages at the time of the first postdoc shows a similar tail, with the same gender and citizenship demographics. The tail in this distribution has approximately the same integral when the average time since the first post doctoral position was begun is accounted for. This suggests that the two distributions are approximately the same, only displaced by about 2.6 years and that the tail in both distributions is due largely to male, non-U.S. citizens who took postdoctoral positions at relatively late ages, rather than to people who have stayed overly long at the postdoctoral level, without advancement.

The percentage of experimental and theoretical postdoctoral fellows is shown in Table 6. All 30 female postdocs who responded to this question indicated that they were experimentalists. The corresponding percentage for men was 68%. The percentage of non-U.S. citizens who indicated they were theorists was somewhat greater (31%) than the corresponding percentage of U.S. citizens (17%).

Table 6: The percentage of experimental and theoretical postdoctoral fellows.

	All	Women	Men	US Citizen	Non-US Citizen
Experimentalist	73%	100%	68%	83%	69%
Theorist	27%	0%	32%	17%	31%

When the survey respondents entered the field of nuclear science, their career goal was overwhelmingly (78%) to become a university professor and/or perform basic research in an academic or national laboratory setting, as shown in Table 7. Further, as shown in Table 8, after several years in the field, the percentage of those who wish to continue in the same direction is even larger (85% overall, 94% for women). This expectation is strikingly at variance with data from the PhDs 5–10 Years Later Survey, which shows that only 62% of men and 83% of women found a job in higher education or at a national laboratory upon entering the workforce after being a postdoctoral fellow. The remainder took jobs in business, government, or a nonprofit organization. The percentage of men and women 5–10 years after their PhDs who are currently employed in higher education or at a national laboratory is even lower (61% and 75%, respectively). These data indicate that, with respect to careers, there is a large mismatch between expectations and reality for 30–40% of the postdoctoral fellows in nuclear science. The fact that the desire to find jobs at universities or at national laboratories remains strong after significant time in the field suggests that the postdoctoral population is largely unaware of this mismatch—and that postdocs do not pursue or receive counseling, training, or the job experience that would afford access to the full spectrum of career opportunities that are available and that may ultimately need to be considered. At the same time, as discussed below, the single largest concern for our survey respondents was the prospect of permanent employment. This concern far outweighed any other. A sizable

percentage of those responding (10–15%) indicated they would not recommend a career in nuclear science to an incoming graduate student precisely because of the current long-term employment outlook.

Table 7: Career goals of postdoctoral fellows upon entering the field of nuclear science.

	All	Women	Men	US Citizen	Non-US Citizen
To be a professor	37%	41%	36%	51%	31%
Academic or Nat. Lab Researcher	41%	41%	41%	25%	47%
Researcher in BGN	3%	3%	2%	5%	2%
Administrator/Manager	0%	0%	0%	0%	0%
Work Independently (freelance)	0%	0%	0%	0%	0%
Start a Business	0%	0%	1%	1%	0%
No Formulated Goal	17%	12%	18%	17%	18%
Other	2%	3%	2%	1%	2%

Table 8: Current career goals of postdoctoral fellows.

	All	Women	Men	US Citizen	Non-US Citizen
To be a professor	34%	53%	31%	43%	31%
Academic or Nat. Lab Researcher	51%	41%	53%	35%	57%
Researcher in BGN	4%	0%	5%	6%	4%
Administrator/Manager	1%	0%	1%	0%	1%
Work Independently (freelance)	0%	0%	0%	2%	0%
Start a Business	1%	0%	1%	2%	1%
No Formulated Goal	4%	3%	4%	1%	4%
Other	5%	3%	5%	11%	2%

The areas of nuclear science in which respondents worked at the time of the survey is shown in Table 9. Twenty-eight percent worked in relativistic heavy ions, 29% in nuclear structure or nuclear reactions, 12% in medium-energy nuclear science, and 9% in nuclear astrophysics.

Table 9: Areas of current research among postdoctoral fellows.

	All	Women	Men	US PhD	Non-US PhD	US Citizen	Non-US Citizen
Nuclear Structure	21%	29%	19%	15%	24%	13%	24%
Nuclear Reactions	8%	10%	8%	9%	8%	9%	7%
Medium Energy	12%	13%	13%	13%	10%	13%	13%
Relativistic Heavy Ions	28%	32%	27%	26%	31%	22%	30%
Nuclear Astrophysics	9%	7%	9%	15%	5%	16%	6%
Nuclear Chemistry	1%	0%	1%	0%	2%	0%	1%
Fundamental Nucl. Sci.	6%	3%	6%	7%	5%	7%	5%
Accelerator Nuclear Sci.	5%	3%	5%	3%	5%	2%	6%
Applied Nuclear Sci.	0%	0%	1%	0%	1%	0%	1%
Other	10%	3%	11%	12%	9%	18%	7%

The work style of postdoctoral fellows is shown in Table 10: 41% of survey respondents indicated that they worked in research teams of 3–6 people, 14% in teams of 7–10; 24% worked primarily alone, and 12% worked mostly with their supervisors.

Table 10: The current work styles of postdoctoral fellows.

	All	Women	Men	US PhD	Non-US PhD	US Citizen	Non-US Citizen
I work primarily by myself	24%	13%	26%	30%	20%	23%	24%
I work mostly with my supervisor	12%	7%	13%	12%	14%	12%	13%
I work in a res. team of 3-6	41%	50%	39%	42%	39%	45%	40%
I work in a res team of 7-10	14%	20%	13%	11%	15%	15%	13%
I work in a res. team of 11-20	3%	3%	3%	1%	4%	2%	3%
I work in a res. team of > 20	6%	7%	6%	4%	8%	3%	7%

When asked the advantages and disadvantages of their individual or team research experience, the top responses in each category were the following:

Advantages	**Indiv research***	**Team research***
Working in a large team; learning things quickly	20%	54%
Freedom; ability to perform independent research	41%	16%
Working with a small team of good people	2%	14%
Working on exciting science/technical developments	5%	4%
Good visibility; chance to network and give talks	12%	6%
Other	20%	6%
Disadvantages		
Being isolated; not enough interaction with others	68%	27%
Poor leadership; poor management; poor mentoring	9%	12%
Too much work; not enough time to do things right	9%	17%
Too much competition/friction with co-workers	0%	20%
Not enough visibility; not enough independence	0%	7%
Other	14%	17%

*Fellows who worked by themselves or primarily with their supervisors were asked about advantages and disadvantages of “individual research”; those who worked in groups of three or more were asked about “team research.”

Survey respondents were asked to indicate the average number of professional meetings attended in the last year, as well as the average number of oral presentations made and the number of publications in journals or proceedings over the same period. The results are shown in Table 11. The average number of oral presentations given by U.S. citizens was significantly lower than the corresponding average for non-U.S. citizens.

Table 11: The number of professional meetings attended and papers given in the last year by survey respondents.

	All	Female	Male	US PhD	Non-US PhD	US Citizen	Non-US Citizen
Average Prof. Meetings	2.3	2.5	2.3	2.3	2.4	2.1	2.5
Average No. of Talks	2.5	2.4	2.5	2.4	2.5	1.7	2.7
Average No. of Papers	5.8	6.3	5.7	5.2	6.6	5.4	6

Evaluation of Doctoral Education and Experience

The areas of nuclear science in which our survey respondents received their doctoral training is shown in Table 12. Thirty-four percent indicated nuclear structure or nuclear reactions as the area of specialty, 24% were trained in relativistic heavy ions, and 10% indicated medium-energy nuclear science.

Table 12: Area of nuclear science in which postdoctoral fellows received their PhDs.

	All	Women	Men	US PhD	Non-US PhD	US Citizen	Non-US Citizen
Nuclear Structure	22%	35%	21%	19%	26%	19%	24%
Nuclear Reactions	12%	17%	11%	10%	14%	10%	13%
Medium Energy	10%	11%	10%	10%	8%	8%	11%
Relativistic Heavy Ions	24%	24%	24%	25%	25%	22%	25%
Nuclear Astrophysics	4%	0%	5%	8%	1%	7%	3%
Nuclear Chemistry	1%	0%	1%	0%	2%	0%	1%
Fundamental Nucl. Sci.	5%	3%	5%	500%	4%	3%	5%
Accelerator Nuclear Sci.	3%	3%	3%	2%	4%	0%	5%
Applied Nuclear Sci.	2%	0%	2%	0%	3%	0%	2%
Other	17%	7%	18%	21%	13%	31%	11%

Table 13 indicates the research sites (university or national laboratory) where most of the respondents' dissertation research was carried out. The results show that universities and national laboratories share positions of roughly equal prominence in providing research environments for doctoral research in nuclear science.

Table 13: The sites where postdoctoral fellows completed most of their dissertation research.

	All	Women	Men	US PhD	Non-US PhD	US Citizen	Non-US Citizen
At my home university	42%	29%	44%	41%	42%	37%	44%
Away from my univ at a natl lab even though I spent most time at my home university	9%	7%	10%	10%	6%	12%	8%
Away from my home univ. at a national lab where I stayed for at least 3 months	32%	50%	28%	34%	30%	35%	30%
Equally at my home univ. and a national lab although most time was at my univ.	3%	0%	4%	2%	6%	3%	4%
Equally at my home univ and a national lab where I spent at least 3 months	6%	7%	6%	6%	7%	7%	6%
At my home university has a direct affiliation (e.g. manages) a natl. lab	8%	7%	8%	7%	9%	6%	8%

The number of postdoctoral fellows who completed a masters thesis involving original research is indicated in Table 14. The percentage of non-U.S. citizens who did so was approximately four times that of U.S. citizens. A possible factor influencing this result is the differences in the educational systems in the U.S. and other countries. In the U.S., a masters degree involving original research is typically not required as part of doctoral training.

Table 14: The percentage of postdocs who completed a masters thesis involving original research.

	All	Female	Male	US PhD	Non-US PhD	US Citizen	Non-US Citizen
Yes	50%	47%	51%	26%	73%	17%	65%
No	50%	53%	49%	74%	27%	83%	35%

Table 15 shows the percentage of postdoctoral fellows who indicated they had practical “hands-on” experience, outside an academic setting, in nuclear science or a related field before or during graduate school. American citizens were significantly more likely than non-U.S. citizens to have had such experience.

Table 15: The percentage of postdocs with “hands-on” experience outside an academic setting before or during graduate school.

	All	Female	Male	US PhD	Non-US PhD	US Citizen	Non-US Citizen
Yes	26%	27%	26%	33%	19%	39%	21%
No	74%	73%	74%	67%	81%	61%	79%

Table 16 indicates the work styles of survey respondents during graduate school. The results show that the percentage of people who worked primarily with their supervisors (28%) during their graduate training is more than twice the corresponding percentage for the current work styles of postdocs (12%; see Table 10).

Table 16: The work styles of postdoctoral fellows during their graduate study.

I work primarily by myself	23%	16%	24%	24%	25%	32%	20%
I work mostly with my supervisor	28%	20%	29%	26%	27%	22%	30%
I work in a res. team of 3-6	36%	37%	36%	38%	38%	37%	36%
I work in a res team of 7-10	8%	17%	7%	9%	6%	8%	8%
I work in a res. team of 11-2(	1%	3%	1%	1%	1%	1%	1%
I work in a res. team of > 20	4%	7%	3%	2%	3%	0%	5%

When asked the advantages and disadvantages of their individual or team research experiences during their graduate training, the top responses in each category were the following:

Advantages	Indiv research*	Team research*
Working and interacting with a team	19%	34%
Good supervision; good leadership; good mentoring	32%	12%
Independence; the ability to do original research	22%	11%
Working in a small group of talented people	8%	18%
Gaining knowledge; learning how to do research	11%	16%
Other	8%	9%
Disadvantages		
Poor leadership; poor management; poor mentoring	32%	41%
Not enough interaction with team members and collaborators	20%	24%
Having to focus narrowly; time constraints to get PhD	24%	18%
Having to learn how to work in large collaborations	4%	12%
Other	20%	5%

*Fellows who worked by themselves or primarily with their supervisors were asked about advantages and disadvantages of "individual research"; those who worked in groups of three or more were asked about "team research."

Table 17 indicates the average number of professional meetings attended by survey respondents during graduate school, as well as the average number of talks and journal publications.

Table 17: Professional meetings attended and papers or talks given during graduate school by current postdoctoral fellows.

	All	Female	Male	US PhD	Non-US PhD	US Citizen	Non-US Citizen
Average Prof. Meetings Attended	5.4	6	5.3	4.9	6	4.7	5.7
Average No. of Oral Presenations	4.5	4.2	4.6	4.2	5	3.7	4.9
Average No. of Papers in Journals or Proceedings	9	8.7	9	8.6	9.3	8.6	9.1

To assess how postdoctoral fellows judge the usefulness of their doctoral education, we asked survey respondent whether, given their experience, they would choose the same career path again. The results are shown in Table 18: 67% indicated they would still get a PhD in nuclear science, and 19% said they would get a PhD in a different subfield of physics or chemistry.

Table 18: What postdocs indicated they would do if they had it to do over again.

	All	Women	Men	US Citizen	Non-US Citizen
I would still get a PhD in nuclear science	67%	60%	69%	66%	69%
I would get a PhD in a different sub-field	19%	20%	19%	26%	16%
I would get a PhD in a different field	6%	7%	6%	5%	6%
I would get a professional degree (MD, JD, etc.)	3%	7%	2%	2%	2%
I would get a professional Master's (MBA, MFA, etc.	3%	3%	2%	1%	3%
I would get an academic Master's (MA, MS, ,etc.)	1%	3%	0%	0%	2%
I would not get a graduate degree	1%	0%	2%	0%	2%

The most common reasons given for their feeling were the following:

Lack of job/career prospects; better prospects elsewhere	58%
Other scientific area is more interesting	19%
Too much time/investment required for too little return	17%
Environment in large collaborations	2%
Other	4%

As to what subfields might be chosen, the most popular areas indicated by those who said they would consider a degree in a different subfield were condensed-matter physics and cosmology and astrophysics, as shown in Table 19.

Table 19: Preferences of postdocs who indicated they should have sought a PhD in a different subfield of physics or chemistry.

Subfield	%
Condensed Matter	31%
Cosmology/Astrophysics	26%
Medical/Bio Physics	17%
High Energy Physics	12%
Other, various	14%

For postdocs who indicated they should have chosen a different field (6% of the total), 50% said they favored a PhD in computer science, and 50% engineering.

Asked about their feelings concerning the usefulness of completing a PhD in nuclear science, almost all indicated that it was probably or definitely worth the effort. Table 20 shows details of the responses.

Table 20: Feelings of postdocs about the usefulness of a PhD in nuclear science.

	All	Women	Men	US Citizen	Non-US Citizen
It was definitely worth the effort	66%	83%	63%	57%	70%
It was probably worth the effort	31%	17%	33%	40%	27%
It was probably not worth the effort	2%	0%	3%	3%	2%
It was definitely not worth the effort	1%	0%	1%	0%	1%

In response to a question concerning other ways, in addition to preparing for a career in nuclear science, that their doctoral education was useful, the top three responses were the following:

Development of a broad range of skills (programming, paper writing, etc.)	28%
Opportunity to network and broaden scientific perspectives	21%
Fulfillment of career goals	18%

Family and Career

Family matters

Among our respondents, 73% of male and 66% female postdoctoral fellows were married or in a committed relationship. As shown in Table 21, there was a significant difference between these populations with respect to the education of the spouse or partner. Women were significantly more likely to have a partner holding an advanced degree.

Table 21: The highest degree obtained by the spouse or partner of postdoctoral fellows.

	Women	Men
Bachelor	0%	30%
Master's	22%	38%
PhD, MD, or JD	78%	30%
Other	0%	2%

As shown in Table 22, women in a committed relationship were also significantly more likely to have a spouse or partner trained in nuclear science. Further, as shown in Table 23, women postdoctoral fellows were much more likely to have a spouse or partner who is currently working full time.

Table 22: The field of spouse's or partner's education.

	Women	Men
Nuclear Science	57%	10%
Other Natural Science	17%	17%
Education	0%	9%
Engineering	9%	13%
Fine Arts	4%	3%
Humanities	4%	9%
Social or Behavioral Science	0%	8%
Business Management	0%	9%
Law	0%	4%
Medicine	4%	14%
Other	5%	4%

Table 23: Employment status of the spouses or partners of postdoctoral fellows.

	All	Women	Men	US Citizen	Non-US Citizen
Full Time	44%	68%	40%	52%	40%
Part Time	8%	0%	9%	15%	6%
Not Employed	30%	5%	34%	22%	33%
Student	14%	23%	12%	9%	16%
Retired	0%	0%	1%	2%	0%
Other	4%	4%	4%	0%	5%

Together, these observations suggest that female postdoctoral fellows may experience different career-related stresses in their personal relationships than men do. In particular, female postdocs are much more likely to have a spouse or partner with an advanced degree in nuclear science who is concurrently working full time. It is reasonable to infer that, for individuals in such relationships, significant stress arises from the difficulty of finding two career positions in nuclear science that match the capabilities and interests of both partners, in the same geographical area. As this circumstance is significantly more common among female postdocs and their partners, it is reasonable to project that, on average, women are more likely to experience conflict between career and relationship than do men.

Table 24 indicates the percentage of survey respondents who lived in the same geographical areas as their spouse or partner. Women were somewhat less likely than men to live near their spouses or partners, and non-U.S. citizens were significantly less likely than U.S. citizens to live in the same area as their spouses or partners. This latter finding might be explained by the short-term nature of most postdoctoral appointments. Many non-U.S. PhDs might come to the U.S. for their postdocs, simply leaving their spouses or partners in their native countries.

Table 24: Percentage of postdocs living in the same geographical areas as their spouses or partners.

	All	Women	Men	US Citizen	Non-US Citizen
Yes	75%	55%	79%	91%	68%
No	25%	45%	21%	9%	32%

The percentage of postdoctoral fellows who indicated that they had children is shown in Table 25. The average number of children for these postdocs was 1.3; the average age of the children was about five years.

Table 25: The percentage of postdocs who indicated they had children, stepchildren, or adopted children.

	All	Women	Men	US Citizen	Non-US Citizen
Yes	31%	21%	33%	28%	32%
No	69%	79%	67%	72%	68%

As shown in Table 26, 43% of men and women indicated that at some time family issues (“marriage,” “children,” and “care for relatives” were given as examples) affected their careers or the careers of their spouses.

Table 26: Percentage of postdocs who indicated that family issues affected their careers or those of their spouses or partners.

	All	Women	Men	US Citizen	Non-US Citizen
Yes	43%	46%	43%	61%	35%
No	57%	54%	57%	39%	65%

The top four reasons given to explain how family issues had affected careers were the following:

My career was compromised in order to find two positions together 38%
My spouse's career was compromised in order to find two positions together 35%
My spouse gave up his/her career to care for children 13%
Our relationship was damaged/destroyed because we could not find two positions together 7%

Table 27 shows the other side of the conflict: 41% of postdocs also indicated that at some time career affected family decisions.

Table 27: Percentage of postdocs who indicated that career issues affected family decisions.

	All	Women	Men	US Citizen	Non-US Citizen
Yes	41%	50%	40%	49%	38%
No	59%	50%	60%	51%	62%

The top four reasons given to explain these impacts were the following:

One or both of our careers were compromised in order to find two positions together 32%
We delayed starting a family/having children due to instability of employment 27%
Our relationship was damaged/destroyed because we could not find two positions together 11%
One or both of us needed to move for a new job 10%

Economic, social, and environmental factors

The distribution of compensation is shown in Figure 3 for men and women, and in Figure 4 for U.S. citizens and non-U.S. citizens. The average compensations for the principal subpopulations is shown in Table 28.

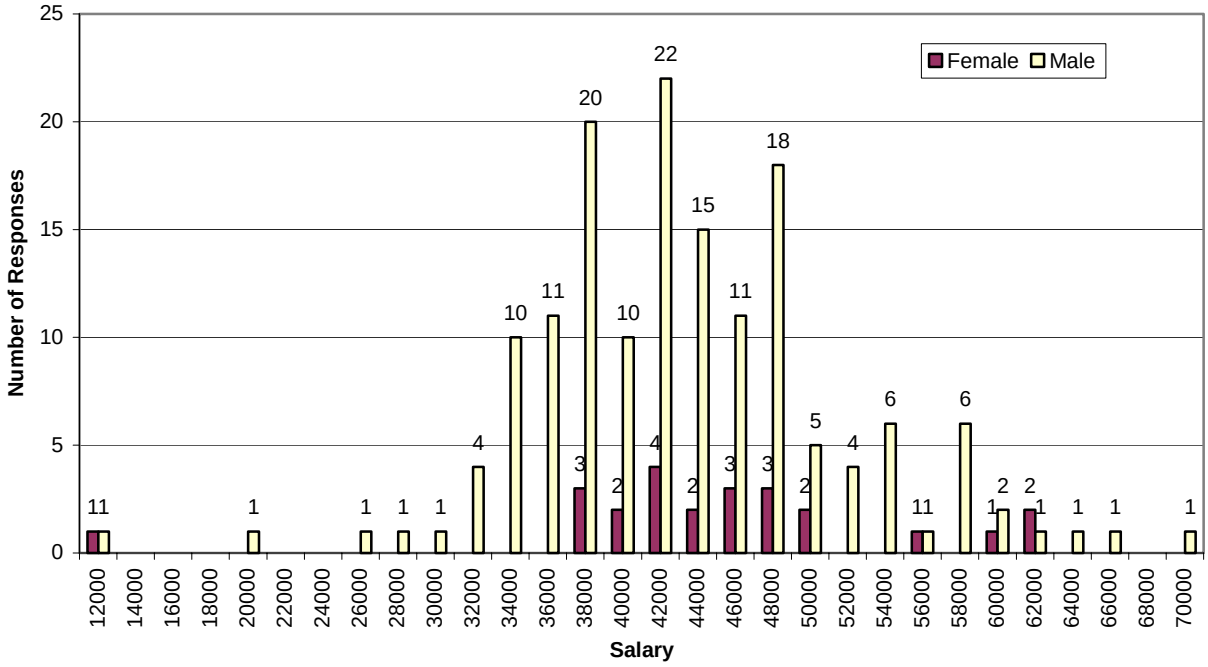

Figure 3: Distribution of salary compensation for men and women post doctoral fellows

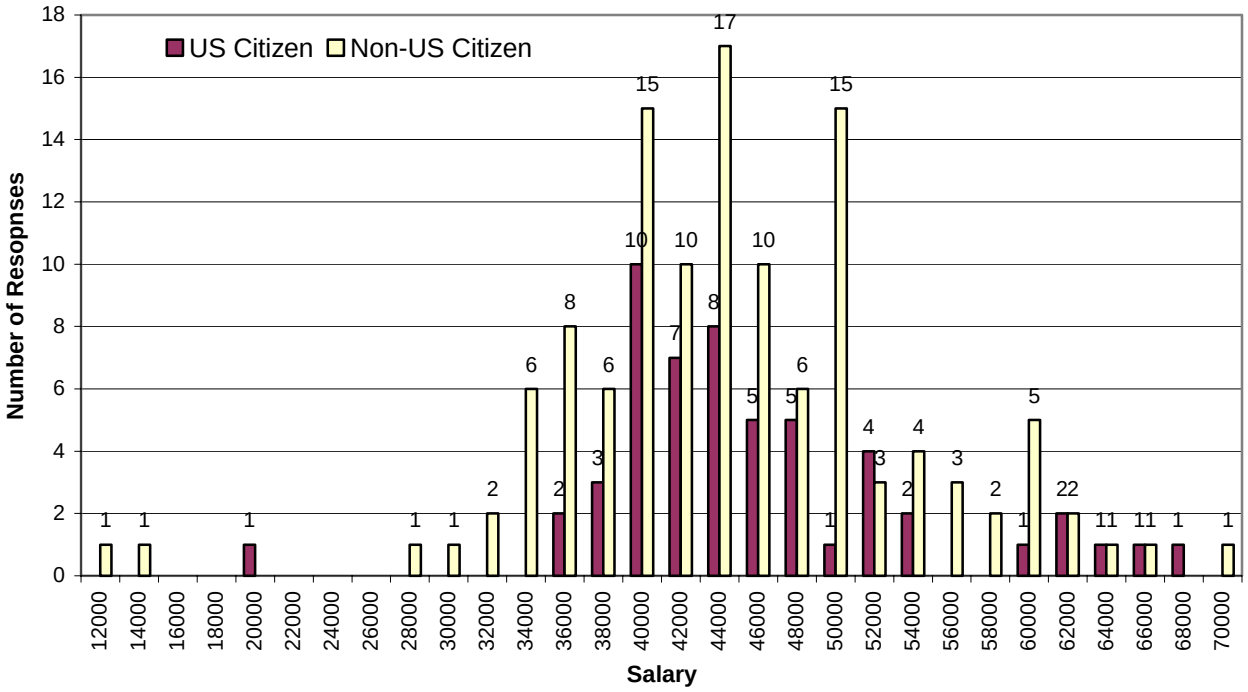

Figure 4: Distribution of salary compensation for US Citizens and non-US Citizens

Table 28: Average annual salary compensation for post doctoral fellows (k$)

	All	Women	Men	US PhD	Non-US PhD	US Citizen	Non-US Citizen
Average Salary	44.5	44.3	44.5	45.5	44.3	46.2	43.7

The average annual compensation for postdoctoral fellows is about $44,500. This average is roughly constant for all subpopulations, though it is somewhat higher for U.S. citizens than for non-U.S. citizens. The distribution of annual salaries is approximately Gaussian between $32,000 and $56,000, with tails at both the high and low ends. The total number of fellows in the tail at the low end of the distribution, comprising mostly male non-U.S. citizens, is about 2.3% of the total. The number in the tail on the high side is about 10% of the total and is composed primarily of men (75%), 27% of whom are U.S. citizens.

Although the general picture of postdoc salaries is acceptable to good, the disparity for fellows in the tail at the low end of the distribution is a concern. A way to address this would be for the field of nuclear science to endorse a minimum salary scale, such as that established by the National Institutes of Health (currently about $36,000 per year for new postdocs), as the minimum expected salary nationally.

The survey posed additional questions concerning the level of satisfaction with the respondents' current compensation and its importance in determining a future career path. The results are shown in Tables 29 and 30.

Table 29: Responses of postdocs regarding their satisfaction with their current salaries.

	All	Women	Men	US Citizen	Non-US Citizen
Satisfied	32%	47%	29%	27%	34%
Adequate	47%	50%	46%	49%	46%
Expected but not adequate	15%	0%	18%	20%	13%
Unreasonably low	6%	3%	7%	4%	7%

Table 30: Responses concerning the importance of salary in determining future career paths.

	All	Women	Men	US Citizen	Non-US Citizen
Important but not a determining factor	84%	79%	84%	75%	87%
Overriding consideration which may decide future career path	16%	21%	16%	25%	13%

The vast majority of postdoctoral fellows (79%) were either satisfied with their salaries or felt they were adequate. Fifteen percent felt their current level of compensation was about that expected for a postdoc, but nevertheless inadequate to maintain a reasonable standard of living. This percentage differed for women (0%) and men (18%), perhaps indicating that male postdocs experience somewhat greater financial pressure. Six percent of those surveyed indicated that their salaries were unreasonably low, in rough agreement with the distributions shown in Figures 3 and 4, considering the number of fellows in the tails at the low ends of those distributions.

Table 30 indicates that, for most postdocs (84%), salary is an important, but not determining, consideration in their future career choices. Sixteen percent indicated that salary is an overriding concern that may determine their future career path. Comparison of the responses of women in Tables 29 and 30 shows that, even though significantly more women than men felt their current salaries were good or adequate, 21% of women felt salary to be an overriding consideration in their career choices. This is somewhat higher than the corresponding percentage for men (16%).

The percentage of postdoctoral fellows who indicated that their employers provided them with health and dental insurance is indicated in Tables 31 and 32, together with the average annual cost of both for all fellows who indicated they had coverage. Fourteen percent of postdoctoral fellows do not have employer-provided health insurance; 29% do not have employer-provided dental insurance. The average amount respondents paid for health insurance was about 3.3% of the average postdoc salary.

Table 31: Percentage of postdoctoral fellows whose employers provided health insurance, and average annual cost.

	All	Women	Men	US Citizen	Non-US Citizen
Yes	89%	80%	91%	90%	89%
No	11%	20%	9%	10%	11%
Average Annual Cost	$1,450	$1,200	$1,500	$1,350	$1,475

Table 32: Percentage of postdoctoral fellows whose employers provided dental insurance, and average annual cost.

	All	Women	Men	US Citizen	Non-US Citizen
Yes	73%	67%	75%	78%	71%
No	27%	33%	25%	22%	29%
Average Annual Cost	$310	$490	$280	$270	$330

As indicated in Table 33, 28% of the U.S. PhDs surveyed indicated they acquired significant debt completing their PhD degree. The average debt incurred was about $20,600, with an root-mean-square deviation of about $14,000. Factors contributing to incurred debt are indicated in Table 34. Only 4% of non-U.S. PhDs incurred debt during their doctoral training, perhaps indicating a difference in the level of tuition support in other countries.

Table 33: Percentage of U.S. PhDs who incurred debt completing their degrees. The average debt among those who incurred debt is also indicated.

	US PhD.
Yes	28%
No	72%
Average Debt Acquired	$20,600

Table 34: Factors contributing to debt incurred during PhD programs.

	US PhD
Tuition	7%
Housing and Food	43%
Family Support	24%
Cost during transition to Post Doc	13%
Other	13%

Additional survey questions concerned “quality of life” and environmental factors. The respondents were asked whether they strongly agreed, agreed, had no opinion, disagreed, or strongly disagreed with a series of statements. They were also given the option to respond that the question was not relevant for them (that is, to indicate a nonresponse). The results are shown in Table 35, which indicates the “mean” response to each statement for each of the indicated subpopulations. Numbers below 3 thus indicate a positive response; numbers above 3 indicate a negative response. As the table shows, most postdocs appear to have had generally positive feelings about their postdoctoral experiences. In general they felt they were treated ethically, that their advisers treated everyone fairly, and that their advisers took time to discuss the science behind the projects they worked on. Respondents also felt their advisers cared about their development, encouraged and supported them to go to conferences, and communicated expectations and feedback clearly. Most also felt a sense of community with their group.

Table 35: Responses to questions related to social, environmental, and quality of life issues. The numbers indicate the mean response to each statement (strongly agree = 1; agree = 2; no opinion = 3; disagree = 4; strongly disagree = 5).

	All	Women	Men	US Citizen	Non-US Citizen
The person I work for takes time to discuss the science behind my work	2.03	2.23	1.99	1.94	2.08
The person I work for cares about my development / learning needed skills	2.19	2	2.23	2.26	2.16
I am treated ethically / get recognition for my achievements	1.99	2.1	1.97	2	1.99
The person I work for treats everyone fairly	1.97	1.97	1.97	2.01	1.94
I feel a sense of community with my group	2.26	2.45	2.23	2.47	2.19
I feel a sense of community with my group is important	1.71	1.6	1.73	1.67	1.73
The person I work for encourages / support me to attend conferences	2.1	1.96	2.1	2.04	2.02
In my job I get useful training in org., management, and other career dev.	3.11	3.04	3.12	2.84	3.24
The person I work for communicates expectations and feedback clearly	2.2	2	2.24	2.27	2.2
The department I work in care about post doc issues/listens to feedback	2.29	2.5	2.25	2.83	2.67
The person I work for encourages me to develop my own research plan	2.8	2.93	2.78	3.13	2.67
The institution I work for provides help with family/person responsibilities	2.62	2.84	2.58	2.96	2.92
The institution I work for provides access to a gym or health facility	2.29	2	2.35	2.51	2.2

The most negative—albeit not *strongly* negative—response was to the statement that they received useful training in organization, management, and other areas of career development. The near-neutral response to this statement may indicate that the respondents felt they are acquiring career development skills at an adequate level, but that their advisors did not emphasize this aspect of their training. We also note, however,

that the average number of postdoctoral positions that had been held by the respondents was 1.54, suggesting that most who responded were at a relatively early stage of their careers and may not yet have held the type of position that would make the importance of these skills fully apparent.

A final statement in this series was directed to women. Thirty-three percent agree or strongly agree that they were at a large disadvantage, as women, in the field of nuclear science, 20% indicated they had no opinion, and 47% disagreed or strongly disagreed. The reasons given by those who felt they were at a large disadvantage are shown in Table 36.

Table 36: Reasons given by women who felt they were at a large disadvantage in the field of nuclear science.

% of total	% US Citizen	% Non-US Citizen	Response
60%	75%	25%	Women are not treated as a scientific peers
40%	70%	30%	No allowance is made for the need to carry out maternal responsibilities

Women who felt they were not treated as peers indicated that this feeling elicited emotions ranging from frustration and anger to self-doubt. Women who felt a lack of accommodation for their maternal responsibilities expressed feelings of constant conflict between family and career.

Open-Ended Questions

The last section of the survey consisted of eight open-ended questions. These questions, together with the four top responses to each, are indicated below

Table 37: The reason post doctoral fellows chose to study nuclear science

	Question: How did you choose to study nuclear science?
31%	Interest / excitement about the science
23%	Wish to continue this direction based on undergraduate research experience/lectures
12%	The influence of advisor or another important figure
7%	Accidentally

Table 38: How post docs would get others interested in nuclear science

	Question: How would you get others interested in nuclear science?
24%	Outreach: tours, popular lectures on fulfillment of this career/its societal importance
13%	Dissemination of information on major scientific advances and their cross-disciplinary impact
11%	I wouldn't
10%	Through strong / exciting undergraduate programs in nuclear science

Table 39: advice post docs would give graduate students in nuclear science

	Question: What advice would you give to beginning graduate students in nuclear science?
24%	Learn / develop / broaden your skills as much as possible; work hard; be the best
17%	Learn about / plan now for a career outside nuclear science and investigate all the possibilities
13%	Look at the long term prospects / lifestyle and decide if you really want it and really like it
8%	Choose your advisory/topic carefully; work for someone you respect and who respects you

Table 40: Advice post docs would give doctoral programs in nuclear science today

	Question: What recommendation would you offer doctoral programs today?
15%	No idea
14%	Focus on important / exciting areas relevant for society; advertise; look modern and attractive
9%	Provide more / stronger career guidance and job planning / placement help
9%	Promote more cross-disciplinary training and cross fertilization

Table 41: What post docs think would have helped them with their first job search

	Question: What you have helped you with your first job search?
26%	More publications / opportunities to present my work; more contact with potential employers
17%	Nothing
7%	More help from advisor
7%	Better knowledge about opportunities in nuclear science and in other fields

Table 42: Aspects of their doctoral experience post docs are most pleased with

	Question: What aspects of your doctoral experience are you most pleased with?
23%	Experience working on a quality team with talented people
22%	Independence and ability to do independent, original research
18%	The knowledge, confidence, experience, and skills gained
13%	Personal achievement; personal satisfaction

Table 43: Aspects of their doctoral experience post docs are most disappointed by

	Question: What aspects of your doctoral experience are you most disappointed with?
19%	The uncertain future; unavailability of jobs; lack of job stability
11%	Nothing thus far
11%	Lack of respect; lack of intellectual independence
7%	Low salary; lack of benefits

Table 44: What else post docs think should be known

	Question: What else do you think we should know?
22%	Nothing to add
15%	The job situation is horrible; we should not train new people until it is fixed
13%	The survey was good / useful
7%	The visa problem is severe and must be fixed

Summary and Outlook

From the responses to the survey of postdoctoral fellows, we conclude that in the U.S. forefront research programs at universities and national laboratories, as well as state-of-the-art facilities with world-class capabilities, provide an attractive opportunity for doctoral training. This conclusion is supported by the observation that, although only 29% of current postdoctoral fellows are U.S. citizens who received their degrees in the U.S., 25% of the non-U.S. citizens making up the remaining 71% of the postdoc population also received their PhDs in the U.S. This indicates that the opportunity for advanced training in nuclear science in the U.S. is competitive and attractive, bringing many foreign students and postdocs into the U.S. program. Universities and national laboratories play roles of equal prominence in providing research environments for PhD research and postdoctoral training in nuclear science.

Overall, the postdoctoral community is very positive about the postdoctoral experience and the usefulness of getting a PhD in nuclear science, despite significant hardship in some cases, owing to stresses to career and family that result from the temporary nature of the employment and the level of financial compensation. These hardships appear to be accepted as “rites of passage” on the road to a successful career and a permanent position in nuclear science. The vast majority of postdoctoral fellows indicated they are satisfied with their salary or feel it is adequate. Most further indicated that salary is an important consideration, but not a determining factor, in their deliberations about future career paths. Nonetheless, there is a significant disparity for fellows at the low end of the salary distribution that should be addressed by the adoption of a minimum salary scale for new postdocs, such as that established by the National Institutes of Health (currently about $36,000 per year).

In general postdoctoral fellows felt they were treated ethically and that their advisers provided balanced and constructive guidance. Most felt a strong sense of community with their groups. Respondents were less positive—but not strongly negative—about whether they were receiving adequate training in organization, management, and other areas of career development.

Not surprisingly, perhaps, female postdoctoral fellows appeared to experience different career-related stress in their personal and family relationships than do men. Specifically, far more female than male respondents had spouses or partners with advanced degrees in nuclear science with full-time jobs. It is reasonable to infer that, for postdocs in such relationships, significant stresses might arise from the difficulty of finding two career

positions that are close to each other and that match the capabilities and interests of both partners. As this circumstance is significantly more probable for female postdocs and their partners, it is reasonable to project that, on average, women are significantly more likely to experience conflict between careers and personal relationships than men. Approximately 30% of the female respondents also indicated they feel they are at a large disadvantage in the field of nuclear science. Two reasons were expressed for this opinion: that they were not treated as scientific peers and that no allowance was made for maternal responsibilities.

There is effectively no ethnic diversity among U.S. citizens in the field of nuclear science.

The survey uncovered some differences in the graduate training experience for U.S. and non-U.S. citizens. U.S. citizens were much more likely to have had practical “hands-on” experience before or during graduate school and much less likely to have done a masters thesis involving original research. It is not obvious from the survey what impacts these difference may have.

The overwhelming majority of postdoctoral fellows entered the field of nuclear science to become university professors and/or to perform basic research in an academic or national laboratory setting. Among those who had spent several years in the field, the percentage wishing to pursue this direction was even greater. This expectation is strikingly at variance with the reality revealed by data from the survey of PhDs five to ten years after their degrees, which shows that slightly fewer than two-thirds eventually find a job at a university or a national laboratory—and not all of these jobs are in academic research. This suggests a large mismatch between career expectations and the likely reality for 30–40% of the postdoctoral fellows in the field. The fact that the desire to find a job in academe continues unabated after significant time in the field suggests that most postdocs are unaware of this reality and do not pursue or receive counseling, training, or job experiences that would afford access to the full spectrum of available career opportunities—opportunities that may ultimately need to be considered. At the same time, the single largest concern for the postdoctoral population is the eventual prospect of permanent employment. Concern about this far outweighs any other concern expressed. Indeed, a sizable percentage (10–15%) of those responding indicated they would not recommend a career in nuclear science to an incoming graduate student precisely because of the current long-term employment outlook.

This concern about future employment and the expectation-reality mismatch are particularly worrisome in an era of declining university programs and faculty positions in nuclear science, both perhaps consequences of the impression held by many that nuclear science is a “mature” field. The outlook for attracting good students and postdoctoral fellows may not be as bright as it has been in the past. The community of nuclear science researchers is a unique and precious national resource. Prudence and duty call for action to see that it is not eroded.

In summary, the nation’s investment in postdoctoral training appears to be effective and to be meeting the nation’s needs at present. However, there are indications of problems with serious potential implications for the future. In particular, we are troubled by the lack of diversity and the low percentage of women, compared with the situations in other scientific fields [ref 1] and in scientific communities in other developed countries [ref 2]. As observed by former NASA Director Daniel Golden in his remarks to a meeting of the American Physical Society [ref 3], “The United States cannot remain competitive

technologically, economically, or in matters of national defense without a diverse workforce."

Further, the generally positive status of postdoctoral training in nuclear science belies a danger: complacency with the status quo. When Henry Rowland was asked in the late nineteenth century what he intended to do about his graduate students, his response was "nothing at all" [ref 4]. In an era when modern physics was in its infancy and the number of university positions could be counted on two hands, it was not unreasonable to leave the future of the field to natural selection. By contrast, in the field of nuclear science today, the challenge of sustaining a scientifically and technologically advanced workforce to meet the nation's needs and maintain world leadership requires commitment and stewardship. Several shortcomings have already been noted: a lack of diversity in the field, a mismatch between expectations and prospects, and misperceptions of the field's vitality. In addition to working through existing channels to sensitize the community, we urge a concerted, dedicated effort by people for whom solving these problems is *the* highest priority. It is not realistic to imagine real progress can be accomplished without such an effort. Indeed, the problems faced today have been recognized for some time. Yet they persist, despite valiant and meaningful volunteer efforts. And they will continue to persist unless resources are provided for a dedicated attack on the problem.

In light of these findings, and as discussed in detail in Chapter 6–8, we recommend a renewed and strengthened commitment by the nuclear science community to mentoring the next generation of nuclear scientists, to providing effective career counseling and guidance to help ensure realistic expectations, as well as exposure to the full spectrum of possible careers, and to a concerted effort to reduce the time to degree for graduate study in the U.S. We further recommend the creation of an outreach center staffed by specialists in communication and education to spearhead a dedicated effort to research the factors that influence diversity, K–12 education, and outreach; to develop effective strategies to reduce or eliminate deficiencies in these areas; and to coordinate the efforts by members of the nuclear science community to do so. The field of nuclear science must weigh the cost of such an investment against the cost of not making it and decide what is best for the future.

References

[need references]