Science and society, or research institution and journal: A historical retrospection

Motoyuki Akamatsu* **and Hiroyuki Iyama****

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1 Introduction

For the publication of this new journal, we shall review the role of a journal in science and technology research from the perspective of history of science. In the age when there is a plethora of academic journals, it is necessary to state the significance of publishing yet another journal. We believe this will offer food for thought in seeking the direction the journal should take to make scientific and technological contributions to the society, which is our ultimate goal. For this purpose, we shall describe how academic journals, which we take for granted as places to report our research activities, were born.

The birth of modern science greatly owes to the exceptional works of people whom we call intellectual giants such as Galileo and Newton. However, in the background of their success in revolutionizing knowledge in the 17th century were the existences of research institutions and their vehicles or journals that disseminated scientific knowledge to the world. Isaac Newton wrote papers on classical mechanics and optics in *Philosophical Transactions*, the journal of the Royal Society of London, for which he later became chairman, and Antonie van Leeuwenhoek, woolen merchant and amateur biologist, sent a letter describing the world's first observation of microbes using his handmade microscope. The Royal Society of London and Accademia del Cimento of Rome encouraged active communication between the members, and published journals to deliver fresh, real-time information. Communalism, which is one of the important ethos (personalities and habits of a group) of scientific community advocated by sociologist Robert K. Merton in the 20th century, was already established during the age of scientific revolution, and gathering concentrated evidences and disclosure of these information were expected to become useful for the welfare of humankind.

The thinking that swift and active disclosure of knowledge will benefit mutual research exchange among scientists and will eventually contribute to the society originates from Francis Bacon's *Novum Organum* (1620). In the quarrel between the Ancients and the Moderns, the Ancients claimed that truth was revealed in classical knowledge exemplified by Aristotle, while Modernist Bacon emphasized the necessity of accumulating new knowledge or empirical knowledge obtained through experiments and observations, in order to look further in the distance "riding on the giant's shoulders". In his posthumous work, *New Atlantis*, he described the concept of a nation founded on science that will rise in a distant future, and discussed the model of a knowledge system for making contributions to the society. The principle of establishment of academic societies such as the Royal Society was influenced greatly by Bacon's new concept.

Although the system for promoting intellectual exchange among members by publishing the results of research in form of theses in journals was already established in the 17th century, most of them addressed natural historical oddities and extraordinary natural phenomena, and none focused on industrial significance of scientific products. Although facts were reported with honesty and candor, very few included deductive inference based on high-level logic, and hardly any addressed industrial application. The scientific journals started to address social issues only in the 19th century when disciplines matured and individual societies and their journals were published. The characteristic of scientific journals was totally transformed after the Industrial Revolution when discussion on the utility of knowledge became active. Two hundred years after Bacon's conceptualization, the perspective for evaluating knowledge with a measuring stick of "useful knowledge" was born. Later, through births of national support systems, research institutions, and universities of science, the scientific community was systematically organized into autonomous knowledge organization whose freedom of research was guaranteed, and science was eventually positioned at the core of the national plan. However, as symbolized by the establishment of Ig Nobel Prize in the end of the 20th century, knowledge for knowledge's sake was pursued and "useless" researches that lacked relevance to the real world were mass-produced. In this state of affairs, retracing the original purpose of scientific journals and their historical roots is an essential exercise in re-evaluating the relationship between modern science and society.

2 Usefulness of science to the society

One of the disciplines that were eagerly studied in ancient days was astronomy. For example, the oldest estimate of solar eclipse was done by Thales in 585 BC. Since rituals

* Institute for Human Science and Biomedical Engineering, AIST Higashi 1-1-1, Tsukuba 305-8566, Japan E-mail : akamatsu-m@aist.go.jp
** Faculty of Humanities, Niigata University, 8050 Ikarashi Ni-no-cho Nigata 950-2181, Japan

were important in the ancient world, accurate observations were essential. In Egypt, it was known that embalming and preservation technologies were used from fragments of papyrus. Unparalleled, advanced surveying technology was used to build the pyramids. In all early civilizations, metallurgy, the technology for refining metal, was established as core technology. Of course, military technologies were fervently developed in ancient times. Crane and catapult designed by Archimedes were used successfully in the Punic Wars between Rome and Sicily, and Zhuge Liang of Three Kingdom Period, China invented the south-pointing compass and overwhelmed the Wei army. Ancient science and technology were linked closely to national needs. In other words, only knowledge that was useful to the state was nurtured and systematized.

The origin of pre-modern science and technology was generally incidental, and the research system for obtaining new and useful knowledge was not organized, except in some exceptions like the study of medicinal herbs. Although useful scientific knowledge existed, there was no system to retrieve them in organized and systematic manner. In the Middle Ages, research was primarily storage of the ancient heritage and passing them on to the successors.

In modern times, the thinking that scientific knowledge brings benefit to people's lives started from a philosopher, Francis Bacon (1561-1626). In *Novum Organum* written in 1620, he described the public interest and innovation of scientific research and its effect on people's lives, as well as the benefit of technology and knowledge of craftsmen. In a utopian novel, *New Atlantis*, written in 1627, Bacon imagined a national research institute called "Solomon's House" where scientists convened to conduct research, claimed that knowledge contributed to expanding power, and asserted that the domain of human empire can be expanded by natural philosophy. This was the germination of philosophy of science and technology with objective to contribute to society.

From where did the philosophy of social contribution of natural sciences arise? Science as we know now was called natural philosophy at the time, and was considered as one of the studies to acquire knowledge, along with theology and humanities. Since God created nature, knowing nature created by God was to know the act of God, so nature was considered to be the second Bible. The foundation was Christian philanthropy: knowing nature and knowing God by natural philosophy will bring happiness to all humankind. Due to the Inquisition against Galileo's heliocentric theory, science and religion are often considered to be antagonistic, but in Bacon's philosophy, natural philosophy or natural science was an effort to know God.

We must not forget another point in Bacon's philosophy that greatly affected science. Bacon stated that deduction, where inference is made from general principles, tended to fall into error of prejudice and preconception (*idola*), and so one should use induction, where a principle is reached from observation of evidences (empiricism). That was the reason for pushing natural philosophy. Also, basic methodology for science rested on thinking that accumulation of evidences obtained from observations and experiments will expose the principles hidden in nature.

3 Establishment of societies and science academies

In the 17th century when modern science was established, societies and science academies arose in major western cities, as places to exchange and accumulate knowledge of natural science. Universities had only three departments for theology, mathematics, and law. It had no department that specialized in natural science, and subjects such as geometry and astronomy were sometimes taught under the category of liberal arts, which is equivalent to the modern general education curriculum. Natural science here was learned through Classics, and the works of ancient philosophers had authority inscribed in gold. Empirical approach of learning new facts by experiments and observations was not taken. Therefore, a stance of collecting objective evidence and extracting general theory or law was not nurtured, and as a consequence, the university was not an appropriate place to present scientific findings.

In this age, natural scientists continued their study as a hobby while either engaging in proper trade or receiving patronage of aristocrats and royalties. Societies started as places to conduct experiments, to discuss, and to publicize the discoveries and inventions of these natural scientists. Accademia dei Lincei and Accademia del Cimento of Italy to which Galileo belonged were first societies. Royal Society of London (1662-), in which Newton and Boyle participated as members, and Académie Royale des Sciences (1666-) in Paris, France followed. The Royal Society of London is the oldest society that exists to this day. When Japanese hear the word "society", they may think of an organization with an office in a university or a research institution, but these science academies not only served as places to present research results, but also had experimental facilities where the members could conduct experiments (Figure 1). As it can be seen from this, the science academies from which modern societies originated were research institutions or centers.

The science academies created as places where researchers convened to conduct experiments and present research reports were realizations of Bacon's "Solomon's House", and the Royal Society of London, to which Lord Chancellor

Bacon belonged, was greatly influenced by him. Although the Royal Society was "royal" because it was chartered by the King, it did not receive financial sponsorship. It was "private" in the sense that it was operated by financial support of the membership. On the other hand, Académie Royale des Sciences of Paris succeeded in obtaining support from Louis XIV, and became the world's first national research institute where researchers were paid salaries from the royal treasury to carry on their researches.

It was necessary to accumulate scientific discoveries and inventions to seek principles of natural science, and for accumulating scientific discoveries and inventions, a research institution, where accumulation of knowledge was done from a standpoint that scientific findings were equal, was more appropriate than a university, which is a place of authoritarianism (although in reality power play also occurs in society).

4 Publication of academic journal

The societies and academies published journals for their members. They became academic journals to publish the results of natural science studies. The oldest journal which continues to this day is *Philosophical Transactions of Royal Society of London* (1665-) (Figure 2). Henry Oldenburg, secretary of the Royal Society established in 1662, started this journal as voluntary activity.

Oldenburg wrote why he decided to publish the journal in the introduction of the first issue.

The Introduction.
Whereas there is nothing more necessary for promoting the improvement of Philosophical Matters, than the communicating of such, as apply their Studies and Endeavours that way, such things as are discovered or put in practise by others; it is therefore thought fit to employ the Press, as the most proper way to gratifie those, whose engagement in such Studies, and delight in the advancement of Learning and profitable Discoveries, doth entitle them to the knowledge of what this Kingdom, or other parts of the World, do, from time to time, afford, as well of the progress of the Studies, Labours, and attempts of the Curious and learned in things of this kind, as of their compleat Discoveries and performances: To the end, that such Productions being clearly and truly communicated, desires after solid and usefull knowledge may be further entertained, ingenious Endeavours and Undertakings cherished, and those, addicted to and conversant in such matters, may be invited and encouraged to search, try, and find out new things, impart their knowledge to one another, and contribute what they can to the Grand design of improving Natural knowledge, and perfecting all Philosophical Arts, and Sciences. All for the Glory of God, the Honour and Advantage of these Kingdoms, and the Universal Good of Mankind.

Oldenburg stated that complete understanding of natural science can be achieved by collecting scientific knowledge (discoveries and ideas) by scientists and geniuses around the world using the magazine medium, and the scientific knowledge contributes to the state and brings prosperity. The journal was published to put into practice Bacon's empiricism or the attempt to understand a common principle through accumulation of evidences.

After Gutenberg invented the printing technology in the 15th century, book became the medium for communicating scientific knowledge by the 17th century. On the other hand, magazine as communication medium began with *Journal des Savants*, an information magazine for publication of books published in Paris in the 17th century. Oldenburg thought, instead of books that were complete in one volume, the printed medium of magazine, which is a regular collection of various findings, was the most appropriate for accumulating research results of scientists working around the world.

5 Peer review system and originality

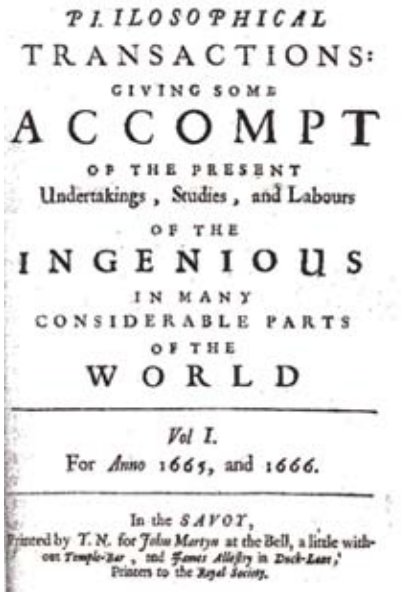
The current peer review system to determine the eligibility of placement of article in academic journal was a system adopted by the *Philosophical Transactions* of the Royal Society. Although Oldenburg selected articles that might be interesting to the members, the article had to be approved

Fig. 1 Activities by members of Académie Royale des Sciences in Paris.
The figure on top shows members doing research in the royal library, and bottom figure shows experiments in the laboratory. From *Macmillan Album of Science* (Hara Shobo) [14].

by certain members to be included in the *Philosophical Transactions*. This might have been due to the fact that Oldenburg himself was not a natural scientist, but it was also necessary to determine the validity of some of the articles with pseudoscience and occult contents as well as hearsays of strange creatures not observed directly.

Natural philosophy, after taking the form of journal and also introducing peer review, took on a format for gaining knowledge different from conventional scholasticism in which truth was pursued from heritage of Aristotle's naturalism and through deduction by propositional logic. The basic stance of natural philosophy became "empirical evidence" first rather than "demonstrative legitimacy". However, it should not be forgotten that the peer review system also had conservative and authoritarian aspects where things that could not be understood by the reviewers were not included.

Another factor that was introduced by academic journals and still has great influence on research today is the preemption of discovery and invention. The regularly published journal stamped time at the moment discoveries and invention were reported therein. The concept of originality appeared around the Renaissance, and the fact that the word "origin" or source developed into "originality" which meant personal capacity expresses well the shift to individualism during the Renaissance. However, there was no method for time stamping back then, so there were many condemnations of plagiarism. The preemption of discovery and invention became clear through publication of research in journals that began in the 17th century, and provided proof of research ability of the individual scientist. While this may be a


PHILOSOPHICAL
TRANSACTIONS:
GIVING SOME
ACCOMPT
OF THE PRESENT
Undertakings, Studies, and Labours
OF THE
INGENIOUS
IN MANY
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OF THE
WORLD
Vol I.
For Anno 1665, and 1666.
In the SAVOY,
Printed by T. N. for John Martyn at the Bell, a little without Temple-Bar, and James Allestry in Duck-Lane,
Printers to the Royal Society.

Fig. 2 Cover of the first issue of *Philosophical Transactions of the Royal Society of London.*

demonstration of individualism, it was also related closely to the employment of scientists. As mentioned earlier, although some scientists were employed by the academy or held professorship at university, many subsisted on patronage of aristocrats. Leonardo da Vinci during the Renaissance, and Galileo and Kepler of the Modern age were under patronage. Therefore, showing one's ability as scientist was necessary to finding good patrons.

Although academic journals were started for the collective interest of providing a place of accumulation of scientific knowledge for the good of all humankind, they also took on the character of individualism with expressions of originality and further advanced to show expressions of self-indulgence, and thus inconsistency developed.

6 Segmentation of scientific knowledge

Returning to the *Philosophical Transactions of the Royal Society of London*, Oldenburg who was secretary of the Royal Society not only transcribed the oral presentations and published them in the journal, but also translated the reports of discoveries and inventions sent from all over the world into English. Oldenburg was a German, and before he became secretary of the Royal Society, he created connections throughout Europe through his job as a tutor for children of British aristocrats accompanying them on the grand tour of Europe to broaden their knowledge. After becoming secretary of the Royal Society, he was able to make the journal successful by collecting discoveries and inventions of natural science with his fluency in language and through his personal connections.

Looking at the articles of the *Philosophical Transactions*, it included stories of some plant discovered somewhere, how to make lens, and stories on Jupiter. The articles were not limited to specific fields. From our current viewpoint, Oldenburg's abilities to read such wide-ranging contents and to translate them are absolutely amazing. However, "knowledge" initially meant full knowledge. Since natural science was a discipline to understand the truth of nature, it was necessary to look at many different natural phenomena to fully understand the workings of nature.

In his writings, Bacon did not think mere collection of evidence was sufficient. He encouraged the stance of carefully inspecting the subject and classifying them by creating lists of present and absent. His information classification system resulted in the segmentation of the natural world and promoted specialization of scientific knowledge. In the knowledge system where natural phenomenon is broken down into the simplest element inevitably assumed the characteristics of reductionism. To clarify law and theory that govern the reduced element, it

was necessary to organize the evidences within a detailed classification system, as much as the accumulation of sufficient amount of knowledge. Therefore, elementalism accompanied segmentation of knowledge, and as a result, academic journals became necessary for each segmented region of nature as places for accumulating knowledge. In the 19th century, societies for different scientific disciplines were established and academic journals for each discipline were published one after the other, as Baconian knowledge classification system solidly took hold.

To pursue knowledge, researches were conducted by dividing the subject into elements, and drifted away from full knowledge that was the original goal of natural philosophy. An English scholar, William Whewell, created the word "scientist" with which we are very familiar in the 19th century. It was a word created by combining the Latin "scientia" which meant "knowledge" and Greek "ist" which meant person with special ability. Unlike a philosopher who aimed for full knowledge, a "scientist" was knowledgeable only in his specialized field, but the term was accepted by natural scientists and continues to be used to the present. There is a long history behind the attitude often seen among science and technology researchers who think it is perfectly okay to be content in the water of their specialization only.

Segmented scientific research is only targeted to part of the whole that is composed by the elements. However, researchers conduct researches believing that that element is the essential to the whole. However, as elements increase, it seems that there is a long road before research of individual elements can make contributions to society.

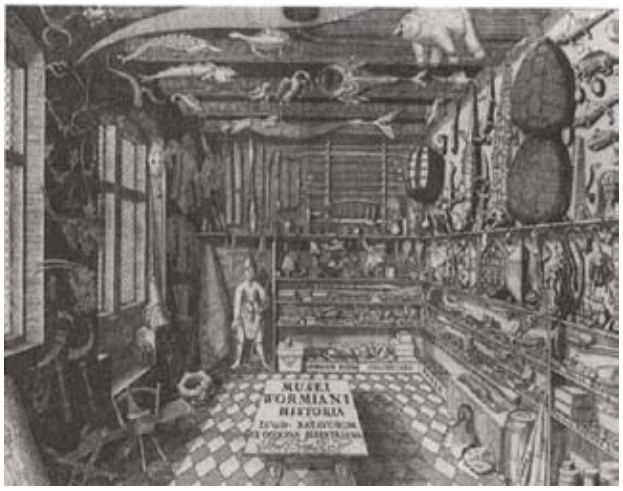

Fig. 3 Interior of the Worm's Museum.[14]
The museum was established in the 17th century by Ole Worm, a physician of Copenhagen. It contained stuffed animals as well as collection of artifacts such as stone tools. The collection seems random but actually is classified according to Worm's thinking.

7 Integration of scientific knowledge

Segmentation of knowledge was unavoidable if the reductionist methodology of science was followed, and at the same time, segmentation of subjects was promoted to warrant originality of research, or in other words, as proof of research ability. To maintain originality of the papers sent to the journals, one must claim novelty of knowledge, but that also meant segmentation of the subject. Pushed by the social behavior of scientists who submitted several papers to journals to present their research ability, science followed the path of segmentation.

The word "system", which had the opposite meaning to segmentation, was used in the 17th century. However, a knowledge system here was how to neatly classify or categorize, and it was an understanding by classification or how to position knowledge as encouraged by Bacon (Figure 3). Although it was difficult to understand unclassified knowledge as a whole, it could be understood as knowledge organized as small classification β in medium classification *A* belonging to large classification *I*.

Although systematizing knowledge would help understanding, understanding here meant to understand positioning (Figure 4). However, understanding of knowledge by systematization was, after all, understanding of segmentation, and was not a bridge connecting scientific knowledge for the good of society. Classification and organization of phenomena were to collect things with equivalent quality, and was not to clarify relationship among phenomena. To create things that will be useful to people and society, it is necessary to seek relationship among evidences and phenomena, and integrate and compose them. However, hardly anything can be learned from the history of science so far concerning activities to obtain "useful knowledge" and "making knowledge useful". The knowledge that natural science pursued was knowledge of evidences of nature, and basic scientific methodology for gaining evidential knowledge was reductionist de-composition of elements. Understanding of evidential knowledge is understanding of "what it is", and is not functional or compositional understanding of "what it can do". For scientific knowledge to be useful to society, it is necessary to understand what can be done with the knowledge. Yet in the process of pursuing evidence by elemental de-composition, de-composition was conducted according to specific functional characteristic of the phenomenon, so there was no accumulation of what kind of functional and compositional characteristics a phenomenon had in the form of scientific knowledge.

Since functional and compositional characteristics of the phenomenon were diverse, expectation and delusion may occur in the process of converting them into knowledge.

As it can be seen in the product realization cases, they are romanticized as success stories, and the processes of integration and composition as evidence are often lost. It is the battle against *idola* of which Bacon warned. However, in the modern world where principles of how to utilize scientific knowledge in society has not yet been discovered, what can be done is to accumulate knowledge of "what ought to be done". This method must be sought without falling into segmentation that was the method for accumulating evidential knowledge in conventional natural science.

8 Conclusion

In the new publication of an academic journal to fill the gap between science and technology and society, we discussed the significance of academic journals by looking through the history of science. Many people may question why a public research institution publishes an academic journal rather than an academic organization, but we hope that people now understand that there is no mystery in a research institution, which can produce results as well, publishing an academic journal to accumulate research results, considering the history that academies and research institutions share the same origin. Moreever, contribution of science and technology to society is the philosophy of Bacon who advanced modern science, marking the starting point of science, and academic journals were started for this purpose. However, if there are reasons for the inability to fill the gap called "valley of death" or "period of nightmare" between science and society in the conventional activities of science including elemental reductionism, we must build new methodology for science and technology to bridge the gap. Rather than depending on approaches from the society side of looking for technological potential, it is the responsibility of the community of science to establish methodology and make approaches from our side. The attempt to publish this journal is an attempt to return to our origin.

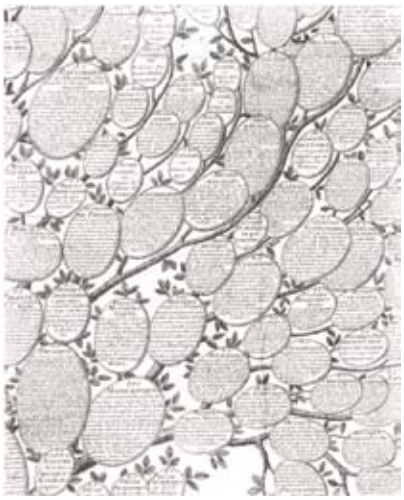

Fig. 4 Tree of Knowledge from Diderot's *Encyclopédie*[14].
Edited by Denis Diderot in the 18 th Century, the *Encyclopédie* is a grand dictionary that covered all sorts of knowledge including art and history as well as science and technology in a systematic manner. This tree of knowledge expresses the classification of knowledge. The branches of the tree show that "science of nature" was divided into mathematics and physics, and physics was further broken down into individual disciplines such as astronomy, climatology, botany, zoology, and others.

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Authors

Motoyuki Akamatsu
Graduated from Department of Administration Engineering, Faculty of Engineering, Keio University. Completed doctorate at Keio University Graduate School in 1984. Doctor of Engineering. Joined Industrial Product Research Institute in 1986. Currently the director of Institute for Human Science and Biomedical Engineering, of AIST. Engaged in research of tactile function, biomechanics, neural network, Cognitive neuroscience, human interface, cognitive behavior model, and others. Has looked at technology and science from standpoint of human using technology. Recently engaged in many joint researches with industries.

Hiroyuki Iyama
Graduated from Department of Chemistry, School of Science, The University of Tokyo in 1978. Enrolled in doctorate program in Graduate School of Science, majored in History of Science and Philosophy of Science, but withdrew in 1983. Master of Science. Assistant of Faculty of Humanities, Niigata University in 1984. Became Professor in 1992. Specialized in history of scientific philosophy, science theory, utopianism, and history of comedy. Books include History of Incidental Science (Taishukan Shoten, 1995), Einstein in Mirror (Kagaku Dojin, 1997), and Evolution of Comedy Performance (Seishisha, 2005). Joint authorships include Modern Theory of Science (jointly with Osamu Kanemori, Shinyosha, 2000). Translation works include Science on Trial (Kagaku Dojin, 1993) and Dr. Hines Criticizes Hyper Science (Kagaku Dojin, 1994), and others.