OCARINA通信

The OCU Advanced Research Institute for Natural Science and Technology

木下 佑一氏
デザイン・イラスト

VOL.8
2019.3

Special Feature Article

Handing over OCARINA's ambitious philosophy to the new university

Having passed the 10-year milestone since its establishment, OCARINA is now entering a new phase. When we look back on the path we have travelled, we recognize anew how the organization and the education for young researchers, performed within OCARINA should be; something we have been concerned with constantly since our establishment. Honest opinions were presented in terms of the tasks to be prioritized in the coming few years upon integration with Osaka Prefecture University.

Revisiting the hardships experienced during establishment, and how we achieved our present state

Dr. Miyano/
This is the last year for Vice Director Kamiya to work as a full-time professor, so we would like to hear a lot from him. Firstly, please tell us about OCARINA's history, its present situation and the future plan for the entire OCARINA organization.

Dr. Kamiya/
Personally, I feel that we must brace ourselves for the upcoming integration event.
After the integration of corporations next academic year, the universities will essentially be integrated within a few years. How OCARINA should act within the new integrated university structure will be an important question.
In this discussion, therefore, I would like to share a common perception with you regarding this issue and consider the future plan.

I have been engaged in OCARINA since its establishment in 2008. At that time, we had no dedicated work space, and it was in that state which we announced the contents of our project studies at the International Symposium held to commemorate its opening in March. That was the beginning of OCARINA.
Dr. Fujii, you were a specially-appointed associate professor at the time. What were your thoughts regarding the project studies?

Dr. Fujii/
What impressed me, looking at the project leader Hashimoto, was that he was spending a lot of time outside of his own research working for OCARINA, writing wrap-up reports and communicating with researchers in different fields of study. Researchers from different fields of study, young researchers and liberal arts researchers were participating in our meetings. I felt that we were trying to create a movement of establishing a new research collaboration system through the integration of different fields.

Dr. Kamiya/
Yes, we were. Though we were a little unorganized at first, we secured a working space and started full scale research in 2010, enabling us to study actively while being stimulated by other researchers, and realize multidisciplinary integration.
In the meantime, the Research Center for Artificial Photosynthesis (ReCAP) opened in 2013. Would you tell us about its establishment, Dr. Amao?

How should we face the crucial stage of university integration?

profile

Professor, OCU
Vice Director, OCARINA

Nobuo Kamiya

Graduated from the School of Science and completed the doctoral course at the Graduate School of Science, Nagoya University. Doctor of science. Worked as a guest researcher at the High Energy Physics Research Institute, Photon Factory (PF), a researcher/ research sub head at RIKEN and the director of the R&D office of RIKEN Harima Center (SPring-8). Became a professor of the Graduate School of Science, OCU in 2005 and took up his present post in 2010. Awarded the Asahi Prize in 2012.

Starting from an empty building, we improved the working environment through trial and error

Dr. Amao/
I have been giving lectures at OCARINA's events and conferences since 2010, mainly talking about the use of CO_2
In the autumn of 2012, I was offered a position as a full-time professor at ReCAP upon its establishment, and accepted the offer. When I arrived in April 2013, the building was empty, and I struggled, wondering how I should start the organization. Thankfully, we progressed smoothly. Research sections were established by companies, and the Fifth Anniversary Symposium was held last year. During the first year, however, I had trouble finding answers to the question of how we should manage the organization, and spent many days relying on trial and error.

Dr. Kamiya/
We really shared the joys and difficulties, didn't we, Dr. Amao. In 2015, the official research building of OCARINA was completed, and various projects have since been proposed and carried out in the building.
You joined in 2015, Dr. Yoshida. Do you have any comments?

Dr. Yoshida/
I was told in my interview that OCARINA was managed by project study teams, and at first I did not understand what this meant. After I arrived, I found that I had to do everything, including making arrangements for students and budgeting. I did not know what to do, nor how to do it.
As for ReCAP, when I came in 2015, some companies had already begun their study and equipment such as desks had been prepared. Thankfully, I did not have many difficulties since I came after other members had worked hard establishing the center. I am still learning from other researchers while observing them.

Dr. Kamiya/
There are various difficulties when starting something. Although there were many problems, we also experienced interesting things that could only be experienced during the startup period.

With OCARINA's support, the range and depth of studies will increase dramatically

Dr. Kamiya/
There is another topic I would like to discuss today: the role of the organization as a whole.
In individual studies, however excellent a project leader is, it is almost impossible for each project to manage large-scale issues such as obtaining research space, project planning and fund negotiation. In the meantime, project studies cannot progress without managing these issues.
Conversely, if the organization can back project studies efficiently, they will proceed smoothly.

With this in mind, I think that OCARINA started without sufficiently discussing its role. In the latter part of this discussion, based on this reflection, I would like to discuss what type of organisation OCARINA should aim to be in the future. I hope we can successfully navigate the university integration by reflecting on such a policy as an organization.
Is there anything that you feel is missing at present when we consider OCARINA as a project organization?

Dr. Amao/
Actually, my primary job is the work for OCARINA, but I am also the Director of ReCAP. I have something to add in regards to working for and observing these two organizations.

OCARINA's general meeting was held in March. Its objective is good, but it is always conducted in the same pattern: participants from each project give a lecture, and that's all. There is no development resulting from the meeting.
Many of the conferences are the same. Even if we invite guest lecturers, there is no follow-up after the conferences, and the results are not used effectively.
I think it is not due to a problem with the researchers, but the lack of an information network. Even when a communication network is set up, it is limited to small-scale communication among acquaintances. To solve this problem, we should review OCARINA's role from that perspective.

Dr. Kamiya/
I see. I agree that it is difficult to establish a lateral network of researchers via the general meetings alone. For the last two years, I have been saying to the project leaders at every leader meeting that we should launch a new project through multidisciplinary integration or collaboration, which is the purpose of OCARINA, but it has not been very effective so far.

Special Feature Article

profile
Professor, OCARINA

Yutaka Amao

Obtained a Doctorate in Engineering at the Graduate School of Bioscience and Biotechnology, Tokyo Institute of Technology in March 1997. Worked as a researcher at the Kanagawa Academy of Science and Technology Foundation in April 1997 and the National Aerospace Laboratory of Japan in February 1998. Became a lecturer (February 2001) and then an associate professor (April 2002) at the Faculty of Engineering, Oita University. He became a professor of OCARINA in April 2013. He has also been acting as the Director of the Research Center for Artificial Photosynthesis since April 2015.

profile
Associate Professor, OCARINA

Ritsuko Fujii

Obtained a doctoral degree (Science) at the Graduate School of Science, Kwansei Gakuin University in March 2001. Worked as a postdoctoral fellow (PD) at the Japan Society for the Promotion of Science, Graduate School of Science and Technology, Kwansei Gakuin University, Osaka City New Industry Generation Center, and the Graduate School of Science, OCU. Became a specially-appointed associate professor at OCARINA and took up her present office in April 2013. She also worked as a researcher at PRESTO, Japan Science and Technology Agency until March 2016. Specializes in biophysical chemistry and spectroscopy.

I agree that we should move in that direction. Does anyone else have anything to add?

Dr. Fujii/
To tell the truth, I felt the same way as Dr. Amao.
As for the mechanism of distributing inquires to the suitable researchers, the URA is fulfilling this role to a certain degree, but they do not have enough staff. We should strengthen the organization and let it play a leading role in information management for OCARINA.
OCARINA is now becoming a hub of specialists. We need a mechanism to support this.

Things that OCARINA can do to expand researchers' lateral networks

Dr. Fujii/
I hope that the project leader meetings will offer opportunities for researchers to present their new ideas and brainstorm.
I picture these as complex opinion exchange meetings held by project teams. Interesting projects etc. can be born by exchanging ideas freely.

Dr. Miyano/
That sounds interesting. Are there any other comments?

Dr. Kamiya/
I am concerned about evaluation. At OCARINA, project leaders, research periods and budgets are determined, but the crucial aspect of evaluation is missing, and no discussion has been made to that effect.

We should evaluate study results periodically to determine project policy. Since studies are implemented according to project targets, if we do not verify and evaluate results appropriately, we might end up just continuing the present studies.

Take for example the artificial photosynthesis project we have been conducting through industry-academia collaboration for the last ten years. It has produced significant results; however, there is no mechanism to evaluate them. If we evaluate this project, how can we present the results? What do you think about this, Dr. Amao?

Dr. Amao/
Firstly, the joint research section with Iida Group Holdings was set up as an industry-academia collaboration, and the verification test started as a true industry-academia collaboration project without financial assistance from the national government. The project can be a model for industry-academia collaboration in that sense.
ReCAP was covered by Fuji Television in December and the program was broadcasted via the national network. We are now discussing the possibility of exhibiting the joint research results at the Osaka Expo. The project has reached the stage of demonstration. Grounded on its basic research, it has steadily proceeded to the application stage.
The discussion has just begun, and I'm looking forward to seeing how far we can proceed from now.

Dr. Kamiya/
What do you think about the project, Dr. Fujii?

The project started as a dream, and the dream is coming true

Dr. Fujii/
The study of artificial photosynthesis was at first considered to be a pipe dream. But when I met Dr. Amao and heard him say that it was his dream, this is when I first felt that it might be realized. It has now reached the stage of verification, and I think we were blessed with the best person for this project.
Recently, Dr. Yoshida has joined and the industrial application of artificial photosynthesis as a form of catalyst has been discussed. Researchers are joining the project from various fields and I strongly feel that the field of study is expanding.

Dr. Kamiya/
Thank you very much. How about you, Dr. Yoshida?

Dr. Yoshida/
I think that interaction with the public has been achieved in a concrete manner. For example, ReCAP is playing the role of a research hub for artificial photosynthesis and promoting joint research with people outside the center. We are fulfilling the role of a pipeline, so to speak, and creating a smooth flow.
However, the workload is falling on one person. I feel the work should be organized as a project and the load shared between many people.

profile

Professor, OCARINA

Tomoko Yoshida

Obtained a doctoral degree (Engineering) at the Graduate School of Engineering, Kyoto University. Awarded the Okamura Award, given to excellent female researchers, and her research was adopted as a project in the "GLOCAL base for constructing society with a smile, intelligence and health" initiative in 2017. Has studied optical functional material science at OCARINA since 2015.

profile

Advisor to the President, OCU
Director, OCARINA

Michio Miyano

Completed the doctoral program of the Graduate School of Engineering, Tokyo Metropolitan University in March 1980. Doctor of Engineering. Was a full-time lecturer, a professor, Dean of the Graduate School of Human Life Science and the Faculty of Human Life Science, director and vice president, and took up his present office at OCU in 2016. Specialized in regional disaster prevention and housing safety engineering. Studying natural disasters such as earthquakes and wind and flood damage as well as daily accidents related to houses for the establishment of a safe, comfortable living environment.

Also, I would like to launch a project on a topic that can only be dealt with by this center, since researchers in various fields of study related to artificial photosynthesis have gathered thanks to Dr. Amao, and contact with the public has been increased. I think we now have people that can achieve such a task.

Dr. Miyano/
That is a wonderful idea. If you have any other comments on OCARINA's present state, please speak about it unreservedly.

Another task for OCARINA is the creation of a nurturing environment for young researchers

Dr. Yoshida/
Frankly speaking, I need more full-time researchers. In particular, I wish to create a relaxed study environment for young researchers. If young people cannot enjoy research, students will hesitate to proceed to a doctoral course. They may become reluctant, worrying that they may have no choice but to become specially-appointed researchers, or have trouble finding a job. It is a waste if young researchers are not nurtured when we have such a good environment and interesting research topics.

Dr. Kamiya/
That is true. This is related to the issue of the number of researchers.
When OCARINA started, some professors were transferred here from existing organizations, since it was difficult to employ new members.

However, even when there are people who hope to come to OCARINA, their organizations or departments do not let them leave, worrying that they will become short of staff. Also, researchers hesitate and do not take the risk. The reason is OCARINA's projects appear to be a jumble of small-scale studies, and they lack the attractiveness that can motivate people to transfer in spite of obstacles and frictions.
I, therefore, would like to propose that we should take advantage of the university integration to solve these problems. Since there is no organization equivalent to OCARINA in Osaka Prefecture University, can we introduce our project studies and seek to establish a framework for joint research in the new university?

Multidisciplinary integration and industry-academia collaboration are just what the new university will aim for

Dr. Kamiya/
First of all, we should start announcing that we should establish an organization without an undergraduate program, like OCARINA.
Such an organization would perfectly align with the aims of the new university. I feel that we have already reached the point just prior to submitting our proposal to realize this.

One of the pressing issues for the new integrated university is the announcement regarding its entrance examination. Departments with educational organizations have already conducted hearings and discussed the issue intensively with Osaka Prefecture University. Open-campus events are scheduled for next summer and we need to communicate the details to first-year high school students there.

The two corporations will be integrated next academic year; however, individual university organizations will be maintained during the transfer period before the final integration three years later. At that time, it will not be enough to simply add together what we are doing now at the two universities.
A lot of things will change in the three years from this April. OCARINA, however, has not reached the stage of active discussion. We need to focus on this issue now.

Dr. Miyano/
In this big tide of university integration and the establishment of a new university, we should not remain passive but become actively involved.
It is important now to sow the seeds required to weather the actual integration scheduled in a few years, in an efficient manner, so that we can greatly develop future studies.

Special Feature Article

True interdisciplinary integration will begin from accepting different standpoints

Seven projects are underway within OCARINA, a single organization. Collaboration should be straight forward, yet the reality is that high mental barriers are preventing it.
Providing an exciting research environment for young researchers is indispensable in creating large-scale integrated projects.
In this discussion, various practical ideas were presented and OCARINA's problems were clarified.

Staffing shortages are preventing collaboration between projects

Dr. Miyano/
Let us discuss the issue of project collaboration, which has been an issue for the last two years. It has been discussed many times but it has not yet been realized. Why haven't we achieved collaboration, and what kind of problems are there? Could we have your unreserved opinions?

Dr. Shigekawa/
We can think of things to try, but we stumble when we actually try to implement them.
It's true that we have issues with staffing, equipment and funds; however, we can manage to solve equipment and funding problems by getting by with what we possess at the start. However, without staff who will actually be involved in a study, we are not be able to start anything.
In the end, whether or not we can acquire graduate students to entrust with the project is vital, that is, whether or not we have that possibility.

Dr. Amao/
I think what Dr. Shigekawa is saying is truly important.
In addition to that, I think there is also difficulty in multidisciplinary integration in itself. For instance, when researchers of applied chemistry and chemical engineering try to conduct collaborative research, it doesn't go well because it takes time for one researcher to comprehend what the other says. It's more difficult in the fields of biology. To study collaboratively, we must start by understanding the other field's terminology.

For example, in the field of catalysts, the unit of volume is cc, but in other fields of chemistry, milliliter is used instead. The units we use are different depending on the field of study. To talk on the same level, we have to start by converting the units. Even we feel it is difficult, thus students would see this as an even higher hurdle.
As Dr. Shigekawa said, various ideas can be shared simply through the exchange of information. However, when we try to begin the joint research, we cannot understand what other researchers are talking about and thus cannot share an overall understanding, which makes the study much more difficult.
We need to create a mechanism to overcome this barrier.

The key to innovation is breaking the mental barriers between fields of study

profile

Professor, Graduate School of Engineering, OCU
Vice Director, OCARINA

Naoteru Shigekawa

Graduated from the Department of Physics, Faculty of Science, University of Tokyo in March 1984, and completed the master's course at the Department of Physics, Graduate School of Science in March 1986. Studied chemical semiconductor hetero binding devices at NTT Atsugi Research Institute for Electrical Communication (present NTT Device Technology Laboratories) from April 1986 until Sep. 2011. Took up his present post in Oct. 2011. Doctor of science.

Dr. Yoshida/
I agree. We need to create the mechanism first. We use to have a system where students were sent to other laboratories in Japan. When we could not study a topic in our laboratory, we sent a few students to another laboratory to study it, which resulted in joint research and academic reports. We need an opportunity for the first step, and it would be difficult to proceed without such an opportunity.
If it is difficult to start with students only, a young teacher could accompany them for the first few days. We need to support them at the kickoff.

Dr. Miyano/
Then, the key to creating the mechanism is students. Do you have any comments, Dr. Fujii?

Studying side by side would be the same as studying in another laboratory

Dr. Fujii/
OCARINA started as a virtual organization, and researchers and students in the fields related to the projects were packed in a large room together.
Then, while sharing the space, rules and interactions in the room developed naturally. People who studied in the room are still very close.

To give an example; the fields of study of Dr. Yoshida and myself seemed close, but many aspects were different, since we dealt with totally different things: soft organisms and hard materials. It was the same for our students.
However, while sitting side by side, we had many chances to communicate and develop an interest in the study topics of other researchers. This provided us with valuable opportunities to hear about other research in our free time.
We talked about problems in our own studies in a relaxed manner. It was just like studying in another laboratory.

I have another idea; when we start a collaborative study, we could have our students study in the counterpart laboratory for a while. If they could study in the same place, it would be a major step forward.

Dr. Miyano/
I see. That is an approach from an educational perspective. What do you think about it, Dr. Amao? What do you think are the obstacles for collaboration between the seven projects in OCARINA?
I myself feel that if terminologies are different and it is difficult to understand each other in terms of the fundamentals, it would be more difficult in OCARINA. All of OCARINA's projects are dealing with distinctive, state-of-the-art topics. It would be really difficult to start a large-scale collaborative project here.

Collaboration is difficult for advanced technology

Dr. Amao/
That is right. For instance, Dr. Yoshida, myself and Dr. Yamada (Engineering) belong to fields that are rather similar to each other. We gathered our ideas and proposed some research projects. Some worked out, but others did not, often receiving comments that they were only a jumbling of ideas.
If we were to seek external funds for projects, in our current state, we would not be able to offer a true multidisciplinary integration.

As this is the present state of collaboration in our field of catalytic chemistry, collaboration with other fields such as electricity and organic materials would be quite difficult.
It is difficult to imagine which part of research our field could contribute to. This is the difficulty of multidisciplinary integration.

Dr. Miyano/
I understand very well. Do you have any comments, Dr. Shigekawa?

Dr. Shigekawa/
As a matter of fact, we asked Dr. Yoshida to give a lecture in the photocatalysts session at the Society of Applied Physics conference a short time ago. At that time, someone commented that Dr. Yoshida was taking an approach from a chemical perspective, but that it might be possible to approach from the perspective of semiconductors.
While chemistry focuses on the exchange of electrons between materials and catalysts, we, researchers of semiconductors, firstly consider how electrons move most efficiently. In short, even if we are looking at the same photocatalysts, we are looking at them from totally different perspectives.
If we can combine the concepts of electrons from the perspectives of semiconductors and photocatalysts, we

Special Feature Article

might be able to find a task yet to be solved, and create photocatalysts that surpass the previous ones. I have a strong feeling that this can happen.
I am not saying that we can produce a specific product in one go; however, if we start by thinking about the differences in our perspectives, we might be able to create something amazing.

Dr. Yoshida/
I would also really like to hear more about Dr. Shigekawa's idea. Even if it might seem unrelated, if we hear and consider it, it could be a starting point.
When we had a joint conference, I was able to discover various things even from students' presentations. Rather than creating materials from scratch, such occasions can produce good ideas.

Integrating exciting initiatives to draw out young researchers' enthusiasm

Dr. Miyano/
I see. I agree that we are not progressing the presentation of projects to the next step. If we provide some opportunities such as academic camps for researchers and students afterwards, we might be able to discover some things.

Dr. Fujii/
It is a good idea to hold some events integrating something enjoyable. I hear there are some active societies in which young members are holding camp-style study meetings.
If we provide such an atmosphere, people might become interested in what others are studying. If we tell students to go and study, they might become embarrassed; however, it is mainly because they do not know other people. If they get to know each other, they might participate more positively.

Dr. Amao/
If that is the intention, it might be better if young people do the planning themselves.

Dr. Miyano/
Young researchers presenting ideas and then integrating Project A and Project B sounds good. However, securing such young researchers is the key issue. Dr. Fujii's idea of gathering students in a large room may help with this.

Project themes do not materialize easily. First, we should provide opportunities for free discussion, with the expectation that varied perspectives and discoveries may lead to a big project.
Do you think it is possible to gather only young researchers?

Dr. Fujii/
Most of the main researchers are committed to the general assembly and accepting the review. Young researchers are willing to accept our requests and many of them are participating in it.

An atmosphere allowing for speaking without shyness is essential

Dr. Fujii/
The problem with the present general assembly is that there is an atmosphere that makes people reluctant to ask questions or make comments. Presentations from seven projects take time and it is difficult to leave time for questions. Also, people get tired listening to presentations from different fields to theirs, making it difficult to provide good comments.
If they could meet each other beforehand, through camps and other opportunities, they might be able to speak without being timid.

Fortunately, awareness of the general assembly is increasing and most researchers know about it. I feel we are approaching the phase of how to put it to practical use.

Dr. Miyano/
I see. What sort of timing do you think would be good to carry out the plan?

Dr. Fujii/
How about calling students to gather and spend a whole day together or stay overnight? They could participate in a competition, with a representative of each team giving a presentation.

Dr. Miyano/
The bar might be too high for the first try if we have them compete. How about group workshops with a few members?

Dr. Amao/
I have attended workshops held by the Japan Science and Technology Agency twice, and their implementation may provide some hints. First, we gather researchers from electric-related fields in chemistry and engineering, and make teams. Each team is requested to produce a research topic that might become a national project. Through this experience, I found that even if a conclusion cannot be produced, it is rewarding enough to think and provide opinions from different perspectives.

Seeds of innovation come from the intersection of multidisciplinary perspectives

Dr. Amao/
For instance, a photocatalysis researcher says, "it will produce hydrogen and oxygen at the same time; therefore, it will explode if efficiency increases"; then a researcher from a different field makes a proposal. "If that's the case, we can separate gasses if we use this method." Important findings could be derived from this.

However, we need to think at which level we should study. Should we start with collaboration among young researchers who are having trouble in experiments, or at a little higher level in which there is difficulty in integrating technologies? There are many things we should consider.

Dr. Miyano/
In the context of the conversation so far, I think we should start with young researchers. They might insist on their own opinions, at first, but they could find something in common after that.

Dr. Amao/
That would need some time, such as a whole day. We also need to determine a topic, and seven projects must arrange the event cooperatively. If we gather people from different groups without any plan or topic, it would produce nothing.
How about having young people present the points in which they are having trouble, and support each other? That might facilitate the production of good ideas.

Dr. Yoshida/
I see. It would be like a joint seminar. It is a good idea to start from points in which we are having trouble.

Dr. Amao/
That is right. At seminars, we usually speak only about things that are going smoothly. It is good to focus on things we are having trouble doing or realizing. When I am facilitating a workshop, I always ask people to speak about things they are having trouble with. If I ask them to speak about their study, they would only say good things.

Dr. Miyano/
Shall we initiate this as an OCARINA proposal, then?

Dr. Amao/
Yes. It would be better to make it informal, inviting participation on a voluntary basis.

Dr. Shigekawa/
It would be great if we could forge strong human relations like in Silicon Valley. Excellent innovations result from this. Even if one out of one hundred ideas is realized, it would lead to incredible results.

Dr. Miyano/
It would be a burden if we took the perspective that something has to result from the workshop.

Overcoming hurdles one by one, to realize an independent graduate school

Dr. Miyano/
So far, we have discussed methods of promoting collaboration between projects. Lastly, I would like to discuss the future tasks of OCARINA.
In terms of organizational issues, you were saying that you need more graduate students. I think that establishing an independent graduate school could be a solution to the problem. We have many hurdles to overcome to realize that. First, how to secure students if the school has no undergraduate courses.

We were saying that professors who supervise graduation theses at the Faculty of Science and Faculty of Engineering could acquire students. At the Urban Research Plaza, they are acquiring adult students. OCARINA could also consider admitting adult students.

Dr. Amao/
I think there is no problem in establishing a new graduate school and admitting adult students.
Many people who are in charge of joint research in companies have a master's degree. I often hear that they hope to obtain a doctoral degree. If we respond to their needs, companies may support their employees to become graduate students.

Dr. Miyano/
It is reassuring that we could acquire some students from companies. From today's discussion, I now feel it is essential to involve young researchers. In the new integrated university, if OCARINA has a vision to become a leader in developing young researchers, it would be a strong selling point.
Today we discussed the specific methodology. Next, I would like us to take it one step further.

■ Research Introduction

The Carbon Dioxide Reduction Mechanism Using a Metallic Oxide Semiconductor Photocatalyst

profile
Specially-appointed assistant professor, OCARINA
Muneaki Yamamoto
Obtained a doctoral degree (Engineering) at the Materials Process Engineering Department, Graduate School of Engineering, Nagoya University. Took up his present office in April, 2018.

Photocatalysts facilitate chemical reactions by means of optical energy. Research on optical-chemical energy conversion using photocatalysts has been attracting attention in recent years. This process uses unlimited solar energy (optical energy) to reduce water and carbon dioxide, and stores them as useful chemicals (chemical energy); therefore, it is now highly expected to become a technology used to solve environmental and energy problems. The reduction of carbon dioxide in particular is important, since it enables the recycling of carbon resources, which are anticipated to be depleted soon. Carbon dioxide reduction using photocatalysts has the potential to simultaneously solve the issues of carbon resources depletion and global warming.

We are mainly studying the reduction of carbon dioxide in water, using metallic oxide semiconductors as photocatalysts. When irradiated by light with greater energy than their band gap, metallic oxide semiconductors produce electron holes and excited electrons in the valence band and conduction band respectively. The electron holes and excited electrons move to the semiconductor surface and facilitate oxidation and reduction respectively (Fig. 1). In the case of carbon dioxide reduction in water, the following two types of reduction are considered to progress competitively.

$CO_2+2H^++2e^- \rightarrow CO+H_2O$ … ①

$2H^++2e^- \rightarrow H_2$ … ②

e-: excited electron

In order to reduce carbon dioxide in water, the reaction of Formula ① needs to be facilitated selectively; however, hydrogen ion reduction (Formula ②) proceeds more easily than carbon dioxide reduction (Formula ①) due to a thermo-dynamical preference. Thus, it is important to selectively facilitate carbon dioxide reduction by modifying the photocatalyst surface with an appropriate catalyst (catalytic promoter) that can control reaction activation energy.

Through previous studies, silver promoters have been confirmed to be effective in carbon dioxide reduction (Formula ①), and some promising photocatalysts modified with silver promoters have been reported. We also succeeded in facilitating carbon dioxide reduction in water, using gallium oxide photocatalysts modified with silver promoters [1]. However, the catalytic function mechanism of silver promoters in carbon dioxide reduction has not been clarified yet.

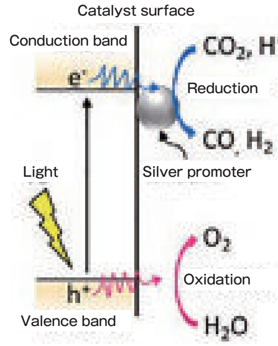


Fig. 1: Reaction mechanism of silver-added semiconductor photocatalysts

If the mechanism is identified, it will enable the optimization of silver promoter's modification state, thus improving the reaction activation and selectiveness as well as decreasing the amount of precious metal used. In addition, the creation of a new, more effective catalytic promoter is anticipated.

In order to identify the catalytic function mechanism of silver promoters in carbon dioxide reduction, it is essential to accurately analyze the chemical state and electron structure of silver promoters, as well as the absorption state of carbon dioxide, and grasp the reaction mechanism by combining the two analyses. Thus, we aimed to clarify the carbon dioxide reduction mechanism through detailed characterization of gallium oxide photocatalysts modified with silver promoters, and the observation of carbon dioxide molecules absorbed into the photocatalyst surface. The following are the research results.

■Changes in the Chemical State of Silver Promoters during Reaction [2,3,4]

The chemical state and electron structure of silver promoters added to modify gallium oxide photocatalysts were analyzed in detail by means of various spectroscopic methods (X-ray absorption microstructure analysis, ultra-violet and visible ray absorption spectroscopy, transmission electron microscopy and X-ray diffraction analysis). As a result, it was found that in the catalyst modified with a high amount of silver, silver particles were partly oxidized and formed a complex oxide structure at the interface with gallium oxide before reaction. After

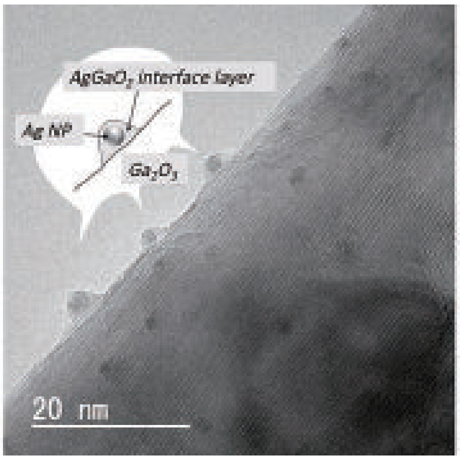


Fig. 2: TEM image of a silver promoter on the gallium oxide photocatalyst surface

reaction, the silver changed to a metallic state, and catalytic activity increased with time; therefore, it was presumed that the excited electrons and electron holes were used to reduce the complex oxide in the early stage of reaction and that the silver changed into a metallic state with catalytic promotion ability. In contrast, in the catalyst modified with a low amount of silver, tiny metallic silver clusters remained, which indicated that the catalyst activity was high in the early stage of reaction yet decreased as the reaction progressed due to aggregation of silver particles.

■Observation of Carbon Dioxide Absorption Status by Means of In-situ Infrared Absorption Spectroscopy [1,4,5]

We developed an in-situ infrared absorption measurement system to observe reacting molecules' absorption and detachment status, which vary depending on the chemical state and atomic structure of the catalyst surface, and monitor their reaction mechanisms. The carbon dioxide reduction mechanism that progresses on the surface of silver-added gallium oxide, which was observed with the system, is described below.
The infrared absorption spectra in a carbon dioxide atmosphere showed absorption attributable to carbonate and hydrogen carbonate. The result showed that weakly acidic carbon dioxide reacted with basic sites on the catalyst surface: hydroxyl and lattice oxygen, to produce two respective substances. Following ultraviolet irradiation, absorption attributable to carbonate and hydrogen carbonate decreased, and formate-attributable absorption occurred anew; meanwhile, formate-attributable absorption did not occur in the case of visible ray irradiation, which did not excite gallium oxide. Thus, it was confirmed that carbonate and hydrogen carbonate were reduced by excited electrons in gallium oxide, which were produced through ultraviolet irradiation, and changed to formate, a reaction intermediate.
Formate was in a stable state on the photocatalyst surface; however, in a water vapor atmosphere, the formate-attributable absorption peak broadened. Following vacuum evacuation, the broadened absorption peak returned to its previous state, which indicated that the formate reacted with water molecules reversibly. When the formate was irradiated with ultraviolet rays while reacting with water molecules, its absorption decreased, carbon monoxide was produced, and absorption of the hydroxyl group on the surface increased. This proved that formate reacting with water molecules underwent photodecomposition to produce carbon monoxide. Based on the results, we proposed a carbon dioxide reduction mechanism (Fig. 3).
Next, we examined the change in the absorption behavior of carbon dioxide due to a difference in the chemical state of silver-added catalysts. As a result, it was found that carbon dioxide is not absorbed into metallic silver or metallic silver clusters, yet it is absorbed as a carbonate into the complex oxide of silver and gallium. Also, it was confirmed that the amount of the reaction intermediate produced through optical illumination was large in the photocatalyst mainly consisting of silver clusters, which showed that silver clusters promoted the production of the reaction intermediate.

Recently, we have been implementing various in-situ measurements of reactions (operand analysis) and trying to create new photocatalysts based on our original catalyst design principle.

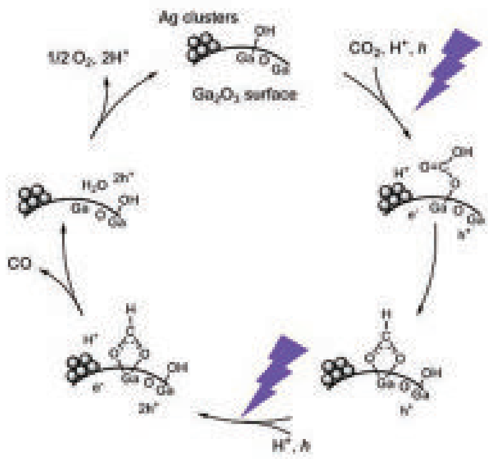


Fig. 3: The proposed carbon dioxide reduction mechanism

References

[1]M. Yamamoto, T. Yoshida, N. Yamamoto, H. Yoshida, S. Yagi, *e-J. Surf. Sci. Nanotechnol.*, **12**, 299 (2014).

[2]M. Yamamoto, T. Yoshida, N. Yamamoto, T. Nomoto, S. Yagi, *Nucl. Instr. and Meth. B,* **64**, 365 (2015).

[3]M. Yamamoto, T. Yoshida, N. Yamamoto, T. Nomoto, A. Yamamoto, H. Yoshida, S. Yagi, *J. Phys: Conference Series,* **712**, 012074 (2016).

[4]M. Yamamoto, T. Yoshida, N. Yamamoto, T. Nomoto, Y. Yamamoto, S. Yagi, H. Yoshida, *J. Mater. Chem. A*, **3**, 16810 (2015).

[5]M. Yamamoto, S. Yagi, T. Yoshida, *Catalysis Today*, **303**, 334 (2018).

Research Introduction

Design of Functional Heterogeneous Catalysts based on the Structural Information of Crystalline Materials

profile
Specially-appointed lecturer, OCARINA
Hiroyasu Tabe
After obtaining his PhD degree at the Department of Synthetic Chemistry and Biological Chemistry, Graduate School of Engineering, Kyoto University, in 2015, he worked for Kansai TLO Co., Ltd. as an administrator of the university technology transfer. In 2017, he joined OCU as a specially-appointed assistant professor at the Graduate School of Engineering and promoted to a specially-appointed lecturer at OCARINA in 2019.

I was warmly welcomed to Osaka City University Advanced Research Institute for Advanced Research (OCARINA) as a specially-appointed lecturer in January 2019. I have been working on the preparation of functional crystalline materials based on coordination chemistry and biomolecular chemistry since I was pursuing my PhD. In OCARINA, I eager to start a research project aiming at environmental-friendly reactions, such as photocatalytic energy production and removal of toxic compounds, using a novel catalyst. Catalysts can contribute to chemical processes by enhancing the rate of a chemical reaction. Catalysts are classified into two groups, homogeneous and heterogeneous catalysts, depending on their forms during the reactions. Heterogeneous catalysts are widely used in industry, because they have high activity, durability and recyclability. Crystalline compounds are a powerful candidate to obtain heterogeneous catalysts because their highly ordered structure can be characterized by spectroscopic methods including single-crystal X-ray structure analyses. I am interested in protein crystals and coordination polymers as a template for the novel heterogeneous catalysts. Herein, I summarize my research to review the recent progress and point out future directions.

Porous Protein Crystals as Functional Heterogeneous Catalysts

Protein crystallization is the process of formation of a protein crystal, which is useful in the study of protein structures by single-crystal X-ray structure analysis. Protein crystals can serve as porous molecular frameworks because mesopores ranging from 5 to 100 nm are formed by gaps of protein monomers in the packing structure. Several reports have shown that "porous protein crystals" have the potential to be a new solid material. Herein, we designed heterogeneous catalysts by modifying metal complexes or nanoparticles to appropriate functional groups originated from the amino acid residues of subunit proteins. Among proteins, hen egg white lysozyme (HEWL) was chosen as a catalyst support because HEWL crystals can be obtained abundantly, crystallized in tetragonal and orthorhombic lattices by varying the crystallization conditions and stabilized by cross-link treatment using glutaraldehyde.

An organoruthenium complex, which is known as a precursor to a versatile catalyst for transfer hydrogenation, was immobilized in cross-linked HEWL crystals in the tetragonal form and orthorhombic forms [1]. Single-crystal X-ray crystallography suggested the selective coordination of His15 residue to the

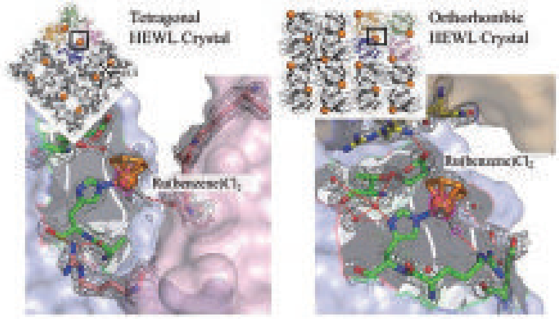


Fig. 1: Lattice structures and active site structures in HEWL crystals immobilizing Ru(benzene)Cl_2 complexes in the tetragonal (left) and orthorhombic (right) forms.

ruthenium ion both in the tetragonal and orthorhombic crystals (Figure 1). Catalytic activities of the crystals were investigated for transfer hydrogenation of acetophenone derivatives. When only organoruthenium complexes were employed for the catalytic reaction in buffer solution, the complexes could not catalyze transfer hydrogenation. Organoruthenium complex-HEWL composite dissolved in the buffer solution showed less catalytic activity and enantioselectivity compared with the crystals because of the absence of the stable ruthenium-His15 coordination supported by the hydrogen bonding networks formed in crystal lattices. Interestingly, the enantioselectivity could be controlled by interactions of the substrate with organoruthenium complexes in the mesopores of the tetragonal or orthorhombic crystals.

Next, a composite catalytic system for the photocatalytic hydrogen (H_2) evolution was constructed using porous HEWL crystals [2]. Precise co-accumulation of the catalytic components in a mesopore is important to construct a photocatalytic system with an efficient electron transfer. Rose Bengal, which is an anionic photosensitizer molecule, and hexachloroplatinic(IV) acid (H_2PtCl_6), which is a precursor of platinum nanoparticles (PtNPs), were immobilized in cross-linked HEWL crystals. The crystal structure of the HEWL crystal was determined by single-crystal X-ray crystallography, suggesting the functional groups from Lys1 and His15 coordinate to the platinum complex (Figure 2). Although unambiguous positions of rose Bengal were hardly determined, rose Bengal is expected to be immobilized with positively charged area composed of Arg5, Arg125 and Arg21. The distance between the binding sites for platinum complexes and those of rose Bengal are enough close for electron transfer (ca. 2 nm). Photocatalytic H_2 evolution was performed by the photoirradiation of a phosphate buffer dispersion containing the

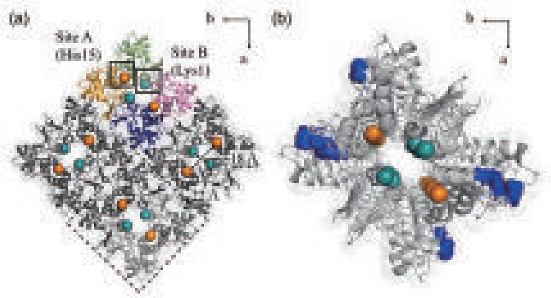


Fig. 2: (a) The overall structure a HEWL crystal immobilizing the platinum complex and rose Bengal. The Pt atoms are represented by spheres. (b) Magnifications of a pore indicated by a dashed square in (a). Blue residues indicate potential adsorption site for rose Bengal.

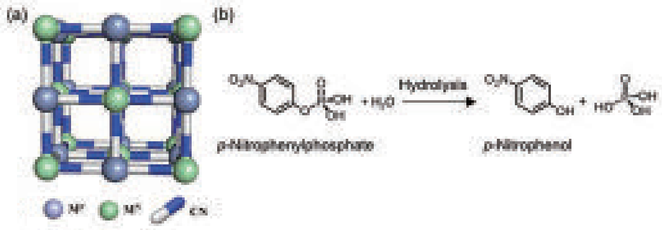


Fig. 3: (a) Partial structure of a cyano-bridged polynuclear metal complex. (b) Scheme of the catalytic hydrolysis of organophosphates.

HEWL crystals. An efficient H_2 evolution was observed after the induction period by visible-light irradiation. According to the control group, the efficient H_2 evolution was resulted from the precise co-immobilization of rose Bengal and PtNPs in the mesopores of cross-linked HEWL crystals.

The research on porous protein crystals also involves the adsorption-desorption of gas molecules, the electron transfer with the long-lived charge separation and the diffusion of organic molecules within the mesopores [3-6]. Since these research areas are closely related to those of the main topic of OCARINA, I am looking forward to collaborating with the OCARINA faculties.

Heterogeneous Catalysts Constructed by Coordination Polymers

A coordination polymer is a polymer of metal complexes containing metal cation centers linked by bridging ligands. This structure is remarkably attractive for a heterogeneous catalyst, because the metal ions as a potential catalytic active site are periodically located on the surface of coordination polymer particles. One of the best-known coordination polymers is Prussian blue, which has been used as a pigment since 1700s. Prussian blue is composed of iron ions, however, the systematic replacement of iron ions to other metal ions leads to various cyano-bridged polynuclear metal complexes. The composition of cyano-bridged polynuclear metal complexes can be described as $M^N_x[M^C(CN)_6]$, where M^C ions are coordinatively saturated and M^N ions can act as catalytic active sites because of their coordinative saturation (Figure 3a).

Cyano-bridged polynuclear metal complexes composed of various metal species were prepared by choosing 3d metal ions [7]. The complexes were dispersed in the buffer solution containing organophosphates, which are known as an agrochemical residue in foods (Figure 3b). The catalytic activity of the complexes was enhanced by employing M^N ions in higher oxidation states. Interestingly, the catalytic activity was also enhanced by employing M^C ions in higher oxidation states, although only M^N ions act as active sites. This result suggest that M^C ions easily modulate the electronic structure of the M^N ions by changing the electron donation ability of a CN ligand through an M^C–CN bond. The surface acidity of each complex estimated by the heat of pyridine desorption calculated from the temperature-programmed desorption measurement is strongly correlated with catalytic activity.

The research summarized above has been implemented under the supervision of Prof. Yusuke Yamada from Osaka City University. I would like to appreciate his guidance and suggestions. I am also profoundly grateful to the researchers and students in Yamada Laboratory for their collaboration. I feel deep appreciating for the encouragement by Prof. Susumu Kitagawa (Kyoto University) and Prof. Takafumi Ueno (Tokyo Institute of Technology) and the collaborators in the Institute for Integrated Cell-Material Sciences (iCeMS), Kyoto University.

I spent my teenage years here in Osaka, and thus it is a great opportunity working in OCU after spending 11 years in Kyoto. After obtaining my PhD degree in 2015, I worked in Kansai TLO, which is a subsidiary company of Kyoto University. My important task was to create intellectual properties and maintain industry partnerships, which are crucial for collaboration and bringing technologies to market. The daily discussion with faculties from various departments encouraged me to think about my own research idea. I would like to contribute the main purpose of OCARINA, "connecting the academic research and the society to develop a better regional community", using the experience and strategy that I obtained. I have recently been instructing Scottish country dance, a folkdance of Scotland, to the students belonging to the folkdance club of OCU. After obtaining the instructor's license from the Royal Scottish Country Dance Society, the headquarter of Scottish dancing, in 2016, I have been contributing to familiarizing dancers in Japan and overseas with the joy of music and communication. Although the dance seems to have nothing to do with my scientific research in OCARINA, a sense of learning the foreign culture – to explore the unknown world followed by the instruction to students – has a lot of common with the research.

References

1.H. Tabe et al., *Chem. -Asian J.*, **2014**, 9, 1373–1378.
2.H. Tabe et al., *Appl. Catal. B*, **2018**, 237, 1124–1129.
3.S. Abe, H. Tabe et al., *ACS Nano*, **2017**, 11, 2410–2419.
4.H. Tabe et al., *Chem. Commun.*, **2016**, 52, 4545–4548.
5.H. Tabe et al., *Inorg. Chem.*, **2015**, 54, 215–220.
6.H. Tabe et al., *Chem. Lett.*, **2015**, 44, 342–344.
7.H. Tabe et al., *Catal. Sci. Technol.*, **2018**, 8, 4747–4756.

■ Activity Report

9th OCARINA International Symposium

Date: March 6 (Tue.) and 7 (Wed.), 2018　Venue: Large Conference room, Media Center 10th floor, OCU

Invited Speakers

〈Special Speakers〉
Dr. Pu Qian (Researcher, University of Sheffield)
Dr. Laurean Ilies (Associate Professor, Graduate School of Science, University of Tokyo)
Dr. Xing Yi Ling (Associate Professor, Nanyang Technological University)

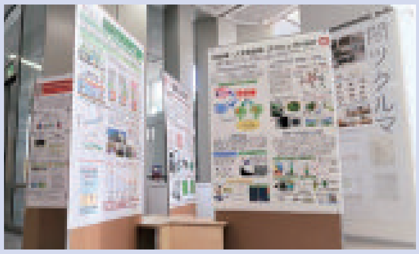
〈Guest Speakers〉
Dr. Katsura Sugawara (Director, Regenerative Medicine Business, Japan Tissue Engineering Co., Ltd.)
Dr. Mitsuhiro Terakawa (Associate Professor, Faculty of Science and Technology, Keio University)
Dr. Tasuku Hamaguchi (Researcher, RIKEN SPring-8)
Dr. Shin-ichiro Ozawa (Specially-appointed Research Associate, Research Institute for Interdisciplinary Science, Okayama University)
Dr. Masahiro Ueda (Professor, Graduate School of Frontier Biosciences, Osaka University)

Symposium photo was taken for the first time.

Ten speakers from OCARINA reported the accomplishments of seven ongoing projects, and five researchers from other universities, a company and a research institute in Japan gave lectures regarding various fields of study. Mini symposiums were also held on the topics of cryo-EM structural biology and catalysis, and three world-famous foreign researchers delivered special lectures. The lectures covered a broad range of topics including advanced research, pioneering product development and a large-scale project led by Osaka City.
In addition, the annual poster presentation was held and 61 researchers participated. They made one-minute oral presentations in English, and lively discussions were held during the poster viewing. Of the 54 subjects, 18 were selected as poster awards, of which three special awards, the Presidet's Award, the OCARINA Director's Award, and the ReCAP Director's Award were selected.The selection was made by the judges' evaluation and the votes of the symposium participants.
The symposium was considered a success, with 151 participants from domestic and foreign research institutes and companies.

<Project Poster Exhibition>

Posters introducing OCARINA's ongoing projects in an easy-to-understand manner were exhibited in the Tsukuruma lounge of the Media Center from February 26 through March 8, 2018. At present, these posters can be viewed on OCARINA's website.



1st Workshop for 2018: "Plant Colors and Food"

Date: Oct. 2 (Tue.), 2018　Venue: Large Conference room, Media Center 10th floor, OCU　Host: OCU Support Office for Female Researchers

Dr. Ritsuko Fujii (OCARINA) and Dr. Akiko Kojima (Graduate School of Human Life Science) organized a mini symposium in cooperation with Dr. Nami Yamamoto from the Faculty of Education, Wakayama University. The keynote speech was given by Dr. Leenawaty Lilmantara, Rector of Pembangunan Jaya University and the principal investigator of the Ma Chung Research Center for Photosynthetic Pigments (MAPCC) in Indonesia.
The keynote speech involved a study on the medicinal efficacy and commercialization of traditional food and medicine made from various Indonesian plants. The three Japanese researchers presented their researches on plant colors and food from the different perspectives of structures and functions of plants and education regarding diet.
＊This symposium was held as part of the MEXT Program for Supporting Research Activities of Female Researchers (Hubs and Collaborations). The program aims to improve research skills of female researchers and promote international joint research. This was our second year of participation.

Dr. Leenawaty giving a lecture on Indonesian traditional batik clothes

5th Okamura Award for Female Researchers -Award Ceremony and Commemorative Lecture

Date: Dec. 21 (Fri.), 2018　Venue: Conference room, Media Center 10th floor, OCU　Host: OCU Support Office for Female Researchers

The encouragement award for graduate students was given to Ms. Akiyo Ozawa (2nd year of doctoral program, Department of Applied Chemistry and Bioengineering, Graduate School of Engineering) who studied under the instruction of the OCARINA professor Tomoko Yoshida, and an award ceremony was held. At the commemorative lecture meet after the ceremony, Ms. Ozawa spoke of how the catalyst state she discovered during catalyst development was similar to an environment for female researchers' study. She also spoke about what she valued, as a mother of two children. Dr. Tomoko Yoshida, Ms. Ozawa's recommender and instructor, provided heartfelt, passionate comments of encouragement, which made for a highly animated meeting.

OCU Tenure-Track Study Conference 2018

Date: Dec. 10 (Mon.), 2018　Venue: Meeting room, Media Center 1st floor, OCU　Host: Tenure-track teachers

The OCU Tenure-Track Study Conference was organized and held by tenure-track instructors. OCU Chairperson Hiroyuki Sakuragi, who worked as OCU Vice President and Chairperson of the Tenure-track System Promotion Committee concurrently, delivered an opening address and a keynote speech on OCU activities for young researchers.
Following that, a tenure-track instructor gave a presentation, and OCU tenure-track Associate Professor Eriko Nakadai and Associate Professor Taka-aki Asoh at Osaka University, who used to be an OCU tenure-track instructor, gave a lecture regarding their recent study. Many participants including OCU researchers and students asked questions, and lively discussions followed. Lastly, OCARINA Director Michio Miyano gave a closing address, wishing for the further progress of young researchers.

Lively discussions were held.

OCARINA Seminars

OCARINA seminars are held to provide opportunities for the members of OCARINA to talk with researchers of other institutions and give presentations on their research results. Eight seminars were held this academic year. Please visit our website for detailed information.

40th	Date	Mar. 15, 2018/ 4:00pm-5:00 pm	Venue	Faculty of Science, Lecture Room 10 (E211)
	Guest	Dr. Takahiro Yamashita (Graduate School of Science, Kyoto University)	Organizer	Akihisa Terakita
	Theme	"Behavior of Photoreceptor Proteins in Vertebrate Eyes and Brains"		
41th	Date	Mar. 5, 2018/ 4:00pm-	Venue	Faculty of Science, Lecture Room 4 (F205)
	Guest	Dr. Pu Qian (Researcher, Univ. of Sheffield, United Kingdom)	Organizer	Ritsuko Fujii
	Theme	"Cryo-EM structure of the Blastochloris Viridis RC-LH1 Complex at 2.87 Å"		
42th	Date	June 21, 2018/ 4:00pm-5:30pm	Venue	Faculty of Science, Lecture Room 4 (F205)
	Guest	Dr. Hideki Kandori (Graduate School of Engineering, Nagoya Institute of Technology (Chairperson, Biophysical Society of Japan))	Organizer	Akihisa Terakita
	Theme	"Frontline Research on Microbial Rhodopsin"		
43th	Date	July 17, 2018/ 5:00pm-6:10pm	Venue	Faculty of Science, Lecture Room 9 (E101)
	Guest	Dr. Kazuo Inaba (Professor, Shimoda Marine Research Center, University of Tsukuba)	Organizer	Makoto Miyata
	Theme	"Ciliary Motion Control and Evolution"		
44th	Date	July 25, 2018/ 4:30pm-5:30pm	Venue	ReCAP 2F, Seminar Room,
	Guest	Dr. Peng Wang (Associate Professor, Renmin Univ., China)	Organizer	Ritsuko Fujii
	Theme	"New Insights into the Primary Light Conversion Process in Bacterial Photosynthesis"		
45th	Date	Aug. 8, 2018/ 5:00pm-6:10pm	Venue	Faculty of Science, Lecture Room 10 (E211)
	Guest	Dr. Yosuke Tashiro (Lecturer, College of Engineering, Shizuoka University)	Organizer	Makoto Miyata
	Theme	"Unraveling the Mystery of Membrane Vesicles (Bacterial Missiles)"		
46th	Date	Oct. 30, 2018/ 5:00pm-6:10pm	Venue	Faculty of Science, Lecture Room 10 (E211)
	Guest	Dr. Guillaume Dumenil (Institut Pasteur, Paris, France)	Organizer	Makoto Miyata
	Theme	"Vascular Colonization by Neisseria Meningitidis"		
47th	Date	Dec. 13, 2018/ 5:30pm-6:40pm	Venue	Faculty of Science, Lecture Room 10 (E211)
	Guest	Dr. Daisuke Shiomi (Associate Professor, Department of Life science, Rikkyo University)	Organizer	Makoto Miyata
	Theme	"Bacterial Morphosis Mechanisms using Cytoskeleton Proteins and their Control Factors"		

What is OCARINA?

The mission of OCARINA (OCU Advanced Research Institute for Natural Science and Technology) is to find solutions for global-level energy and environmental issues and complex and advanced research subjects, and contribute to the establishment of a sustainable society. As an urban-type university that promotes multidisciplinary research, we set up research projects across the graduate schools.

Since its foundation in 2010, OCARINA has been carrying out large-scale projects with competitive research funds, while promoting globalization, integration of different fields, training of young researchers, and recruitment of female researchers.
Currently, we have seven big projects at the four OCU research departments of Graduate School of Science, Graduate School of Engineering, Graduate School of Life Science and Graduate School of Medicine. The most distinguishing feature of OCARINA is the integration of different fields, which is conducted by a small number of selected researchers. With the major city of Osaka as our base, we will continue to promote original research, including collaborative research related to medicine.

History of the Osaka City University Advanced Research Institute for Natural Science and Tehnology

2008	March	Founding Anniversary International Symposium held
	April	The OCU strategic key research project (2008-2011) started
	December	International Workshop held on the efficient use of sunlight energy
2010	March	Enforcement of official regulations(start of activities as an official bureau)
	March	1st International symposium held
	October	2nd International symposium held
	November	Building 2 renovated for research floors of OCARINA
	December	Opening symposium for building 2 of OCARINA held
2011	March	3rd International symposium, "Kakuno memorial," held
2012	March	Annual meeting and the OCU strategic key research project(2008-2011) debriefing held
	April	The OCU strategic key research project (2012-2014) started
	July	School of Science Building C completed, partial occupation
2013	March	4th International symposium held
	April	2 new full-time staff members appointed
	April	New projects started
	June	**Research Center of Artificial Photosynthesis opened**
2014	February	Partial occupation for the new School of Science Building
	February	One new full-time tenure track staff member appointed
	March	One new full-time tenure track staff member appointed
	March	5th International symposium held
	April	One new full-time tenure track staff member appointed
	April	The OCU strategic key research project (2014-2015) started
2015	March	6th International Symposium held
	April	One new full-time staff member appointed
	April	Three new project started
2016	March	7th International Symposium held
	April	The OCU strategic key research project (2016-2017) started
	April	ReCAP authorized as a Joint Usage/Research Center by Ministry of Education, Culture, Sports, Science and Technology (MEXT)
	April	One new project started
2017	March	8th International Symposium held
	April	One new project started
	August	One new project started There are currently seven projects being promoted
2018	March	9th International Symposium held

Osaka City University Advanced Research Institute for Natural Science and Technology
3-3-138 Sugimoto, Sumiyoshi-ku,Osaka 558-8585, Japan
TEL：06-6605-3111
FAX：06-6605-3636
http://www.ocarina.osaka-cu.ac.jp/