Transformation in Modern Science and Modern Rationalism

By Murakami Yoichiro

The birth of modern science

It is generally accepted that modern science in Europe originated in the "Scientific Revolution" during the 16th and 17th centuries. The "Scientific Revolution," advocated in the mid-20th century, is defined as the process in which systematized explanations, offered on nature since the classical period, were replaced on an individual basis by those of modern science.

More specifically, this means that in this process, which started with the substitution of a Ptolemaic geocentric model by a Copernican heliocentric model, Galen's theory was replaced by W. Harvey's theory of the blood circulation, and the Aristotelian theory of motion was changed to a new theory of modern dynamics at the hands of Galileo, Descartes and Newton.

A general understanding on the establishment of modern science based on a concept of "scientific revolution" was afforded in general history as the tenets of Herbert Butterfield and Alexandre Koyré, who first advocated the concept, were firmly established. As a result, in Japan, too, this interpretation is introduced in high-school textbooks on Occidental history.

But for many years I have continued to point out the insufficiency of the interpretation. I, therefore, want to start my essay with an explanation of my position, because it directly affects how we understand modern science.

The insufficiency of this "Scientific Revolution" is explicable in the context of its anachronism. First, according to this line of thinking, Copernicus, Kepler, Galileo and Newton are simply called "scientists" without reservation whatsoever, although in their days, no European language had either a word or a notion corresponding to "scientist." As is widely acknowledged, the English word "scientist" was coined around 1840 by W. Whewell, and this was the case with other European languages.

Judging from the concept of present-day science, it is believed that science is based on the denial of all manner of value judgments, as well as religious values. Whether such a belief is right or wrong may be open to philosophical debate, but few scientists have doubts about this belief. However, Galileo and Newton, as well as Copernicus, were quite different from "scientists" in that they based their knowledge on Christian outlooks on the universe and nature, and their pursuit of knowledge was endorsed by what had motivated them to try to improve their understanding of the "Holy Design." To call these people "scientists" is an anachronistic act of imposing a modern approach to science on the 16th and 17th centuries.

Second, Europe in those centuries was not the sole arena for their activities. Leading thinkers of the day such as Pico della Mirandola, Robert Fludd, Johann Andoreae and Marsilio Ficino are almost all ignored now for having irrational and mysterious views, but it is conceivable that they were not so different from the aforementioned so-called "modern scientists" as much as we imagine. In this respect, too, we have committed a glaring anachronism.

In other words, it is thought that what we refer to as "science" was not directly linked with Copernicus, Kepler, Galileo, Descartes and Newton, but that another revolution was needed somewhere else for the birth of "science." Among other things, Christian and theological views had to be excluded from knowledge. I find evidence of this in the 18th century philosophy of the enlightenment. What I describe as

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Newton (left), Copernicus (right): to call these people "scientists" is an anachronistic act of imposing a modern approach to science on the 16th and 17th century

The University of Tokyo was the first university in the world to have a faculty of engineering

"Secular Revolution" can be comprehended, on a knowledgeable level, in terms of an attempt to approach the investigation of what to do so as not to get God involved in explanations, or interpretations, of nature and humanity.

Such an attempt resulted in the 19th century development of what we mean to describe as "science." The premise that science is or should be systematized knowledge existing without relevance to a theory that religion provided humanity with the values they were seeking was made clear at that time. This was substantiated by the concept of "wertfrei" (value-free) propounded by Max Weber.

Another feature of modern science is subdivided specialization. Not to mention the "classical division" of science in terms of physics, chemistry and biology, further subdivided specialized areas were developed in them, resulting in the birth of the "epistemic community" of specialists, where a body of knowledge peculiar to such a community was formed. This also happened in the 19th century.

Modern science and technology

Because science represents a knowledge-intensive form of activity, there is no choice but to depend, as a basic rule, on universities, the traditional arena for such activities. As a matter of fact, some universities in Europe started having what corresponds to a "department of science" in the second half of the 19th century.

In addition, the aforementioned epistemic community (which we will refer to as a scientific community) was founded to meet the requirements of specialized fields, and people in the strata of society, called "scientists," gradually became members of such a community. In the second half of the 19th century, they published academic journals, which carried their opinions in terms of academic papers, instead of in book form. It was in those days that "Nature," reputedly one of the most prestigious science journals today, was first issued. Books can expect to attract readers in general, whereas papers can only expect to be read by "fellow scientists," who numerically account for one-10,000th, or one-1,000th, of ordinary book readers.

Western "philosophers" up to the 17th century zealously pursued knowledge about nature, prompted by their desire to increase their understanding of the "Holy Design". But after the "Secular Revolution," 19th century scientists were driven to widen their horizons by their own curiosity. People who shared the same curiosity formed a scientific community. In this sense, modern science, established in the 19th century, is often referred to as "curiosity-driven science."

Such a form of intellectual activity took hold gradually in Western society and expanded while modern industrial technology was in the process of developing without relevance, basically, to the rise of modern science. When we list originators of modern industrial technology, such as L. Singer, A. Carnegie, T. Edison, R. Ford, N. Otto and C.F. Benz, we learn that they were neither university-educated nor members of the scientific community. The French word "entrepreneur" is the most appropriate word to describe them.

This is endorsed by the fact that it was after the turn of the 20th century that engineering, or technology, took its place at an educational institution called a university. In the 19th century, technology, freed from apprenticeship and guilds, came to be taught at school. Schools set up in the 19th century, such as, for example, TH (Technische Hochschule) in German-speaking areas, and land grant colleges in the United States, otherwise called A & M, i.e., agricultural and mechanical colleges, had nothing to do with universities.

On this score, Japan was the sole exception. The University of Tokyo was founded in 1877 as a modern university in Japan. The university, which started with the faculties of law, medicine, literature and science, added a faculty of engineering in 1886, making it the world's first university with such a faculty. Kyoto Imperial University, established in 1897 as a second state-run university, had a faculty of engineering from the start. This means that in Japan, university-educated technologists with degrees had already been active in various sectors of society in the late 19th century. This phenomenon, without precedent in the rest of the world, can be considered to be a typical instance attesting to the

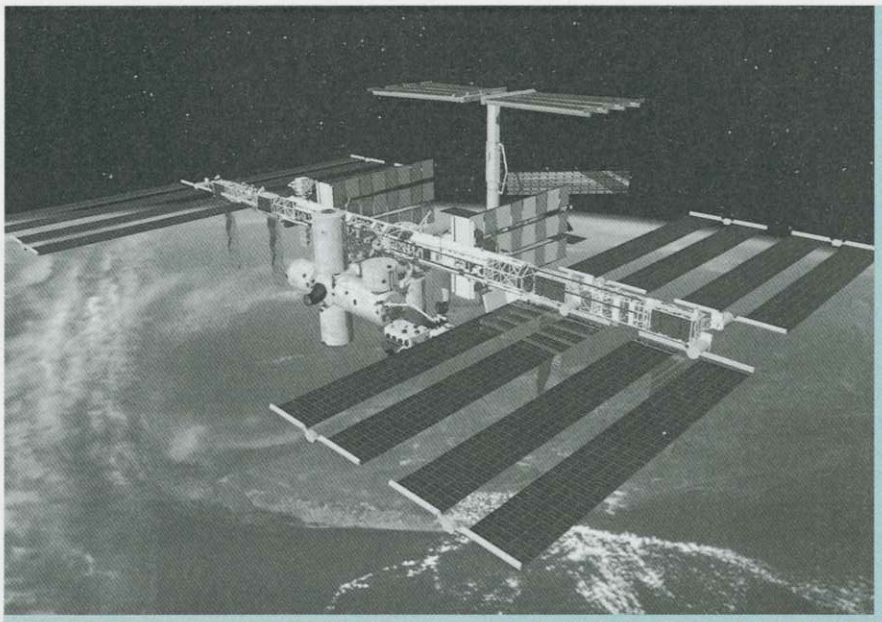
absence, in Japanese society, of any prejudice against technology in the intellectual world.

Changes in modes of scientific research

In the middle of the 20th century, science started undergoing vast changes. The most remarkable change emerged in the modes of scientific research. M. Gibbons, H. Novotny and others expressed such changes in terms of mode 1 and mode 2. These modes roughly correspond to what I originally termed as "prototype" and "neotype." In the traditional type, that is, "prototype" (mode 1), of research, the objective lies in gratifying the curiosity inherent in researchers. When we take into account the creation of a scientific community by people sharing a common curiosity, it can be said that the curiosity exists inside the specific community of scientists. The objectives of research are in the minds of scientists.

However, in the new type, that is, "neotype," of research, the purpose focuses on external society. For example, research on "missions," set by some sectors — military, industrial and social welfare — in society outside the scientific community, is conducted in the form of "undertaking" by researchers. This type of research is described as being "mission-oriented." In the eyes of society in general, research activities are grasped in the context of "exploitability," i.e., how expertise, developed, pooled, distributed and utilized within the community of scientists, can be exploited for their purposes.

Prototype research is financially supported on the same principle as assistance for operas, theatrical plays and other cultural activities, that is, on the philanthropic principle, whereas neotype research is undertaken in a form similar to normal business contracts in terms of "placement and acceptance of an order." Especially, when the government places an order, funds that are payable to a group of scientists are covered by taxes. If not, the people of a democracy bear the responsibility to indirectly support scientific research, undertaken by way of social investment.



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A model of the International Space Station: science and technology will become more crucial issues in the next century

In prototype research, individual researchers are the entity, and in the case of joint research, it is conducted, in many cases, by people working in almost the same scientific domain. Neotype research, on the other hand, is generally undertaken in the form of a project, and normally, the specialties of researchers involved are extremely wide-ranging and diverse. Conceivably, as individuals, project researchers may have the awareness of being driven by a desire to satisfy their curiosity, though, as a whole, they try to attain objectives that have no bearing upon their professional and individual purposes.

It must not be forgotten that behind the birth of neotype research is an increase in the number of scientific researchers. Even at the beginning of the 20th century, scientific research was not a profession. Einstein worked in his spare time on the theory of relativity while serving as an engineer with the Swiss Patent Office. Very few people who had the irresistible curiosity that drove them to become researchers were able to become scientists as well in those days. Even now, people like them are to be found among researchers, although scientific research has become a job opportunity with society preparing a variety of posts for them in a move to support a vast reserve of researchers from universities and postgraduate schools.

Transformation of intellectual activities called science

The ratio of neotype research to all forms of scientific research has been on an upward trend for many years. In fact, changing modes of research are gradually transforming the contents of intellectual activities termed science. In such circumstances, scientific research has come to be considered in terms of the intellectual activity of resolving individual matters of reality, rather than building a grand knowledge-intensive system that is designed to establish ubiquitous laws that govern the dispensation of the world and the universe.

Once, science was construed or emphasized, or criticized as representing part of "Weltanschauung," i.e., as a way of interpreting the world. This implies that the motto of passing elemental benefits of science on to future generations, or the rationalism and materialism that form the quintessence of science, were accepted or denied as a means to determine how to approach and understand the world. Today, however, there are very few people outside, as well as within, the scientific community, who interpret, emphasize, or criticize science in that context.

Science exercises an influence over our thought and our way of thinking because scientific knowledge, rather than its basic outlook on the world, works willy-nilly as a factor in changing our living. Knowledge of DNA functions in heredity and vital reactions enables gene diagnosis and treatment by means of reproductive technology, or the production of farm crops using recombination technology. And this sometimes takes on a decisive meaning for our living and life, the fact of which forms the basis on which people ponder intellectual activities in terms of science.

This can be taken to mean on the contrary that science has at last ceased to be the monopoly of some intellectuals and is becoming the common property of people in general. Herein lies a crucial dilemma. A tendency is in evidence for the intellectual contents of science to become more and more subdivided in the midst of ever-intensifying specialization, thus going far beyond the capacity for public comprehension. Still more, whether we like it or not, such subdivided scientific knowledge influences and transforms the living and lives of people in general in a great variety of ways, and knowing this, they take it for granted to some degree. This is because they bear part of the responsibility, if not directly, for the furtherance of scientific research.

Science and society

Thinking this way, we realize the need for a re-examination of science from a new perspective. In other words, we must have a new viewpoint for "science and society" or "science and technology, and society", or STS. This viewpoint involves a broad range of latent problems. Now, I would like to look at the problem solely in the context of what I have discussed so far.

First is the educational issue. Basically, science has in the past been taught at elementary, junior and senior high schools with a view to enabling pupils and students to comprehend the contents of individual natural sciences through lectures, in accordance with the stages of their growth. Traditionally, those receiving higher scientific education are restricted, in principle, to college or university students majoring in science and engineering. But the type of scientific education (or, at least, part of such education), in the circumstance referred to above, should be programmed on ideas that are a radical departure from conventional thinking. More specifically, there is a need to introduce new curricula that are not only restricted to science and engineering students or non-science and engineering students. These should be aimed at all students so as to give them a precise grasp of things, such as the place scientific research takes in society, how interrelated such research is with human lives, how it is financially assisted, how it is controlled (or not controlled), how human resources are assigned to scientific research and how they are managed, or what scientific research means to modern society, as well as the contents of individual natural sciences.

Next, the presence of such a field as science and technology policies is expected to carry greater weight at administrative levels. This is the case with local, as well as central governments. Problems at administrative levels are not confined to prioritizing themes for research and development undertaken on a governmental level, allocating funds, training R&D staffers and assigning trained personnel to jobs. Science and technology must be considered politically important to the maintenance and development of society as are welfare and hygiene or telecommunications and transport, or diplomacy and national defense.

Third is the problem of researchers' attitudes and abilities. Ultimately, this can boil down to the problem of education, but researchers are required, among other things, to have a sharp insight into society as a whole and its future, and a keen sense of responsibility. In addition, they need the practical ability to manage research and the skill to explain exactly to people in general the contents of their specialized research.

Fourth, there is something people in general must do. Once, they used to regard the scientific community as a world of specialists doing only what attracted their interests, but today, they can no longer assume an air of indifference to scientific research. Just as social policies for economic and military systems are determined by parliamentarians elected by each voter, so people are required to have the awareness that R&D policies that influence their lives have a political dimension, and that in this sense, they must consider scientific research in terms of an issue for which they are responsible, if not directly. This is because every citizen has some level of indirect involvement in scientific research activities.

I believe that the acknowledgment of such new developments will determine whether 21st century science can become an intellectual activity serving the cause of humankind in the true sense of the word. JJTI

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