"Earth-set" image taken by the HDTV camera on "KAGUYA(SELENE)" ©JAXA/NHK

Hokkaido University Faces Up to Global Warming

The Earth has fallen into a critical situation because of global warming caused by greenhouse gases which have been emitted into the atmosphere with the development of human society. What kind of problem is global warming? What is going on in nature? What do people throughout the world think about this problem and what is to be done about it? Faculties and graduate students who carry out research in global warming at Hokkaido University had a round-table discussion about this up-to-date topic.

Round-table discussion

Masatomo Fujiwara, Associate Professor at the Faculty of Environmental Earth Science
Jun Nishioka, Associate Professor at the Institute of Low Temperature Science
Takeo Horiguchi, Associate Professor at the Faculty of Public Policy
Takafumi Mayama, Second-year Student in the Master's Program at the Graduate School of Engineering
Fang Ma, Second-year Student in the Master's Program at the Graduate School of Economics and Business Administration
Mao Matsuyama, Ph.D candidate at the Graduate School of Letters

Chairman: **Yoshinori Furukawa,** Professor at the Institute of Low Temperature Science

Furukawa: Today's theme is global warming. This is a common buzzword at the moment, but when we give it serious thought, it's clear that it relates to all disciplines. With this being the case, it might not even be possible to explain what global warming actually is. Because it's a major issue though, I think today's discussion will succeed if we can shed light on this matter using specific examples and images. In this session, we'll take turns to discuss a number of areas from our respective vantage points. First of all, Dr. Fujiwara will explain global warming from the standpoint of natural science.

"A one-degree increase in temperature turns out to be a problem if atmospheric temperatures are compared to body temperatures." –[Fujiwara]

My name is Masatomo Fujiwara, and I've been observing atmospheric variations in the tropical region for about 15 years. Today, I'd like to explain global warming based on the 2007 report produced by the Intergovernmental Panel on Climate Change (IPCC). The Earth's average surface air temperature had increased by approximately 0.74 degrees over the 100 years of the 20th century. It was about 13.7 degrees around 1900, but is 14.5 degrees now. We call this global warming. Because it's only a matter of one degree, some would argue that it's just a small increase, but compared to human body temperature it's the same as an increase from 36.5 degrees to 37.5 degrees. So we can say that the Earth has a slight fever and is feeling ill.

The next questions would be whether greenhouse gases are actually increasing and whether they are really caused by human activities. Let's take a look at CO_2, the most influential greenhouse gas. The snow in Antarctica and Greenland is thousands of meters deep, and if we dig it up, we can take out the old air trapped inside the ice there. This means we can measure CO_2 concentration as far back as 650,000 years ago. According to the data, the concentration used to fluctuate between 180 and 280 ppmv, but over the last 200 years, which is the period since the Industrial Revolution, the concentration has suddenly increased by 35% to 360 ppmv, and continues to increase every year. We don't think this sudden increase was a natural fluctuation. We can also use isotopes to differentiate between natural and man-made CO_2, and have confirmed that the increase in CO_2 was caused by human use of fossil fuels.

The last question would be whether the rise in CO_2 levels is really the cause of global warming. The only way to confirm the causal relationships would be to conduct an experiment to compare a case where CO_2 increases, as it is doing now, with a case where it doesn't. To do so, a computer program called a climate model from various institutes in the world was used, and it was confirmed that global warming actually took place when greenhouse gases such as CO_2 increased. We can estimate surface air temperatures in 100 years' time by projecting future social activities and greenhouse gas emission increases, and by inputting these estimates into the climate model.

Clouds over the border region of Vietnam, Laos, and Cambodia. Taken from a passenger plane (around 10 km altitude) by Fujiwara.

[Discussion]

Furukawa: Temperatures have increased by 0.74 degrees. Instead of actually feeling a temperature rise, what we actually see is some years with a lot of severe weather, for example, strong typhoons hitting Hokkaido that we didn't see before. What we seem to feel in our daily lives is that the ranges of fluctuation have expanded.

It's often said that these phenomena are closely linked to the progress of global warming. Is this true?

Fujiwara: Well, it's difficult. Global warming covers a time span of 50 to 100 years. We have to be careful because people's memory span is about 10 years, and we tend to talk about things in such a relatively short time frame. The IPCC says it's "likely" that typhoons are getting bigger because of global warming. They used the term "likely", and the term denoting a higher probability is "very likely". As for whether the phenomenon of stronger typhoons is within the scope of natural fluctuations or whether they're caused by climate change, I don't think we can say with certainty that it can be explained statistically at the moment.

Horiguchi: Is it reasonable to believe that the overall CO_2 concentration in the Earth's atmosphere is uniform whether it's over industrialized countries or developing countries? Or does it differ between industrialized and developing nations, strictly speaking?

Fujiwara: Strictly speaking, the concentration is different. First of all, because CO_2 has a long life time, it's thoroughly mixed. But if the concentration in the Northern Hemisphere is compared with that in the Southern Hemisphere, the Northern Hemisphere's is higher.

Furukawa: There is an international arrangement for regulating CO_2 emissions. Isn't it premised on the assumption that CO_2 concentrations are the same everywhere? Emissions into the air vary from country to country though. In the premise, the amounts in the atmosphere are uniform, and the whole Earth is taken into consideration for these amounts. If the premise breaks, the assumption doesn't hold, does it?

Horiguchi: Exactly. The target number is for the whole Earth. But it's also reasonable to think that the effects of greenhouse gases per se have regional characteristics, isn't it?

Fujiwara: That relates to a time-scale aspect. Here, we're basically thinking about the average of the entire Earth. If such and such is the global CO_2 concentration, how do individual regions react? This is the way of thinking here. Of course, each region reacts differently.

Nishioka: When we simulate global warming, we make predictions based on various socioeconomic scenarios. Are many social science researchers studying how feasible such predictions are? When we talk about developed and developing nations around the world and about the interests of individual nations, there will be a wide variety of predictions. But are people making practical predictions or performing objective analysis in a level-headed manner?

Horiguchi: I think objective discussions are also being made at the IPCC. They discuss economic effects according to various scenarios as well as the political or institutional responses that need to be made.

"Marine ecosystems are in fine balance" –[Nishioka]

My name is Jun Nishioka, and I work on oceanography and investigate what's going on in the ocean by chemical methods. Today, I'd like to explain about how there are systems in the ocean that are in delicate balance with each other, and how disrupting this balance might change the climate and marine resources.

Phytoplankton inhabit the surface of the ocean and play an important role in circulating materials. What this means is that phytoplankton perform photosynthesis and use the CO_2 in the seawater to produce organic matter. The phytoplankton are eaten by zooplankton, which are then eaten by fish, and then by mammals. This is the marine ecosystems. Phytoplankton and zooplankton sink when they die, completing a system of circulation that helps transport carbon deep into the ocean. Of course, most of the dead phytoplankton and zooplankton are decomposed by bacteria into CO_2, which returns from the sea surface into the air. Looking at the entire mechanism, an increase in phytoplankton play an important role in the global carbon circle. Because plankton are also eaten by fish, they considerably affect the fluctuation of marine resources.

Iron in seawater is the key element to the growth of phytoplankton. Iron plays a crucial role in the bioenergetics of metabolism of phytoplankton. However, iron concentration is not enough for

Field observation from Reseach Vessel.

supporting phytoplankton growth in certain region of the ocean. To reveal this, oceanographers around the world recently embarked on a grand experiment of sprinkling iron into vast areas of water in the ocean where not enough organisms are produced. We found that sprinkling iron increased the amount of phytoplankton, and the water changed to temporarily absorbing CO_2. If this can be done in certain areas, it might be possible to artificially control the amount of carbon and the volume of marine resources that the ocean contains.

On the other hand, when we look at natural iron distribution in the waters of the Oyashio Current near Japan, for example, iron is constantly supplied from the continental shelf in the Sea of Okhotsk. We know that this iron transporting system has helped maintain abundant ecosystems in the waters. The movement of the water, which transport iron from the continental shelf, is driven by sea ice formation process in the Sea of Okhotsk. Recently, the amount of sea ice production in the Sea of Okhotsk has decreased due to global warming, and there are concerns that this decrease could adversely affect the rich ecosystems of the sea.

Five samples of marine phytoplankton.

[Discussion]

Furukawa: Did the iron experiment conclude that it's possible to sequester CO_2 into the ocean?

Nishioka: We learned from the experiment that it's possible to artificially increase phytoplankton biomass by sprinkling iron. From our observations and the experiment results, we also learned that dead phytoplankton do not effectively sink deeper into the ocean, which was against our predictions, and that most of them decompose into CO_2 in shallower layer. The experiment was highly regarded though, because it scientifically proved that there are vast areas of water where phytoplankton growth is limited by iron.

Fujiwara: What made the researchers conduct that experiment? Was the motivation the carbon fixation?

Nishioka: There were two motives. For one thing, we didn't know if iron was enough for supporting phytoplankton growth or not in the ocean, so we tried to clarify its role in the phytoplankton ecosystem in terms of pure science. The other motive was related to venture business activity in the U.S. and Europe. An increasing number of these organizations have embarked on the business of emissions trading, such as sprinkling iron to make the ocean absorb CO_2. Because we didn't want people to jump into scientifically uncorroborated undertakings and adversely affect the environment or damage marine ecosystems, we introduced the experiment with the aim of clarifying what would actually happen scientifically. The answer from scientists as of now would be that we should not sprinkle iron recklessly.

Fujiwara: That's a relief, I thought scientists just tested an eccentric idea.

Nishioka: This experiment is highly regarded in that it has helped deepen our understanding of the ocean ecosystem. At the same time, we've also learned that the natural world can't be controlled so easily.

Fujiwara: So we should try to minimize CO_2 increases in the air. This would be the best thing humans can do, even though it's difficult. If we actively try to change variables, we'll end up with unexpected changes in unexpected places. We've come to understand that this is how the systems of Earth and nature work.

"The international community has reached a consensus on levels of philosophy and principles. The problem is how to substantiate them."–[Horiguchi]

My name is Takeo Horiguchi, and I'm studying international law as it relates to environmental protection, especially the precautionary principle. With regard to global warming, a number of international laws, rules and systems have come to the fore on a global basis. Examples include the UN Framework Convention on Climate Change concluded in 1992 and the Kyoto Protocol of 1997. The first one primarily stipulates the philosophy, objectives, principles and organization of global warming control, and the second lays down the more specific obligations of individual nations.

International rule-making isn't easy under the present circumstances though. Rules in today's international community have been established primarily in the form of treaties, but these can bind only nations that agree to them. That is, if you say no, you don't have to abide by the rules. To avoid these constraints, various contrivances have been used to establish environmental treaty systems, including a method referred to as the framework convention and protocol approach. First of all, areas that are easily covered by consensus-building, such as the basic objectives of a treaty, principles to realize the objectives, and organization to negotiate specific measures, are determined as a framework convention. Negotiations for specific rule making are then held within the framework based on scientific research results, and the outcome of the negotiations is summarized in the form of a protocol. This modality has actually been used in tackling global warming problems.

As far as global warming issues are concerned, nearly the entire international community has reached a consensus at least on the objectives and principles of the framework convention. For instance, it was stipulated as one of the treaty objectives that the concentration of greenhouse gases should be stabilized on levels that won't cause significant adverse effects. The precautionary principle was also proposed as the basic idea behind realizing the objective. It stipulates that the lack of full scientific certainty shall not be used as a reason for not taking measures to prevent environmental degradation. There is also another principle that allows for differences in obligations to be established between developed and developing nations. On the level of these principles, the international community has already reached a consensus.

The problem now, though, is how to materialize and give shape to them. The Kyoto Protocol was an important achievement, but failed to win the agreement of the U.S., and other major carbon dioxide emitters like China aren't bound by its terms and conditions. It's also a problem that the protocol only covers the period from 2008 to 2012. Now that discussions on the post-Kyoto Protocol framework are taking place, we face the major problem of how to secure the broad participation of nation states and how to allocate burdens among them to prevent global warming.

[Discussion]

Furukawa: How many countries have ratified the framework convention? One of the major problems with the Kyoto Protocol is that the U.S. withdrew from it. If Al Gore, who won the Nobel Peace Prize last year, had won the 2000 presidential election and become president of the U.S., the country might not have left the convention.

Horiguchi: More than 180 countries have ratified the framework convention. We can say that most of the nations on Earth have joined. I think the reluctance of the U.S. is partly attributable to President Bush, but it's also because the coal industry is powerful there and the ratification of conventions also requires Congressional approval. So we can't simply say that it depends on the President whether or not we can make progress, but it seems that the next one will tackle global warming issues more seriously.

Furukawa: Global warming is a very serious problem, and we're at a crucial point in establishing whether or not humans will be able to exist on the Earth in 100 years time. I think leaders around the world are also

well aware of this. In reality, though, international movements are slow to make progress. Why is that?

Horiguchi: Rule-making in the international community is based on consensus among nation states, which is fundamentally different from domestic societies where parliaments and other legislative bodies exist. If countries have conflicting national interests, rule-making is very difficult. It's a common understanding of the international community that global warming is a pressing issue, but it's not easy to decide which countries should fulfill what obligations. There isn't enough scientific knowledge of global warming, and the economic impact of regulations varies among countries. Under these circumstances, it takes time to establish specific regulatory systems. At long last though, we've reached the stage where we have a framework to share awareness of issues and negotiate on a regular basis.

Fujiwara: Was the precautionary principle devised around the time of the Montreal Protocol, a treaty designed to prevent the depletions of the ozone layer? I think this concept has caused, so to speak, a paradigm shift in that it transcends existing frameworks in the world. Who develops such new ideas in the international politics? How do such new ideas spread around the world?

Horiguchi: The precautionary principle in international law originated from European regulations on marine pollution in the North Sea. In the 1980s, a representative of West Germany advocated the precautionary principle for the first time and won the support of other European countries. The approach later came to be adopted for various environmental issues because the limitations of scientific knowledge of such issues were recognized and serious problems started happening. The establishment of the precautionary principle makes it possible to give effective guidelines for environmental protection. Needless to say, international institutions such as the UN Environment Programme, scientists and environmental NGOs have played an important role in the spread of the precautionary regulatory systems.

Nishioka: It seems that environmental issues are a set of problems that humans have never faced before. People are learning about what is going on in the natural environment, and are seeking to control it by using international laws at the same time. I think this is unprecedented.

[Kyoto Protocol]
The official name is the "Kyoto Protocol to the United Nations Framework Convention on Climate Change." This protocol was agreed upon on 11 December 1997 at the 3rd Conference of the Parties to the treaty (COP-3) held in Kyoto.

[IPCC]
The official name is the "Intergovernmental Panel on Climate Change." It assesses the scientific, technical and socio-economic information relevant to climate change. There are three working groups :WGI deals with the scientific basis of climate change, WG II deals with the impacts and options for adaptation, and WG III deals with options for mitigation.

"Bioethanol is touted as an ideal technology because it will prevent the total amount of CO_2 emissions from increasing."–[Mayama]

My name is Takafumi Mayama, and I'm in the second year of the Master's Program at the Graduate School of Engineering. I'd like to introduce bioethanol from the viewpoint of engineering. Bioethanol is alcohol produced from plants such as sugarcane and corn, and is expected to replace gasoline in the future. It seems that large amounts of bioethanol are already in use in the U.S. and Brazil. Its main characteristic lies in the fact that it does not increase the net amount of atmospheric CO_2. Plants absorb atmospheric CO_2

and produce organic matters through photosynthesis. Then, people use bioethanol produced from the organic matters for energy, and the bioethanol turns back into CO_2 and H_2O. During the process, unlike the case of using fossil fuel, atmospheric CO_2 doesn't increase. Bioethanol is becoming widespread because it not only avoids net CO_2 emissions from automobile but may also actually reduce them. The problem, though, is that machinery is needed to cultivate the plants used in making bioethanol, and the gasoline burned in the process emits CO_2, meaning that the net CO_2 emissions might actually be positive. There is another problem, which I think is the most serious. Bioethanol and food share the same ingredients, so any excessive dependence on bioethanol will cause food shortages for humans and livestock. The price of corn and other grains has actually been skyrocketing recently.

Field of corn which can be used as the material of bioethanol.

[Discussion]

Fujiwara: I tend to worry about disadvantages rather than advantages, but I believe that those promoting bioethanol should have a rather rosy view of the future. When we think about energy sources, we have oil, coal and nuclear power. We also have hydraulic power, solar power and wind power as natural energy sources. Now we have biomass and bioethanol. I think there are two points to be made from an engineering perspective. The first is how much energy can be produced and how efficient it is, and the other is the ease of use. Gasoline is probably easier to use and burns readily because it's liquid. Cars driven by nuclear power would be difficult to be realized. Bioethanol is wonderful in that it hardly produces any CO_2 at all, if true, but what about its energy efficiency, the amount of energy it produces and its ease of use?

Mayama: It's thought to have almost the same energy efficiency as gasoline, which is why it's considered so promising. Because plant cultivation requires machinery, and CO_2 is produced when bioethanol is burned, the amount of CO_2 will ultimately increase. The increase, though, is much smaller than the amount that's produced when fossil fuels are used. Solar and wind power are also difficult to control because they involve dealing with nature.

Fujiwara: OK, once we have ethanol, then it can be used like gasoline. Now, how much arable land is needed to produce enough ethanol? Will an area maybe the size of Japan be necessary to produce enough to replace gasoline for all vehicles in the world? Or will it be more like the size of Hokkaido, or maybe the size of the U.S.?

Mayama: What I can tell you is that it will need to be an area much bigger than Japan-we'll need an extremely large area of land. If we're aiming to replace all vehicle fuel with biomass, consumption will outpace plant growth and it won't be possible to keep up.

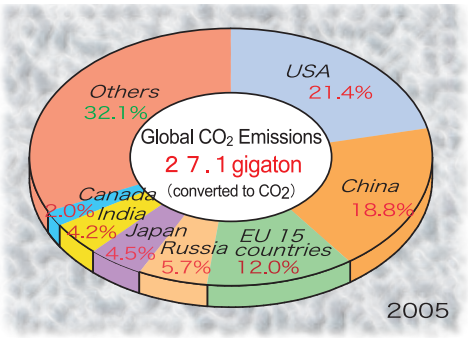
Nishioka: Is there a possibility that biomass will be in significant demand and will be produced very efficiently? If so, things may be different. Is it possible to produce fuel more efficiently without generating unnecessary CO_2? Have we reached the limits of our capabilities?

Mayama: There are limits, but we also have to explore the various possibilities.

"China appears willing to cooperate in the Clean Development Mechanism."–[Ma]

My name is Fang Ma, and I'm an international student from Dalian, China. I studied Japanese language and culture at the Hokkaido University of Education for one year from April 2005. I enjoyed my various experiences in Hokkaido, including cherry blossom viewing in spring, skiing in winter, hot springs, tea ceremonies, Zen sitting meditation, seeing how waste is separated in Japan, the Yosakoi Soran Festival, the Ainu Museum and so forth. What struck me most in those days was that the sky over Hokkaido was much bluer than that over Dalian, which made me think about environmental issues. Living abroad gives you a perspective on your own country. Considering my country, which faces environmental issues and problems with inequality between the haves and have-nots, I came back to Japan last autumn and began studying environmental economics at Hokkaido University. I hope to contribute to resolving environmental problems in China in the future.

There are two types of anti-warming measures: the engineering approach, which includes methods such as energy-saving technology, and the economic approach that takes advantage of market principles. Specifically, the international community must standardize and formalize the three Kyoto mechanisms of the Kyoto Protocol, that is, Joint Implementation, the Clean Development Mechanism (CDM) and international emissions trading. Because China is not obliged to reduce greenhouse gas emissions though, CDM is the only way for my country to enter the carbon market. In CDM, developed and developing countries jointly implement projects, and the developed countries that invest in developing countries can use the projects' greenhouse gas emission reductions to help achieve their own reduction goals. CDM is attracting the attention of developed countries because it's difficult for them to meet their reduction targets through domestic efforts alone. The mechanism is also attractive to developing countries because they are provided with funds as well as technological expertise by developed countries. Currently, the Chinese government is willing to participate in CDM projects. To date, more than 20 such projects have already been authorized by the central government, and overseas countries are also putting cooperative frameworks into place.



Based on IEA "CO_2 EMISSION FROM FUEL COMBUSTION" 2007 EDITION. "EU 15 countries" refer to the EU's member countries at the COP3 (1997).

[Discussion]

Furukawa: Beijing's hosting of the 2008 Olympics has highlighted environmental issues in China, hasn't it?

Ma: Yes. Because environment, culture and sports are the important themes of the Olympics, I hope China will seize this opportunity to address the environmental issues it faces.

Fujiwara: Are there any changes in awareness among people? For example, do people discuss environmental issues at home?

Ma: No, I don't think many people do.

Fujiwara: But aren't there people suffering from asthma, for example, due to air pollution? In Japan, pollution used to be a major social problem.

Ma: We have pollution, and victims of it are suffering, but they don't receive money from the government. Of course, pollution is reported in newspapers and on TV news programs though.

Fujiwara: Don't victims ask for improvements or file lawsuits?

Ma: An increasing number of people participate in the activities of nongovernmental organizations, or NGOs, which are very popular now. That said, NGO activities aren't so easy.

Furukawa: To what extent has the Clean Development Mechanism (CDM) started in China?

Horiguchi: With regard to CDM, the issuance of emission units has already begun. The Kyoto mechanism theoretically aims to involve the entire international community to reduce greenhouse gases at the lowest possible cost, but there are a number of problems with this. One of them is that the operation of the CDM system per se incurs costs because emission reductions must be monitored and certificated.

Furukawa: China holds the key to addressing global warming in every way. In China, CO_2 emissions are skyrocketing, although I think that's natural considering its population.

Ma: Indeed. Right now, the largest CO_2 emitter is the U.S. and the second is China, and they might well trade places in the near future. China isn't obliged to reduce greenhouse gases, but if it does, it will have a great effect on the global reduction scenario.

"Human beings' view of nature as an object may have caused the current environmental crisis."–[Matsuyama]

My name is Mao Matsuyama, and I'm a graduate of Hokkaido University's School of Science. While conducting my graduation research, I began to doubt the scientific habit of separating myself from nature and observing it as a target of analysis. Then, I moved to the current laboratory at the Graduate School of Letters because I wanted to study the relationships between human beings and nature or the environment. I'm currently researching Hundertwasser (1928 – 2000), an artist and architect from Vienna who tackled environmental issues. He focused on harmonious coexistence of human with nature, and made about 30 projects later in his career in search of structures that could overcome the traditional architectural method and modern, rationalistic architecture. "Window rights" is one of the characteristics of his architecture, and stated that a person in a rented apartment must be allowed to lean out of his window and paint the outside within arm's reach in colors of his choice. This was based on his belief that even residents of rented apartments should be able to recover an ordinary way of living without being forced into uniform, anonymous rooms, meaning that they could recover their homes as the centers of their world. He also introduced "the Five Skins concept": the first skin is biological; the second skin is clothing; the third skin is the home; the fourth is the social environment; and the fifth is the global environment. He believed that the re-establishment of normal relationships with homes would serve as an opportunity to recover relationships with its outer skins of the social environment and the global environment.

Thinking about the term environment, environs means surroundings, and humans are always at the center. That is to say, people suggest protecting the Earth or solving environmental problems because it's a necessity for human beings themselves, or is needed for us ourselves to continue living. Looking back on the relationship between humans and nature, I think we can see the causes of the current environmental crisis in our views toward nature at an early stage. In science, for example, nature is viewed as an object that is to be analyzed. Also in the field of arts, by the time landscape painting was established, nature was viewed simply as an object of drawing. That

is, painters considered themselves as an existence separated from the nature they were looking at. The very way of viewing nature as an object caused the current situation of environmental crisis. So I think unless we change that attitude or awareness, we won't be able to fundamentally address the issues involved even if we manage to solve individual problems. This is the focus of my research right now.

Hundertwasser, 1998 ©Hannes Grobe.

Hundertwasser house ©Andrzej Barabasz, 2002.

[Discussion]

Fujiwara: You said that viewing nature as an object is the root cause of the problems. But I think that this is inevitable because of the structure of the human brain. I believe that human beings can view things only as objects. I think science is something that pursues truth and seeks to find answers in a way that will convince everyone. In trying to achieve this, phenomena are viewed as objects and segmentalized into individual elements for analysis. They are then rearranged on a logic track, and I think this process constitutes understanding.

Matsuyama: Contemporary art includes a field called environmental art or earthwork. There's an artist called Christo, for example, who wraps small islands in fabric. He tries to give the observer the viewpoint of being part of the work instead of the viewpoint held when looking at it from the outside.

Fujiwara: I'm not sure if we're talking about the same thing, but there were arguments in the 70s and 80s that science, which features segmentalized analysis, wouldn't be able to solve environmental problems, and that reductionism would not be enough and integration would be necessary. But the arguments failed to gain ground or produce specific solutions.

Nishioka: Having listened to your remarks, I think global warming issues clearly portray that humans are part of the Earth's system. Scientists realized that human beings are part of the Earth and nature only 20 to 30 years ago, and I think problems such as global warming and ozone layer depletion played a major role in this regard.

Matsuyama: I see. Scientists have also come to think that humans should also be considered part of nature. It seems that the paradigm shift occurred a little earlier in the art field, but we can safely say that artists are still searching for the next new models.

Furukawa: Today, people working in different fields of expertise have assembled and talked on the single theme of global warming. It has given me a glimpse into the discussions about the global environment that are under way in various directions. I think continuing such discussions is important for addressing environmental issues in a well-balanced, comprehensive manner.

Matsuyama: In trying to solve environmental problems, asking for the opinions of those in different fields every time will get us nowhere, but it's important to know that various opinions exist and that a range of discussions are taking place everywhere.

Fujiwara: I think problems with global warming boil down to problems with modern civilization. They amount to civilization issues that people in all fields must become involved in. It's important to engage in discussions from a broad perspective. More importantly, we need to hear about the various discussions that are under way, but there aren't so many opportunities to do so. We can only learn about discussions on aspects of natural science as well as political and economic aspects in a fragmented way. I feel that times have changed from an era when experts worked hard in their respective fields to a situation where everybody should understand the whole picture and check if the overall direction is correct.

Furukawa: Thank you very much.