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Science, Two Cultures, and Postwar Japan/*

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/* I dedicate this article to the memory of Kinuko Kubota, whose passing was reported in the press soon after the Rikkyo Symposium. I owe her the conversation quoted in the text. */

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1. Science and scientists

My original plan for this symposium was to comment on the postwar science in Japan from an American perspective. In other words, I wanted to discuss science in the context of the two cultures on the opposite sides of the Pacific. As I listened to the talks and discussions of the participants, however, nostalgic memories came back to me of the endless evenings I had spent with my roommates in the dormitories of my student days, and certain thoughts struck me like a revelation. First of all, I could not help but sense what C. P. Snow termed the problem of the "two cultures"[1]. Instead of the two cultures I had in mind, his problem had to do with a deep gap between the scientists and the "literary intellectuals", not only in terms of their interests and preoccupations, but also in the ways their respective minds work. Then I also realized that there are certain themes which share some commonality, if only a superficial one, between humanistic and scientific trends. Somehow I did not get alarmed as Snow did over the gap; on the contrary, I was stimulated by the experience. At any rate I began to think that, as one of the few scientist participants, it would be appropriate for me to speak to these points. So I would like to start with a capsule charcterization of the scientist./*

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1) C. P. Snow, *"The Two Cultures and The Scientific Revolution,* The Rede Lecture, Cambridge Universtity Press,1959.

/* In contrasting science with humanistic disciplines, I use the word science in broad terms, combining science and technology; science in the narrow sense can also be divided into natural and life sciences. I do not make such distinction here, but it is inevitable that I will be speaking from my own prejudices as a physicist.*/

Broadly speaking, the subject of science is nature, as opposed to man and its creations like society, history, and art, although science regards the latter as being imbedded in the former, so to speak, and thus forming a part of the objective reality.

The scientist, as a human being, may be characterized as forward-looking and optimistic. He believes in progress, particularly the progress of knowledge. ("What's new?" are his daily greeting words.) The knowledge is cumulative, continuous, and controllable, which makes progress possible. This belief of the scientist is being continually butressed by his experience.

As a result, the scientist has self-confidence. He is sure of succcess; he thinks in his heart that science is one of the prime movers, if not the only one, of the human society.

The scientist believes in objective truth and universality. In seeking an answer to a question, he assumes that a) there is an answer, b) the answer is unique, and c) the ultimate judge of the truth is Nature (or God).

Such beliefs on the part of the scientist also bring with them some idiosyncracies. Thus a kind of utilitarianism operates in his mind. ("Nothing succeeds like success.") There is also a bit of modesty and insecurity (becuase he is not the ultimate judge). At the same time, he finds security in the knowledge that there are objective truths. Research can sometimes serve him as an escape from the uncertainties of the human world.

Finally, there are esthetic elements in science. Scientific laws are perceived by scientists as reflecting the beauty and harmony of the natural world in a rather abstract sense. The art of research becomes the art of guessing what nature regards as truth and beauty. But the abstractness of beauty comes in various grades. For example, there is often a visual appeal in the mathematical equation expressing a physical law, and the intrinsic beauty of its content can become indistinguishable from the more tangible beauty of its form. Unfortunately, this is a difficult point to convey to non-scientists.

2. Science in postwar Japan

It is not my purpose here to discuss the place science holds in Japanese culture in general. That would be too big a subject. Suffice it to say that the scientific tradition in Japan germinated in the Tokugawa period, then rapidly developed after the Meiji era. It is true that H. Nagaoka, a leading physicist in the Meiji-Taisho period, first had to agonize over whether the

Japanese had innate aptitude for science. But this is a thing of the past.

One summer in the early fifties, I was driving across the deserts in the Southwest of the U.S. with my friends. Our conversation in the car turned to the question of the future of Japan. One of my companions remarked, "We are now driving on this magnificent highway through the desert, and there are many highways going in many directions. But we can only drive on the highways. The American society is like this highway system. Japan, on the other hand, has no highways. You are free to go in any direction, even though the going may be very rough."

Now, thirty years later, what does the highway system of the Japanese society look like? To me it looks like the highway system of Canada. Canada has only one trunk highway. You can go only east or west; there is no other choice. A great change has indeed taken place. Japan has outstripped the U.S. in some ways, both good and bad.

Let me turn to a statistical comparison of the two countries on science and engineering, higher education, etc.[2] The U.S. has about twice the population and the GNP of Japan. So the two countries are roughly comparable on a per capita basis. This situation holds true in many other respects as well, as can be seen below.

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2) *International Science and Technology Data Update*, prepared by the U.S. National Science Foundation, 1985; *Science Indicators*, the 1985 Report by the U.S. National Science Board.

Both countries spend about the same percentage (2.5-3%) of GNP on research and development. Both have about the same proportion of scientists and engineers engaged in research and development (750,000 in number in the U.S., and 340,000 in Japan). The U.S. produces about 100,000 first university degrees annually, Japan 40,000.

Are there any differences, then? Indeed there are differences, which are found in the way the numbers are apportioned to subcategories. For example, the U.S. spends two-thirds of R&D money on defense, Japan only about 3%.

A comparison of university education also reveals interesting differences. The annual production of doctoral degrees is over 30,000 in the U.S., 7,000 in Japan. Of these, natural science comprises 35% in the U.S. vs. 12% in Japan; engineering and agriculture, 12% vs. 27%; social science, 19% vs.1%; other, 35% vs. 60%. For the first university degrees, the corresponding figures are: 11% vs. 3%; 9% vs. 23%; 11% vs. 41%; 69% vs. 33%.

From these comparisons I get the impression that 1) the U.S. is staggering under the burden of defense; 2) Japan's efforts are directed more to industry and practical problems than to basic science; 3) the U.S. produces, even on a per capita basis, more doctorates than Japan. But of course these are not surprising results; they just confirm our common sense knowledge. (A similar survey of European countries also shows certain national characteristics.)

So much for the numbers game, but there are also some intangible things that are important. In many respects, Japan is a nation with a very high degree of uniformity, and its educational levels are high. Just the opposite is true for America. It is my belief that the dominance of Japanese industrial products over the world is largely due to the general excellence and uniformity of Japanese education at elementary and middle school levels. By the same token, the U.S. is suffering from a lack of a high and uniform standard of formal education.

Strength in one sense, however, can be weakness in another, and vice versa. When it comes to higher education, or research activities in science, I still see a gap between the U.S. and Japan. It appears that the gap reflects the different courses the two countries have followed after the war. In a sense, the gap may have widened. In Japan, for example, I often notice a disturbing lack of social and humanistic training among physics graduate students and postdoctorals who are otherwise well educated in a formal way. This seems to me symptomatic of the present day Japanese society.

Japan has an excellent reputation in physics. There are great names like H. Yukawa, S. Tomonaga, and S. Sakata who made truly original and outstanding contributions to elementary particle physics./* As it happened, all of them studied or worked in Kyoto. Is it a coincidence, or is there something magic about Kyoto? (Note that K. Kikuchi, Nobel Laureate in chemistry, is also from Kyoto.) This is a question often raised among my American and Japanese colleagues who are interested in the history of physics in Japan.

/* H. Yukawa predicted in 1935 the existence of meson, a hitherto unknown particle, as an agent for the formation of the nuclei of the various elements. Not only did he turn out right, he also established by his theory a new conceptual approach to the ultimate composition of matter, which the great physicists of the time in Europe had failed to realize.

S. Sakata, a student and collaborator of Yukawa's, elevated this approach to a methodolgy and philosophical viewpoint, motivated by his Marxist ideology. In essence it is to admit that there are any number of elementary particles that may not be permanent components of matter but will manifest themsleves as one explores nature further. He articulated and practised it with considerable successes of his own.

S. Tomonaga, unlike Yukawa and Sakata, had some experience in studies abroad. During the War, he proposed a new way to address certain inconsistencies in the quantum theory of elementary particles. He developed it into what is called renormalization theory, independently of a few other physicists. This theory was vindicated by the discovery of new effects in 1947.

The ideas initiated by Yukawa and Sakata, and by Tomonaga constitute two of the main paradigms of particle physics.

Historical analyses of the contributions of the above physicists are found in: L. M. Brown, *Yukawa's Prediction of the Meson Theory*, Centaurus, 25, 71-132, 1981, and the biographies of Yukawa, Sakata, and Tomonaga by the same author, to appear in the *Dictionary of Scientific Biography*. See also:

Proceedings of Japan-USA Collaborative Workshops on the History of Particle Physics in Japan, 1935-1960, to be published. Earlier reports are available as: *Particle Physics in Japan, 1930-1950*, Vol. I and II, preprints published by the Research Institute for Fundamental Physics, Kyoto University, RIFP-407 & 408, 1980.*/

It is surprising how, during the thirties and fourties, a group of people represented by Yukawa, Tomonaga, Sakata, and Taketani began to develop a new school of theoretical physics with a clear vision and a well articulated philosophy. There was also very active experimental physics under leaders like S. Kikuchi and Y. Nishina. Japan was second only to the U.S. in cyclotron facilities.

In spite of these pioneering contributions of the Japanese physicists, this branch of physics has been dominated by the U.S. after the war. Only very recently has the American dominance begun to be threatened by Europe, which has been spending twice as much as the U.S.

What has happended to Japan? Certainly there was severe economic disruption after the war. Experimental physics had to suffer naturally. One can also blame the leaders for their often excessive and corrupting infulence. Perhaps all this is a natural course of things. But I also think that the postwar educational system has something to do with it.

Scientific research is more of an art than science. It requires free and spontaneous excercise of imagination. At the same time, science is built on accumulation of knowledge and techniques. These elements are not neccessarily in harmony with each other, but one must master both to be creative. The Japanese postwar education seems to have scarificed one side of the conflicting demands in favor of the other.

3. Some scattered comments

The postmodern in physics

I have already characterized science and scientists, keeping in mind the contrast with their humanistic counterparts. I would like to come back to this general theme, but now with emphasis on the similarities between the two camps that I have noticed during the symposium.

I was much intrigued by the term "postmodernism" that came up frequently in this symposium. Although its meaning seemed nebulous to me, the word reminded me of the present trend in elementary particle theory. Knowing as I do how this trend in physics arose in the course of its own historical developement, it is difficult for me to believe that there is any meaningful connection with the postmodernism discussed in this symposium. Nevertheless I am tempted to draw an analogy between them.

A series of new theoretical and experimental discoveries were made in particle physics in the early seventies, resulting in a vastly enlarged and unified view of the physical laws and of the structure and history of the universe./* This new image of the world is still mostly conjectural, but an interesting point is that theoretical progress seems to be feeding on itself, going beyond the realm of our ability to test it in the laboratories. In this sense it is a departure, perhaps an aberration, from the tradition of modern science in which theory and experiment go hand in hand. My reference to postmodernism, however, does not imply any value judgement on either side of it based on the connection.

/* Here I am speaking of such theoretical paradigms as grand unified theories (GUTS), Kaluza-Klein theories, and the more recent superstring theories which claim to be the ultimate synthesis of everything. An anlysis of the point discussed here is given, using a different terminology, in Y. Nambu, *Directions of Particle Physics*, talk given at MESON50, jubilee symposium commemorating the meson theory held in Kyoto, 1985, to be published. */

The scientist in the society

This topic may be thought of as a continuation of the characterization of the scientist that I have attempted above. The problem of the two cultures is certainly related to the fact that science requires a specialized language, which in turn requires specialized training and environment. So the scientists who can speak it form a small minority group in the society. (There was once in my reseach institute an anthropology student who "lived" among us and studied the scientist "tribe".)

The subjects of interest of the scientists are also specialized, and usually not shared by the majority. In contrast, the language and interests of the humanists are universal to all members of the society, and as such may be intuitively understood without special trainig, even though this may be sometimes an illusory impression. So the problem of the two cultures seems to be somewhat lopsided.

On the other hand, there are concerns the scientists naturally have about certain social problems. Scientists can become social activists. I am a little surprised that, during this symposium about the postwar Japan, the problem of nuclear war did not come up at all, nor for that matter, the problem of war itself (not the consequences of the War).

The danger on the scientists' side regarding social awareness is that, they can extend their self-confidence and expertise in their specialty too far into other domains of human society, in which they are actually entitled only to common sense opinion. I regret to say that Robert Oppenheimer was a tragic case in point.

Looking toward the future

As I have stated in the beginning and developed subsequently, my main theme has been to put science in contrast, once against humanistic culture, and once in the context of the Japanese vs. American comparisons. In the latter I have pointed out that science in postwar Japan has made advances in parallel with the general material advances, but the same uniformizing forces that made the industrial and technological superiority possible may have hurt the diversity and spontaneity that are not only essential to scientific pursuits, but also to the well-being of the society as a whole.

On the American side, one sees the opposite problem. They need to raise the general level of scientific literacy. The problem becomes more acute as technology gets more sophisticated. There are enough diversity and vigor in the society, but sometimes they border on chaos, and the "Yankee ingenuity" alone will not do. It is an interesting question to ask which society, America or Japan, will better be able to narrow the gap between the scientific and the humanistic culture.