NATIONAL INSTITUTE FOR MATERIALS SCIENCE

NIMS NOW

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2017

New strategy in the era of open innovation

M³ launched






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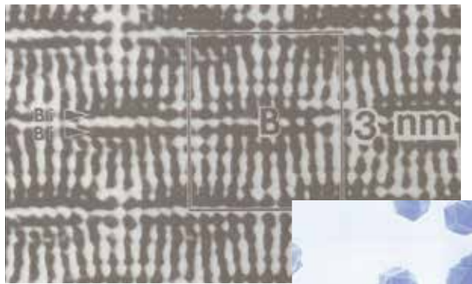
In October 2016, NIMS was promoted to a designated national research and development institute.
The missions of designated institutes are to produce the world's highest level of R&D results and facilitate research collaboration among industry, academia and government.
Moreover, the designated institutes are expected to lead the effort to make Japan the most innovation-friendly country in the world.

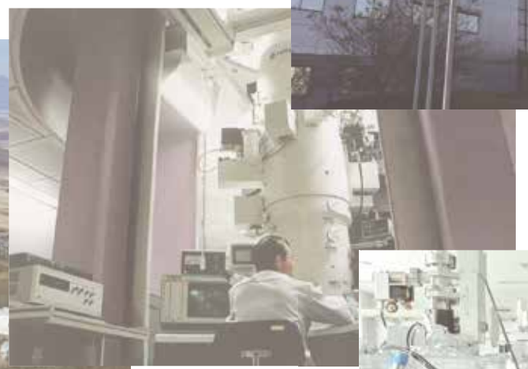
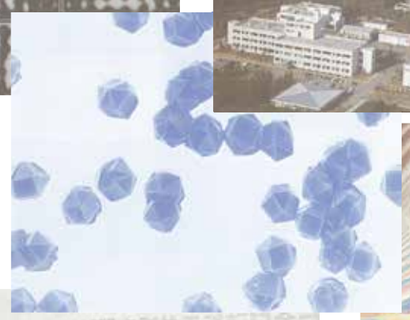
NIMS has been supporting Japan's industries as a materials research specialist, and is therefore resourceful in leading efforts to create innovation.

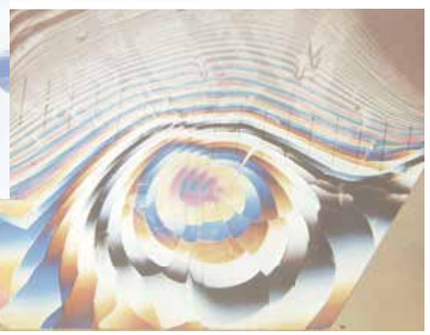
NIMS has acquired rich knowledge and experience and advanced equipment over the last 60 years, including when it was called the National Research Institute for Metals and then the National Institute for Research in Inorganic Materials.
Another asset of NIMS is represented by the diligent and uncompromising researchers who steadily study materials.
NIMS's unmatched resources make it possible to transform innovative ideas into novel technologies.

The new strategy of NIMS, M³ (M-cube), has swung into action to bring together industry, universities and research institutes and make the most of its resources.

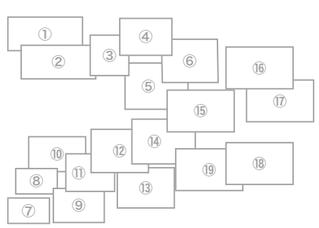
NIMS continues to evolve under the fundamental principle: the true value of materials is in their use.
It will make another major step forward.






[National Research Institute for Metals (NRIM)] (1) NRIM when it began operation in Meguro, (2) Superconducting materials research building, the first NRIM facility constructed in Tsukuba (1975), (3) Atmosphere rolling mill, (4) Facility for fatigue tests and creep tests opened to the public (1974), (5) Location of Tsukuba Office before construction, and (6) Experiment of multistage continuous steelmaking underway. **[National Institute for Research in Inorganic Materials (NIRIM)]** (7) Government office in Iogi (1966), (8) Main building of the government office in Komagome (1968), (9) Opening ceremony after relocating NIRIM to Tsukuba (1972), (10) Modulated structure of bismuth-based high-temperature superconductor observed using an ultra-high voltage electron microscope, (11) Diamond microparticles obtained using a vapor deposition method, (12) Aerial view of NIRIM at the location now known as Namiki Site of NIMS (1975), (13) Differential interference micrograph of a silicon carbide single crystal, and (14) Ultra-high voltage electron microscope in operation. **[NIMS]** (15) NIMS at the Sengen Site, (16) Creep testing machines, (17) SiAlON phosphors, (18) Cell culture lab (clean room) at the former Biomaterials Center, and (19) Ultrahigh vacuum sputtering cluster used for thin film deposition.



Interview with President
KAZUHITO HASHIMOTO

NIMS takes on new missions by founding M³ (M-cube)

NIMS has made a new start as a designated national research and development institute. To fulfill its new missions, NIMS is planning a new framework called M³. NIMS President Kazuhito Hashimoto, who has many years of experience working in academia and is also knowledgeable about industrial sector and national policies, is expected to show strong leadership in this initiative to facilitate collaboration among industry, academia and government. We asked President Hashimoto about NIMS' new missions through the M³ framework.

Why was NIMS, a group of materials research specialists, selected?

NIMS was promoted to a designated national R&D institute in October 2016. NIMS, which has been leading materials research as a national institute, will undertake even greater missions. Specifically, the following is stated in the basic policy formulated based on the "Act on Special Measures concerning the Promotion of Research and Development by the Designated National Research and Development Agencies":

1. Serve as a core institute to lead Japan's innovation system,

2. Achieve the world's highest level of R&D results, and

3. Take a pioneering approach in the operational aspect in order to accomplish the second mission.

In other words, people expect NIMS to serve as a venue for collaboration so that knowledge gained in academia can be transferred to industry, and produce R&D results that meet the world's highest standard. These missions are very challenging, but they reflect people's great expectations for us. Two other national R&D institutes, RIKEN and National Institute of Advanced Industrial Science and Technology (AIST), which also earned the designation this time, are much larger organizations than NIMS, as their budgets are about four times greater than that for NIMS. Moreover, the scope of our research is limited to the materials field. Despite these limits, NIMS has received the designation. I believe this happened because our potential was recognized. These three institutes will lead Japan's innovative efforts together.

M³: a framework to accomplish the missions

Viewing this corporate status transition as a great opportunity, we worked to create a new framework to undertake the missions since the new act mentioned above passed at an ordinary Diet session in May 2016. We first discussed what the key concept of a designated national R&D institute should be. We reached a conclusion that NIMS ought to aim at providing venues for bringing together people, tools and funding from industry, academia and government as a core institute that firmly leads Japan's innovation system. Then, we translated the idea into a concrete framework for accomplishing the missions while taking into account the present situation of Japan's industries.

Our ideas eventually took the shape of M³ (M-cube). The three "M"'s represent three venues to be created by NIMS: the Materials Open Platform (MOP) that promotes open innovation by industries and research institutes, the Materials Global Center (MGC) that serves as an international research center to attract people, tools and funding from all over the world, and the Materials Research Bank (MRB) that serves as world-class research infrastructure to make the most of MOP and MGC activities. These three venues will function interactively, enabling NIMS to serve as a global hub for materials R&D, and to boost activities in materials science.

Promoting "horizontal collaboration"

Japan's industries have been able to stay competitive globally through independent operation by individual manufacturers. That is, each company has undertaken all steps of production from R&D to product-making. On the other hand, industries overseas have made a major shift in their approach over the last 10 years—Open innovation has become a common practice as they actively outsource manufacturing to other organizations, incorporate R&D products created by venture companies, or collaborate with other companies.

Open innovation has been practiced in Japan, too, but it always takes the form of "vertical collaboration" where a partnership is formed between a university or research institute which performs basic research, and a private company which puts the basic research results attained from the university into product-making or practical application. That is because such partnership often brings win-win outcomes as it allows both parties to focus on tasks they are strong at (i.e., basic research and product-making).

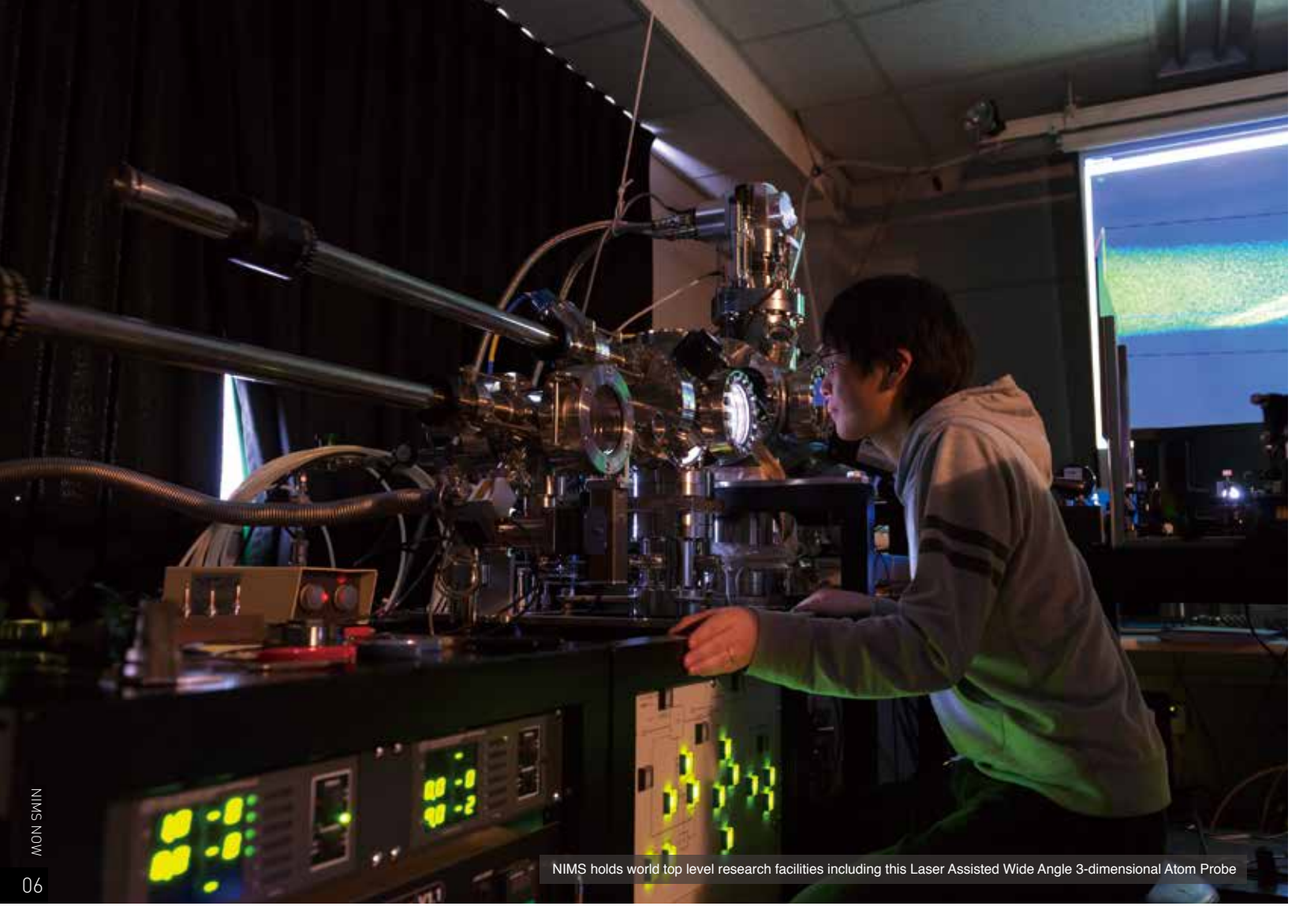
In contrast, open innovation in the form of "horizontal collaboration" has been uncommon in Japan. Horizontal collaboration takes place between private companies in the same industrial sector, and is a framework whereby they work together only in a part of a project where collaboration benefits both, and compete with each other in the rest of the project. If this type of collaboration can be popularized, it will help bring together people, tools and funding from the entire industrial sector, which will then attract more investments. The Japanese government also views horizontal collaboration as vital to strengthening the global competitiveness of Japan's industries. However, it is challenging to promote collaboration between rival companies for obvious reasons. We thought that NIMS can make a contribution to overcome this issue.

NIMS and its predecessors, the National Research Institute for Metals and the National Institute for Research in Inorganic Materials, combined together have received national funding for more than 50 years. As a result, we were able to attract some of the world's leading scientists and equipment to NIMS and have gained strength in problem-solving oriented projects. We consider these resources of NIMS as Japan's assets and would like to make them available to industries for their effective use and horizontal collaboration. That is the purpose of founding MOP.

Performing basic research jointly

The problem of horizontal collaboration is that even though we generally know the importance of it, it is difficult for participants to actually determine the appropriate extent of open collaboration in each specific R&D project. The greater the extent of open collaboration is, the more beneficial it will be to the entire industrial sector, but there is also a risk that collaborating companies may lose their competitive edge.

Under such conditions, the basic research divisions of most private companies tend



NIMS holds world top level research facilities including this Laser Assisted Wide Angle 3-dimensional Atom Probe

to possess similar equipment and work on similar research objectives independently. However, joint efforts in basic research can be beneficial to participants since basic research does not directly tie with product-making or commercialization. In this light, we are planning to encourage private companies to transfer a part of their basic research functions to NIMS.

Most private companies are making slow progress in long-term basic research due to economic reasons and obligations to make achievements on a quarterly basis. Moreover, it is becoming increasingly difficult for each company to complete basic research projects by itself, while an interdisciplinary approach to research has made some success in producing novel results in recent years. That is why horizontal collaboration is a promising approach.

When we implement MOP, appropriate research themes need to be selected because inadequate themes potentially result in taking jobs away from company employees. Horizontal collaboration is truly effective only if adequate basic research themes are selected. So, MOP must offer attractive research projects that can be achieved only through collaboration between private companies.

Creating an attractive open innovation framework

We plan to start MOP with initial focuses on steel and polymers, since NIMS has strength in these fields and Japan is internationally competitive in these markets. Accordingly, we have invited top companies in these fields to join MOP. So far, three steel manufacturers and five chemical manufacturers are considering the invitation positively.

Participation of NIMS researchers in MOP is also critical to make this major NIMS effort a success. To convince already busy researchers to undertake this mission, it is important that the MOP initiative be attractive and rewarding. One attractive feature of MOP is that basic research accomplishments made by NIMS researchers can be readily transferred to collaborating private companies that work on product-making and practical application. However, we do not think that alone would be good enough, and are currently considering concrete plans to make MOP more attractive and worthwhile for NIMS researchers.

In addition, to bring together all knowledge and expertise from across Japan, we will implement a cross-appointment system to invite university researchers to MOP.

Encouraging frank talk between participants

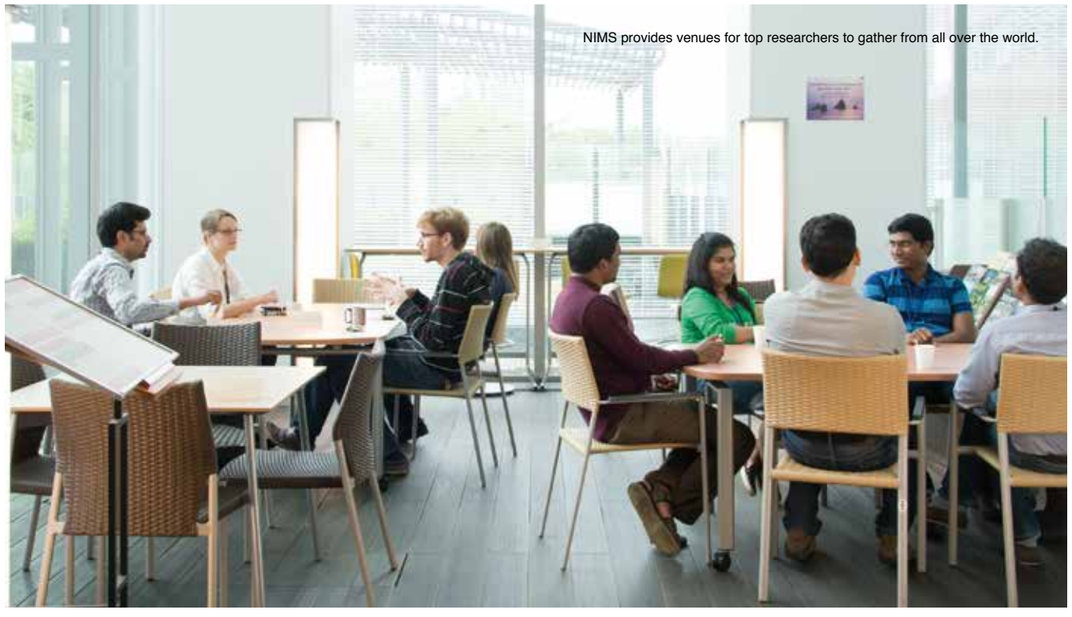
If we succeed in inviting outstanding Japanese researchers and acquiring high-quality equipment available in Japan, our next step would be to attract talented researchers from across the world. We can achieve this through MGC. Specifically, we will invite brilliant young researchers using the

globally recognized NIMS's tenure track system, the ICYS program, and attract people, tools and funding from collaborating organizations in Japan and overseas to MGC. Then, we will establish MRB, a world-class research infrastructure, which is designed to facilitate smooth research activities by groups of capable researchers participating in MOP and MGC. In order to create a research-friendly environment for them, we plan to not only provide necessary experimental equipment but also establish a data platform to accumulate and effectively use a large amount of information. While university researchers can join MOP only by signing an employment contract using the cross-appointment system, MRB will actively invite regional university researchers by paying their travelling and accommodation costs when they come from a distant location.

When these three "M"'s function harmoniously, they are expected to attract people, tools and funding to NIMS, which will subsequently strengthen NIMS's problem-solving capability and attract even more people and tools, like a positive spiral. The Japanese government has found the concept of M^3 significant and decided to fund the project. So, we are set to launch the M^3 initiative in a full-fledged manner from April 2017 as a means to fulfill the missions of a designated national R&D institute.

Last, I personally believe that the key to success depends on whether researchers who are coming to NIMS to participate in M^3 can engage in frank discussions, for example, to identify research areas in which they can work together, or the types of skills and experiences needed to achieve their goals. In this regard, I started my career in academia and am familiar with industries and national policies. Because of these experiences, I know very well the situations of these three sectors—industry, academia and government—and look forward to having frank talks with them. I feel this kind of commitment is my obligation as NIMS President. You might see something new and amazing emerge from NIMS.

(by Akiko Ikeda, Sci-Tech Communications)



NIMS provides venues for top researchers to gather from all over the world.

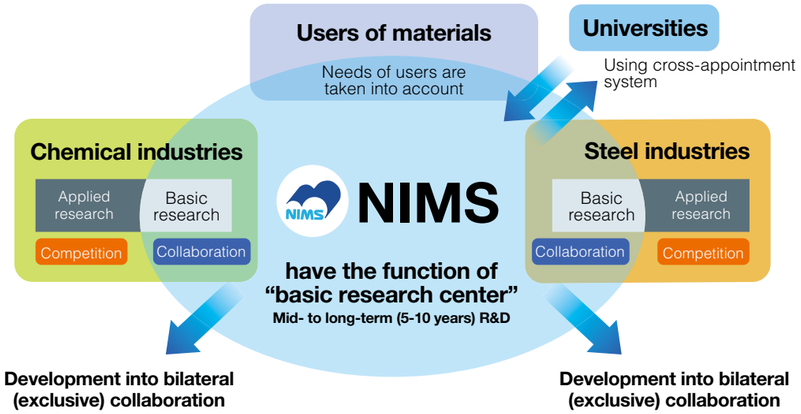
M³—the Program for Strengthening Innovative Materials Development

Consolidating **basic research functions** of industries and research institutes

MOP

Materials Open Platform

We will establish industrial-sector-specific, NIMS-led open platforms by bringing in basic research functions of private companies.
Then, we will boost the creation of innovation through "horizontal collaboration" among private companies in the same industrial sector.



NIMS

Strengthening Japan's materials development capability

by serving as collaboration hubs specific to industrial sectors

Establishing **global research center** that brings together people, tools and funding from all over the world

MGC

Materials Global Center

We aim to establish a global center that attracts people, tools and funding, and inviting talented young researchers and research organizations for joint studies from around the world by using NIMS's tenure track system (ICYS program).

Developing **world-class research infrastructure** to make the most of MOP and MGC

MRB

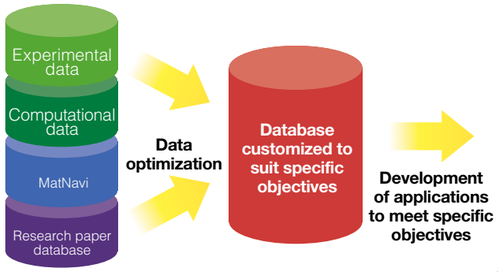
Materials Research Bank

Knowledge — Insight — Technique — Tools

Establishing a world-class data bank

Creation of materials data platform

We aim to form a platform that facilitates the use of big data by compiling reliable research data accumulated at NIMS along with data from academic institutions, private companies, etc.



Contributing to regional revitalization

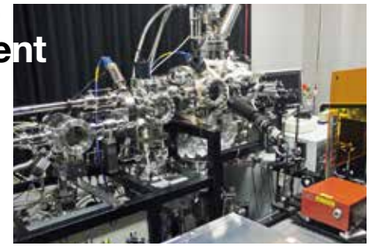
Knowledge network

We will form a knowledge network based at NIMS through providing research equipment and funding to outstanding researchers from all over Japan, thereby promoting regional revitalization and innovative research.

Shared use of attractive research environment

Access to world-class measurement facilities

We will make an array of advanced measurement facilities available widely to researchers, allowing them to collect high-quality, reliable data and perform analysis from various angles.



Special Round Table Talk

The missions of the designated national research and development institutes

The corporate statuses of the National Institute for Materials Science (NIMS), National Institute of Advanced Industrial Science and Technology (AIST), and RIKEN were renewed to designated national research and development institutes on October 1, 2016. What are the expectations for the designated institutes? And how will they meet the expectations? The presidents of the three institutes discussed these matters, with nonfiction author Kazuma Yamane moderating the talk.

Kazuhito Hashimoto

President of the National Institute for Materials Science (NIMS)

"Japanese industries are internationally competitive in materials research. NIMS has a responsibility to create innovation and lead revitalization of Japan's economy"

Leading collaboration among industries, universities and national research institutes

Yamane: Three national institutes, at which the three of you serve as president, underwent a transition to become designated national R&D institutes in October last year. First, what is your resolution on this transition?

Hashimoto: People's expectations for science and technology are growing rapidly these days. Revitalization of economy is Japan's major political agenda, and to address this issue, it is vital to generate innovations through R&D activities and give the achievement back to the society. Japanese industries are very competitive internationally, and Japan's academic standards are also at the world's top level. Despite these facts, however, I feel Japan's capability to create innovative products has been weak in recent years. That is largely because industries, universities and national institutes carry out R&D activities in isolation. The roles of national R&D institutes are to carry out basic research and share the outcomes with the industrial sector, thereby demonstrating leadership in society. Designated national R&D institutes are expected to stand at the forefront of this endeavor. I am feeling immense responsibility to meet these expectations.

Chubachi: To create innovation, it is vital to strengthen collaboration among industries, universities and national institutes even more. As president of AIST, I hope our organization will play a central role in promoting open collaboration among these three sectors in order to build a sustainable society and industries. To this end, we will engage in goal-oriented basic research leading to innovative technology, share research outcomes with industries, and foster innovative researchers. We will commit to these tasks with even more vigor than before.

Matsumoto: Designated national R&D institutes are defined as institutes that create the world's highest level of research and development results. At RIKEN, researchers in various fields, including life science, physics, chemistry and engineering, interact freely on a daily basis in discussion, and perform groundbreaking and advanced basic research. Through such interaction, innovative ideas emerge. However, there is a difference between merely having seeds of innovative ideas and actually creating innovation. We will continue to engage in basic research as before, and at the same time, we will intensify our efforts to construct a system by which we can contribute to create the innovation as Japan's strength.

Finding the form of ideal society through discussion between scientists and nonscientists

Yamane: Japanese researchers engaging in scientific and technological research have great skills and talents. So, why is it uncommon for them to be innovative?

Matsumoto: Acquisition of knowledge and skills is not enough to generate innovation. In addition, leading-edge science today has been divided into many specialized fields, and researchers tend to confine themselves within their specialized fields. In order to generate innovation successively, we need people who have a vision of an ideal society filled with fascination and dreams, upon understanding the current status of Japan's science and technology.

Yamane: I think it would be a good idea to involve nonscientists in discussions regarding the form of ideal future society.

Chubachi: I think so, too. As far as college students are concerned, only 30% of them are science majors. Since the majority of people are nonscientists, their viewpoints are indispensable for crafting a vision of the ideal society.

Hashimoto: The 5th science and technology basic plan, which launched from FY2016, put forward the future vision of ideal society under the concept of Society 5.0. The 5th plan is fundamentally different from previous similar plans in terms of approach; while the conventional plans envisioned future society based on the level of technology achievable, the 5th plan discusses the form of an ideal society first, then suggests the type of technology necessary to achieve that goal. Society 5.0 represents the concept of a "super-smart society," which is an elaborate fusion of cyberspace and physical space (the real world). The formulation of this concept involved not only scientists, engineers and governments but also industries. Therefore, it is vital for scientists to work with researchers in cultural studies and social science, as said by Mr. Yamane and Dr. Chubachi, to find consensus on the form of the ideal future society.

Matsumoto: Our other task is to encourage researchers who tend to focus intensively on their own research to consider collaboration with other researchers in different fields.

Hashimoto: I agree. Japanese society today is about to undergo a big change, but many scientists are not aware of that. It is vital to invite both scientists and engineers as key players to discussions on the vision of future society. Otherwise, such discussions may not lead to sound and satisfying decision making. So, I want scientists and engineers to be aware of that new role seriously.

Research to be preserved, and research that needs change

Yamane: I was very impressed by many things I observed during my visit to your institutes before this talk. One such thing was creep tests performed at NIMS. I saw that steel rods that are used in power plant boilers and pressure containers were subjected to continuous tensile force, and distortion and durability measurements were carried out. I was told that this particular test had been continuing for more than 40 years, and made a world record for the duration.

"To create innovation, it is vital to strengthen collaboration among industries, universities and national institutes. AIST will play a central role in promoting open collaboration among these three sectors"

Ryoji Chubachi

President of the National Institute of Advanced Industrial Science and Technology (AIST)

Hiroshi Matsumoto

President of RIKEN

"We need to generate innovation through groundbreaking and advanced basic research. It is vital to build a system which provides job security and flexible job options to researchers"

Hashimoto: Creep tests are most fundamental studies that contribute to Japan's industries in terms of upholding their global credibility. However, these studies are often underappreciated and considered even unnecessary from the viewpoints of producing many papers and obtaining patent rights, and due to the current public expectations for novel scientific discoveries. Fortunately, previous NIMS leaders understood the value of basic research such as creep tests and therefore preserved these studies. As the current president of NIMS, I strongly support this tradition. On the other hand, I also recognize that some types of research activities need new direction. It is important for leaders of national R&D institutes distribute the limited resources appropriately.

Chubachi: AIST has been conducting geological surveys on active faults and updating measurement standards for a long time. These efforts are also often underappreciated. However, information provided from these research efforts has great importance to Japanese people and society as it supports their living and economic activities in a profound way. These research activities that require perseverance can be implemented only by national R&D institutes, and we have a responsibility to continue these efforts.

Matsumoto: Some people do not understand the value of basic research. In this regard, the vision of basic researchers is critical. For example, the 113th chemical element nihonium, which was discovered recently, breaks down instantaneously. However, some researchers are attempting to understand the instantaneous nuclear reaction of nihonium with the goal of applying the findings to improve the disposal of nuclear wastes. It is important for us to convey this sort of information and its value to society.

Making research profession more attractive

Yamane: Are there new plans to attain and foster talented researchers?

Matsumoto: We have many issues concerning the current system to train young researchers. It is difficult for young researchers to tackle long-term, creative basic research because many of them are appointed for a fixed term. Some of the brilliant researchers are recent college graduates. At RIKEN, we are planning to launch a system which will allow us to solicit such college graduates from around the world, provide them with sufficient salary and research funds, and offer a liberal and conducive study environment in which they can focus on research for five to seven years.

Chubachi: A researcher in his mid-30s recently told me that he finally became a permanent employee and for the first time he was able to think about major life events such as marriage and having his own house. If he represents the average researcher, could we call this profession attractive? We must improve the current personnel system in this sector while incorporating the opinions of young people.

Hashimoto: At NIMS, we are considering launching a similar system which allows outstanding young researchers to take charge of laboratories and conduct research responsibly.

Matsumoto: One of our missions is to build a system which provides job security and flexible job options to researchers. This goal cannot be achieved by one organization but requires discussion involving national R&D institutes, universities and industries.

Establishing a center for collaborative research on new materials and steel at NIMS

Yamane: As designated national R&D institutes, have you set forth any intriguing plans?

Hashimoto: We are planning to create a collaborative research base at NIMS and invite industries in two fields: chemical and steel industries that produce new materials (see pages 4-9). Japan is internationally competitive in these fields. Industries in the same field usually compete with each other, but for certain projects, it is better for them to work together in order to achieve major advancements in research. We intend to identify such projects, so researchers from industries, universities and NIMS can work on them jointly.

Matsumoto: It is important to seek new ways of collaboration among industries. RIKEN used to have a solid network with industries, called the Riken Konzern. We are now planning to launch an updated version of the network as a means to offer RIKEN resources to industries for their use and ask them to share expenses. Through this system, industries can perform basic research at lower cost than doing so by maintaining their own laboratories, while RIKEN can secure funding sources for its operation.

Chubachi: AIST has set a rather ambitious goal of tripling the amount of research funding acquisition from private firms over the next 5 years starting FY2015, by strengthening AIST's role of bridging technology and industries. To achieve this, we are working to establish collaboration laboratories, the names of which represent the collaborating companies, in AIST. We are also taking initiatives to set up Open Innovation Laboratories (OILs) at universities as bases for collaborative research among industry, academia and government. I believe that active interactions among national R&D institutes, industries and universities will facilitate the growth of Japanese industries and universities in terms of their research capabilities.

Yamane: AIST, RIKEN and NIMS are unique on their own ways, but they also share some things in common. By these institutes working together and competing with each other, I believe they can effectively promote research of great significance, application of research accomplishments to society, enhancement of the research environment, and technological development across Japan. Moreover, I have a feeling that something positive and exciting will arise through collaboration among 27 national R&D institutes. As the presidents of three designated national R&D institutes, your responsibilities will probably expand, but I have great expectations for your future endeavors.

(by Shino Suzuki, PhotonCreate)

"I hope this three-man talk will promote the strengthening of networks among research organizations under the leadership of these three national R&D institutes. I expect something positive and exciting will arise successively through collaboration among 27 national R&D institutes"

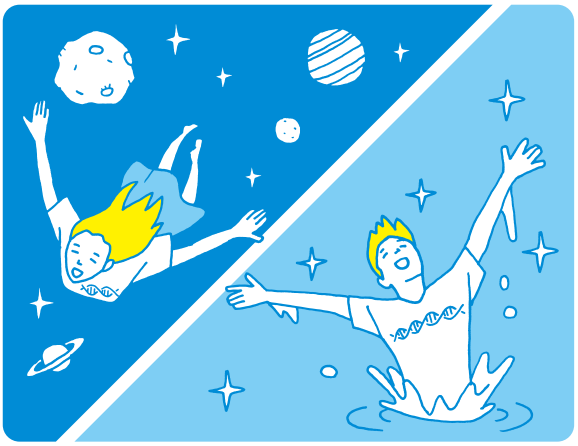
Kazuma Yamane

Nonfiction author,
Specially appointed professor
of the Department of Economics,
Dokkyo University

NIMS NOW INTERNATIONAL
No. 2
2017

Where did life come from?

Written by Akio Etori
Illustration by Joe Okada (vision track)



It is a big mystery as to when and where life originated.

In his 1859 publication of "On the Origin of Species," Charles Darwin presented the idea that all organisms are related to each other in the sense that they all came into existence through the course of evolution. However, he was unsure about life's origin, and he only suggested in a private letter that the first lifeform might have been formed in a warm little pond.

If you view lifeforms simply as protein solutions enclosed in a lipid membrane, you might wonder how amino acids, the building blocks of proteins, originated.

The theory of chemical evolution of life provides an explanation to this question. Chemical evolution suggests that life arose gradually following the formation of organic substances, such as amino acids, from inorganic matter.

This concept was first postulated by a Soviet biologist, Alexander Oparin. According to Oparin, life began in a primordial soup of organic matter, which formed through chemical evolution.

The theory gained much attention when American chemist Stanley Miller performed experiments in which he created a gaseous mixture imitating the primitive Earth's atmosphere, placed it into flasks, and exposed the gases to repeated electrical discharge for one week. As a result, amino acids were synthesized.

There are alternative theories. One of them is the iron–sulfur world hypothesis proposed by German chemist Günter Wächtershäuser in the late 20th century, which suggests that life began not in a primordial soup but on the surfaces of iron sulfide minerals such as pyrite (FeS_2). He hypothesized that a series of chemical reactions took place on pyrite surfaces, which led to the creation of organic molecules and eventually to lifeforms.

Hiromoto Nakazawa, a NIMS emeritus fellow, has also proposed a unique hypothesis that organic compounds, including DNA, were formed when ironcontaining meteorites collided with Earth. He and his coworkers experimentally demonstrated that a simulated meteorite impact led to the formation of biomolecules.

Some scientists doubt the spontaneous occurrence of life on Earth.

Svante Arrhenius, a Swedish scientist who won the Nobel Prize in 1903 for his work on electrolytes, put forward a hypothesis now known as panspermia. It presents that lifeforms exist throughout the universe, and they arrived at Earth in the form of spores.

Also, astrobiology has gained popularity in recent years. Joseph Kirschvink, a professor at the California Institute of Technology, is a leading figure in this field. He has presented the idea that life on Earth might have originated in Mars.

Life on Earth is thought to have emerged 3.8 billion years ago. Professor Kirschvink has said that conditions of Earth back then were unfavorable for the birth of life.

That is because the surface of early Earth was covered almost entirely by the sea and there was no land. In contrast, Mars 4 billion years ago had both lands and water. Moreover, it had abundant mineral supply, vital to biological activities including RNA synthesis. In this light, ancient Mars might have had an environment far more favorable for life to emerge than ancient Earth.

We are still uncertain about how life began. However, astronomy, biology and space observation technology have been making rapid progress in recent years. New studies indicate the possible existence of planets outside our solar system with a life-friendly environment similar or superior to Earth.

With new discoveries, the mystery of life's origin might be solved in the not-too-distant future.

Akio Etori: Born in 1934. Science journalist. After graduating from College of Arts and Sciences, the University of Tokyo, he produced mainly science programs as a television producer and director at Nihon Educational Television (current TV Asahi) and TV Tokyo, after which he became the editor in chief of the science magazine Nikkei Science. Successively he held posts including director of Nikkei Science Inc., executive director of Mita Press Inc., visiting professor of the Research Center for Advanced Science and Technology, the University of Tokyo, and director of the Japan Science Foundation.

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