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The Workforce Needs of Pharmaceutical Companies in New Jersey That Use Nanotechnology: Preliminary Findings

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This report is the third in a three-part workforce assessment study series that explores the emerging effects of nanotechnology on the demand for, and educational preparation of, skilled workers. The series was designed to build policy-relevant knowledge of the labor market dynamics of nanotechnology-enabled industries and to foster better alignment of nanotechnology education with the skill needs of employers.

The first report, *The Workforce Needs of Companies Engaged in Nanotechnology Research in Arizona*, used interviews, focus groups, and an on-line questionnaire to profile a single labor market - identifying the skill needs of high-tech companies in Arizona and the types of nanotechnology educational programs being developed at post-secondary institutions in the region. The second report, *A Profile of Nanotechnology Degree Programs in the United States*, examines the development of nanotechnology-specific degree programs. In this third report, researchers performed interviews with pharmaceutical and biotechnology companies based in New Jersey to understand how nanotechnology is affecting their workforce needs.

REPORT SUMMARY

This report discusses findings on the workforce and skill needs of two large pharmaceutical companies (Schering-Plough and Merck) based in New Jersey that use nanotechnology in their R&D and product development activities. Findings are based on four in-depth interviews with corporate executives, a research fellow, and a manufacturing plant manager. Researchers experienced difficulty recruiting additional participants.

Those who were interviewed, however, supported several findings from previous studies on employer demand for nanotechnology workers. First, employers interviewed for this study reported employing few highly skilled nanotechnology workers. Both Stephan et al. (2007) and Van Horn & Fichtner (2008) also found limited demand for skilled nanotechnology R&D workers. Second, as noted in Van Horn & Fichtner, pharmaceutical employers hired workers with traditional degrees and provided most training on specialized nanotechnology skills, including interdisciplinary skills, characterization, and knowledge of size and scale, on the job rather than in the classroom. Finally, future hiring needs were difficult for these employers to predict, a finding also supported by Van Horn & Fichtner.

A unique finding of this study is that nanotechnology has affected the skill and knowledge needs of different classes of workers, albeit in moderate ways. R&D workers are, of course, the most highly and directly affected, but workers in manufacturing and corporate positions in the pharmaceutical industry have also had to acquire new knowledge and skills relevant to nanotechnology. Manufacturing workers need technical characterization skills and a general knowledge of nanotechnology. Corporate executives and lawyers must understand ethical, health, and safety issues, as well as the basic science involved in addressing them. The need for such knowledge may be industry-specific, as public concerns have focused on the use of nanotechnology in consumer products developed by some pharmaceutical companies.

The limited demand for skilled nanotechnology workers and the lack of detailed awareness of the skills needed are not surprising given that nanotechnology is still emerging. Employers are still envisioning the possibilities for nanotechnology, and many current workers have learned about it informally in the lab, rather than the classroom. As nanotechnology matures, policymakers should track how hiring trends and skill and education requirements change to better align workforce education with evolving employer needs.

INTRODUCTION

There is much speculation among scholars about the extent to which need for skilled nanotechnology workers will grow as this emerging technology is adopted across a wide range of industries. A much-quoted estimate from the National Science Foundation estimates that up to 2 million nanotechnology workers may be in demand by 2015, including 800,000 to 900,000 in the U.S. (M. C. Roco & Bainbridge, 2001); (Hullman, 2006). While estimates by other scholars are at once more ambitious and more conservative, a review of the literature reveals general consensus that demand for nanotechnology workers is likely to rise significantly after 2010 (Hullman, 2006). Currently, however, demand for skilled nanotechnology workers is growing, but remains small nationwide (Stephan et al., 2007).

While many scholars have written about the potential for nanotechnology in the marketplace, however, less is known about how the skill and workforce needs of employers are evolving in real time, in particular industries, and within specific regional labor markets. Demand for skilled nanotechnology workers may currently be limited, but to understand the types of skills, knowledge, and educational credentials that workers will need as demand increases, it is important to study the workforce needs of employers as they emerge.

The first report in this series, *The Workforce Needs of Companies Engaged in Nanotechnology Research in Arizona*, found that employers have difficulty projecting their future demand for skilled nanotechnology R&D workers, but they are clear on several broad skill and educational needs. First, employers in this region stated a preference for hiring workers who earned degrees in traditional scientific disciplines and performing the training related to nanotechnology on the job. These same employers noted, however, that interdisciplinary knowledge and skills were necessary for nanotechnology work and were difficult to find among job applicants. In general, nanotechnology employers in Arizona were not concerned about a shortage of skilled workers and were confident that the educational system would respond appropriately to market demands (Van Horn & Fichtner, 2008).

This report was designed to complement the above study, building an understanding of the workforce and skill needs of nanotechnology employers within a particular industry in a separate labor market. Focusing initially on pharmaceutical and biotechnology firms based in New Jersey that use nanotechnology, the purpose of the study was to ascertain whether the views of

these employers are similar to those found in the Arizona-based study. In addition, this research attempted to explore how the adoption of nanotechnology was affecting a wider range of workers, from R&D to manufacturing to marketing, administration, and other types of positions.

Much has been written about the potential for nanotechnology to transform the pharmaceutical and biotechnology industries. Nanobiotechnology, the use of nanotechnology for biological or biochemical applications, is one of the fastest growing areas of nanotechnology research, as well as one of the most controversial (Malsch, 2005). Applications of nanotechnology in the life sciences include the development of new drug delivery methods and improved formulations for consumer products, from sunscreen to anti-aging creams.

Key research questions for this study of the workforce needs of pharmaceutical and biotechnology companies included:

- Which types of workers are affected most by the use of nanotechnology in the bio/pharma sectors?
- How is the introduction of nanotechnology in the firm affecting the skill and knowledge requirements of these workers?
- Which post-secondary majors/disciplines provide the most transferable skills and knowledge for nanotechnology-affected workers in the bio/pharma sectors? (nanotech degree vs. traditional disciplines or other interdisciplinary degrees)
- Which skills and knowledge sets are most difficult to find among current workers? New job applicants?
- What steps are firms taking to address skill gaps related to the introduction of nanotechnology? (e.g. changes in hiring practices or internal training/professional development)

The findings presented here are preliminary. The research is based on in-depth interviews with four representatives from two large pharmaceutical firms based in New Jersey - Schering-Plough and Merck. Those interviewed included two corporate executives in charge of research and consumer products, respectively, a research fellow in a consumer products division, and a drug manufacturing plant manager. Researchers attempted to conduct numerous additional interviews at small and large companies, as well as a focus group, but were unable to secure access to participants despite repeated attempts.

Researchers used nanotechnology patent data developed by Shapira & Youtie, 2008,[1] news reports, and a nanotechnology stock index maintained by the industry publication, Small Times to identify biotechnology and pharmaceutical companies currently using or performing research in nanotechnology. Attempts to recruit study participants included direct calling, referrals through corporate executives, and introductions through and speaking engagements with five state and regional industry associations. These associations included the Healthcare Institute of New Jersey, BioNJ, the Commission on Science and Technology, Bio-1, and the New Jersey Technology Council. With assistance from these member organizations, researchers invited representatives from over 35 industry firms known to be using nanotechnology to participate. Where possible, researchers included the names and locations of company-based nanotechnology patent holders in interview requests.

The reasons for the difficulties securing participants for this research are not known, since most requests went unanswered. However, several possibilities exist. First, it is possible that the amount of nanotechnology work being performed at these companies is so small that corporate executives contacted were not aware of its use within the company. At least two firms refused because representatives claimed that nanotechnology work performed at the company was very limited. In addition, some company executives may have been reticent to discuss the firm's use of nanotechnology due to rising public concerns over the use of nanotechnology in consumer healthcare products. Finally, given the high rate of mergers and acquisitions and other disruptive forces in the life sciences industries, it is possible that officials simply did not have the time or inclination to participate in the study at this time.

FINDINGS

Three preliminary findings emerged from the research effort. These include:

Finding #1: **Pharmaceutical companies reported limited demand for nanotechnology workers in regulated and unregulated product divisions and future hiring needs were unknown.**

[1] These data were developed as part of another research project funded through the Center for Nanotechnology in Society at Arizona State University.

One company reported on their nanotechnology activities in drug delivery, including pararenturals, or drugs that are either injected or delivered ocularly, as well as in non-sterile and other liquid pharmaceutical formulations. The other company discussed their work in unregulated consumer product development, including skin creams.

In both cases, employers reported that very few senior-level, skilled, nanotechnology workers were needed in their divisions and that nanotechnology work elsewhere in their company was limited. For example, one company reported that the part of their consumer products division performing nanotechnology-enabled R&D employed nearly 300 people total. However, only 10-12 of these worked with products that use nanotechnology and even fewer had much direct involvement with nanotechnology on the job. Of these, two were senior-level scientists, while four to five others comprised junior R&D workers and laboratory technicians who require more limited nano-specific skills and knowledge. Similarly, the manufacture of these same products required only 1-2 people in a plant of over 150 workers to have any level of nanotechnology-specific knowledge. In drug development, the ratio of workers who interact with nanotechnology to those who do not was similar.

At a corporate level, one employer reported that workers in marketing, sales, legal, and general management need to develop knowledge of the company's use of nanotechnology, but knowledge requirements were not deep. In addition, this employer did not recruit corporate workers who had specialized experience or training in nanotechnology concepts, but rather introduced workers to relevant issues on the job.

Neither company was able to speculate about the extent to which hiring of such workers is likely to increase in coming years. As one employer noted, "Our use of nanotechnology is so limited and the use of regulated products will take years to bring to market, so it is impossible to know whether demand for nanotechnology workers will rise significantly – or when." (Interview, November 2008)

Finding #2: **Employers interviewed preferred traditional degrees and training workers on the job. Skills gaps include interdisciplinary knowledge, especially at the intersection of biology and chemistry.**

Key skills that workers require, especially those in R&D positions, include characterization skills. Characterization involves using techniques to probe the internal structure of materials in order to measure, observe or analyze them to understand how they will react with other elements, according to employers. Workers also need to develop an understanding of size and scale, as well as interdisciplinary skills that cross chemistry, biology, physics, and engineering. An understanding of health and safety issues, flow characteristics, and the processes and principles involved in creating drug formulations is also important for technical nanotechnology workers in the pharmaceutical industry, according to employers.

The companies consulted for this study prefer to hire workers with traditional degrees. Representatives from both employers interviewed agreed that R&D and advanced manufacturing workers learn most of what they need to know in chemical engineering and/or physical chemistry degree programs. For example, characterization skills are generally taught in these programs.

Neither company reported targeting their hiring to students who had gained nanotechnology experience in a university setting. Instead, employers reported that nanotechnology-specific training has been done on the job through mentoring. Both companies included in the study, however, were planning more comprehensive and formal nanotechnology training for incumbent workers. Manufacturers also offer formal in-house workshops to train workers on nanotechnology-related equipment.

Employers reported that areas where the most new training or education is needed include safety training for lab technicians and interdisciplinary skills. Both employers noted that since many of their skilled nanotechnology R&D workers were trained in chemical engineering or physical chemistry, the primary area where new knowledge and skills were needed was in biology. As one employer noted, "More workers need to develop a better understanding of how the chemical formulations that use nanotechnology interact with biological systems – living cells." (Interview, December 2008) Both employers agreed that this type of knowledge is difficult to teach informally on the job in a short period.

***Finding #3*. While the number of jobs affected by nanotechnology is small, it affects the knowledge and skill requirements of multiple job categories to varying degrees.**

The occupations that are most often referenced when discussing changing skill and knowledge requirements brought about by the introduction of nanotechnology are high-level scientific positions, such as chemists, pharmaceutical scientists, and engineers in areas such basic research, product formulation and analysis, and clinical trials. While these positions are undoubtedly the most affected by nanotechnology, skill and knowledge requirements for other positions are also affected to lesser degrees. In the lab, for example, lab technicians must learn new safety procedures for dealing with nanotechnology, as well as basic characterization skills.

Other types of positions affected by the use of nanotechnology in the firms contacted for this study include:

- Manufacturing engineers
- Corporate executives
- Marketing and sales staff
- Legal staff

Manufacturing engineers that design and oversee the calibration and operation of equipment that processes nanoparticles have had to learn basic nanotechnology concepts, such as characterization, concepts of nanoscale size and scale, and processability - essentially the fluid and particle dynamics knowledge to understand how nanoparticles react and interact in different mediums and under different forces. Other key areas of knowledge for manufacturing workers include heat-mass balance, heat transfer, and flow characteristics. Readers should note however, that only one or two experts in these areas may be needed throughout the manufacturing plant. Other workers at the plant may need a minimal introduction to the new equipment, but nanotechnology specific knowledge is generally not required, according to interviews. At the plant where a manager was interviewed, the nanoparticle machine in question was only run about three times per year. According to the plant manager, even the skilled workers only spend less than 1% of their time on the nanotechnology processing equipment right now.

Other types of work that have been affected by the introduction of nanotechnology in the pharmaceutical companies included in this research include corporate executives and marketing and sales workers. Especially with regard to the use of nanoparticles in unregulated products, such as sunscreen, corporate managers and marketing and sales staff have had to become educated on both the basic science behind nanotechnology and the social, legal, ethical,

health, and safety concerns associated with its use. Both companies acknowledged public controversy over the use of nanoparticles in some product formulations. For example, as one corporate executive mentioned, "our marketing and sales team has to understand how to approach tricky questions about permeability of nanoparticles. Some of our anti-aging products claim they are transforming skin at the cellular level. But with nanotechnology, many people are concerned about nanoparticles penetrating the skin and entering the bloodstream. Marketing and sales staff need to understand the basic science of the nanoparticles, as well as the current studies on their safety, and be able to balance and deliver this information effectively to the public and others." (Interview, October, 2008)

CONCLUSIONS

Although the research presented here is preliminary, many of the results are similar to those found in other studies. Van Horn and Fichtner (2008) and Stephan et al. (2007) found limited current demand for highly skilled nanotechnology workers, as employers in this study also noted. Van Horn et al. also found that employers were not yet seeking nanotechnology workers with new types of degrees, but rather preferred to train workers who had earned relevant traditional degrees on the job. At the same time, however, employers in both studies discussed a need for workers to develop more interdisciplinary skills and knowledge to be effective at nanotechnology work.

The fact that this study found that nanotechnology was having at least some affect on the knowledge requirements of jobs outside of R&D may have implications for business school and related curricula. Non-science workers may need to develop a more comprehensive understanding of the basic science of nanotechnology, as well as the ethical, legal, social, health and safety implications of using nanotechnology in consumer products. Whether this is a skill/knowledge need that extends beyond the life sciences industries to other nanotechnology application areas is an area for further research.

Overall, these findings and those of other studies suggest limited current demand for skilled nanotechnology workers or for nanotechnology-specific credentials for these workers. On the other hand, employers acknowledged skill gaps around interdisciplinary knowledge that are difficult to address with on-the-job training and the fact that the knowledge needs of various classes of jobs are changing to some degree in response to the introduction of nanotechnology. It could be that, due to emerging nature of the technology, no consensus has yet

emerged among employers around the need for new types of nanotechnology education and credentials. Whether demand for specific types of nanotechnology education and training will emerge as the field matures is something that will be important for researchers to track.

At some point, education systems may need to change – even radically so – to allow nanotechnology to reach its full social and scientific potential. However, this and previous research, suggest that employers have not yet embraced such a paradigm shift. Given the still emerging nature of nanotechnology, its nascent applications in the marketplace, and the currently small demand for highly skilled nanotechnology workers, this finding is not surprising. As in the case of information technology in its formative years, there is limited demand for skilled workers and employers appear to have no broad awareness of the need for entirely new types of education or degrees for nanotechnology. The most likely reason for this is simply that this is all very new for employers – they are learning as they go, still trying to grasp the totality of new skills and abilities that nanotechnology requires. Over time, this awareness, and patterns of employer skill demands, may change.

Beyond the scope of this research, more data will be needed on how the workforce and skill needs of employers evolve as nanotechnology itself evolves. Whether a paradigm shift occurs or not with regard to the demand for nanotechnology-specific degrees and credentials, such research will at least inform the ways that traditional disciplines can modify their educational practices to incorporate the priority nanotechnology-related skill needs of employers.

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