論説 Commentary

The role and characteristics of chemistry in the age of sustainability: The International Year of Chemistry and Japan's new Science and Technology Basic Plan

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Introduction—the first decade of the 21st century

2011 is the International Year of Chemistry. It is also the year in which the government's Fourth Science and Technology Basic Plan starts.

Let us, therefore, look back at the events that took place in relation to science and technology policies in the first decade of the 21st century. First, in 2001, the government newly established the Council for Science and Technology Policy and the Ministry of Education, Culture, Sports, Science and Technology in January, and adopted the Second Science and Technology Basic Plan in March. In this plan, the Budapest Declaration of the World Conference on Science (1999), "Science in society and science for society," was emphasized for the first time as what science should be in the 21st century.

In September of the same year, the World Trade Center in New York was destroyed in terrorist attacks, arousing the presentiment of a "bad start for the 21st century" throughout the entire world.

In 2004, the government turned national universities into independent administrative entities, and in 2005 restructured the Science Council of Japan.

At the end of 2004, the Council on Competitiveness in the U.S. released the "Innovate America" report (the "Palmisano Report"). The report indicated that innovation would be the most important factor in solving issues that the people, society, and economy confront through the 21st century, and set off an "innovation" boom throughout the world. The boom was not temporary. Since then, "innovation" has been included in many countries' policy papers, including the Augustine Report of the U.S. and the Third Science and Technology Basic Plan of Japan, and has been finalized in the OECD's "New Innovation Strategy" launched last May.[1)]

In 2005, the combined GDP of the seven major industrialized nations fell below that of the developing countries for the first time in one hundred and thirty years.[2)]

In 2008, the Lehman's fall took place, pushing the world economy to the edge of a precipice. In the same year, the G-20 was formed as the power of industrialized nations to adjust the world economy weakened. Last year, China finally overtook Japan and now ranks second in the world in terms of GDP. Not only the center of economic activities but that of the world's scientific activities is now shifting rapidly from the West to the East, to developing countries such as China and India, whose research and development investments and number of papers produced are increasing sharply. The "Age of Calm" with long "prosperity" may have come to an end for Japan.

Amid such circumstances, the good news is that a rapidly increasing number of Japanese have won a Nobel Prize. Over the past decade, ten Japanese people received the Prize, of which six were in chemistry.

The International Year of Chemistry and Japan's Fourth Science and Technology Basic Plan

The International Year of Chemistry, under the unifying theme of "Chemistry—our life, our future," aims to raise awareness of chemistry among the general public, encourage interest in chemistry among young people, generate enthusiasm for the creative future of chemistry, and help realize a sustainable society.[3)] These aims are the same as the purposes of Japan's Fourth Science and Technology Basic Plan to be started this year.

The core of the Fourth Plan is the shift from science and technology policy to science, technology and innovation policy. The shift can be considered a significant transformation from the policy taken since the establishment of the Science and Technology Basic Plan in 1995, in which heavy investment has been made in specific areas (discipline-oriented), to the policy of solving issues (issue-driven), which can be seen as a global trend now. The Director of the National Science Foundation and the Director of the Department of Energy in the U.S., with whom I recently had an opportunity to talk, also expressed their willingness to restructure the research mechanism to bridge basic research and social needs and expectations.

I think the framework of modern science and technology, institutionalized for over two hundred years since the 19th century, is being forced to review how academic society should function, the setting of issues, forming of groups of researchers, methods of peer review and human resource development, and assessment methods of results. Because this does not apply only to Japan, it is necessary to design a new international structure for science and technology in order to solve global issues.[4)]

Change in the political system and reform of the mechanism of policy decision

In 2009, there was a big change in the Japanese political system. The government, which had been ruled almost uninterruptedly by the Liberal Democratic Party for sixty years since the end of World War II, changed hands to the Democratic Party of Japan. This changeover also had a great impact on science and technology policy. Under an enormous budget deficit, the science and technology budget was no longer untouchable, and, at one point, it was feared that the Fourth Science and Technology Basic Plan may not be formulated. Fortunately, the new plan was adopted as scheduled, also setting a target of 25 trillion yen (1% of GDP) as

governmental research and development investment for the next five years.

I think that all those concerned should clearly realize the significance of the exceptional adoption of the new Science and Technology Basic Plan amidst the political change, when most other important policies, such as those on taxation, decentralization and the pension system, have not yet been decided. Also, the historical background of the plan should be recalled. In 1995, the government established in a bipartisan way the Science and Technology Basic Plan, based on which a new basic plan has been adopted by the government every five years under bipartisan support. I think that this legislative system and past results have made the formulation of a solid plan possible even under political confusion. The next issue is to realize the plan, but the adoption of the plan bears great significance.

Characteristics of the methodology of modern science and research system for problem-solving

As I stated previously, I think the Fourth Plan advocates the development of a new research system to solve issues. I would now like to indicate a few perspectives on the history and methodology of modern chemistry. "Modern chemistry has adhered to the particulars and diversity of reality. It may have lagged behind physics in light of building a learning system pursuing abstraction and generality. However, facing a new environment in which scientific knowledge must be exercised not to make use of nature but to predict the changes in nature, I think the time has arrived for chemistry's methodology to play an important role."[5] "Chemistry, being more complicated than biology and biotechnology, is too difficult for the general public to understand and have confidence in."[6] Also in the field of physics, it is said, "There is a limit to reductionism. By adopting research methods focusing on diversity, new discoveries are becoming a reality. Approaches from both reductionism and diversity are necessary."[7]

When we take a look at history, modern chemistry, since Lavoisier and Liebig, has created various values in society, the economy and in people's lives through repeated synthesis and prediction that are characteristic to chemistry, as well as analyses of nature. In recent years, modern chemistry was quick in developing the concept of green chemistry, and has led the age of sustainability, which is an aspect that differs from that of other academic disciplines centering on discovery. It is also true that chemistry, being closer to society and the public, has had a negative image as a source of pollution.

The journal *Nature* featured articles on the state of chemistry in 2001[8] and in January of this year.[6] To my eyes, there seems to have been an obvious change in the journal's view of chemistry over the past ten years. Is it because chemistry has changed or because society has changed? Has chemistry improved its value in the first decade of the 21st century amidst changes in global systems and rules? Has it created its own new rule? I hope readers will compare the two articles. It is noteworthy that the journal *Nature* described chemistry as being "the central science."[6]

Conclusion

A few years ago, I attended an international workshop held under the theme of "chemistry in the 21st century," where I, as a businessman, posed the following presumptuous questions. "Will chemistry, existing between physics and biology, lose its value as an academic discipline in the 21st century? Are there any great challenges left for chemistry? Will it decline into service provision?" In response to these questions, an eminent Japanese chemist who had temporarily returned from the U.S. answered resolutely that "young chemists support today's success of life sciences and biotechnology in the U.S.," with which I remember myself being much impressed.

Darwin has been quoted as saying that "it is not the strongest of the species that will survive but the one most responsive to change." This may apply not only to living species but also to academic disciplines.

As "Green Innovation" and "Life Innovation" become foci not only of science and technology policies but also of domestic and international socioeconomic policies, I will watch with anticipation how chemistry evolves in the future. While politics and administration can promote formal changes in science, it is the scientists and scientific communities that can change the essence of science.[9] In light of all these new circumstances, it is necessary that academia in its entirety promote education and create an ethos that will foster methodology, historical perspective, and a world view of chemistry, as well as transfer knowledge, for the future generations of chemists.[7]

1) "OECD New Innovation Strategy", May **2010**.
2) The *Economist*, Jan. 21, **2006**.
3) International Year of Chemistry 2011 Japan Committee, Aug.6, **2010**.
4) Tateo Arimoto, "Shift in the center of scientific research activities to Asia and the Asian Research Area scheme," *Chemistry and Chemical Industry*, May **2010**.
5) Hiroyuki Yoshikawa, "Chemical Imperialism?," *Chemistry*, vol.65 No.5, Opening essay, **2010**.
6) "Chemistry's understated majesty", editorial, *Nature*, pp.5, vol.469, "Celebrating Chemistry—The future of the central science", 6 January **2011**.
7) "<Discussion> From the site of research," "Perception of the times. World view and Creativity: after discussion," Tateo Arimoto, "Science & Technology and Ethos of Knowledge II: What science stands for and where it is headed," edited by Research Institute of Science and Technology for Society, Japan Science and Technology Agency, Maruzen Planet, March **2011**.
8) "A discipline buried by success," editorial, *Nature*, pp.399, vol.411, 24 May **2001**.
9) Tateo Arimoto, "Turning point of science and technology and Japan's system," *Illume*, vol.30, Dec.20, **2003**.

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