The 3rd SPARC Japan Seminar 2017 "Beyond Open Science"

Panel Discussion

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●Hayashi We would like to begin the final panel discussion. We have asked Prof. Fukagai, the former head librarian of Yokohama National University and member of the SPARC Japan Governing Board, to be the moderator for this panel. To begin, we have set aside some time for Prof. Fukagai to propose the issues to be discussed. After that, we will ask the panelists to come to the stage to participate in the panel. Prof. Fukagai, please.

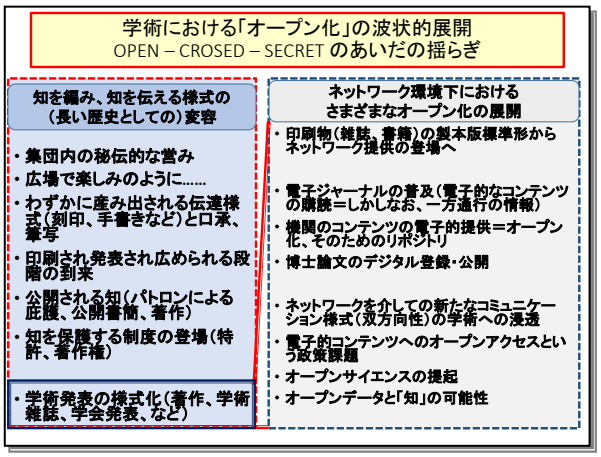
Taking Scientific Knowledge Seriously: A Consideration in the Era of Open Science

●Fukagai Along with the talk by Prof. Paul David covering the background, we have heard from Dr. Murayama about the current trends, as well as from Ms. Joseph, Prof. Kurata, and Ms. Ichiko about how databases are being set up, as well as the various functions being performed by libraries. I would like to provide a general overview connecting all of these topics.

A Wave of Change in Academia: Openness

To begin, although openness is moving forward in academia, in a way, the beginning of academia was open (Figure 1). In classical antiquity, Socrates held discussions in town squares. That is where supremely open conversations were held regarding knowledge. However, just before Socrates's time, there was the Pythagorean school that held in secret the knowledge of its inner circle. As a contrast, it was from this time that knowledge was brought to the fore to be enjoyed, and openness began.

Although written materials began to accumu-



(Figure 1)

late in this way, written knowledge was difficult to handle until only recently towards the end of the middle ages. In the middle ages, written materials were copied by hand by those who were trained to do so, and that was how book-like written materials were created. Then, due to technological innovations, they began to become widespread.

Once mass-produced written materials entered the picture, the issue became about whose knowledge was being written, who published whose knowledge, who owned the knowledge, and how the efforts of those publishing the knowledge were being rewarded. Accordingly, various issues related to rights including copyrights and patents were worked out, and eventually even came to be supported by the legal system.

Such trends continued, and from the 19th century, academia gradually became subdivided and institutionalized. By the 20th century, various fields similar to those that exist today became clearly established. Until the beginning of the modern era, lines between departments in European universities were extremely fuzzy. There, academia was not minutely divided. Accordingly, except in special situations, such things as field-specific journals did not exist. Academia used to be highly comprehensive, but since around the 19th century, it started to become more and more specialized, and even in modernizing Japan, disciplines were developing with their own characteristics that fulfilled limited purposes until they became the departments that we see in universities today.

While that was happening, after we enter the 20th century, the role of academic journals became more and more central, and by the end of the 20th century, journals were becoming digitized, with electronic journals becoming the axis around which academia revolves, and this brings us to the developments of the present day.

Networked environments enable the tale of progress in openness, but considering that fact, the advent of printing technologies and its associated dramatic developments were indeed a great revolution. Prof. David touched upon these points in his lecture this morning. Such progress has led to electronic journals, and not only are electronic contents being compiled in journals, but repositories are also working to store other things as well.

In Japan, especially with libraries acting as a base, immediately after entering the 21st century, and with the move towards open access, people started to store various contents. Furthermore, in the case of Japan, research institutions and academic educational institutions did all that they could to create their own systems, and there are now an immense number of established institutional repositories. Since institutional repositories were already set up, it would appear that the issue of open science appeared overnight. This is what we heard from Dr. Murayama this morning. The typical feeling in Japan is that open science suddenly burst forth around the mid-2010s. Prof. Setsuo Arikawa was the chairman of a Cabinet Office committee, and considering Prof. Arikawa's background, he first relied on libraries, and without the administrative sections of universities understanding open science, it became the job of libraries in a blink of an eye. Then there was a time when library staff had a hard time explaining it within universities. However, we are now closing in on the next step of the process.

In 2016, the general assembly of the Japan Association of National University Libraries took on

various issues including open science and laid out their 'Vision 2020'. I took on a supporting role in helping set up Vision 2020, and Figure 2 shows what I created a short time before that. Conventional libraries seek out academic knowledge contained in books and journals as required, and then that knowledge is processed, turned into new books or journals that, if deemed acceptable, would then be acquired by libraries. This is the conventional cycle. If there is not enough knowledge contained in a single research institution, then they will borrow from others.

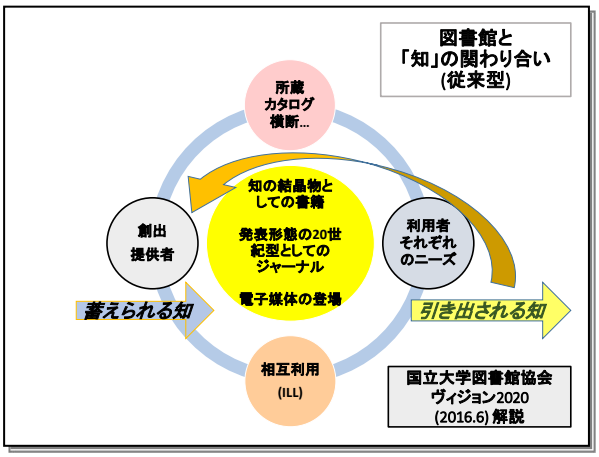
I will move to the next topic, on which I will speak in detail. If nothing else, those currently doing research who think that the 1980s style is the way to go about doing research are already dinosaurs (Figure 3). The generation of researchers who are used to using the electronic journals that were set up in the 1990s to read papers are the types of researchers to advise research students, and are at the center of today's way of doing research. Even for those in the natural sciences, just a short time ago, there were no electronic journals, and journals were something to be photocopied.

Along with the development of electronic journals, the impact factor evaluation system gained prominence. In that case how will the contributions and evidence found in electronic journals be collected? Additionally, along with that comes various issues related to research misconduct and research integrity.

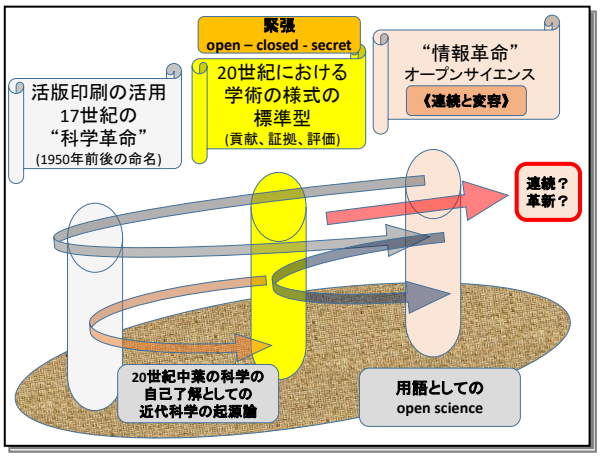
Speaking strictly from the perspective of the technology that makes getting information on the web possible, there is continuity when moving from electronic journals to open science. However, although there may be continuity, it may also not be the case. The reason is that people write their own papers based on their research results, and people think it is normal that being first is a good thing. With researchers trying to be the first, it makes them very wary of opening up their data in their research process. Therefore, in the end, although there is continuity, such a transition may not happen, and since we are in this state of confusion, the current situation (continuity or discontinuity) is that academia is undergoing some strange changes.

Looking Back at the Past, Considering Modern Knowledge

When thinking about this, Gutenberg letterpress printing and aspects of what is called the Scientific Revolution of the 17th-century provide us with many points of reference. Considering the



(Figure 2)



(Figure 3)

radical changes occurring throughout the 20th and 21st centuries in how information is disseminated and how communication is done with regards to information, looking at it through the lens of what happened in the 17th century will provide us some insight on what is happening today.

In the mid-20th century, either at the time of intense fighting during World War II or in its aftermath, there was a time when scientists were drawn into national schemes on what to do about international frameworks. At that time, the people who tried to seriously consider scholarly knowledge would sometimes use the phrase 'Scientific Revolution' and began discussions on the 17th century.

Of course, the term 'Scientific Revolution' did not exist in the 17th century. It became an academic term in the middle of the 20th century. By looking back at the 17th century with a mid-20th century mindset, there were some who sought to define 'academia' and 'knowledge', although they were few in number.

Accordingly, regarding the issue of open science as part of the modern information revolution, I would like for us to try throwing twin boomerangs at the past, and by doing so, it may help us find some insights into the present situation. I believe that half of Prof. David's talk was based on such a strategy. Knowing that one boomerang was thrown towards the past from the mid-20th century, throw another boomerang from the beginning of the 21st century towards the 17th century, and then for the science that links the mid-20th century to the present, try to throw a boomerang that goes a short distance to the near past. By doing so, we will be able to examine what is happening in the present.

Rather than throwing boomerangs backwards only towards the past, we are thinking about progressing forward. If we throw a boomerang towards the future, I do not know whether that boomerang will come back or fly off on its own. However, by using the past as a reference, let us consider exactly what knowledge can be obtained from the open science that is coming into being. That is what we are doing now.

Accordingly, rather than taking up topic of open science 'knowledge', I would like for us to consider the open science 'theory of knowledge', and I would like everyone to consider how to create a framework on how to discuss it.

As far as I have noticed, the term 'open science' was used only once in a 1000-page book from the 18th century, but it is believed that its meaning was completely different to how we use it today. Additionally, at the end of the 19th century, there was the 'open science scholarship' offered by universities such as Cambridge and Oxford, but I do not know exactly what that was.

Open science began to appear in the titles of academic papers in the mid-1980's, and the couplet of 'open science' and 'closed science' came into being. After that, 'open science' in quotation marks began to appear in the titles of several papers by Prof. David in the 1990s, such as Prof. David's 'The Economics of Open Science'. This is why we are able to have this discussion today, and why we have invited a scholar who is participating in difficult debates on what open science is.

As an aside, there was a repository in the 18th century (Figure 4). However, it was in print.

Libraries are currently facing new challenges (Figure 5). Although I do have one slide remaining, there is not time to cover it. Taking advantage of my position as moderator, I would like to

continue the discussion by taking sections from this slide bit by bit and have our panelists consider the topics therein.

●Hayashi　Prof. Fukagai, thank you very much.　I would like to move on to the panel discussion, so I would like to ask the speakers to come up to the front.

I would now like to pass the microphone to our moderator, Prof. Fukagai.

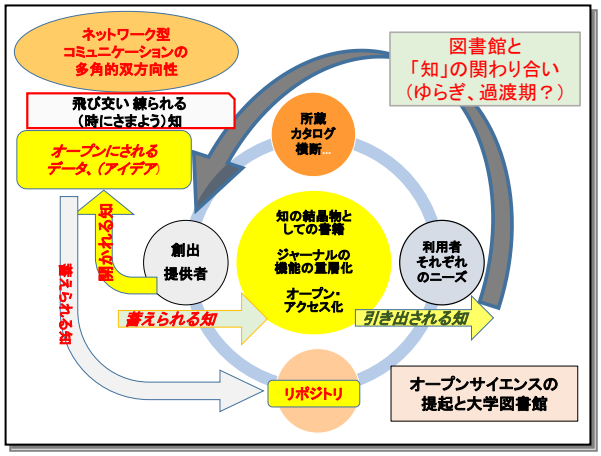
●Fukagai　While bringing up slides along the way, I would like to say something a bit dubious.　I am a history of thought researcher, and conduct research on such topics as social ethics.　Prof. Kurata uses recent media profusely, but I hardly ever do so.　For my first several years, I wrote papers by hand, and it was a time when I would literally use scissors and glue to cut and paste, and so I am not yet used to the new way of doing things.

In the natural world, it is normally thought that humans are superior to animals.　Although there are a number of things for which animals are superior, one characteristic of humans is that they leave records (Figure 6).　Leaving records, humans are able to carry out so-called privileged work by depending not only on their own memories, but on the memories of others.

Above all else, humans conduct scientific investigations.　Curiosity arises from humans feeling, "That is odd," and then science is born.　Science does not come from humans thinking, "This is inexcusable," or, "This is amazing."　However, if humans think, "This is odd," and then dig into that oddity, then science is born.　In that case, since oddities alone cannot be understood, humans try things out, conduct experiments, or use records left by similarly-thinking people as points of reference, conduct further discussion, and enjoy conversations about such oddities.

This is how it has been until now, but if we are to go from, "That is odd," to, "I want to know," how is the massive amount of data being collected going

(Figure 4)



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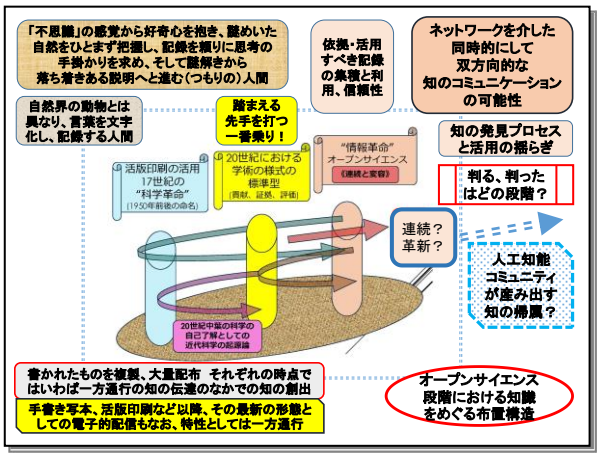

(Figure 6)

to be useful? If there is too much data, how will we be able to find the data that we need?

Dr. Murayama or Ms. Joseph, what do you think?

●Murayama Regarding the knowledge generation cycle brought on by science, I think we should consider whether the positioning of data is a new issue or not. Data is not special, and it consists of subjects of observation, experimental results, or accumulations of subjects of observation or experimental results. I believe that data is information that you see with your eyes that is sensed directly by your brain, such as in the past when people such Lord Kelvin observed the tidal bores that flow into canals, which gave rise to ideas on hydrodynamics. Seeing that as a sensor is today's modern way of doing things.

With regards to recent science, it is my opinion that the feelings of, "That is odd," are being separated from science. In other words, when linking scientific knowledge to daily life sensations such as the sky being blue due to the red portion of the solar spectrum being absorbed, although photographs or the light spectrum of the sky are useful as data, there is no daily life sensation with regards to the absorption frequency bands of plasma in outer space. In other words, the science driven by subjects based on oddities sensed by touch have gone away, and questions arise only during interactions among those in narrow fields with specialized knowledge, within what are often called silos. I believe it has become common that solving those types of questions are becoming scientific targets. Since such specialized data is extremely valuable and important, we cannot get away from doing science that is far removed from exploring oddities sensed by touch.

As to whether we should repudiate such a situation, no, we should not. That is advanced science, and indeed, since I am in the position of asking the government for public funding in order to do necessary science, as for what comes out of that reorganized science, while scientists in that situation pursue their interests or oddities, as to whether that pursuit is productive for the next step for the human race, I would suggest that it is becoming a new mode, that it is possible. I believe that we have nearly a fully-formed image of the necessity of amassing and reassessing the position of knowledge assets as data in order to do so.

●Fukagai Although previously I asked such a question, it can be said that oddness being linked with curiosity, as well as special assumptions, are separate vectors. In antiquity, sensations of oddness were relegated to the world of astrologists, witches, or shamans, and since they were good at explaining and duping people, for oddness to become science indeed required the use of quite difficult assumptions. Indeed, it is because science is something that can be seen that being curious about oddness makes people try to explain it using science.

Although Dr. Murayama said that scientists on the cutting-edge have already moved away from oddness, I believe that before long it will act as an entryway for children who wish to follow the path of science.

●Murayama Although this may be off topic, science is something that humans use to lead to the best conclusions based on how to collect evidence and logic. In the past, religious practice such as in

Buddhism were the basis for governing principles of countries and groups, but now science is serving the function of governing principles. For that, in order to create the best compass for the future and future guidelines, science is the only logical foundation on which to do so. Science must be cultivated as important behavioral principles of humankind, and for the sake of humankind, it is extremely important for policymakers or the community of government decisionmakers to understand that we must keep cultivating science.

●Fukagai Thank you very much.

●David I would like to add a dimension of time to the discussion. We would like to have a lot of data about the natural world as well as a lot of data that is generated by experimentation. In the case of the natural world, the question is whether we need it now. People who study the natural world study replicating phenomena that are not going away, and even if it is going to go away, we need to consider assigning priority to capturing observation of the phenomenon. The temporal immediacy of having access to observations of the natural world is qualified by a forecast about what will disrupt or impede our ability to observe when we are ready to make sense out of the observations. In other words, you could record now for future use if you thought that in the future, due to another natural process such as volcanic eruptions, it would be no longer possible to make the same observations of the stratosphere, troposphere, and so forth. There would be a good reason to take the data now if you thought that you are going to be able to use it in an effective way within a certain time frame, such as when the next expected eruption of a major volcano is predicted. Then you would consider that, by the time the next eruption is going to happen, we would be able to make more intense observations of certain phenomena.

Similarly, if there are species that are going to go extinct and their habits, behaviors, and physical attributes will be lost to us. Some of the genes from which they derived are in the gene pool and will interact with others, so we would like to have observations on those before they disappear.

I confess that I am an economist, and I always think about resource allocation. We have scarcity in our ability to observe. What is the prioritization of observing? One set of criteria would be whether something will be around for us to observe when we are ready to do something with those observation. Conversely, we need to consider whether something will persist into the future. Therefore, it is a very complicated process to consider what data we need to take now. That is true of social phenomena as well, so we need to think about this.

●Murayama I remember that some economists or social scientists discussed about future market externalities outside of time. Maybe we need to find a similar thing.

●David I would like to add a footnote to Professor Fukagai's reference to an early use of the phrase 'open science scholarship'. 'Open science scholarship' is a modification of the term 'open scholarship'. Open scholarship is scholarship to which anyone can apply. You do not have to come from the county of Essex. You do not have to be the child of a Protestant priest, or anything like that. Then the modification is that this is an open scholarship in

science. It is in a scientific field, so people say it is science scholarship and it is an open scholarship, and I think that is the way it should be understood. As someone who did not grow up in England but have spent a lot of time there, it is a continual discovery of my ignorance of what the phrase actually means now versus what it meant in the past.

●Fukagai Since Mr. Hayashi already asked questions of our three afternoon presenters, this is going to be a very simple question. Including institutional repositories, Japan has a variety of things. For example, Keio University has such valuable items as a letterpress-printed Gutenberg Bible. To Keio University's credit, although they analyzed it, made it open, and are working on large projects with it, this is not typical of Japan where treasures just sit collecting dust. This is homework to be done not only within the library segment, but also by research institutions that have collections. However, in that case, just because there are treasures, even if catalogs are created in Japanese, the problem is that it is not guaranteed that they will be well disseminated.

I would like to ask Ms. Joseph something. There is a chance that papers written in English by Japanese researchers will be read internationally, but for Japanese academic information for which this is not the case, how well known is it in the English-speaking world, especially in the United States? Among those who deal with academic information, what is said about the way that the dissemination of Japanese academic information is executed?

●Joseph When the language is not English, in the US and internationally, oftentimes the scholarship does not get the recognition it deserves. One of the applications of open and one of the potential benefits of open research is that you can translate these materials. There is no restriction against translating any open material. Therefore, at least in theory, if dissertations and theses are originally created in Japanese are made available under true open access conditions, they have a better chance of reaching a wider audience, and that includes in an English-translated form. That is a service that could be provided. A lot of times, when we promote open access, we get a reputation of being people that just want something for free. Translation is potentially a very valuable service that someone could provide over a layer of important research that would otherwise not reach the wider audience that it deserves.

●Fukagai Is there anything that Prof. Kurata or Ms. Ichiko would like to add on this topic?

●Ichiko Although I have asked others about it, senior researchers are able to read it even if it is written in Japanese, and they are also able to write in Japanese. However, those involved in the process of research can read Japanese, but they do not make presentations in Japanese. That is why, conversely, when I asked whether presentations are made in a Japanese medium, I have heard that the hurdles to doing so are quite high if researchers are not senior enough.

I believe that, in this age of competition, the issue of language is always being taken up as a topic within universities, but I got the feeling that people have awakened to the truth that, if things are open, then they can be translated. Although there were various copyright marks mentioned be-

fore, also from that perspective I would like to disseminate the value of openness.

● Joseph Since we have historians here, one of the ironies that we hear about translation is that the history field is the one discipline that is particularly keen on translations being derivative works that should not be allowed under open access. Therefore, I am curious to hear your reactions regarding whether this is a good thing or not.

● David Translations are a derivative work because a good translation involves interpretation to express the thought. Nuance requires interpretive translation, and there is a large literature on the problem of translating poetry. It is impossible to translate poetry. You can read the poem, you can try to convey the rhythm, the timber, and the sentiment, but this is a creative act. Anyone who has tried to translate even a simple haiku would agree with this.

The problem of an open creative commons license is that, although it is intended to restrict people from taking your work and reproducing it in derivative form, you can create something by leaving some parts out or by manipulating the text to create something different. On the slide I showed you, there is a creative commons attribution only license that does not allow commercial use or derivatives because otherwise, people just take what you have and your name and they can make it appear to be saying anything. Maybe we need to go back to creative commons and ask them to not make a distinction between translation and other kinds of derivatives.

When people ask if they can translate my work, I say yes, but require them to send me the finished translation. I will then get a native speaker of the language at my expense and have them read it knowing my original text. If the person checking the translation comes back and tells me that there were errors in the translation, I go back to the journal and tell them that they can use the translation, but with a list of required changes. I do not give them permission to use the first iteration of the translation. Therefore, it is possible for authors to control translations. Whether this can be automated is something about which I have my doubts, but translation and its status in the law is an interesting and important point.

● Fukagai If we start talking about translation and interpretations, then we will be talking for a long time. Ever since the envoy to Tang Dynasty China, with the translation of the culture of Chinese characters as well as the translation of Western culture following the Meiji Restoration, we started talking about the knowledge that Japan created, or how civilization was cultivated, and these are exactly the kinds of topics that have been taken up ever since by Keio University's Yukichi Fukuzawa, but I will leave it at that.

Since I believe it will spur discussion, I would like to return to my slides and introduce to you what I before could not. Written materials have progressed in one direction from the letterpress-printed Gutenberg Bible towards electronic journals. This is basically a one-way street, and by reading what is published, our thoughts become based upon what has been written up to this point. If I raise my hand first, it is easy to secure budgets, so I first create a research project, and then there is the aspect that meaningful academic contributions are those for which I was the first to get results.

Of course, among the different ways of being interested, what must be clarified was based upon large research question trends found in each scholarly community.

However, from a certain perspective, a large change that is occurring is in with open science, meaning a way to communicate in which open debate is possible. The number of people using hand-written letters even in daily communication has begun to decrease. Starting with e-mail, they are using more casual ways to converse. Since such casualness in academia will blunt precision, and although it is natural that we will get to the point where a different style will come to the fore, two-way communication is still being carried out. People who are geographically separated are conversing as though they were face-to-face, and as a result, there are some collaborative research papers being released where sometimes thousands of people have worked together, but have never actually met each other.

Regarding the possibilities for knowledge in this situation, it is unclear as to whether data can be trusted if it is offered by solid research institutions or solid academic associations. I cannot say whether there is deliberate fraud, and even if the data is precise, it is data that has special conditions, and if I only use such valid data, even if there are no special conditions, if I use data that has the illusion of being valid, then it could lead to strange results, so there are various aspects to consider.

Due to this fact, exactly what are the criteria to use to determine whether we understand something as knowledge or not? In a way, although chances to obtain knowledge are widespread, apparently there is a tendency for things that used to be understood to become no longer understandable. In a sense, what is knowledge, and how should academia proceed? At the stage of open science, although I would like to say clearly that having open debate is preferable to it being closed and hidden, there is the issue of how much needs to be done in order for us to understand.

Compared to academia up to this point, will that be continuous or discontinuous? In Japan, in games like *shogi* or *go*, new moves created by artificial intelligence have begun to topple professional *go* and *shogi* players. By doing so, although I do not know whether artificial intelligence has a body or an identity, but setting that aside, there is resultant knowledge created by artificial intelligence, and within the artificial intelligence community, drills are being done, and conclusions are in the process of being formed.

However, there are different developers and sponsors of artificial intelligence. In that case, should the knowledge created by the artificial intelligence community belong to individual humans, or should it belong to steering bodies or agents? Artificial intelligence is a quasi-child created by humans, and if the artificial intelligence community has something like a community of children, then after the children start to leave the nest, then they may enter an independent world of where parents must not exert control over them. Or, is the artificial intelligence community just like an external hard disk where the knowledge created by the artificial intelligence community is the property of humans since the original brain was that of humans? Which is it?

Since Prof. Takeda is the brain behind the creation of the ethical code of the Japanese Society for Artificial Intelligence, and because he participated a bit in the discussion yesterday, just as a bonus

topic, I would just like to say that, if we rush into such a murky issue, then the knowledge that humans have developed would face an issue that would eventually go beyond the issue of who published first in a journal. However, this is not what I am asking everyone to debate today.

Well, since we have around 30 minutes left, I would like to ask for questions or comments.

●Floor 1 I am from JST. To go along with the tone set by the moderator, I would like to ask a philosophical question. As an actual practitioner looking at open science, although I tend to recognize that it will change things, as to why science is changing from closed to open, I also think we could recognize that the change is coming about simply because there was a technological revolution that made it possible, and nothing more. If that is the case, if there had been the same kinds of information communication technologies available in the 17th century, then the question becomes whether we would have been doing open science since the 17th century.

Now I would like to ask for the panelist's individual opinions, but does open science simply mean bringing us closer to how science was originally conducted? Or, is the technological revolution actually changing the essential nature of science itself? Which is it?

●Fukagai Although this was not directed at any specific panelist, Prof. David, please.

●David First of all, I would disagree with the notion that the essential characteristics of open science is only coming about because of technological transformation. Open science existed. It was the basis for the internationalization of physics and world conferences in the golden age of the emergence of new physics. The controversies over the relationship between classical physics and quantum dynamics were played out in the open. The people all knew each other, and they argued in person in conferences and on paper. The view was that it is a collaboration in the pursuit of knowledge of the physical world, and it was open to everyone across nationalities. It was the internationalization of science with one dimension, but the dimension was that it was collaboration. It was a collaborative search for something to be accepted as at least a working approximation of the truth. We will never get to the truth. There is always more to be understood. However, for the moment, we need to go on with the way we are understanding, the way we capture observations of phenomena, and the way we try to understand the mechanisms driving such phenomena. What is under discussion now is whether open science can be enhanced in its power to deliver good externalities to society at large and do it in a way that is egalitarian, democratic, and engages researchers (not the sponsor and not the patron of the researcher) in deciding what needs to be done and how to do it.

●Floor 2 To me, seeing the slide with the picture of boomerang coming back was incredibly provocative. This is related to a previous question, but we have once returned to the 17th century. That is, to return to the Renaissance, and although the Renaissance may be a bit strange logically, I believe that the conversation would eventually lead us further back to Greece. The Greeks did not have natural science, but what they did have was philosophy. That is connected to Aristotle, and even if

we take Copernicus of the Middle Ages as an example, it is completely philosophy, and in essence, it came about due to the consistency of logic. That is the coherence of logic. That is the learning of the Middle Ages, and something being evidence-based was added in the 17th century. In a shadow that is said to be cast by open data and open science, instead of logic, I believe that there is a concept of working on the consistency of phenomena understood through data.

If in the 17th century there were a lot of data, and if we were to suppose it was like it is today, I believe that there probably would have been natural science. Although even I do not know for sure myself, what I wanted to say was that the discipline was philosophy. In today's world, disciplines are completely specialized. The committees of the Science Council of Japan are prime examples, but anyway, they have become disciplines. The Japanese system of scholarship is also based on disciplines. Thinking on disciplines has become rigid. Movements towards open data and open science will break that rigidity, and it will break down the barriers between disciplines, which I believe may lead back to philosophy.

We could return to the times of ancient Greece where there are no specialists, where various people will be able to consider various phenomena and the natural world from various perspectives in various fields. I believe that we will try to create such a culture, and although this may be a bit absurd, if we are to strive towards doing so, we must change starting from education.

We must not say that there are physics, mathematics, chemistry, biology, or geology, and if that is the case, since music is also a part of philosophy, we must also include music. Unless we change everything about the education system, I do not think that the open science that is now being spoken about can be done at all, nor can it be done with artificial brains.

Indeed, what I wanted to say is that, if we are to do open science, it is not just about the data, but unless we completely change our way of thinking about education, then nothing will be resolved.

●Murayama In a way, what we just heard, as well as what we heard from Prof. Fukagai, were in-depth talks about trying to ascertain whether it is possible for there to be new academics, or new science, but science has endured since the 17th century through to the 20th century and to the present day, and I do not believe that it will be changed. Due to media changing, authorship may change as well. How dissemination is done may change. How publication is done may change. However, I think how we come to conclusions, or how we solve puzzles, will not change.

For example, although I do not know whether I can generalize based on physics, one example is how it was formerly theory-based. In the field of physics, you could not come to any conclusions without mathematics, but that was the physics empire of the 20th century. When people started talking about how they could do something as long as they had data, it was not really true that they could solve anything with data alone. If someone would like to write a paper, unless they properly check whether the thing that their data led them to conform with the physics picture of the past, speaking as someone within this field, just writing a paper about how data expresses certain phenomena will make that paper nothing more than a report. That is, it means that you do not have a proper un-

derstanding.

That is why, regarding what it means to understand something scientifically, although the relative importance of data has drastically increased, today's discussion on data is one side of the pendulum, which is the current situation in which data cannot be properly utilized. Since we are not using all the data that we have, we should use it properly. However, there is another side to the pendulum, and it is not about removing theory or mathematics. Rather, if we wring enough knowledge from the data, then in turn, I believe that there is a sufficient possibility that we will return once again to theory or mathematics. We will not be able to understand unless we have both sides.

Similar to what I mentioned before, we must look into a crystal ball for the future of humans, and although the image found within may be fuzzy, we have no other choice. We need to have both sides since science as a way to construct logic that will become the best guiding principle for the future that will have as its foundation, and that data will allow us to use it as a reason to come to conclusions. That is why there will likely not be a mode change, and I believe that exactly how much the communication part will change everything will become the issue in the future going forward.

●Fukagai If I were asked as to which of the two people I feel closer to, I would probably be in the middle. What I mean is that open science is not borderless science. This means that I believe that it is exactly as Dr. Murayama says.

Rather than hiding the data collected within laboratories and saying that we understand like we did up to this point, once the collected data is put out in the open, the possibility for interpretation by the academic community might become widespread, and people will be able to challenge their assumptions. With research budgets being invested in academia, if we do not succeed by having the similar experiments being done at various laboratories, then by spreading the work of one experiment across multiple laboratories, I believe that it is certainly easier to explain to the general public that budgets are allocated to those with an increased possibility of success. That is why it is desirable to involve as many people as possible in the interpretation of data by making it open. I believe this is probably the same within traditional disciplines.

●Murayama That would expand possibilities.

●Fukagai Yes. However, in that case, the problem is that the current evaluation system is somehow not in sync. I believe there is a problem of it not aligning with the culture thus far of someone posting something first that quickly passes refereeing.

Including topics about managing academic information at the library level, is there anyone that has a question or comment?

●David This question about philosophy, I met the professor that just spoke up (Floor 2) when I was much younger. He was a senior person in a department for a number of years where he was much appreciated. It is a great pleasure to see him again, and to see his continued creativity and to hear the stimulating things he says. The question is whether discipline is outdated, whether it is breaking down today, and whether this is due to digital technology.

I want to look at it from another angle and

think about the role of discipline in equipping people to function within an esoteric field with concepts that are not natural things that you learn as a child. You have to learn their meaning and their significance, so an instructional purpose is essential. The organization of instruction within a disciplinary framework has turned out to be very productive work. A lot of people got educated that way, and most of them who were educated in esoteric subjects actually benefited from it, even by having a clear definition of what they wanted to reject. This is important.

A methodological change has undermined one aspect of classical physics, which is its dependence upon mathematical formulations and solutions to find out the system's tendency towards an equilibrium, and therefore to explain what we would persistently observe. If it was a world of chaos, we would not be able to describe phenomena as stable.

The methodology of mathematical solutions became valued, and the formulation of theories that could be solved with the available mathematics became dominant because calculation was not possible. You could conceptually do the calculations, write down the whole system, and solve it formally. You could do it in a representation, but to actually extract it by calculation was impossible. This was the theorist's edge, and theory dominated the field over experimentation and observation. Everybody was lower that theorists. Eventually, experimental work in astronomy for example created a second pole, and then there were two hierarchies. There was experimental physics, and then there was mathematical, but one of these poles was higher than the other pole. This higher pole is where theorist sat.

The revolution of computers made calculation so cheap that you could get an algorithmic solution from something that was otherwise impossible to calculate. This created a little revolution, and there are some good stories of meetings between people who took over the framework of theory from classical physics into economics. Many of those models became paradigmatic in representation of temporal change and so forth.

There was a meeting between physicists and social scientists held at the Santa Fe Institute some years ago. The physicist Anderson first gave a talk about what physicists are doing. Then the late lamented Kenneth Arrow gave a presentation on what economists were doing. At the end of Arrow's talk, Anderson said, "Why are you solving these mathematical problems? We do not prove theorems anymore. We calculate everything. We make simulations of phenomena, calculate, adjust, and so forth. This is the way that we go forward." Unfortunately, the physicist said, "That was a good thing because, now that we are doing quantum electrodynamics, the leading person who developed this showed that you could organize the calculations much more efficiently without computers first." That opened the door to great advances where you could then do the calculations of algorithms informed by these methods. Therefore, there is this back and forth of transformation where technology plays an important role.

This was the problem with Galileo. He could see the moon and that there were spots on it. Skeptics then asked, "How do I know that these spots are just not being produced by the telescope? After all, we cannot verify your findings except by using your telescope. If I build a different telescope, will I get the same answer?" The answer was that they could verify Galileo's findings if they

could build a telescope properly. It does not have to be built by the same person, but it does have to follow the recipe for building a telescope such as for the optics. Then they could see the same thing and the controversy was settled.

● Takeda For example, from the 16th century through the 17th century, mathematics created the value of science, created customers of science, and it is easy to understand that science developed since it became applicable. Conversely, as to what that means today, now we even have computers, and although Dr. Murayama just said that things that cannot be explained physically are rubbish, the truth is that now that is not the case, and there are people who think it is okay if something can be solved through deep learning. Applicability has actually been demonstrated. Perhaps there is the possibility that a separate science will be created, something different to what we call 'science'. If mathematics created the science of today, then it is possible that a separate science could be created that is dependent on algorithms and deep learning by computers. I do not want to discuss whether it will or will not happen, but setting aside whether it can be called 'science', in the world right now there are communities being formed outside the current scientific communities.

This is what I am most concerned about. An intelligent software developer writes an extremely good algorithm. Of course, they may have studied in a scientific discipline, but they are not active in places of science, and they are receiving money for doing so by working at a company. Those types of ecosystems are being developed, and people in those ecosystems have no need to publish papers. That is why there are many papers on algorithms on GitHub. They do not need a scientific reputation. Since they put their algorithms up on GitHub, and since they put their source code up as well, is possible to validate them. They do not need a scientific reputation, and that world is currently coming into being.

What do you want to do with this world? As a question, do we want to bring that into the world of science, or is saying, "It is okay, do what you want," okay? If someone is able to answer this question, I would appreciate it.

● Kurata I would like to bring them in, or I have an image of what it means to bring them in, and it is what I talked about in my presentation, the Scholarly Commons. In other words, in a form that includes private researchers, I believe that there should be some kind of commons where people within the same framework, or who have the same methodologies, can gather to pursue some kinds of specific goals with regards to some kinds of phenomena. It is my desire that there be some kind of future scholarly communication ecosystem.

● David Yes, machine learning is the big thing, such as training an algorithm to make decisions and matching faces. Algorithms can take in a lot of pixels and then discriminate between two different things. Part of the idea is that human beings can learn by pattern recognition if their data or observations can be displayed in a way such that they can may observe certain recurrent spatial patterns. Since we start with the question of whether humans can learn to be able to extract interesting and stable epiphenomena from the display of patterns by taking an awful lot of data and manipulating it and transforming it until you find something

that is very striking, the issue here is human learning. Can humans have perception limitations, but also have pattern recognition that people learn at a very early stage? A lot of decisions that we make without even thinking involve pattern recognition. Examples include blink responses, or ducking your head induced by objects flying past. This is done without processing. A lot of things are encoded in the old brain.

We are therefore able to perceive things of a certain kind that are historically dependent. Therefore, the question is whether we can work with machines that will display things for us, and whether we can perceive the things that we might be interested in because they have a distinct signature or pattern. This is a limitation of people working with machines. On the other side, we have machine learning. Can machines work with people? Is machine learning something really different than a simulation? Essentially, you need to train the machine on how to recognize these faces and what to do, so you are training it the way you would like it to behave. Therefore, now you are replicating yourself into the machine. All of your limitations are now conveyed to make the machine in some respects as smart and as dumb as you are because you cannot train it unless you use your human intelligence to get it to behave 'properly'. AI is not solving those problems. Those problems will persist.

●Floor 3 I am a member of the Council for Science, Technology, and Innovation of the Cabinet Office of the government of Japan. I would like to explain from my perspective about Prof. Paul David's way of thinking. Humans have been observing natural phenomena using their five senses. Humans have obtained various tools in order to do so. I recognize that AI is probably one of those tools. There are many things that humans miss if they rely only on their five senses. By using AI to process data, there are cases where AI can pick out peculiarities that humans miss, or that humans cannot capture.

Conversely, although until now we would create theories in our head and then conduct experiments, today it is also possible to extract theories through the use of AI. In that way, there are now AI scientists coming to the fore. That means that even now there are some types of routine experiments that are being done by AI. In the future, what wisdom will humans use in order to take the next steps? Although this goes back to what was talked about at the beginning, it is indeed true that humans use their senses to capture something that is interesting or odd, use that in their next experiment protocol, and then create hypotheses. In that way, it is interesting because there is back-and-forth interaction.

However, we need to be careful not to leave everything to AI since doing so would bring into question what humans are, or what scientists are. Since there are some incredibly interesting things going on right now, we must train people also as part of education in how to skillfully include such things in their work.

What I fear most right now is that our generation became adults before we became able to use such tools as computers, but today's children are being raised in an environment where such tools have existed all along. Unless we deliberately create opportunities for children to have experiences that pique their curiosity such as an abrupt feeling of, "The wind feels good," or "What is that?" in

the real world rather than virtually, then they will not become fully-formed humans. I am aware that this is a problem area.

●Fukagai Thank you. As a summary, you have said about half of what I as the moderator must say.

In the mid-20th century, in living things, for example the society of ants, we searched for hints of human morality, but in the future, it may be artificial intelligence that provides us with those hints for morality. That may not be scientific, but it may be applicable from the perspective of its behaviors being useful. If I were to touch upon the words just spoken at the end, information terminal textbooks are starting to be used in school education, and in five years those students will be entering universities. Conversely, in this age of books with spines becoming rare, libraries lie in wait, including what exactly they are to do. However, in the beginning of the 20th century when people would walk and ride horses and bicycles were rare, if we think of it being similar to how we are now a motorized society, perhaps it is not a big deal. Regardless, I believe that today was an incredible opportunity to consider what will happen to knowledge in the future.

To all the panelists, please forgive me for asking questions so similar to Zen riddles. Thank you very much.

●Hayashi Thank you, Prof. Fukagai, for fulfilling the role of moderator. With this, I would like to end the panel session.