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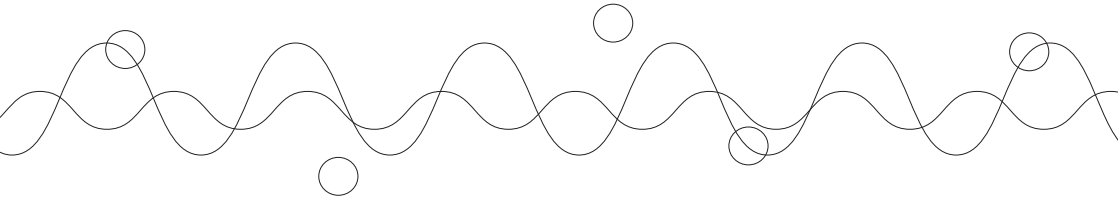
Policy Seminar Series on
"Scientific Knowledge for 21st Century and
Scientific and Technological Innovation Policy"

Symposium Proceedings

Exploring a New Liberal Arts Culture for Science and Society in the 21st Century



CRDS JST
国立研究開発法人科学技術振興機構 研究開発戦略センター
Center for Research and Development Strategy, Japan Science and Technology Agency

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■ Introduction

Since 2013, Center for Research and Development Strategy (CRDS) of Japan Science and Technology Agency (JST) has held "Policy Seminar Series" to deepen historic and geographical perspectives on Society and Science and share with the stakeholders of Science and Technology Policy. CRDS invited natural scientists and humanities and social scientists across various fields to grasp the characteristics of modern science and society, and discuss the future issues to be solved.

Progress in science and technology in the modern era, even though it is considered from the 16th century to the present age, is only 500 years which is only a momentary event in the human history. Nevertheless, there was a large isolation between the ancient Greece / the Middle Ages and last 500 years as to the elucidation of nature's conscience and the transition of the philosophy / thought.

Above all, majority at one time has believed the development of modern science dominated the aspect of mathematical methods can express nature's conscience, even solution of problems in human society and methods of consensus building.

Nonetheless, the further progress of science and science-caused social changes since the beginning of the 20th century has brought far outweigh our expectations from the past trend of the development of modern science and technology. For over fifteen years of the 21st century, rapid and enormous change in various environments around our civilization has been observed. And, now, we recognize unstableness of value norms and its foundation cause by the evolutional evolution of science and technology including information communication technology.

In 1999, the World Science Congress held in Budapest co-sponsored by UNESCO and The International Council for Science (ICSU), as celebrating the 21st century, a series of discussions with the theme of "New Commitment of Science for the 21st Century" was held and later “World Declaration on the Use of Scientific Knowledge "(Budapest Declaration) was adopted.

1. Science for knowledge Knowledge for progress (Science for Knowledge)
2. Science for Peace
3. Science for Development
4. Science for society and science for society (Science in Society and Science for Society)

In the Declaration, the responsibilities of human beings in the 21st century living in a planet called the Earth, especially roles of scientists, have been clearly described, then it is important for natural scientists, social scientists, and humanities scientists to fulfill their obligations and cooperate among themselves to wipes out the negative effect that natural science may cause. It is the way to achieve prosperous future to provide all generations living in the present and the future sustainable and sound global environment; therefore, the Declaration noted that any culture can contribute to scientific knowledge with global value.

In the very beginning of the 21st century, the Declaration is expression by scientists themselves and discipline for themselves on what scientists should do and what role and responsibility they should take for the sustainability of humanity and the Earth.

In this series of discussions, based upon the spirit of the Declaration, CRDS aims to create new social and economic value based on the knowledge of science and technology, in other words,

we have been seeking "creation and use of scientific knowledge towards the realization of science and technology innovation" and "science technology and innovation policy" for that purpose.

Consequently, based on the accumulation of these discussions, CRDS held a symposium on the theme of 'Exploring role of a new Liberal Arts Culture for Science and Society in the 21st Century' to pursue Science in Society and Science for Society, with expectations for young people to place our hope under a complex and unpredictable era.

This brochure is a record of the symposium organized as follows. We would be grateful if readers feedback comments and thoughts after reading.

1) Time and Place

September 6th, 2016 15:30-17:30
JST Tokyo Headquaters (K's Gobancho), meeting room 4F-B

2) Participants

Chairman: Masahiro Kuroda, Principal Fellow of CRDS, JST
Professor Emeritus of Keio University
Discussant:
Hiroyuki Yoshikawa, Special Counselor to the President, JST
Former President of ICSU
Tateo Arimoto, Professor of the National Graduate Institute for Policy Studies (GRIPS)
Kazuo Iwano, Principal Fellow of CRDS, JST
Former Director of Tokyo Research Laboratory, IBM
Tomohiko Fujiyama, Principal Fellow of CRDS, JST
Former Senior Vice President of Mitsubishi corporation

3) Program

Participants discussed on the main subject, 'Exploring role of a new Liberal Arts Culture for Science and Society in the 21st Century', from following five viewpoints:

1. Our Current Age: The Three Norms of Globalism—Democracy, Market Principles, and Science and Technology: introduced by Mr. Tomohiko Fujiyama

2. Science: From Analysis to Design—the Changing Shape of Science and the Limits of Analysis: introduced by Prof. Hiroyuki Yoshikawa

3. Policy: From Policy Formation to Implementation—Stakeholder Diversification and the Importance of Theme Selection and the Policy Process: introduced by Prof. Tateo Arimoto

4. Society: The Blurring of the Real and Virtual, Their Correlations with Real Existence, and the Path to Restructuring: introduced by Dr. Kazuo Iwano

5. The Liberal Arts: A Foundation for Transdisciplinary Thought about the World and Society: introduced by Prof. Masahiro Kuroda

■ Symposium

Masahiro Kuroda:

Alright, I would now like to call into session our symposium on "Exploring the nature of a new liberal arts culture for science and society in the 21st century." I look forward to having a lively dialogue with you all.

With the advent of the 21st century, science, technology, and the impact they have on society have demonstrated major changes and will, I believe, sustain their pattern of change on into the years ahead. What exactly are the background forces that have brought us into this age? That's the first question I would like everyone to think about together today. Let's start with Mr. Fujiyama.

■ 1. Our Current Age: The Three Norms of Globalism—Democracy, Market Principles, and Science and Technology

Tomohiko Fujiyama:

I'd like to focus on the norms of globalism that have shaped our current age. We talk about the modern era but if we place that into its broader historical context, it started around 500 years ago with the Age of Discovery. Even at its shortest, that period stretches back at least 300 years, but I think we should recognize that the transition from the late 20th to the early 21st century marks a significant turning point in the course of modern history.

Modern globalism is a concept that was primarily born in Europe and nurtured within the cultural setting of the West. Understandably, it was built on a foundation shaped by the Western liberal arts. Call it the liberal arts or call it education, but it was Western culture. Although cultural diversity is certainly something that has been formally embraced by the modern world,

the norms that form its essence were shaped by the normalization of globalism and accepted as rules. I believe it convenient for our purposes here to think of these norms or rules in terms of three concepts: democracy, market principles, and science and technology.

However, maybe we should realize that at this point in time, the power or will to accept these rules has been waning worldwide. In the beginning, these rules were established not only on the basis of some dialogue with consensus, but also through dissemination in combination with military might or economic power. Consequently, I believe their precarious position is something we need to take very seriously. The belief that we should trust in science and technology as a dominant principle is in itself actually a relatively new concept, as you all know. To me, it would seem acceptable to view this in terms of a transformation from belief in sorcery to belief in science.

I want to touch on some data from around the recent turn of the century. Let's assume that the US, Japan, the EU, Canada, and Australia have fully embraced or internalized the aforementioned norms or rules of globalism. Up to the year 2000, this group of nations together accounted for over 70 percent of global GDP. However, by 2016, their combined share had slipped to an estimated 50 percent. The implication is that these supporters of globalism have seen their share of global economic power decline. In terms of population, this same group of nations today accounts for around 15 percent of the world total, another reason why the rules of globalism no longer work as well as they once did. As a discrete manifestation of that trend, the shadow of populism has penetrated into many regions under democratic rule, and has even gained prominence in certain advanced nations, as evidenced for example by the words and actions of Republican presidential candidate (at the time of this symposium) Donald Trump and the recent, hasty national referendums held

by the parliamentary democracies of Greece and Great Britain. Indeed, I feel as though we are witnessing before our very eyes exactly the event that Plato, Tocqueville, and Ortega all feared. I suspect, moreover, that it may be deeply interrelated with the collapse of the middle class, which has shown support for it.

On the subject of market forces, some commentators have increasingly warned that we may not be able to avoid a repeat of the past speculative bubble and its collapse. In particular, various questions remain unsettled since the collapse of Lehman Brothers. For example, with the inadequate headway made with financial reforms, is it safe to say the financial markets are as healthy as the financial technologies (FinTech) on which they operate? Is current government involvement in the markets acceptable? Are we okay with the way the credit rating agencies operate?

Within the sphere of science and technology as well, serious concerns have emerged in particular over the issues of human ethics and the societal impact from the life sciences and artificial intelligence. Additionally, granted the dominance of science and technology in massive projects, some see major issues with how projects originate and how their objectives and processes are being managed. By some accounts, a growing number of people have reservations about scientific progress in general.

In effect, democracy, market principles, and science and technology gained strength as an indivisible set of concepts backed by a variety of logical arguments and the liberal arts in the frontier civilizations of Europe. The first argument I wish to present today, therefore, is, shouldn't we always think about and deal with these three elements as components of a single system?

In other words, I am of the view that we need to think about setbacks for democracy not only in terms of democracy, setbacks for market principles not only in terms of market principles, and setbacks for science and technology not only in terms of science

and technology, but as problems that need to be addressed within the context of the system as a whole. Indeed, it is my understanding that people with this kind of multifaceted perspective—for example, Prof. Amartya Sen or Prof. Schwab at the Davos meeting—have acknowledged that we now live in an age where these rules of globalism, albeit valuable assets to humanity, may nevertheless be lost unless they are revised in some way.

Kuroda:

Thank you. To summarize, I believe you are saying that globalism was created by a Western culture-centric modern society on the basis of three logical standards or rules, namely, democracy, market principles, and science and technology, and that in line with this historical view, these rules have caused chain reactions within the modern context that, while not necessarily putting them in danger of collapse, have placed them on shaky ground. I would like to ask our other panelists about this view. Mr. Iwano, what do you think? I gather that advances in information technology and the evolutionary trends in science and technology that IT has fueled in turn are now having a major impact on globalism. How does that perspective sound to you?

Kazuo Iwano:

Economic motives have spurred strong growth in IT. As with cutting-edge advances in science and technology, the feeling is that IT has value if it's good for society and business. However, one question that has been raised is, what kinds of values are actually applied by society or the business world? I feel this has fostered an atmosphere where more people now insist we must strive to recover our spirituality or return to our roots as human beings.

That said, within the context of Western civilization it may indeed be the case that democracy, market principles, and science and technology are being shaken on their foundations. However, I feel something can be said for this renewed interest in spiritualism and philosophy on a more fundamental level. Even if people are more interested in philosophical subjects, they've not really had any guiding principles to work with over the past century or two. I think what we are seeing now is a growing thirst for that sort of thing, for a sense of spirituality. I wonder how that trend fits in with the tremors we are now witnessing with the rules of globalism.

Fujiyama:

I think this is a trend that has been under way since Descartes' day but the rules that control our world have come to the surface now that philosophy has lost its standing as the father of all sciences. That is why I think the issue of spirituality as noted by Mr. Iwano just now is a worthy subject for this dialogue in the scientific and also the societal context.

Takeo Arimoto:

In connection with Mr. Fujiyama's comments, the modern age gradually matured following the development of the nation-state system and the establishment of its policies or public policies, as I will discuss later. However, I think the time has come to ask ourselves how this system or framework itself should be changed or adapted within the current age of globalization. I'd appreciate if Mr. Fujiyama would share his views on that subject.

Fujiyama:

You mean in terms of the concept of the nation-state?

Arimoto:

In terms of the nation-state system and the three rules.

Fujiyama:

The notion of the nation-state coincided with the process of democratization that came out of the French Revolution and the English Magna Carta and spurred the breakup of regional communities and a period of market formation. History tells us that the communities that survived this experience formed a single group as modern states. Conversely, the Asian countries that were left behind at that point later experienced extreme pain as part of their baptism into this new doctrine of globalism, and were compelled to accept a set of beliefs entirely at odds with our own. Fortunately, Japan leaped right into that process, undergoing changes that involved abandoning certain ideals while retaining others. By contrast, most other Asian countries as well as most of the countries in Africa did not do as well with this transformation and have struggled with difficulties up to the present age. Indeed, we can probably agree that China, for example, has only recently embarked upon its own transformation.

Kuroda:

In that connection, as Tocqueville explained, the ideals of individualism or belief in citizenship were factors behind America's independence. In effect, each and every citizen embraced a certain spirit of independence that resulted in the creation of a system. As I see it, that system was driven by a spirit or yearning that favored the creation of a society or a civil society that could reap the benefits and generate a new system of values. Presumably it was the spirit of independence or perhaps a cultural influence of some kind that supported individualism and

formed the basis for this process. I suspect, however, that this cultural influence was upset in some way, and that such an event signaled a loss of trust in science or a loss of mutual trust among citizens as the new Age of Science took shape. However, Prof. Yoshikawa, how does that sound to you from a scientific perspective?

Hiroyuki Yoshikawa:

Well, let's see. This is something I sensed from Mr. Fujiyama's remarks but one dimension of democracy and free market doctrine as well as science is that they each emerged as a rejection of the past. To put it in extremely simple terms, democracy emerged as a response to dictatorship. Free-market doctrine, moreover, developed as a rejection of economic systems under totalitarian control. If we apply this perspective, then science can be seen as having a dimension that rejected social authority based on religion. Incidentally, although I say they were rejected, they still exist to this day. The world still has dictatorship and the forces of religion, yet while they may still demonstrate some of the evils of their past, I think science even today still has the power to counter them. However, if the foundations of democracy and science are being shaken, we will be in trouble if the next thing to replace them is yet another form of dictatorship or religious authoritarianism.

As Mr. Iwano suggested, we would have a problem if a popular yearning for a renewed sense of spirituality resulted in an immediate regression to past forms of religious devotion. This may best be termed a battle of ideas but when our present belief systems are being shaken up, it is essential that we act to identify the new sources of instability rather than carelessly allow ourselves to revert to past ideas that we've already rejected. I feel

that this will pressure modern society to make some serious decisions.

Fujiyama:

Very true. In an age where the norms or rules of democracy, market principles, and science and technology are already being shaken on their foundations, it is an entirely different matter altogether to ask whether it's okay to place them on precarious ground. We have many alternative courses of action still available. For example, we might explore revisions to the rules of democracy or implement programs of education that give us a new form of democracy. On the subject of market principles, we might consider changes in perspective on markets that engage in trading goods for money or adopting a new outlook toward the financial markets and market segments that exploit FinTech.

Although it's essential that these actions be properly taken, in many countries it should be noted that this discussion has made little in any headway because vested interests are given priority. I think it would be appropriate to frame the question of how we should begin thinking of ways to protect democracy, market principles, and science and technology. However, given that the populations of China and India in particular and also of many Islamic nations are growing, I would also agree that it will be important to come up with proposals that have the support of citizens in these nations and encourage them to participate or have their views integrated into the discussion.

Iwano:

Whenever I hear the terms democracy, market principles, or science and technology, somehow I get the feeling that the underlying economic doctrines, national power, and things of that nature are all considered to be good. When I talked about

spirituality earlier, I meant that different values might be emerging based on the belief that all will be fine as long as societies are economically affluent, or beliefs along those lines. So, aside from following a path that involves protecting the three rules of globalism, I sort of had the feeling another, alternative path is available.

Fujiyama:

No doubt, changing values are a background influence but right now we are discussing the things that are treated as rules or norms. If we are going to think about changing values, then the question turns to what it is about the rules that needs to be adjusted. That said, if a clear pattern of change has been observed in the underlying values, I think it will be necessary to point out the relevant issues and discuss them separately.

Kuroda:

From an economics perspective, when Adam Smith penned *The Theory of Moral Sentiments* and *An Inquiry into the Nature and Causes of the Wealth of Nations,* the Industrial Revolution was well under way along with advances in science and technology. However, society at that time did not yet operate on market principles. In fact, income disparities were actually widening and the traditional fabric of society was then falling apart. That was the social backdrop when Adam Smith began pondering the true character of humanity in earnest. Although the true character of the human race was marked both by a strong sense of altruism on the one hand and self-interest on the other, if left to its own devices, self-interest would dominate and create a society marked by extreme instability and inequality. However, Smith came up with a mechanism that would in effect convert the spirit of self-interest into a form of energy and help create a society

marked by the optimal efficient use of the wealth. I think that was perhaps the only discovery made in the field of economics for some time but from that point up to the 20th century, market principles did not very effectively mesh with the market mechanism to resolve problems in the marketplace. Indeed, I cannot help feeling that economic disparities only continued to widen….

Fujiyama:

In his book, *Economics of Good and Evil*, Tomas Sedlacek states that everyone has misinterpreted what Adam Smith wrote. In *Wealth of Nations*, Smith uses the phrase "an invisible hand [of God]" only once to describe how self-interest in its totality results in the optimal distribution of resources. By contrast, as Sedlacek argues, the points made in *Moral Sentiments* are more important, and the root ideas of economics as described by Smith had a moral element whereas the history of economics thereafter left morality almost entirely out of the picture all the way up to the period of the neoclassicists. I think this is an extremely important point that, if tied together with the theory of market principles discussed earlier, would presumably lead to arguments for a sweeping revision of economic fundamentals.

■ 2. Science: From Analysis to Design—the Changing Shape of Science and the Limits of Analysis

Kuroda:

I think the society that Adam Smith encountered during the Industrial Revolution was one that saw huge strides in science and technology led by such individuals as the Scottish inventor James Watt. As time went on, scientific theories continued to evolve, eventually allowing consideration for all aspects of our world. Through the 20th century and now into the 21st century, I have this feeling that the field of science is actually in the process of undergoing yet another major transformation. Prof. Yoshikawa, I wonder if you could share with us from your perspective the changes you anticipate coming in the field of science, or in the role of science as a rule of globalism.

Yoshikawa:

The issue of changing norms or rules is a tough one. From a slightly different angle, though, I'd like to explore one change in the situation for the sciences, namely the divergence from the humanities. Sir Isaac Newton is known as the father of modern science but that is a perspective that arose from the philosophy of nature. In brief, that was a field engaged in a search for rules governing the natural world that would serve as a supporting foundation for theology, and as such, it was interested primarily in problems that did not allow the humanities and the sciences to be treated separately. Although Newton in that context was even misunderstood as a heretic, the rationality behind his ideas is believed to have had a major and far-reaching impact.

I think this also applied to the philosophers Diderot[1] and d'Alembert.[2] Diderot's *Encyclopédie* was finally completed after over 20 years of work. Many writers contributed to the *Encyclopédie*. Their articles were not limited to science in the strict sense but rather broadly spanned topics in philosophy, the arts, and even the glassmaking and machinery building crafts. In other words, the *Encyclopédie* covered practically everything, in a sense documenting all aspects of the world including human intellectual activity from a realistic rather than conceptual perspective. Because it was a compendium of rational knowledge, it could have been described as a scientifically systematic work. Maybe this is going a bit too far, but I think the *Encyclopédie* even established a starting point for modern science. By that, I mean it covered virtually every aspect of human thought and activity, from philosophy, nature, politics, legal rights, peace, the literary arts, the fine arts, music, and other humanities to the social sciences, astronomy, dynamics, material science, manufacturing technology, and craftsmanship. On top of that, it was systematically organized and even incorporated highly detailed illustrations. The reason I view it as such is because it was produced as something that treated the "essence" of modern science as one integrated whole rather than attempting to differentiate between the humanities and the sciences. Incidentally, the natural sciences including material science today are engaged in an effort to build a comprehensive understanding of the universe, and the elementary particles of matter are now a key theme. However, that idea is not something unique to the modern age. The notion that the universe was built with mathematics is something that had already been entertained back in Newton's day. Accordingly, it contained a certain element

1 Denis Diderot, an 18th-century French philosopher.
2 Jean Le Rond d'Alembert, an 18th-century French philosopher, mathematician, and physicist.

of faith that, eventually, the universe would be explained in mathematical terms that everyone would accept. I believe this idea has survived into our modern age. Nevertheless, in contrast to this, the problems that concern humanity cannot be explained with mathematical theorems. Humans apparently are not mathematical designs. That is where a major divergence in methodology arose. Since then, it has proved all but impossible to merge or fuse the natural sciences with the humanities.

I myself find this odd. To give one example, I was recently engaged in an investigation of trends in psychology. It was a study of concepts used in the field of psychology. The concepts began with Aristotle and were extremely well-defined in their metaphysical context. It was the great Jean Piaget[3] who had taken on this task and endeavored to develop theories with the scientific method. Piaget had conducted psychological experiments with children in the field of developmental psychology. Harnessing hypotheses based on his findings from that research, he then sought to establish psychology as a field rooted in the scientific method. However, his approach met with resistance from traditional psychologists. In fact, empiricist psychologists in the US almost never cite Piaget in their research. Not much has been written unambiguously about this point and it is my own conjecture as someone from outside the field, but as I see it, the act of developing conceptual theories based on experimental research relating to the developmental psychology of children and then applying those concepts to humans in general, including adults, should not be thought of as a scientific approach that treats experimentation or rather empirical experience as a necessary condition. However, faced with the reality that one cannot improve the precision of research on human-related phenomena as readily as is possible with

3 Jean Piaget, a Swiss psychologist.

experiments that concern natural objects or events, one ultimately has to proceed in line with something resembling a metaphysical approach when exploring the nature of concepts that apply to humans.

Theories developed on that basis are, in the final analysis, not possible to prove. From the standpoint of scientific integrity, scientific endeavors concerned with themes in the natural world have shown great strides with the aid of experiment-based verification. By comparison, the disciplines concerned with human themes still seem to be at a stage predating Newtonian mechanics, or not yet even at that level.

I think the effort to introduce the scientific approach into the humanities did not turn out well because the natural sciences were too rational. In particular, from a human-centric perspective, I think it would not have been possible to achieve any order by traditional sciences. Today, however, human-related themes are also a subject of scientific endeavor and experimentation, albeit within ethically acceptable limits. The anthropologist Juichi Yamagiwa, for example, has been engaged in reflections on human behavior through his observations of gorillas. To many Christians, that methodology was difficult to accept and such research was accordingly out of the question. Up until only 20–30 years ago, this sort of approach was deemed unacceptable. This resistance, along with various other factors, was the reason why the science of phenomena related to humans as a special case did not demonstrate much progress.

In short, the main reason was the difficulty associated with observing human behavior. Observing phenomena of interest to physics is okay, but not the phenomena of human behavior.

As indicated earlier, research in the field of psychology has been exceedingly difficult. From the perspective of the natural sciences, experiments in the field of psychology seem immature and it appears that researchers in the field can perform only

experiments without any apparent rules in the true scientific sense. For that reason, in the final analysis, experiments in psychology seem to hark back to the days of Aristotle.

In short, the only way open to researchers is to devise non-contradictory, narrative-style explanations that have a single rationale. This is why the element of philosophy as discussed by Mr. Fujiyama becomes a necessity. It is a regression to an older methodology.

In the field of modern physics, experimentation takes the lead and rationalization tends to follow. Look at Prof. Takaaki Kajita's research, for example. The existence of neutrino oscillations was a theory or rather a hypothesis derived from the results of various experiments that contradicted the expectations of pre-existing theories. Kajita's research demonstrated the validity of that hypothesis through experimentation.

Researchers in the field of human studies, however, have no data of that kind to work with, and accordingly end up devising general explanations that seem rational to themselves for a variety of phenomena, in effect adopting an Aristotelian approach. This underscores just how different the sciences of the humanities and the natural world have become.

I want to turn now to the theme I was given to discuss, namely the shift from analysis to design.

We trust the human made tools of the natural sciences to analyze natural phenomena and also analyze other humans. Any knowledge so obtained thus brings about advances in our understanding. Design, however, is the reverse of analysis and involves the act of applying knowledge to devise artificial or man-made things that are intended to help humans achieve certain goals. This could be construed as nothing more than a relationship between understanding and design, of action and reaction, but understanding can bring meaningful results even if one separates the human element from nature whereas that is clearly not

possible with design. The acquisition and application of knowledge are together major themes for modern science. Granted that this same world of science now handles both aspects, the current situation has been marked by the manifestation of a major contradiction. To simply state my conclusion, analysis and design have many features in common. Logic uses analysis to create principles or rules. This is the same logic that harnesses design to develop design methods. Each approach involves the formation of hypotheses.

Let me digress for a moment on the topics of design and hypothesis formation. Japan has been described among other things as a nation that lacks any history of discovering important scientific laws that would facilitate entry into new fields of endeavor, or of creating new products based on entirely new concepts. However, it is a nation that has generated beneficial knowledge based on new scientific laws or products, spurred advances in scientific theory, and manufactured world-leading products. The discovery of new laws and invention of new products are essentials for the advancement of science and technology. However, the generation of fundamental knowledge that helps strengthen existing systems is also a necessity for the advancement of science and technology including the formation of many hypotheses. As this suggests, the nature of design varies country-by-country.

This provides an important perspective in understanding the Budapest Declaration in 1999. The Declaration notes that science is no longer independent from society and incorporates the weighty assumption that the meaning or value of science itself is defined when social objectives are established. This is equivalent to saying that science has a responsibility to design the methods that help society meet its objectives, whether they be efforts in development or the restoration of peace. The notion of "science for society" implies that the concepts of science will not be well-

defined unless we apply the limitation that they be in society's interest. This perspective enables us to see several things. If the field of design is included within the scope of science, it introduces a human element. Truth in this context thus cannot be defined solely through verification based on traditional scientific experiments. Society's choices rather than scientific experimentation thus assume the role of verification.

Take cars for example. Under the influence of market forces, only quality cars survive. Establishing design methods with the same logic or reasoning that's applied to the discovery of new laws is impossible if the verification process is conducted within the confined world of the scholarly professions. The instant that you include "design" within the scope of scientific endeavor, the existence of society takes on fundamental value from the perspective of science. This idea is one of the assertions made in the Budapest Declaration and is given expression by the "science in society" phrase at the end of that document.

Discussions on this theme have been held by the International Council for Science. It is necessary that we too fully understand the implications of that fact and pursue discussions that help place science in its proper context. In the process, we must also bear in mind the past crimes committed in the name of science including eugenics and human-centrism. Additionally, we must reexamine many of the proposals and recommendations issued by scientists that did not take the existence of society into full account. It has been pointed out that applications of scientific knowledge have resulted in an array of serious paradoxes: for example, improved comforts of life with environmental devastation, improved affluence with income inequalities, heightened international commerce with regional tensions and conflict, and uncertain outcomes from the technologies of the life sciences. The scientific knowledge available to address these issues remains in short supply.

Altruism, for example, will provide us with extremely valuable insights into ways to solve these assorted modern issues. To that end, it will be necessary to free ourselves from perspectives that demand the localized optimality of the scientific approach. Moreover, it is essential that we think of humans as an integral element of the natural environment. These changes may allow us to form a consensus on a new mythology for science. In the absence of dialogue on these topics, science probably will not be able to serve as the kind of norm or rule described by Mr. Fujiyama.

Although scientists in the future will be engaged in research on an enormous range of topics within existing fields as well as fields that stretch beyond the traditional scope of science, in Japan many in our own generation seem not to have awakened to this fact yet. However, many in the younger generation already have. Members in the Science Council of Japan's Young Academy in particular can be expected to command a huge presence in the years ahead.

Kuroda:

Mr. Arimoto, design as discussed by Prof. Yoshikawa just now, and the science and technology policies in which you have been involved, are, I believe, very much concerned with harnessing the principles of design engineering to implement policy. What changes has the modern age seen in this?

Arimoto:

Public policies on science and technology are now approaching a major turning point in many countries. As I see it, within the larger trend of globalization, they have begun to change through their interactions with the three rules of globalism. Looking back over the past 200 years, the field of science was systematically organized in the 19th century and the meaning of

the term "scientist" was formally defined. Peer reviews and the activities of academic societies were established and in the 1930s, grants, contracts, and fellowships were adopted as tangible tools of public policy on science and technology. However, on a fundamental level, policy continued to support traditional discipline-based research.

Over the past 200 years or so, many countries that are described as advanced industrial nations today exploited science and technology as leverage to expand their economic and military power, partly influenced by colonialism. However, as Mr. Fujiyama noted earlier, the power of the G7 nations has sharply waned in recent years, and this in turn has had an impact on various institutions of modern society including the field of science and technology. Specific public policies on science and technology were established in the 1930s at the earliest and in the postwar era at the latest. In that light, I think now would be a good time for sweeping change.

However, things that deserve to be retained should be retained. I'm referring to the beneficial aspects of modern science. As to what they are, Mr. Fujiyama's earlier comments were right on the mark. Some areas deserve to be maintained whereas others need to be changed. I believe this applies to methods of funding, the review process, and the delineation of different sectors. We need to put much more effort into policies that will serve as mechanisms for the generation of new ideas that help to identify and find solutions to societal issues. I don't believe much will change in this respect if we depend solely on a bottom-up approach from within the science community. The 21st century has in fact ushered us into a complex and uncertain age. It's vital that the topics of science for policy or the philosophy of science for policy be discussed and debated within the public space, that consensus be built, and that society and science achieve a more harmonious relationship. Unless we achieve these things, the structure of

antagonism will persist and confront us with an extremely perilous situation. We should be clearly aware that as policy tools to that end, it will be necessary to prepare structures and funding that help create processes and settings for discussions by a diversity of people to identify current challenges and determine what actions should be taken to deal with them. This should include the activities of the Science Council of Japan's Young Academy as Prof. Yoshikawa just mentioned.

Kuroda:

Earlier in his comments, Prof. Yoshikawa noted that if we think of the humanities as a field of science, they are still in a pre-Newtonian stage. I myself have said that economics is a pre-Newtonian discipline. When I said that, I stressed that economics and the social sciences should be responsible for addressing social challenges of the kind described by Mr. Arimoto, and that economics must serve as a discipline that aims to solve the problems facing society. In my view, the humanities must be design-oriented. However, one point made by Prof. Yoshikawa that I don't yet quite understand is that the benefits and drawbacks of a design-oriented discipline are ultimately determined in the marketplace, by the marketplace. The field of economics has endeavored in earnest to define rules for market design. If something has gone wrong with those rules and the marketplace is accordingly unable to function effectively, I have doubts as to whether that marketplace will be able to actually say anything conclusive about economics as a form of design engineering.

Yoshikawa:

I believe rule-making is of course something scientists can do. By contrast, while corporate planners and private consumers

engage in activities that are bound by market standards, such people typically have little if any knowledge of market standards that have been articulated in the language of economics. However, if one were to precisely define principles of conduct for these market participants, develop a school of economics that conforms to those principles, and incorporate "designs" for economic behavior, the result would be a form of evolutionary economics that integrates a human element.

Science has no experience with the question of how to make an economics of that nature more comprehensible to people or influence their principles of conduct. Everyone behaves instinctively. An altruistic element is needed. Desire and greed are natural traits, but if everyone is preoccupied with their own self-interest, the result may be social instability that comes back to bite you. Take animals, for instance. Self-interest alone is not enough for survival of the species. Many animals are unable to live unless they allow other animals to live. That is how they have preserved their species.

However, by what standard can you assign a value to this type of instinctive altruistic behavior? Economics has nothing to show us in that respect. It may be that something exists for specialists in the field, but I feel that economics has absolutely no channels through which it can influence individual behavior.

Kuroda:

When I stated that I felt that the humanities and the discipline of economics in particular were still in a pre-Newtonian stage, it was because I get the feeling that while economics may make rules or have design as its ultimate purpose, unless it adopts a more analytical perspective with respect to identifying the economic phenomena that influence design or better understanding of current economic structure, it will, in the sense

you've already described, be unable to fulfill a market design role if it is only occupied with the rule-making thesis based on rules handed down from above.

Yoshikawa:

I think the conclusion is obvious. Even if one is not locked in a closed room away from the rest of society, it will still be absolutely impossible to come up with suitable rules as long as one is thinking within the confined world where the rules of science are devised. That may be because economics needs a different set of rules than those possible to articulate in scientific terms.

As I see it, it is that one must design an evolutionary structure of knowledge relating to economics as a type of self-contained social system. That's why I think it's absolutely impossible to think about these rules within the confines of a laboratory, and that the discipline itself needs to have an evolutionary structure that is always dynamic and equipped with parameters that enable it to ask how current society is likely to change or what new courses of action people are likely to follow if the government implements a certain framework.

The reason is that up to now, the discipline of economics has relativized or downplayed the point that rules are not something that economists apply to society and that society—comprising the discipline and its users—possesses an evolutionary structure.

This is something that the sciences or at least the natural sciences from the earliest days of their establishment have never had to take into consideration. Or rather, they were able to avoid that task. In reality, I think the biggest challenge for science was to treat everything including humans as subjects for observation and on that basis, build a social structure whereby science and society could evolve together. However, that is not what has happened. A well-known scientist has said that society cannot be

a subject of scientific scrutiny because, as with the principle of uncertainty, the mere act of observation or of implementing social policies would immediately have the effect of changing the nature of the observed subject. That is in fact the case but science in the years ahead needs to address this problem as well. Observed subjects as well as their observers all undergo change. Accordingly, it is the job of the scientist to visualize the evolutionary structure underlying this process. Modern scientists still do not realize they have this responsibility.

Fujiyama:

I think Prof. Yoshikawa's comments about the relationship with society and the need to restructure science are understandable. However, at one point, you made the statement that humans are not based on mathematical designs. I am now more worried, however, that the day may be approaching when humans can be described as being based on mathematical designs and that the human mind does not regard the subject of science and technology with equanimity.

First, I would like Prof. Yoshikawa to share his views with us on this issue. Another issue has to do with thinking about science within a broader context. In the West, science began to develop after it had been divided up into several well-defined fields. With the Eastern approach to thinking, which may to some extent reflect a dimension resembling mysticism, the entire spectrum of science has been viewed intuitively as one whole, as a totality. The Eastern way of thinking carries a lot of power. Although it has been described as nonscientific, maybe we won't be able to break beyond the current age without relying on it. Given that understanding, I have the perception that eventually we will have to blend Eastern thought—for example, the ideas of

Zen Buddhism—together with the things we've labeled "science" up to this point. How does this sound to you?

Yoshikawa:

I agree. The idea that humans are mathematical designs has begun to garner attention. That is certainly the case in the life sciences and information sciences where everything can be defined in mathematical terms. They've set those conditions and are operating on the basis of huge assumptions. But I do find all of that rather objectionable.

I believe we would make mistakes if we were to use existing mathematical skills. A different category of mathematics is needed. Mathematics was created by mathematicians, human beings. In Euclidean geometry, a straight line was a concept selected to represent the essence of a lined-up series of lumpy, thin stones. Philosophers see that as an operation of fundamental intelligence that humans bear as part of their intrinsic, true nature. Conversely, through sustained observations of nature, it is said that mathematics reflects the nature observed inside our genes. However, aside from the human form, we can see many other complex features but there was no one to plot those as mathematical expressions in the past, right?

If we can look at humans and come up with a form of mathematics to express what we see, then by all means I think it would be fine to fully utilize that. Actually, our field of design engineering has attempted to mathematically handle a variety of ideas including the concepts we talked about earlier. I would like us to guarantee that the mathematics utilized for such purposes will not end up annihilating the human race.

Regarding the other question you brought up, Mr. Fujiyama, as I see it, Western philosophers have, within the limits of their own thought processes, sought to create a world without

contradictions. That is rationalism, an effort to build even non-empirical understanding into a speculative world without contradictions. Eastern thought, on the other hand, assumes from the outset that contradictions are certain to exist. This is because human understanding of the natural world is by no means complete. There are always things we don't understand.

I think the recent revival in Eastern thought is due to the insight that human understanding has its own limits. The Western approach strives to define problems and create rules that address those problems alone. If this approach is repeated enough, one should be able to come up with holistic explanations that are consistent. That is the narrative of Big Science. However, it will probably never be possible to come up with a description of our world that is completely consistent. What is more, even if the partial explanations of the world that we now have available are individually consistent, they are still not inclusive. They purposely ignore things that will not be a focus of concern for now. I can only think of the earlier-cited issues of environmental devastation and economic inequality as nothing other than outcomes of that approach.

Kuroda:

Maybe I am misunderstanding something here but in my readings of Popper[4] and others, they repudiate holistic theory and talk about building up science in a piecemeal fashion. I may be mistaken but it seems to me that the Eastern view of science is extremely holistic in the way it looks at the world. What is your view?

4 Sir Karl Raimund Popper, the Austrian-born British philosopher.

Fujiyama:

If we define it in terms of (Eastern) culture, it's the world of the mandala[5]. As with mysticism, this is the sublime, empirically based view of the world in its totality. It is a world that does not distinguish between East and West and may feel like a continuation of the world as described by Bergson.

Yoshikawa:

The piecemeal idea was presented, I think, in the interest of criticizing communism, which, as a historicist ideology, emphasizes revolution in deference to historical principles that are unaffected by natural change or progress in the realm of science and technology. I have no idea whether Popper's lack of interest in the discovery of new rules marking a scientific revolution had any correlation with his criticism of historicism but as an example of the piecemeal approach, he cites the process whereby the craftsman perfects his work through trial and error. This arguably resembles the evolutionary process in nature. First, one moves a little bit in one direction, then changes direction in order to adapt, then undergoes changes of one's own. In that respect, Popper may be described as using a heuristic[6] argument. I am not sure because I haven't studied enough to be able to criticize Popper, but this is where Popper's scientific argument eludes me. He uses the term "piecemeal" but acknowledges without argument that the discovery of new scientific principles is an external process.

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5 A Hindu or Buddhist, graphic symbol of the universe specifically : A circle enclosing a square with a deity on each side that is used chiefly as an aid to meditation

6 Here, the speaker uses the term in its empiricist sense. In computer science, it usually refers to the trial-and-error method of discovery.

Arimoto:

The rationalism that Prof. Yoshikawa mentions or rationalism as used in the modern sense has long been an undercurrent of influence. However, what is rationalism, exactly? I believe Kant also said this but isn't rationalism one of the theories that has led us to where we are today?

Although it would be dangerous to progress from there straight into mysticism, we have rationalism on the one hand and a cumulative approach of some kind on the other—call it a way to achieve balance through the linkage of community-based experience and accumulation of knowledge. This, I think, would lead to a framework for the solution of problems society faces, as discussed earlier.

Fujiyama:

The microscope was invented back in Goethe's day. There's a well-known story that upon looking into a microscope and being told that "this is the true world," Goethe exclaimed, "Indeed, this is the true world, but not truth for humankind." Truth for humanity is bliss for humanity as we are limited to only five senses. If we redefine truth as humanity, then we face the extremely important question of what humanity is in the post-modern age.

Iwano:

The debate over "wisdom computing" is relevant to this discussion. During the JST-sponsored session of the Euroscience Open Forum (ESOF 2016) that gathered in Manchester, England, discussion focused on the question, "What is wisdom?" In Western society, the term "wisdom" typically refers to science and technology or the accumulation of scientific truth, and the session discussions seemed to treat it as an extension of knowledge.

However, if you look in the dictionary, wisdom in the Buddhist world is, as Mr. Fujiyama noted, the power to recognize truth, and wisdom in that sense is treated as a singular whole. In that case, wisdom computing must strive to identify the essence of the whole picture, and to that end must ask what is needed to achieve that goal. The discussions during the ESOF session concluded that as an extension of methods enlisted to date, we would not reach that goal with Big Data or through the accumulation of AI. The implication from that is that science and technology do not possess the dimension necessary to identify the nature of things in a holistic way. How do you see this?

Arimoto:

I participated in that same session and was strongly impressed by Dr. Nicole Dewandre, a mathematician, philosopher, and advisor to the European Commission's Director-General of the Directorate General for Communications, Networks, Content and Technologies. Although Dr. Dewandre shares the European flavor of rationalism, she does not exhibit Descartes' choppy style. She articulated ideas about correlations, relationality, the relational self, and the reassessment of modernity and stated that she planned to explore the information-based society, leaving me with the feeling that she would be able to readily handle the dialogue here today.

Fujiyama:

European scientists, philosophers, and government officials seem to be more strongly concerned about the roadblocks facing European civilization than their American counterparts. Many that visit Europe to participate in these discussions come back with the idea that perhaps the East may hold clues that can help Europe with its situation.

Kuroda:

This has been an extremely interesting discussion and I look forward to our continued discussions in the final session of our symposium.

■ 3. Policy: From Policy Formation to Implementation—Stakeholder Diversification and the Importance of Theme Selection and the Policy Process

Arimoto:

I want to talk about a real-world subject that was mentioned earlier today. As I see it, over a period of 50–60 years after World War II, policies on science and technology in the advanced industrial nations followed meandering courses that reflected the relevant circumstances of each nation. Science in the past 200 years or so has been institutionalized. A variety of academic societies, scientific journals, university degree programs, research frameworks, and methodologies have emerged during that period. These things have all interacted with one another, leading to the formation of public policies and the implementation of programs of public investment. However, today these frameworks and methodologies are approaching a major turning point. In my view, that is now the consensus in most nations. For example, Europe has Horizon 2020, a program of policies on science and technology that comprises three well-defined pillars: scientific excellence, industrial leadership, and societal challenges. This program aims to achieve goals that are clearly in the public interest and has advocated strategies to that end. For comparison, Japan has announced its Society 5.0 concept but has not yet come out with clear strategies or assessment protocols to put that plan into effect.

As Prof. Yoshikawa and Mr. Fujiyama noted earlier, from the level of policy to researchers in the field, science and technology are now approaching a huge turning point that has been 400 to 500 years in the making. However, we do not as yet have a shared awareness of that outlook. We first need to have a consensus on this age in which we've arrived. Yet I suspect policymakers are

continuing to focus on acquiring budgets for their own, respective programs, while consensus remains elusive.

If we can reach that consensus and have a program in place like the Horizon 2020 program with its three core pillars, I believe it will be possible for each sector to have a dialogue on role-sharing arrangements. That dialogue would be focused not on competition for budget appropriations but on the creation of a new structure of shared values and a reallocation of resources.

One question is how effectively will policy work in such an age of transition? Scientists are, after all, curiosity-driven. Otherwise, they would lack incentive or motivation. Given that fundamental reality, how well can top-down guidance from policy resonate with these bottom-up factors? Depending on the levels of resonance and trust achieved, I would think the answer is to build programs that ensure major benefits with limited investments. To that end, I believe it will be crucial to allocate some of the funding typically earmarked for Big Science, even if it is only 1 percent, to set up frameworks in the form of public policy that encourage dialogue spanning across different sectors and organizations and countries, and provide settings for diverse forms of interaction, particularly among members of the younger generation.

Over the past five years or so, I've been working together with Prof. Kuroda on "Science for Redesigning of Science, Technology and Innovation Policy(SciREX)" project. This has been driven by the objective of merging the top-down approach of policy with inputs from active scientists, making it as evidence-based as possible, on that basis creating an ecosystem that facilitates cooperation by policy makers and scientists within a climate of mutual trust, and finally cultivating human resources with the capacity to serve as bridges between the two. Prof. Kuroda has often made this point to me but it's vital that policy makers, policy administrators, and active scientists achieve a state of

coevolution. Many countries have begun concurrent efforts in that direction.

If we inquire into the reasons for policies on science and technology in the first place, over the past 200 years many nation-states have had policies of this kind in place, and during that time the priorities of the national interest have been military power and economic power. In effect, the 19th and 20th centuries were an era for the projection of hard power. The 21st century must not become an extension of that. In exploring the values that humankind needs in the 21st century, the time has arrived for serious thought about merging the public policies of nation-states with those of the global community (for example, to make contributions in science and technology that will facilitate the creation of sustainable societies). To that end, this will involve the development of policies as well as an environment that together give the younger generation hope. I know I must be careful with my terminology here but as I see it, many within the current generation of young researchers in Japan seem to share a certain sense of nihilism about what they are doing. That is both sad and something that will prevent them from achieving good results with their work. In fact, they don't even know what they are working on. However, we must take steps to remedy the state of confusion among young Japanese scientists that seem not to understand their position within the world or the current age.

Yoshikawa:

I suspect that the nihilistic attitude shown by some young researchers comes from the fact that Japanese society still lacks a system for proper evaluations. Society has not been receptive enough to the fact that new scientific innovations lead to new technologies that benefit society itself.

Arimoto:

In an age of transition, I guess not much can be done about it but when evaluating we tend to look back in time, so enormous value is placed on the measure of how beneficial a contribution has become for the economy. We haven't yet switched to a mindset or a framework that asks how valuable a scientist's discipline is to the task of opening up new disciplinary sectors or helping build a new society.

Iwano:

I think this is an extremely important topic. One reason why I feel policy has been less than adequate is that it has not effectively fulfilled the roles of spurring serious investigations into the human, social, or economic impact, implications, or potential stemming from science and technology or of disseminating that knowledge to the world at large. IT in particular has up to now been thought of mainly as something for the business world or for corporate accounting processes. However, when a technology has advanced this far, it can carry huge implications for change in the structure of society, in the way we think about things, and in the fundamental relationships between society and business. The same may be said for AI. Society has not yet been informed of those implications, nor have that many people given the subject much thought. We've seen a much stronger tendency to treat IT in terms of various buzzwords, from AI, Big Data, and IoT to cloud computing, Cyber-Physical System(CPS), FinTech, and so forth, and to ask only what the technologies can do or how they can be applied. However, it is more important that we be thinking about the impact that these technologies and the thinking behind them will have on the world, society, business, and our daily lives and what kind of value they will or must add. Now more than ever, when we contemplate the stunning advances made in the field of

IT, I think it's imperative that we also think about these other aspects.

Whenever I visit an AI community, I encounter researchers who seem to think it's okay to be doing what they do out of pure interest or curiosity. However, this is the other side of nihilism, and extremely dangerous in my view. From a policy perspective, unless we set up structures to rigorously explore and inform society about the impact, implications, and potential of a given technology, we may end up allowing advances in science and technology to get out of hand.

Furthermore, unless we actually make an effort to devise social and economic impact models, we will not have fulfilled our accountability to society. This is a topic that economists and computer scientists must discuss within a context that transcends their respective fields. Achieving mutual understanding is not easy. However, I think the problem itself presents many difficulties. For example, the development of ecosystems for service platforms, their social and economic impact, the development of components to deliver social services, integration technologies, and the rebalancing of values are all important yet difficult themes. Nonetheless, I feel that we need policies that foster these efforts.

Fujiyama:

I totally agree with Mr. Iwano regarding the issues he has just raised. This relates to something Mr. Arimoto said earlier as well. I believe that policies on science and technology are the policy context here, and I feel that this applies to science and technology alone. In other words, modern civilization has been built on a foundation of three rules of globalism that together form a package. Consequently, I believe the idea of exploring policies as a tool to coordinate the relationships between the marketplace and

science and technology no longer constitutes an effective approach.

The reason I say this is because many advanced nations are currently struggling with conditions of extreme fiscal austerity and are hard-pressed to continue funding the operations of multilateral institutions, with the consequence that neither these nations nor the multilateral institutions command the roles they once did. In addition to that, some nondemocratic nations are more readily able to allocate a significant share of their budgets to defense-related spending on science and technology. If you look around the world, that is what's happening and some of those countries are relatively nearby. Bearing this in mind, efforts to harness the power of the marketplace as a means of bringing about advances in science and technology should be promoted. Of course, private-sector business leaders have an important role to play here, but so do policy-based arrangements; I think this perspective is extremely important right now.

If market principles and science and technology combine to drive more funding toward the achievement of SDGs[7] and other undertakings that reflect human values, we can expect to see a significant improvement in the currently shaky situation for the rules of globalism. However, on the subject of policy, currently I feel that at least with respect to science and technology, we tend to focus too much on sources of seed money. Is that not the case?

Arimoto:

Research and development has long been an existing goal, and postwar policies on science and technology have been focused on ways to promote that. I think this was once true for most nations. That focus, however, is now in question. For that reason,

7 SDGs: Sustainable Development Goals approved by a resolution of the UN General Assembly in September 2015.

going forward, considerations of this matter must be conducted with attention to a broader, higher layer of value. Another point is that policy must have a global context in the form of SDGs that extend beyond national borders and the boundaries of individual fields, and must also take many factors into account and lead to the implementation of concrete measures. I believe the SDGs are a great concept that science and technology should contribute to through the 21st century. They clearly lead to new 21st-century values, as well as human and global ethics. It is also important to note that efforts to achieve their goals have been launched not only by institutions within the public sector but also by companies in the private sector.

Multinational firms can no longer earn high marks solely through the pursuit of profits. This situation, I believe, reflects the beginnings of a growing social reaction to the ideas of neoliberalism. Your comments just now are extremely important. The people that form policies on science and technology need to shift to a different mindset that allows them to think and act from a somewhat broader perspective.

Fujiyama:

I think strategies or mechanisms to harness market principles will be even more important than the role of science and technology in promoting SDGs. With the world the way it is, I believe the financial community obviously has the power to put together mechanisms for that purpose.

Kuroda:

The topics you've all just raised are something that I've been thinking about for some time. I've been wondering about ways to measure the impact of science and technology policy on society in a tangible way but the economics is still too primitive. Economics

simply does not yet have the theoretical tools or perspectives to effectively measure or understand science and technology. Therefore, unless steps are purposely taken to better connect the design-related aspects including the analytical dimension, I feel economics will not be able to serve the role you've described.

Yoshikawa:

It's probably pointless to criticize Japanese policy frameworks here but in connection with the earlier-mentioned issue of nihilism among the younger generation, under the current Japanese framework, writing lots of research papers has become an absolute essential for scientists to maintain their livelihoods. Even if they understand that the SDGs offer a set of global rules that link society and science together on a level higher than the standards for the production of research papers, the reality for many scientists is that unless they have their papers published by leading journals, earn awards, and otherwise follow the traditional path toward scientific accomplishment, they will not gain recognition as scientists. Young researchers are aware of this. Young Academy members are constantly expressing their views on the subject. Many probably would like to relocate abroad so that they can finally live free from the curse of the current system and research funding. However, if they did leave to pursue their careers in another country, they would discover that not a cent of funding is available to them there. Mr. Arimoto cited a figure of 1 percent (of research funding) but that is not something the national government can do under the pressure of public expectations. The sources of funding available for research also reside within our cursed system.

Although I've stated before that it will be necessary to engage in research that is funded by independent foundations and thus free from dependence on the limited public revenues

entrusted by the public, that arrangement will be extremely difficult to achieve. However, regardless of the difficulties, achieve it we must. In some countries research funding by foundations can be comparable in scale to government funding. In Japan, this is not the case at all because we do not have any foundations with such scale. However, we do have the same spirit.

Presumably we must assume the SDGs are outside the scope of competitive research funding under the current system. We need to reconsider the research frameworks that place researchers in a bind. Otherwise, as Mr. Iwano noted earlier, the consequences pose serious risks. Many researchers now feel that because they can pursue research that interests them under the current framework, it's their mission to do exactly that and a waste of time to think about doing anything else. However, they adopt this attitude not because it is the research they really want to pursue, but because that's their path to survival within the current framework. I believe it would be okay to see not 1 percent but maybe 10 percent of young researchers free themselves from the system. We need to find and build mechanisms to facilitate that.

Arimoto:

Another option is the relatively new idea of scientific advocacy. Although this has been around for a long time in a practical sense, it is only in the past few years that we've seen a global platform take shape to facilitate it as a concept and then as a real activity. This concept of scientific advocacy emerged in response to the strains that policy makers and scientists in each country faced in trying to build bridges with one another and achieve a measure of synergy on subjects ranging from the March 2011 Tohoku Earthquake and the ensuing Fukushima nuclear disaster to the L'Aquila Earthquake in Italy and issues

surrounding GMOs. Because it's a relatively new undertaking, if young researchers were involved, their value would not be fully recognized within the circles of academic societies.

That is precisely why, as Prof. Yoshikawa noted, it's dangerous for young researchers to free themselves from the shackles of the current system. It's one reason why seismologists involved with research on the L'Aquila quake were put in jail. Nonetheless, many people around the world involved in the fields of science, national politics, and administration have, I believe, begun to wake up to the fact that the global trend in scientific advocacy is important as something that gives science new value. In Japan, that realization has not yet taken adequate hold.

Kuroda:

I think scientific advocacy is extremely important but to be engaged in that, scientists have to be recognized scholars in the traditional sense. While I feel that tradition is fairly deep-rooted in the West, it is something that has yet to be cultivated in Japan.

Arimoto:

Although this role has begun to find acceptance at related international conferences, what exactly are scientific advocates? Who are they? First of all, you have the pure scientists. Then you have people who specialize as advocates to earn income for their own fields or projects. Yet another type is the honest broker. Honest brokers are individuals who possess scientific knowledge, foster dialogue that takes society's needs and values into account, and present quality policy options based on a comprehensive approach that transcends their own field of expertise. In its code of conduct, Germany's National Academy of Sciences describes the knowledge required for scientific advocacy as consisting not only of the knowledge that enables advocates to maintain their levels

of pure academic understanding but also knowledge that facilitates the creation of social value through dialogue with society.

■ 4. Society: The Blurring of the Real and Virtual, Their Correlations with Real Existence, and the Path to Restructuring

Kuroda:

I want to change the subject now to something with which Mr. Iwano is probably most familiar, namely, changes in the structure of science. As I see it, information technology (IT) is the field that has had the biggest impact on society and redefined the shape that society has been compelled to assume. Mr. Iwano is the proponent of Reality 2.0 and sees it as a model of interaction between the cyber and real worlds. Do you think the evolution of IT including artificial intelligence (AI) will, through its impact on society, encourage researchers to think about that impact and their responsibilities and act accordingly?

Iwano:

I've stated this before in various settings, but the impact of IT on society has developed enormous scale. In the process, advances in IT have spurred three important changes.

First, up to the 1990s, business-critical infrastructure was key to developments on the cutting-edge of information science and technology. From the year 2000 forward, expectations have outstripped the reality that this would function as society-critical infrastructure. The scale of that expectation has been enormous. The expectation is that unless IT spurs changes in social and industrial structure and, through its own power, brings about a restructuring of various forms of social infrastructure and social services, it will not boost Japan's power as a nation or society. It is essential, however, that IT engineers and researchers also participate in discussions of value and the kind of society that needs to be shaped. I think this has become a social obligation of specialists in this field. Current awareness on this issue centers

around the question of how to fulfill that obligation and deliver the technologies required for the purpose. I think the next stage will be decisive for research currently under way. The focus for the next battlefront has gradually shifted to the universe or humankind. At that point, we will be in a world marked by questions about values, the goals of the human race, and the problems surrounding the notion of wisdom. That is the third stage and it is the stage we are moving into now.

Additionally, in relation to the economic principles that have been a focus of our discussions today, the main source of business value has shifted from goods to services. The share of economic value generated by goods alone has traced an unavoidable downtrend. Goods now create more economic value when embedded into the structure of services. This has been highlighted by the almost real-time updating of service value and the provision of global services that are backed by cloud computing and the Internet. That backdrop has been shaped by progress in the technologies for Big Data, optimization, and AI. I have discussed this shift in value from goods to services fairly extensively with Prof. Yoshikawa, but services comprise the delivery of functions. Contributions from the delivery of functions cannot be significant unless the functions or services are properly positioned within their network of relationships or ecosystem.

Accordingly, the way one builds a social service platform or ecosystem should be the decisive factor behind success. This has become a matter of extreme importance. The ecosystem, moreover, must be dynamically designed. The next factor of importance will have to do with the re-distribution of value.

Another point, and one that has also been extensively discussed in Europe, is that various boundaries have become blurred. The largest boundary is that between the real, physical world and the cyber world. This, too, has become blurred. The significance of that development is that their identities are

undergoing change. The "Reality 2.0" world that we have put forward is a universe marked by ambiguity. From one angle, everything appears to have the aspect of a cyber entity. From another angle, it has the aspect of a physical entity. The true nature of any particular thing cannot be fully grasped unless we take both aspects into account. In one sense, physical and cyber entities have become inseparable. When we apply this perspective, the nature of a variety of identities will change. I am talking about the identities of the individual, community, institute, society, and nation. As these identities change, so too will the services that cater to them. I think this is the world that has arrived.

Additionally, given the context I described moments ago about fluctuating or shifting identities, the implication from the fluctuation of a given boundary is that the relationship between the individual and the community has also entered a serious state of flux. The point, in other words, is that conditions defining the company as an organization where individuals engage in the performance of contracted duties are becoming more fluid. Even more importantly, the involvement with AI and the boundaries between human and machine are I think being shaken up as well. Steve Fuller, a philosopher of science who visited Japan in March 2015, noted that people today now have no qualms about using contact lenses as if they were part of their own bodies. Initially, people began using contacts on a trial basis. In time, we can expect to see more and more people became pioneers because they think of embedding devices or components into the human body as an interesting idea. Fuller noted that as these pioneers debut and act on their values, we may witness a rapid blurring of the boundaries between human and machine in much the same way that people lost their sense of discomfort about contact lenses. This is an example of a change in identity.

A variety of keywords come to mind when we view things this way. This has been touched on in earlier discussions but as science and technology have continued to undergo these rapid advances, only a small percentage of individuals or organizations now have the ability to visualize the implications for the resulting society or humankind and share their views with society. Accordingly, these individuals or organizations will end up being entrusted by society to handle this role. What about the impact on society, and what do we do about it? For example, we entrust the treatment of brain tumors to neurosurgeons. By the same token, these individuals and organizations will be accepting a weighty societal commitment. That is what I meant earlier when I talked about society's expectations. Scientists and engineers are responsible for their respective fields. In that sense, I believe they have huge obligations to society and command a social presence of commensurate scale. However, I see problems with the fact that society and its professionals in these fields do not yet clearly recognize this structure of social give-and-take.

I want to talk now about some of the things we can expect to happen in the next 10 to 20 years. Changes in relationships with the universe will have extremely important implications for business and the boundaries of identity. It seems certain that in the end, tax systems and the locations where we decide to start a business will be influenced by the mechanisms that dictate how we charge for each transaction in the context of those relationships. To some extent, I think the relationships between individuals and between different services will eventually become universal.

Reality 2.0 has two dimensions. Whenever the universe and services are marked by ambiguities, the stage will be set for the creation of an ecosystem of new services or functions. A service platform of this kind represents one dimension. In effect, it's a service platform that creates an ecosystem of social functions.

The other dimension has to do with privacy or the new services that are likely to arise as an outcome of the redefinition of identities. In that sense—and this I think is something Prof. Yoshikawa brought up as it relates to design engineering—the design of social structures or mechanisms has taken on major importance.

It is in that context that we will face several fundamental issues that must be addressed, including questions about what humans are, or what identity means. This process is unlikely to function that well unless we devise a platform that allows for the sharing of our findings with society as well as an ongoing exploration of questions relating to levels of societal maturity or social acceptance.

A while back, we had some discussion on investments in science and technology. Now, though, I think what society really wants is accountability, for example, to have explanations as to why certain investments are worthwhile. However, public trust will be extremely important in that context because we won't be able to cite hard numbers for the return on investment. As I see it, we will need to work within the existing social structure to determine how we gain that social acceptance. This is the direction in which I feel we are headed.

Yoshikawa:

I fully agree. However, on the subject of realization, I am unclear about a number of things. Mr. Iwano, in your comments on the use of contact lenses, you didn't mention whether there's resistance from people who don't wear them. I mean from people before they've even tried them, not after the fact. When the first automobiles came into use, there was opposition from people who had never ridden in them. I think more study needs to be devoted to the dynamism of professional design and social choices.

Automobiles were chosen and endured on the basis of market mechanisms that were not necessarily rooted in economics. If we explore the subjects of design and choice here on a deeper level, they confront us with a more difficult dimension. In reality, people who make the choices need not be individuals who have already utilized an automobile. Those who do use automobiles become more powerful. Business managers can make decisions more quickly if they have the capacities provided by information technology, and they are more powerful if they have AI tools. These factors differentiate existing users from everyone else. Is it acceptable to direct this resistance from non-users toward a societal Ancien Régime? This brings up the issue of the piecemeal approach as described by Popper. I am referring to the mythology of scientific progress and feel that we must seriously consider whether it deserves scrutiny in accordance with Popper's critique of historicism. I would like Mr. Iwano to discuss ways of surmounting inconsistencies of this kind.

Iwano:

As you suggest, we are heading into a world where the traditional values of the economically powerful will no longer suffice. Whether the benchmark is spiritual or one of empathy, we have to think about the kind of place we want to live. Furthermore, on the subject of redistributing value, not everything that a person wears is something they've earned through their own labor. It's also essential to have frameworks that effectively redistribute a society's wealth. Those, I think, would include the income issues or values that regulate the economic system, but unless we have mechanisms of that kind in place, the issue of social fragmentation will only intensify, as Prof. Yoshikawa indicated.

Fujiyama:

You've given us a scenario where scientists and engineers are entrusted with obligations of some kind, and of course they do have lofty roles to fulfill, but are you saying that we must create a social system that enables society to entrust them with those roles?

Iwano:

Yes, that's correct. Currently, neither society nor its professional classes have spelled out what is being entrusted, and awareness of this issue is nonexistent. However, the implication is that in real terms, this structure of relationships is inevitable. As Mr. Fujiyama has pointed out, it is necessary to have structures that enable society to entrust obligations to its professionals and for those professionals to fulfill their obligations.

Yoshikawa:

I want to discuss a concrete proposal. Social analysis is a research theme for quite not a few scientists now. However, the humanities and social sciences in their current form unfortunately seem to offer very little in the way of conclusive findings from research on social change caused by science and technology. Given the influences from science and technology, the task of observing social trends appears likely to become a major part of the mission for science. Engineers develop new technologies because they believe they can contribute to society with the new knowledge they acquire in the process. However, investigations concerned with the penetration of new technologies into society will prove inadequate if their analytical efforts rely on the market mechanism alone. Technologies now spread through society for reasons beyond the scope of the market mechanism. With that in mind, I believe the academic disciplines have an

important mission to take a somewhat more-coolheaded approach and explore how humanity is likely to change and evolve under these conditions.

Fujiyama:

That sounds like a new argument for consensus-building.

Iwano:

A philosophical dimension is also needed.

Yoshikawa:

My concern is that prior to consensus-building, researchers would have no information to communicate. Realistically, one could try to use something and intuitively conclude that it's good, but that's in reference to the old market mechanism. However, the cyber dimension of Reality 2.0 does not include this type of market, does it? No market exists unless you come to the physical dimension. From a layperson's perspective, the physical world can only have an indirect influence on the cyber world. However, the strictly defined world of the specialist of course includes a market. I'm concerned about these two market-related questions.

It's my position that science has a role to observe that. However, researchers typically do not have budgets for that purpose. I feel that this is more a problem for the humanities than the social sciences, but have not heard anything specific.

Iwano:

In that respect, I think the IT field has also reached a major turning point. However, at the individual, societal, and national levels, this impression that we've approached a turning point is not widely shared. Perhaps that is our responsibility but I

nevertheless find it rather scary. Maybe people at Google or other companies may have awakened to this.

Fujiyama:

On the subject of information as it relates to the issue you just raised about the future, some people have been discussing this for some time. They concluded that IT did not create a flat society. On the issue of national sovereignty, they should have taken notice and treated that as a serious issue when China clamped down on Google. Consensus-building is not something that can be achieved with a simple approach. It involves more than the question of who will agree with whom, and is something that must involve society as a whole. The same may be said for the question about who wields authority. This also applies to your earlier comments about those who have authority and those who don't, but people are going to have to speak out more forcefully on this issue going forward. However, judging from world history, the winners in that context are likely to secure their positions through preliminary action rather than speaking out.

Iwano:

That may be true. Some people have already taken that position. Signs of this trend are probably visible at Google, Airbnb, and Uber. We have to be prepared before we go with that theory.

Kuroda:

I believe scientists are the only ones capable of sympathizing with or voicing the idea that this may be the world of our future. Scientists must first make the effort to inform others and humankind in general about this.

Iwano:

That's true.

Yoshikawa:

It's likely that science has many research domains of this kind to look at.

Iwano:

Yes, if there are so many even within the field of IT alone, I have a feeling there must be many in other fields as well. Take the life sciences for example, or brain research.

Fujiyama:

A certain percentage of people within the scientific community view the ELSI program as a procedural obstacle. However, that's not accurate. We will be in trouble if they don't look at this more closely and recognize that their responses to ELSI are in the interest of scientific advancement.

Iwano:

People need to think harder about what they are doing and how society views the flip side, and bring up the issues they see. While this is something that involves policy, it is not a role that society fulfills.

Arimoto:

Society launched the Internet around 1992, about 25 years back. Initially, during its first 10 years, it was utilized almost entirely for business purposes and that's the image the general public and people worldwide had in mind whenever they heard the term "IT." However, in the past few years, the Internet has

gained status as critical infrastructure for social services, the daily lives of citizens, and even the survival of humankind. I believe academic societies need to adopt this historical perspective on the transformation of the Internet. How many people actually see the Internet this way?

Iwano:

The second stage for society, humanity, and IT arrived around 2005 in the form of smart cities and smart communities. However, in the past 10 years, and this applied to smart grids as well, companies and researchers formed clusters of IT point solutions that were considered socially beneficial. Because these developments were not enough to change society, this year the National Science Foundation in the US launched its Smart and Connected Communities program solicitation, which incorporates perspectives on social and behavioral economics. It appears some people have been alert after all. In addition, President Obama launched the Computer Science for All program. The idea is to introduce solid computer science education courses, mainly computational thinking, into school curriculums from kindergarten to the 12th grade in an effort to build these kinds of social systems, train designers, and cultivate student creativity. I think the US has taken notice. It has awakened as a nation.

Fujiyama:

In that development I perceive a restoration of sovereignty. The way things are now, our world is on the brink of forgetting the very concept of sovereignty. Successful mediation to that end is in itself a policy, and this I think is what is needed for policy to gain legitimacy.

Iwano:

A little while earlier, Mr. Arimoto brought up some points about policy for science and science for policy. Although the structures for these ideas are good, I think someone will have to shoot a (policy) bullet. We have to have a bullet of some kind. At this turning point in time, I sense that the field of IT expects this as an obligation of those of us who are scientists or engineers.

Yoshikawa:

As to policy, I think the question will be centered on what it will be. As I see it, policy should be aimed at creating structures that can bring about improvements on the whole and mitigate distrust. I think we shouldn't have a policy implemented unless it is going to be reliably assessed by someone, economists for example, to measure its outcome. That is the approach to policy, and policy should never dictate what science should do or be. I think policy can do nothing more than create an ecosystem, a type of system created by real, live people or scientists. Although I wouldn't call it fascism, a policy that attempts to do more than that would end up creating a type of inductive or guidance-oriented system. That certainly would not be a wise path. Because it will be a system devised by real people, everyone will have roles to fulfill and funding accordingly would be allocated for the fulfillment of those roles. I think certain types of intensive investment are out of the question for the purposes of scientific research. If we are going to invest in military research, we should also invest in sociological research aimed at preventing war, because that, after all, is science, too. That's my view of policy. It is pointless for policymakers to say anything about the question of whether or not to fund military research. They are not in a position to wield such control. That is something the Science Council of Japan has been doing, though.

■ 5. The Liberal Arts: A Foundation for Transdisciplinary Thought about the World and Society

Kuroda:

I think practically every subject covered in our discussions to this point is linked to the question of the type of liberal arts education that will serve as a foundational pillar of support for science in this new century. As Mr. Iwano suggested a few moments back, in a world marked by steady advances in IT, we need to foster a model of science that clarifies the identities of individuals, harnesses each of those identities within their respective social settings, and enables society to operate in a consistent way. In my view, the liberal arts probably serve a background role as a type of influential rule or norm. However, as noted at the beginning of this symposium, certain categories of individualism together with Greek philosophy and natural philosophy formed the core of the liberal arts education that supported modern science up to the 20th century. It was from this foundation that the ideals of democracy emerged along with the principles of market doctrine as a form of social system that supported democracy. Further, the scientific principles that supported market doctrine and democracy settled into a quest for logicism-based rationality, leading to the development of modern science as we know it today. All of this is now undergoing major change. The changes in science have been accompanied by signs of upheaval in democracy and market doctrine. Finding ways to mitigate these new and unsettling trends will, I believe, demand a set of new standards of liberal arts education for the 21st century. I would like now to have each of our panelists weigh in and share their own views on this point. Let's start with you, Mr. Fujiyama.

Fujiyama:

I currently chair the Liberal Arts Study Group within the Business-University Forum of Japan, to which Prof. Yoshikawa also belongs. As Prof. Kuroda suggested in his introductory remarks, the meaning of the term "liberal arts" has changed since the time of the Greek philosophers and has been used with a variety of different meanings. The modern liberal arts mean different things to different people. However, I will refer to the liberal arts here in the broader sense as a form of cultural education that affords a deeper understanding of fields other than one's own specialization and facilitates interdisciplinary efforts toward the solution of problems. Assuming that the liberal arts also referred to the ability to empathize with and understand others, it seems reasonable that it would change that context as society transitioned from one historical era to the next. In my view, the liberal arts in our modern era require three things.

First, as Prof. Yoshikawa mentioned early on, is the need for deeper exchange and fusion between the natural sciences on one hand and the human and social sciences on the other.

Second is the need for a fusion between theory and practice based on alliances between industry and academia. Earlier I repeatedly mentioned a fusion between the marketplace and science and technology, but here I want to underline the need for sensibilities or perspectives that will accelerate that relationship.

The third requirement has to do with something that has been around since ancient times. The market principles, democratic ideals, and efforts to promote science and technology that were discussed earlier may in a certain sense be common elements contributing to civilization itself. However, while we have cultural traditions of our own in Asia, some of that cultural heritage has been lost. I feel that not enough understanding has been shown for this form of regional cultural diversity, and that efforts to integrate the favorable attributes of regional cultures

into globalism have not been effective. In short, acceptance of regional cultural diversity is the third requirement. In particular, within the globalism context, it is extremely important that more understanding be shown toward China and Islam. In turn, China and the Islamic nations need to learn more about the beneficial aspects of globalism.

Let me add that Japan is perhaps unique among non-Western nations in that it thoroughly assimilated the ideals of globalism following the Meiji Restoration (1868). To put it another way, Japan is well-aware of the pain that comes from a headlong rush into globalism. For that reason, it understands the pain that developing countries now endure as they question why they must comply with certain rules, while at the same time Japan is familiar with the dignity that is associated with the legacy of globalism. So Japan is a nation of ambiguities, and as such it is a nation with a major role to play.

By assimilating the three requirements for the liberal arts that I have now cited, Japan will, I feel, have a historic role to fulfill as a pioneer in the drive to place globalism on a more-stable footing.

Kuroda:

Thank you. Let's now hear from Mr. Arimoto.

Arimoto:

I've made it a point to discuss these things with young students, researchers, and business professionals. I think it crucial that everyone acquire the ability and basic knowledge to think about where their research or business is positioned within the major trends of our time and within the world at large. To have that ability, they need to be given a certain amount of background. Liberal arts education may fill that role. Instructors in that field

will, I believe, have huge responsibilities to bear. Many in the younger generation today endeavor to pour all of their learning into their own specialist "silos." Because they treat their respective research fields as the starting point in research labs, or when choosing topics for research, there are many young people who neither think about nor see anything outside their own fields. If they would do a little investigative work or engage in discussions with peers in other fields, they would be able to step beyond the boundaries of their own specializations and develop an understanding of where their own research themes fit within the larger picture. In any event, it is important to apply a broad perspective and clearly understand your own position within a given time and space. That is your identity and something that will help you establish your own sense of values within the changing world of the 21st century. I am confident that members of the younger generation will be able to accomplish great things if only they are given the opportunity.

Kuroda:

I think you've made some extremely valid points. In other words, not just young people but each and every individual will be unable to establish an identity for themselves unless they have a liberal arts education that has equipped them with an accurate view of history and the world. Mr. Iwano, I'd like you to comment next.

Iwano:

Math, music, and astronomy have been treated as elements of a liberal arts education. In addition, though, Jeannette Wing, a scholar that has carried her career from Carnegie Mellon to the NSF and from there to Microsoft, states that computational thinking also will be needed in the years ahead. In effect,

computational thinking will be an element of the new liberal arts curriculum. In the process of developing structures and systems for global society, engineers will be able to build comprehensive, systematic frameworks only if they have an understanding of virtualization, system architectures, componentization, systemization and integration. Without that grounding, I think they will be out of luck.

In addition, as Mr. Arimoto just said, it's important that people have the ability to empathize with others. On top of this, I believe it will be necessary for people to adopt a fundamental attitude that enables them to acknowledge the benefits that science and technology provide to society and humankind and think about our objectives as individuals and as species. Unless scientists and engineers have this perspective, I doubt that they will be able to accept and act on the obligations society entrusts to them.

Kuroda:

It appears you are saying it will be necessary to create a society in which we can identify our values if we assimilate these things as elements of a liberal arts education. That sounds difficult.

Iwano:

Empathy may be understood as referring to the fundamental connections with those around you, with the world beyond national borders, or with the planet.

Kuroda:

It is empathy that Adam Smith describes in his *Theory of Moral Sentiments*. He called it sympathy. He says a lot about it but Smith analyzed the ways that sympathy can be nurtured.

Iwano:

Ultimately, I feel that is the key issue.

Arimoto:

I think what Adam Smith was saying was that networks of sympathy exist within societies with foundations that allow market principles to operate. That is why they work so well. Smith studied a great deal to understand global historical trends in a variety of academic fields including astronomy and physics. Smith also stated that it's important to seek change through dialogue with old theories whenever new theories arise. Otherwise, major change will not be forthcoming.

Kuroda:

I think Smith was truly the leading man of letters in his day.

Arimoto:

He stated that the bonds of sympathy survive over the long term both in time and space.

Kuroda:

Lastly, let me call on Prof. Yoshikawa to wrap this session up for us.

Yoshikawa:

I perceive a problem with how people including members of the younger generation can now have the motivation to acquire a liberal arts education as described by Prof. Kuroda.

I think learning a foreign language is the number-one motivation for most people. By some accounts, a language comprises certain innate and physiological elements whether one is compelled to learn it or not. But that does not explain everything. If it's a language that reinforces our behavior, we will study it as much as we like.

According to one theory on the origin of language, when humans left the jungle and migrated into the savannah, they were motivated by the fear of being eaten by lions unless they communicated and shared information with one another. That was a scenario portrayed, for example, by the Swiss linguist Ferdinand de Saussure, but why did humans then go on to acquire language ability? They acquire it in the same way during the childhood stages of development, yet no one gives them any motivation.

Why can't liberal arts education resemble that? When you attempt to give a student instruction in engineering, he may have zero motivation to learn and accordingly will not remember anything. Language skills are something that everyone wants to have and can utilize. Will the liberal arts ever be like that? Can't the motivation to learn a language be oriented toward education in the liberal arts?

Up to now, for example, when people born in the early postwar years finished high school, they typically enrolled in a university degree program. At that time, many might have decided to become engineers. Their motivation was that they thought they would contribute to national affluence or improved standards of living if they were able to design useful inventions or do good work. Japan was still an impoverished nation and

everyone hated poverty. Everyone wanted Japan to be affluent like the US. They believed this would be possible if they studied hard. Their motivation (to learn) was based on this extremely simplistic thought process.

By contrast, the motivation to study liberal arts seems much more distant. As I was listening to Mr. Iwano today, I had the feeling something else is happening here. Students are now motivated to study by the thought that they will be losers unless they do this or that. For example, many young people become computer-savvy on their own without training of any kind. Children have good memories, too. No one has given them motivation. Why is this the case with computer skills but when the subject is something like mechanical engineering, no one will even listen to the instructor? This question is hiding something huge that we've possibly overlooked.

I think these are questions for policy science. What is liberal arts education? Should we learn the classics? In the beginning, we could not survive without these things. Accordingly, I feel that awakening students to that fact and arousing their interest will be a methodology for education in the liberal arts.

Fujiyama:

But then, when is that education going to occur? Some are of the opinion that graduate students should be compelled to receive this education once more during their doctoral programs. I think it would be better to provide liberal arts education to students during their middle school years. Unless young students are imprinted to some extent with the idea that becoming a specialist is not in itself the way to solve problems, they won't be able to broaden their perspectives. Having multiple perspectives can help one develop vision. So it is imperative that we teach students the importance of having multiple perspectives while they are still

young. We don't have any compulsory courses in our curriculums for this but at a minimum, it's vital to inform students that they should develop several perspectives. Altogether, a class of students could have as many as 100 perspectives. Although it would be difficult for any single student alone to have that many perspectives, it will be necessary to provide them with an early education using practical examples so that they at least understand the need to have multiple perspectives.

Iwano:

This also applies to many other subjects like math. Students are less likely to be able to contemplate difficult concepts unless they've been introduced to them or thought about them at an early stage. That is why students should engage in early exercises that expose them to really difficult topics. Otherwise, later they may find themselves unable to think more deeply about those topics no matter how much education they've had. As Mr. Fujiyama suggested, junior high school may be the best time to start.

Fujiyama:

As an example, you could have students read an entire text even if they claim they don't understand the content.

■ Concluding Remarks

Kuroda:

Thank you, everyone. Economics is my profession. In my readings of Adam Smith, I've come away deeply impressed by the strong curiosity he demonstrated toward humanity and human society. In his *Theory of Moral Sentiments*, Smith drew from trends in natural philosophy to shed light on the nature of humanity and how human society operates. In reading Smith, I find him to be surprisingly careful in his discussions of human behavior. I have to admire the fact that Smith could not have engaged in his analysis without a significant degree of education in the liberal arts.

Prof. Yoshikawa mentioned the French *Encyclopédie* earlier. England had David Hume and others with their own encyclopedia slightly different from those of countries on the European continent, with treatises on subjects ranging from physics to the methodologies of natural law. Adam Smith was well-educated in the field of physics and I believe also had deep knowledge of the field of astronomy but I think this was because he had a desire to utilize methods from these fields to shed light on the nature of humanity.

I feel his methods differed from the natural sciences then developing on the European continent in that they enabled him to achieve a tight bond with the ways of life in human societies. This may also have been due to the fact that the Industrial Revolution started earlier in England.

Yoshikawa:

It seems the time has come for us to try something similar. Society used the laws of established physics to develop quality materials and launch new industries, but that era is over. Now we

must devote more serious thought to the conditions in which humanity has been placed. The future has presented us with several paths that could lead to the end of the human race.

Kuroda:

Humanity needs that sense of crisis. I honestly think so.

Yoshikawa:

That has also been true in the past. Adam Smith was concerned about the lack of a societal sense of crisis back in his day, and posed the question of how to bring a chaotic society under control. Despite the conditions of his era, Smith found a solution to that problem using an academic approach. Consequently, I feel that we must develop visual models of the problems facing society today. We should assume leadership to that end. We will not be the only ones to attempt to find solutions to these problems. Future generations will carry on with that quest, develop new disciplines, and eventually find solutions.

Kuroda:

Should we after all be pursuing serious thought on the issues of Science for Society or Science in Society as articulated in the Budapest Declaration?

Arimoto:

The Budapest Declaration is now approaching its 20th year. We need to revisit and reexamine its content and discuss it with our foreign colleagues. I visited Europe about a half-year after the March 2011 Tohoku Earthquake. While there, officials for academic societies in several nations informed me that after the devastation from the 1755 Lisbon Earthquake and tsunami,

Europe witnessed a strong diversification in its formerly one-dimensional ideas on education. As the leading thinkers of that era, Voltaire, Rousseau, Kant, and Adam Smith were all moved by this disaster to think more deeply and share their ideas with society. It has been rare in world history to see a natural disaster have such an impact on an economic superpower like Japan. I recall a comment by someone with the strong expectation that Japan is in a position to develop a new philosophy. We must respond to that expectation.

Kuroda:

Whenever I read works penned by Yukichi Fukuzawa [8] following the Meiji Restoration, I am left highly impressed by the exceptionally philosophical level of his thought. Why is it that we do not see any philosophical works like that now?

Yoshikawa:

It's regrettable. Japan has lost that cultural climate and perhaps will go on living according to the mythology of the postwar economic recovery, but that mythology has already been destroyed. I want to look forward to the creation of a policy science rooted in new philosophical principles.

Fujiyama:

I think Japan now has fewer economic experts with any philosophical background.

8 Fukuzawa Yukichi is a Japanese author, educator and publisher who was one of the most influential man outside government service in the Japan of the Meiji Restoration (1868).

Kuroda:

I thank you all for the valuable insights you've shared throughout this long symposium.

■ Profile of Participants

Masahiro Kuroda

Dr. Kuroda (Ph. D Business and Commerce, Keio University) is Principal Fellow, Center for Research and Development Strategy, JST. Professor Emeritus of Keio University and Visiting Professor of National Graduate Institute for Policy Studies. He was Professor, 1982- 2004, Vice President (provost) of Keio University, 2001- 2005, and President of Economic and Social Research Institute, Cabinet Office, 2005- 2008. He was President of the International Input-Output Association, 1997-1999 and currently Chairman, the Advisory Committee for Science for STI Policy, MEXT, Japan since 2013. Publications: "General Equilibrium Analysis of Japanese Economy "(co-author, 1974), "Introduction of Empirical Economics" (1984), "Quantitative Analysis to General Equilibrium" (1989), "An Introduction to Economics" (co-author, 2001);" The Order of the Sacred Treasure, Gold Rays with Neck Ribbon" (2016).

Hiroyuki Yoshikawa

Professor Hiroyuki Yoshikawa is now Member of Japan Academy, Special Counselor to the President, Japan Science and Technology Agency(JST) where he is leading to design national research programmes for realising the sustainable prosperity in society by integrating sciences, natural, medical, technological, social and literal. Through his recent positions: President of University of Tokyo, President of Open University, President of National Institute of Advanced Industrial Science and Technology, Director General of Center for Research and Development Strategy (CRDS) of Japan Science and Technology Agency(JST), he developed a method of integration of different disciplines for sustainability research. His academic subject is General Design Theory, which is common through different engineering disciplines. He was President of International Couscil of Science(ICSU), 1999~2003, and worked for its reformation.

Tateo Arimoto

Tateo Arimoto is Professor and Director, Science, Technology and Innovation Policy Program at the National Graduate Institute for Policy Studies(GRIPS) and also Principal Fellow, Center for Research and Development Strategy(CRDS) at Japan Science and Technology Agency(JST).He previously served as Director General of Science & Technology Policy Bureau of the Ministry of Education and Science.He has played an active role in public policy making and implementation in the area of science, technology and innovation in Japan. He has been a co-chair person of the OECD study project on scientific advice. He has published several books and numerous papers in quality journals and given many invited lectures/seminars on science, technology and innovation in national and international conferences such as OECD, APEC, EU, ESOF, WSF, STS Forum and AAAS. Main Publications: "Scientific Advice-STI Policy Making in the 21st Century",by T.Arimoto et al. University of Tokyo Press, 2016,in Japanese (English summary available).

Kazuo Iwano

Dr. Kazuo Iwano has been working for Mitsubishi Chemical Holdings Corporation as Chief Digital Officer since January, 2017 to realize innovative business model and digital transformation by utilizing digital technology and its concept. He had been working for proposing IT policies to ministries of Government of Japan as Principal Fellow, Center of Research and Development Strategy (CRDS), Japan Science and Technology Agency (JST) from 2012 to 2016. He also helps Mitsubishi Corporation as an advisor to develop new business opportunities based on information technology. Before joining Mitsubishi Corporation in March 2012, he had been in IBM since 1975 and engaged in various jobs such as VP of Emerging Businesses Opportunities, Director of Tokyo Research Laboratory, and VP of Yamato Software Laboratory. He graduated Tokyo University in Japan with Mathematics major in 1975 and he acquired Ph. D. in Computer Science from Princeton University in 1987. He is a member of IEEE, ACM, and SIAM, a fellow of Information Processing Society

of Japan since 2003, and an associated member of Science Council of Japan since 2004. He has been a visiting professor of Tokyo Institute of Technology since 2010.

Tomohiko Fujiyama

Tomohiko Fujiyama was born in Tokyo in 1953. He graduated from Tokyo University, Faculty of economics in 1975, joined Mitsubishi Corporation in 1975. He spent company life mainly as an economist or corporate strategist. Currently, Principal Fellow, Center for Research and Development Strategy(CRDS), Japan Science and Technology Agency(JST). Corporate Advisor of Mitsubishi corporation (2013-2016), Senior Vice President (2008-2013), Deputy Chief Representative, Mitsubishi (China) corporation (2002-2004), General Manager of Corporate Strategy and Research Department (1993-1997). He also has experiences, Attend several government's councils. And then, Mitsubishi art gate program selection commissioner, Research Associate, Policy Alternatives Research Institute of Tokyo University.

■Editors of Symposium Proceedings

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K's Gobancho,7 Gobancho,Chiyoda-ku,Tokyo 102-0084

Tel:03-5214-7481

Fax:03-5214-7385

http://www.jst.go.jp/crds/

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