

To all students: Graduate school is an investment in the future!

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A constructive, aggressive atmosphere

In May and July I had the opportunity to visit two biotechnology firms whose research centers are located on the east and west coasts of the United States. Both companies had successfully developed pharmaceuticals that are already on the market or about to be released, and both were bought out by major global drug companies while retaining the venture company names they had when they were first established. Accordingly, in essence the companies are positioned as research centers for specialized technical fields under the umbrella of the drug companies. During my visits I had a chance to participate in a roundtable discussion with their young researchers, who were synthetic chemists, biochemists, and cellular biologists. Through the questions they asked and the R&D (research and development) discussions we had, I sensed their advanced knowledge, pioneering spirits, and constructive aggressiveness, in both very high-level academic debates and extremely practical discussions. Although I have many similar opportunities to visit chemical and drug companies in Japan, the atmosphere is markedly different. The difference at the American companies is in the stimulating atmosphere of free debate backed by the researchers' own curiosity.

This cannot be dismissed as merely a racial difference between Americans and Japanese. In fact, the researchers at the venture firms I visited were of various races. The decisive distinction is that the researchers in the United States all hold doctoral degrees (Ph.D.). Another important difference is likely that they are proud of their degrees, and engaged in friendly competition from the same position while doing joint research facing in the same direction. These factors are reflected in the difference in atmosphere I mentioned above. What I would like the readers of this essay—students affiliated with the Chemical Society of Japan—to be aware of is the fact that most of those who are called “researchers” at western companies hold doctoral degrees. In contrast, Japanese companies have a mix of doctoral and master degree-holding researchers. Moreover, many of the researchers who do hold doctoral degrees obtained their Ph.D. via dissertation through research at a company after earning their master degree.

Up to now, chemical-related companies in Japan have relied on master's degree-holding researchers for their corporate capabilities (research and development strength and labor force). However, with the current drive by countries in Asia and elsewhere to advance export businesses by capitalizing on low-cost labor, Japanese companies cannot survive the price competition that the export business entails. Furthermore, as seen in countries like South Korea, China, and Singapore, many firms in Asia are taking in researchers who live overseas and have doctoral degrees. They are not just steadily building the capacity to catch up with more advanced technologies, but also the ability to engage in original research and development, and there is even a palpable

sense that they have the momentum to overtake Japan in product quality. Japan has extremely strong chemical research and development capabilities in both academia and industry. However, it seems that everyone probably feels that even Japan's chemical industry is headed toward shaky ground if it retains exactly the same framework as it has up to now. The industrial map of the world, and especially of Asia, is clearly changing—and at a rapid pace.

A doctoral course graduate school scenario that traces out a career path

Graduate schools in Japan have a low percentage of students going on to a doctoral course. This phenomenon originates from the fact that contrary to graduate schools in the western countries, Japan has historically run a graduate degree system divided into master's courses (first part of doctoral course) and doctoral courses (second part), as well as that there was a strong tendency that students who advance to doctoral courses mainly aimed at becoming researchers in academia. However, at present the number of outstanding students who pursue doctoral courses in Japan has declined, due to concerns that the odds of being able to gain a position in academia after completing a Ph.D. are low (although the odds were low in the past as well, discussion of this fact on the Internet and elsewhere has fanned students' fears in this area) and a weakened sense of aspiration to become an academic researcher. Master's course graduate students also hesitate to advance to doctoral courses because of rising university tuition costs and the commensurate extra burden on parents that support their student life. Further spurring the decline is the widespread negative information on the Internet about the difficulty that a Ph.D. has in securing employment and post-doctoral problems. Under such circumstances, it is perhaps inevitable that fewer exceptional students pursue doctoral courses.

Of course it is important for excellent master's degree holders to be active in industry, and it is true that such people have supported Japanese industry up to now. Nevertheless, as I caught a glimpse of at American venture firms mentioned at the beginning of this essay, it is also a fact that the force that drives aggressive research and development at a firm with a pioneering spirit is likely to spring from researchers who have received sufficient training in doctoral courses. The question facing Japan's graduate schools now is whether they can create an environment in which outstanding students can advance to doctoral courses with the hope of a future career path and receive the appropriate training. It is hence necessary that the training (educational curriculum and research) in the graduate courses should be appealing to such students. This surely requires the training to be challenging and a shade different from master's course training^{1,2)}. The content of the training must also be attractive from the standpoint of businesses. That is, the training should cover material that

makes companies proactive about hiring people who have undergone the training³⁾.

In addition, considering the surging university tuitions, economic support is essential. There needs to be enough support for graduate students on doctoral courses to be independent and put their all into study and research. It is surely insufficient for only some doctoral students chosen by the Japan Society for the Promotion of Science to be independent. A budget for research centers like global COEs (Centers of Excellence) that support doctoral students will continue to be crucial in creating an environment of friendly competition. However, advisers to doctoral students should not rely on that alone, and cannot rest in their efforts to squeeze out economic support from their own research expenses as compensation for students advancing the research. Without this compensation, the aim of creating an environment for excellent students to pursue doctoral courses will be nothing more than flowery words espoused by faculty when it serves their ends.

Japan's chemical-related businesses also need to lend a hand in creating career path. For graduate students going on to doctoral courses to trace out a career path after completion of the courses, businesses must show strong inclination to hire doctorate holders. Recently the Japan Chemical Industry Association led the formation of the Chemistry Human Resources Development Program⁴⁾ (backed by the Ministry of Education, Culture, Sports, Science and Technology and Ministry of Economy, Trade and Industry in Japan). The program not only promotes proactive hiring of the human resources sought by industry, but also it goes further to promote economic support. Through such support, the association also provides advice for graduate departments. The program is a wonderful attempt to cultivate human resources as a joint effort by industry, academia, and government. However, the number of businesses participation in this program is not necessarily very large. If we consider the future of high-level chemists in Japan, there surely ought to be an increase in industry participation. Such a stance on the part of society would embolden doctoral students to design career paths and motivate them to continue in their education.

Calculate the risks; Then take them!

Similar ideas to those I have written in this commentary can already be seen in commentaries contributed to this publication by professors^{1~3)} and in Subcommittee for Considering High-level Human Resource Development and Internationalization⁵⁾ formed by the Chemistry Committee at the Science Council of Japan. Nevertheless, the reason I dared to take the space to write

this essay is that I long to have this message reach the students who read this publication. The title is imbued with this sentiment. The highest level of graduate school education is not obtained solely by the efforts of those who teach, but by the ambition of those who receive the teaching—that is, the graduate school students themselves. Pursuing a doctoral course is an investment in your future. Being an investment, it naturally involves risk. The above-mentioned strengthening of graduate school training and economic support are merely ways of helping to mitigate that risk (though of course universities should not neglect this area). Most students in chemistry-related departments will pursue a master's degree program and seek employment when they complete it. This is because the students deem this to be the greatest benefit of graduate school with the least risk. Although risk calculation is important, you are living in a time when you will need to be active on the global stage and increase your added value as a scientist. To accomplish this, boldly taking a risk should remain an option. In taking that risk, I would like to see the talent you possess grow immensely and have your investment pay maximum dividends. Those dividends are what will be a driving force supporting the future of chemistry and chemical industry in Japan.

- 1) Iwao Ojima, *Science and Technology Research and Education in Japan—A View from U.S.A.*, Chemistry & Chemical Industry, **2010**, 63, 789.
- 2) Hisashi Yamamoto, *What I expect from young researchers: Train yourselves to write competent proposals*, Chemistry & Chemical Industry, **2011**, 64, 387.
- 3) Mutsuhiro Arinobu, *Students' ability to find employment and university education*, Chemistry & Chemical Industry, **2010**, 63, 955.
- 4) Chemistry Human Resources Development Program: Graduate School Postdoctoral Course Support Systems through the Chemical Industry (<http://www.nikkakyo.org/documentDownload.php?id=4193>)
- 5) Subcommittee for Considering High-level Human Resource Development and Internationalization, Chemistry Committee, Science Council of Japan (<http://www.scj.go.jp/ja/info/kohyo/pdf/kohyo-21-h117-1.pdf>)

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The commentary shown here is written by one of the members of the Commentary Committee of the Society, and the author is basically responsible for the contents. The Society acknowledges that this is important and worth publishing. Opinions and comments of the readers are highly appreciated.
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The *Kagaku to Kogyo* (Chemistry & Chemical Industry) Editorial is responsible for the English-translated article.