Yamaguchi University Research Activities

2014 Vol.2

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Masaaki OKA
President

Yamaguchi University is comprised of eight faculties and nine graduate schools. The university has its origins in Yamaguchi Kodo, a private school founded in 1815 by Ueda Hoyo, a feudal clansman of Choshu Province; Yamaguchi University will therefore celebrate its 200th anniversary in 2015. It is located in an area which had a great effect on the Meiji Restoration, Japan's period of modernization. This area was significant for creating a unique cultural climate which prepared the country for the challenges of the new world. This spirit is still alive and is reflected in the university's philosophy "A Place of Wisdom: Discover it, Nourish it, and Realize it." Along with its focus on education, research, and social contribution, the university aims to contribute to the development of Yamaguchi Prefecture, Japan, and the world.

More than ever before, the university is expected to promote globalization, create innovations through research, and contribute to the revitalization of the region. The university conducts research that exhibits its strength as a university boasting a diverse range of courses and cross-faculty research. Further, it also recognizes that research activities require international networking and cooperation.

The brochure "Yamaguchi University Research Activities" has been issued for the purpose of introducing the university's remarkable research activities at home and abroad. I hope that this brochure will promote cooperation among researchers and enhance interest among potential students in studying at Yamaguchi University.

Contents

Individual research and interdisciplinary collaboration

The research vision and strategic research initiatives of Yamaguchi University

Yamaguchi University has some strategic initiatives to promote interdisciplinary research activities. One of these is the 'Core Clusters for Research Initiatives of Yamaguchi University', where several groups conduct research in priority areas designated by the university. Through this project, teams of researchers expand their research communities and advance interdisciplinary research, starting from basic research to applied research and then to commercialization. 21 research groups in the five priority research areas are participating at present.

'The Research Institute for Time Studies at Yamaguchi University' was established in 2000. The objective of the Institute is to establish time studies as a new interdisciplinary research area through understanding different fields of studies from the viewpoint of time, and to present research findings to the public. It is the only institute for time studies, pursuing research through integrating the humanities and sciences. Through diverse activities, the Research Institute for Time Studies aims to become an international center of time studies through presenting its findings to the world.

Yamaguchi University advances the promotion of all research activities of the university through these strategic initiatives. It aims to establish research centers which will conduct leading research. For this purpose, the university encourages international exchange of research at home and abroad and aims to produce world-class research findings through interdisciplinary collaboration among researchers in specialized fields.

Hidetoshi MIIKE
Trustee (Academic Research, Academic Information)
Vice President
Director of The Organization for Research Initiatives

Core Clusters for Research Initiatives of Yamaguchi University

The priority research areas:

1. to develop technology that will contribute to realizing a low-carbon and sustainable society.
2. to create innovation in the fields of life science and medicine.
3. to contribute to the development of the history, society and culture of Yamaguchi, and also of (South) East Asia.
4. to develop technology contributing to providing information on the environment, climate variability, predictability, and disaster prevention etc.
5. to integrate the humanities and sciences, leading to the future and the 200th anniversary of Yamaguchi University.

The Research Institute for Time Studies

山口大学 時間学研究所

Photos below are posters of symposiums and seminars held by RITS

Interview with Prof. Shoichi Kai, Director of The Research Institute for Time Studies

You became the director of The Research Institute for Time Studies (RITS) in June 2014. Could you please tell us your past relationship with RITS, if any?

Prof. Kai I was a guest professor of RITS for three years from 2010 and once gave a seminar at RITS in some relation with time studies. The title of my seminar at that time was something like "Rhythm and Noise", in which I discussed how noises are related to the formation of periodic rhythms and I also showed that they play a rather positive role in this formation. Such a role of noises was a new finding and unexpected. Another occasion was maybe around 5 years ago when I gave a lecture at RITS as an invited speaker at the annual meeting of the Japan Society of Time Studies. Though I don't remember the title and content of the talk anymore, I think it was related to pattern formation.

We have heard that you conduct research in various fields. What is your research as your life work?

Prof. Kai My research has been in physics in nonlinear dynamics and complex materials over for 40 years. Much of my research has focused on fundamental studies to clarify the mechanism of pattern formation in various nonlinear systems. I conduct research on both non-living and living systems, e.g. fluids, crystals, polymers, liquid crystals, chemical reactions, brains, bacteria and plants. If I gave you keywords about my work, they would be complex physics, electro-convection, turbulence, chaotic behavior and oscillations, that is, chaotic and regular structures in space and time. My goal was then to find the formation principle and formation universality for such structures as fundamental physics in systems far from thermal equilibrium. Unfortunately I could not successfully achieve my goal before my retirement because too many difficult problems were involved.

Shoichi KAI

Director of The Research Institute for Time Studies

Professor Kai received his PhD degree from Kyushu University in 1977. Since then he worked at Kyushu University as a research associate (Department of Electronics), at Stanford University as a postdoc (Department of Chemistry from 1979 to 1981), at Kyushu Institute of Technology as an associate professor and later full professor of Electrical Engineering. From 1994 he was a professor of Applied Physics at Kyushu University and retired in 2012 (Professor emeritus of Kyushu University).

Comments on expectations for the development of RITS

Hidetoshi MIIKE, Vice President of Yamaguchi University

Dr. Heisuke Hironaka hoped to develop a unique research field at Yamaguchi University when he was the president (1996-2002). At that time, an active research group in the field of 'chronobiology' of Yamaguchi University was one of the world leaders in the field. Then Dr. Hironaka decided to start the new area of research 'time studies' by integrating the humanities and sciences, and The Research Institute for Time Studies was established in 2000.

Currently, lots of research related to time studies is being conducted at RITS by researchers of RITS and many guest researchers. International symposiums and seminars are held regularly by RITS in order to present research findings and to familiarize the public with time studies.

I think it is important for the expansion of RITS and time studies to steadily let people know about our research activities. This will increase the number of fellow researchers wishing to participate. I expect RITS will become a core research center and many top level researchers of the world will come to research at RITS.

What is the relation between your research and Time Studies?

Prof. KAI When I was a guest professor of RITS, I noticed, from the viewpoint of interdisciplinary science based on nonlinear dynamics, that "Time Studies" was very similar to "Complex Physics and Sciences". I would say now both almost overlap each other and must have the same goal.

As the director of RITS, what is your opinion of Time Studies now and what does the future hold for Time Studies?

Prof. Kai The field "Time Studies" is not yet well established and it is in a similar situation to "Complex Sciences" some years ago. The word "Complex Sciences" was born in the 90s, i.e. already more than 20 years ago. At the beginning, research fields covered by "Complex Sciences" were not completely established, and neither was its meaning. But now most scientists understand what it is and how broad. As "Time Studies" is younger than that, it has not yet reached such a level and it is still localized in narrower and more individual fields. Knowing the current development of the field "Complex Sciences", however, I am quite sure that it has a great opportunity, perspective and possibility for future development.

Please tell us your expectations and goals for the future of RITS.

Prof. Kai At first I expect that researchers from broad fields, such as mathematics, physics, chemistry, biology, medicine, economics, sociology, philosophy, the humanities, literature and so on, would participate together and exchange ideas on time studies at RITS as a unique center. The most important role of RITS is not to make cooperative research in similar fields but rather to encourage the exchange of fresh ideas from researchers to researchers among quite different fields, that is, the creation of intellectual capacity and knowledge. We should not require short term output but long term incubation and ripening of ideas as well as collaboration. As a result the field "Time Studies" will be established as a really interdisciplinary science. After that, I wish, it will spread out from RITS to all over the world. This is currently my dream and, I guess, would be also an aim of Professor Emeritus Heisuke Hironaka who is the founder of RITS, a former President of Yamaguchi University and a Fields Prize winner as well.

TOPICS

Prof. Kai met Dr. Heisuke Hironaka

Prof. Kai had a meeting with Director Emeritus Dr. Heisuke Hironaka, former president of the university. Dr. Hironaka said that in his opinion, there were few opportunities for interdisciplinary exchange when he was the president, and that he had felt the importance of such opportunities was not being recognized in Japan, to judge from his experiences at institutes abroad such as Harvard University. Therefore, his goal was to create opportunities for discussions beyond research fields in the university, and in this way, he decided to establish the RITS. Dr. Hironaka emphasized that it is important for researchers to express their technical knowledge simply to others in order to communicate smoothly, and also to listen to researchers of different fields in order to understand some fundamental concepts relating to their own research areas. (June 24, 2014)

Dr. Heisuke Hironaka is a mathematician. He was bone in 1931 in Yamaguchi prefecture. He received his Ph.D. in 1960 from Harvard University. He was awarded the Fields Medal in 1970. He was a president of Yamaguchi University (1996-2002).

Dr. Heisuke Hironaka

COLUMN

Time and Free Will Takuo AOYAMA

My philosophical research interests are time, language, freedom and the mind-body relationship. More recently, I have been thinking about the problem of time and free will, a problem that concerns both the humanities and sciences. For example, a recent introductory book* explains clearly how the progress of neuroscience and social psychology affects our understanding of free will. Assume that the voluntary movement of hands is determined by the brain activity prior to the conscious will to move. (Some scientific data partly support this hypothesis.) In that case, can we say the movement is caused by free will? If so, how should we define 'free will'? These questions are not mere intellectual speculation, but they are tightly connected to our ethical practice in assigning responsibility. I would like to continue researching these topics and reporting the results to society, mainly from the viewpoint of time studies.

* A. R. Mele (2013) A Dialogue on Free Will and Science

Assoc. Prof. Takuo Aoyama joined the RITS as a lecturer in 2006. He was appointed as an associate professor since December 2009. He was awarded the Ishimoto Prize of the Philosophy of Science Society Japan in 2006

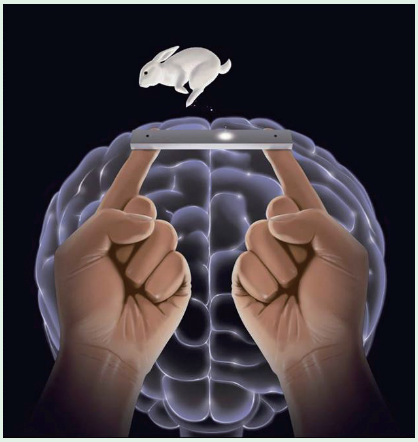
Lectures on Analytic Philosophy
Takuo Aoyama (2012)
Chikumashobo Ltd.

The Philosophy of Time Travel (New Edition)
Takuo Aoyama (2011)
Chikumashobo Ltd.

Introduction to Research

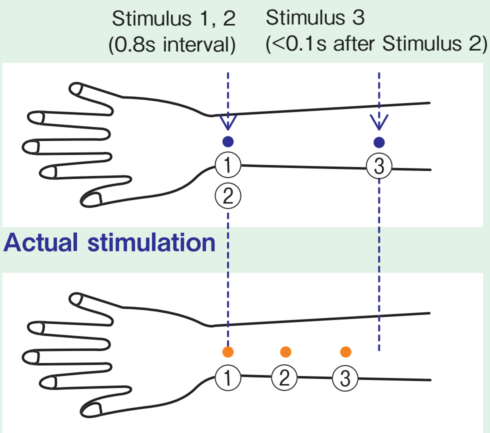
The mysterious "Cutaneous Rabbit" illusion –Postdiction–

Prof. Makoto Miyazaki of RITS uses psychological and neurophysiological approaches to investigate the mechanisms of the brain's information processing. Sensory illusions provide clues for such mechanisms. One well-known sensory illusion is called the "cutaneous rabbit," where one feels as if a small rabbit is hopping along the skin (Fig.1). When physical stimuli are presented in rapid succession, the second and third stimulations are perceived to occur not at the actual location of the stimulations, but at locations closer to each other, as shown in orange in Figure 1. It was reported that the region corresponding to the points of perceived cutaneous illusion is activated in the somatotopic map of the brain. This is the result of Stimulus 3, which occurs later, retroactively influencing the perception of Stimulus 2 that has already occurred; this is a very mysterious phenomenon as it appears to contradict our established views of the physical world. This effect demonstrates what has been termed as "postdiction" and is attracting widespread attention.



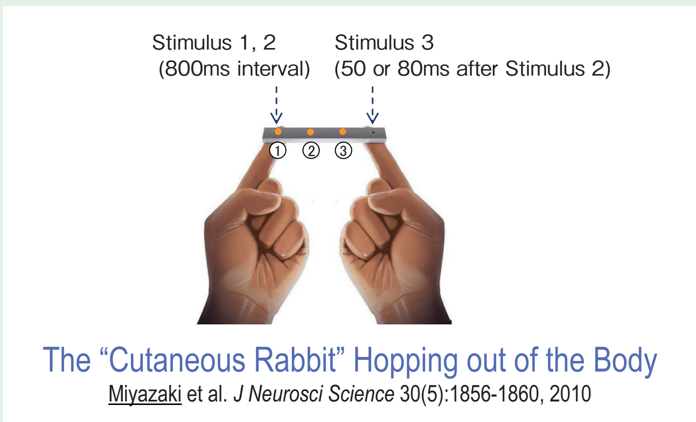
Prof. Miyazaki's recent studies have shown that the cutaneous rabbit is felt not only on one's skin, but is also perceived along an external object that is being held in one's hand (Fig.2). This suggests that the brain processes the external object as part of the body. Application of this theory to the development of instruments such as prostheses is eagerly anticipated.

Figure 1:
Stimuli triggering "cutaneous rabbit"



Perceived stimulation
Sensory illusion of three distinct locations being stimulated in sequence

Figure 2:
Sensory perception felt on an external object



TOPICS

RITS held an academic symposium in Fukuoka

RITS held an academic symposium titled 'Possible application of the internal clock to learning, exercise and business' co-organized by the Japanese Society for Time Studies in Fukuoka Prefecture on June 7.
Prof. Makoto Akashi of RITS gave an outline of the mechanism of the biological clock and explained how health risks arise from the ways in which the biological clocks of modern humans are not attuned to natural rhythms.
Fuminori Ono, who is an Associate Professor in the Faculty of Education at Yamaguchi University, reported findings showing that we perceive length of time by the rhythm of the day.
Researchers from other universities and laboratories also presented research results related to the biological clock. An active discussion about the surprising relationships between fundamental abilities and human health to the biological clock followed, with questions posed and opinions expressed about modern society, where natural rhythms are not emphasized.
This symposium is held every year on a date close to June 10, 'Time Day', and topics related to time are discussed.



Prof. Makoto Akashi

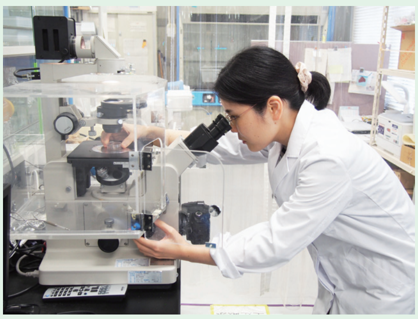
Introduction to Research

Findings related to the biological clock

The research results of Akaishi laboratory are shown on the online *Cell Reports* journal which is published by Cell Press on May 1 (paper 1) and July 10 (paper2) in 2014.

(paper 1)
In the current model of the mammalian circadian clock, PERIOD represses the activity of the circadian transcription factors, either independently or together with CRYPTOCHROME. The authors provided evidence that PERIOD has an entirely different function from that reported previously. Overall, the results support the hypothesis that PERIOD plays different roles in different circadian phases: an early phase in which it suppresses CRYPTOCHROME activity, and a later phase in which it acts as a transcriptional repressor with CRYPTOCHROME. This buffering effect of PERIOD might help to prolong the period of rhythmic gene expression. These research findings contribute the development of chronobiology.

(paper2)
The circadian clock is entrained to environmental cycles by external cue-mediated phase adjustment. However the mechanism of feeding-induced phase resetting remains unclear. The authors report that insulin may be involved in feeding-induced tissue-type-dependent entrainment. In the experiments, insulin-induced phase shift in peripheral clocks was dependent on tissue type, which was consistent with tissue-specific insulin sensitivity, and peripheral entrainment in insulin-sensitive tissues involved the signaling pathways. These results suggest that insulin may be an immediate early factor in feeding-mediated tissue-specific entrainment. These research findings are expected to be the first step in resolving the entire control mechanism of the circadian clock.



(paper 1) Akashi M, Okamoto A, Tsuchiya Y, Todo T, Nishida E, Node K. A Positive Role for PERIOD in Mammalian Circadian Gene Expression. *Cell Reports* 7(4):1056-1064, 2014
(paper2) Sato M, Murakami M, Node K, Matsumura R, Akash M. The Role of the Endocrine System in Feeding-Induced Tissue-Specific Circadian Entrainment. *Cell Reports*, Published online (July 10, 2014), DOI:10.1016/j.celrep.2014.06.015

The Research Institute for Time Studies

The Research Institute for Time Studies (RITS) at Yamaguchi University was established in April 2000 when Dr. Heisuke Hironaka was the president of the university. The aim is to create Time Studies as a new interdisciplinary area of study by understanding nature, human, society, and culture from the viewpoint of time, and for society to benefit from the research results. The activities of RITS provided an important opportunity for the establishment of the Japanese Society for Time Studies.

RITS is composed of the director, researchers, and administrative staff. About 100 researchers on campus and outside of Yamaguchi University are involved in RITS activities in various ways.

The lectures include topics on time-related areas such as developmental biology, evolution, the birth of the universe, and sociological time. In particular, students are required to understand the interaction between social time and biological time, and to consider the significance and issues of time in human life.

The research organization of RITS consists of four study groups. The researchers work in a wide range of fields related to time studies such as biology, medicine, sociology, philosophy, literature, geology, psychology, economics, and social anthropology.

URL: http://www.rits.yamaguchi-u.ac.jp/

Leaflet

Web site

Director Shoichi KAI (Director of the Research Institute for Time Studies)

Researchers (Full-Time Teaching Staff)

Kenta FUJISAWA (Professor of the Research Institute for Time Studies)
Specialty: Radio astronomy, space physics

Makoto MIYAZAKI (Professor of the Research Institute for Time Studies)
Specialty: Cognitive neuroscience, sports science

Makoto AKASHI (Professor of the Research Institute for Time Studies)
Specialty: Chronobiology, molecular biology, cell biology, time medicine

Takuo AOYAMA (Associate professor of the Research Institute for Time Studies)
Specialty: Philosophy, ethics

Hiroki MIGITA (Lecturer of the Research Institute for Time Studies)
Specialty: Sociology (theory of celebration, history of mentalities)

Miho SATO (Research associate of the Research Institute for Time Studies)
Specialty: Chronobiology, Molecular biology

Group 1
Fields Related to the Harmony of Social Time and Human Time

In modern society, as a result of the arrival of the global information society, the tension between social time and human time has become intense. The aim of this study group is to harmonize social time and human time through the scientific research of these time categories.

Group 2
Fields Related to Biological Time, Evolution and Environmental Change

The research members are studying to understand how environmental changes and biological evolution interact with each other throughout the never-ending and everlasting time. The goal of the research is to elucidate what time is for organisms by obtaining experimental data using various organisms ranging from protozoa to mice.

Group 3
Fields Related to Representations of Time in Multicultural Areas

The question of how to represent time is closely related to cultures and organizations. We examine the difference of representations of time in multicultural areas from the perspective of thought, literature, linguistics, and so on. In addition, we study the conceptual base of time from philosophy and time-related arts.

Group 4
Various Fields in Time Studies

Time is an important concept in a variety of study fields. The concept of time is slightly different in each study field. In this study group, time is considered from many different perspectives in fields such as medicine, agriculture, physics, and engineering, and the possibilities of time studies are investigated.

[Interview]

Manipulating Light: Innovative Artificial Metamaterials

'Metamaterials' might not be a commonly used terminology now; however they can potentially change future daily life by opening up an unusual and new side of the world we have never experienced. Since the possibility of the realization of metamaterials was suggested at the beginning of this century, metamaterials have fascinated many physicists, scientists and engineers. Prof. Atsushi Sanada, a leading scientist in the field, speaks about the potential and future of metamaterials.

Atsushi SANADA

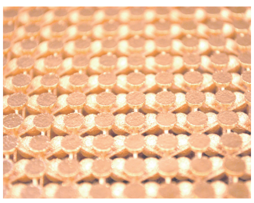
Professor
Graduate School of
Science and Engineering

Prof. Atsushi Sanada received his B.E. in 1989 and his Ph.D. in Engineering in 1994 from Okayama University. He joined Yamaguchi University as an assistant, and became a professor of Graduate School of Science and Engineering in 2001.He studied in outer institutes several times as a guest researcher, in 1994-95 and 2002-03 at UCLA, in 2005-06 at ATR. In 2005, he was a special researcher in the NHK science & technology research laboratory as well. Currently, he is the Coordinator of IEEE MTT-S AdCom Region 10(Asia-Pacific).

What is Left-handed metamaterial ?

――First of all, tell us about the metamateirals you are working on. Briefly, what are metamaterials?

Prof. Sanada Briefly speaking, metamaterials are artificially structured materials consisting of an array of small sub-wavelength pieces of material that mimic natural atoms or molecules. They possess unusual electromagnetic properties that natural materials never exhibit, like an invisible cloak in science fiction movies or animations films, for instance.



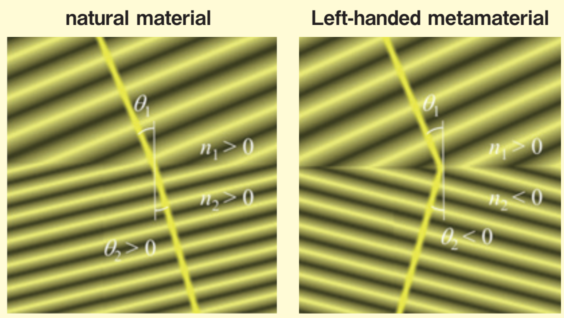
Left-handed metamaterial realization with negative refractive indices

――When did you start working on metamaterial research?

Prof. Sanada At the end of the 90s. I was working on magneto-electric effects of metals, magnetic materials, superconducting materials, and the like at the end of the 90's at YU. It had been known that the magneto-electric effect can be enhanced by combining materials of different kinds, and I was trying to realize novel materials with enhanced magneto-electric properties based on the artificial material concept. In 2002, my research proposal was accepted by the Ministry of Education, Culture, Sports, Science and Technology of Japan and I decided to go to UCLA to proceed to the research area of metamaterials.

In the US, a DARPA program on metamaterials had just been launched at that time and the lab I joined was involved. The main topic in the program was physics, theory, and applications of left-handed metamaterials, so I focused on the subject at the moment. Left-handed materials are materials with simultaneous negative permittivity and negative permeability and this leads to negative refractive indices. In left-handed materials, the electric field vector E, the magnetic field vector H, and the wavenumber vector k of light or electromagnetic waves form a left-handed triplet. That is why they

■Figure 1 Law of refraction $n_1\sin\theta_1=n_2\sin\theta_2$



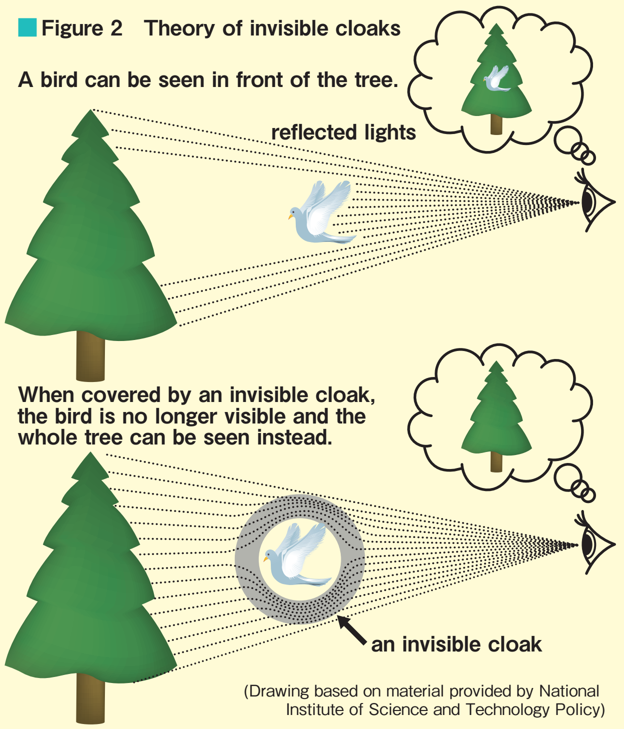
are referred to as left-handed materials. Left-handed materials have gained great attention because they have unusual negative refractive indices: when light strikes a left-handed material, the ray of the light bends with a negative angle of refraction, in the opposite direction to that which occurs with a normal material (Fig. 1). The first demonstration of left-handed metamaterial suffered from inevitable narrow band and high loss characteristics due to the intrinsic resonant nature of its constituents. Therefore, I took a different approach and proposed a new theory based on the transmission line approach of circuit theory. Luckily, I succeeded in experimental verifications of the theory with a novel left-handed metamaterial with an extremely wide band and low loss characteristics. A number of novel, epoch-making devices and antennas with extreme characteristics have been developed at microwave frequency regions so far, based on my theory.

Invisible cloak for real?

——You mentioned that an invisible cloak could be realized by metamaterials, but how does it work?

Prof. Sanada When you see something, say an object for instance, your eyes are detecting rays of light shone, reflected, or scattered by the object. If you have another obstacle just between you and the object, the rays of lights are obstructed and cannot reach you, resulting in the object becoming invisible. In this case, you see the obstacle instead of the object. Suppose we can bend the rays of light and make a detour for the rays around the obstacle, you will again be able to see the object. In this case, the obstacle looks transparent and disappears and you cannot even figure out that the obstacle exists (Fig. 2). Invisible cloaks provide detours for the rays of light. More specifically, invisible cloaks realize transformations of coordinate systems around obstacles. For instance, according to Relativity, rays of light can be bent by a space coordinate transformation caused by gravity. This has already been confirmed by a well-known observation of light from a distant star behind another heavy star. The invisible cloak actually performs an operation equivalent to a space coordinate transformation.

Figure 2 Theory of invisible cloaks



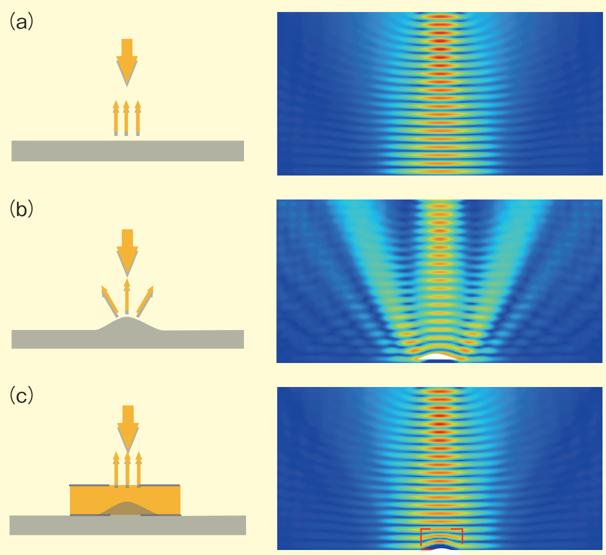
(Drawing based on material provided by National Institute of Science and Technology Policy)

——In a Harry Potter movie or Doraemon cartoon, people put on an invisible cloak to visually hide from others. How realistic is the invisible cloak?

Prof. Sanada Good question. The concept of the invisible cloak has already been demonstrated and will be operational in practical applications in no time, sometime within 10 years, maybe. So far, it is demonstrated at lower frequencies, like the microwave region, and scientists are making extensive progress toward realizing it in the optical region of visible light. Flexible and wearable cloaks may have a lot more issues to overcome but are potentially possible in the same manner.

In addition, similar but different camouflage or illusion technologies have been demonstrated recently. For instance, let me explain an illusion carpet technology developed in my lab. The illusion carpet hides a bump on a floor or a mirror and you cannot see the bump over the carpet at all. The illusion carpet consists of an array of fine metallic transmission lines, and transforms the space above the bump into a square one with a flat floor. Therefore, light waves refracted or diffracted by the transformed space can appear exactly the same as those refracted or diffracted by the flat floor and one cannot see the bump at all (Fig. 3).

Figure 3 Theory of illusion carpets



(a) Reflection from flat floor
(b) Reflected light scattered by a bump
(c) Reflection observed as if without bump

Technically speaking, the structure fully controls all the components of permittivity and permeability tensors, and the challenge here is how to realize it by a structured artificial material, which is the main subject of this research and is gaining attention from all over the world. We have established a rigorous method to design cloak materials. More specifically, in order to realize a cloak material, first the cloak space is transformed into an appropriate coordinate system to accommodate the shape to be hidden, and equivalent material parameters are determined. Then, the space is discretized into small subwavelength areas, and the structural parameters in each of the discretized areas are computed to realize the material tensor parameters. As a result, cloak structures can be systematically designed to meet specifications. So far, the cloak design has been totally empirical and not straightforward. Our approach is the first practical solution for this complicated problem.

(Refer to the Coordinate Transformation.)

Realizing unusual devices and materials

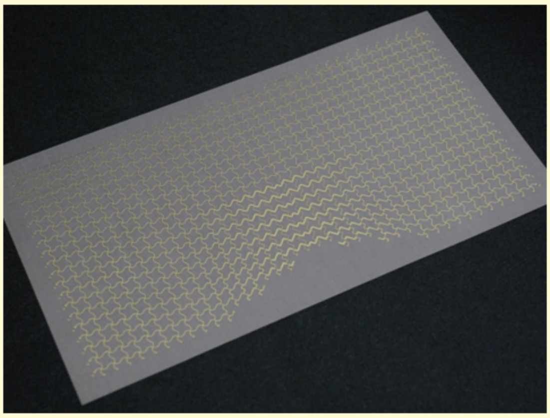
——You have many computers in your lab, don't you?

Prof. Sanada Yes. They are mostly for full-wave electromagnetic simulations of metamaterial designs. For instance, in the carpet/cloak design, dimensions of the small metallic constituents are determined by solving Maxwell's equations with huge combinations of structural parameters based upon our theory. Luckily, we have strong support from some software venders, and selections of simulation tools based on various kinds of numerical techniques are available in the lab.

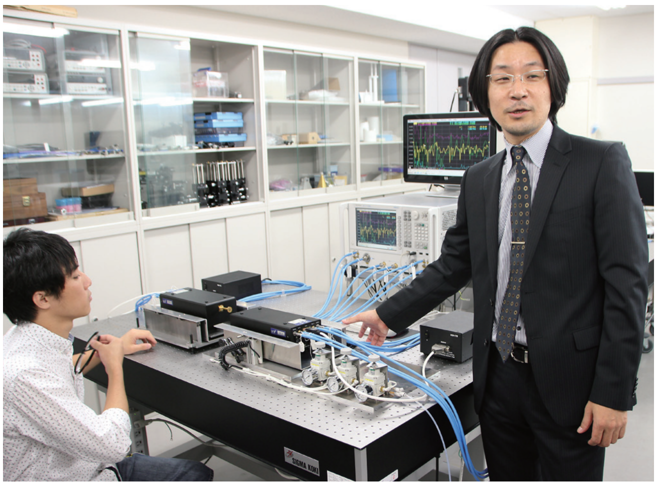
——The room looks highly equipped.

Prof. Sanada Indeed. We have introduced quite unique material measurement systems and nano-fabrication systems supported by the university and the government. We can evaluate diverse properties of natural and artificial materials in a wide range up to Terahertz frequency regions in the lab. Some of the products are the first ones of their kind or our in-house products developed with enormous support from other institutes and companies, and are very powerful and unique.

Figure 4 A model of an illusion carpet

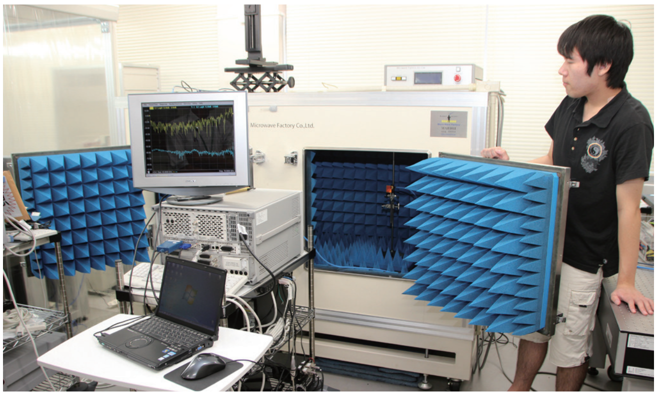


In this illusion carpet, tiny swastika metal pieces are placed at precisely calculated locations.



material measurement systems

bunch of Computers



radio wave darkroom

——You travel a lot in the world.

Prof. Sanada Because I have to. I frequently go abroad not only for lectures and invited talks in conferences or meetings but also for volunteer efforts in the academic community. I often travel abroad with my students to help nurture young researchers' ambitions and sense of globalization.

——What do you teach your students in the lab other than research?

Prof. Sanada I expect students to have a wide perspective and to network with others across disciplines. Many of my students get jobs at companies or institutes in the electronics or communication industries, yet I believe networking helps a lot in the rest of their life.

——How do you picture the future of your research area?

Prof. Sanada We can easily imagine that future research topics will rely heavily on a combination of multiple technologies with researchers in multiple areas. For instance, metamaterial science covers material and device science, electronics, computational science, mechanical and nano-fabrication technologies, chemical science, bio-science and technologies as well as electromagnetics and physics. Exploiting synergic factors would be of more importance.

——Finally, tell us about your dreams.

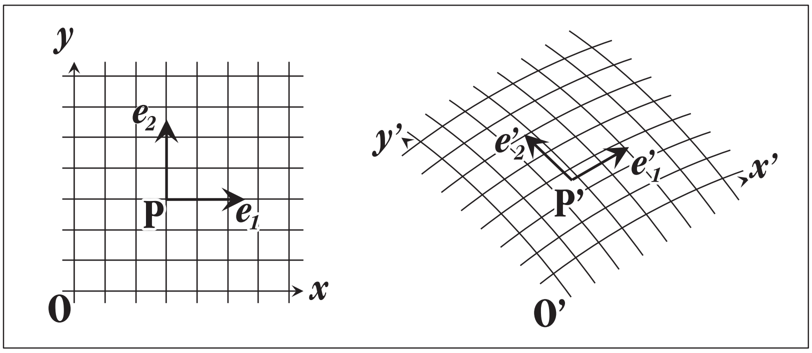
Prof. Sanada I will concentrate on realizing cloaks of invisibility and illusions in the near future, hoping to see the technology become common in our daily life.

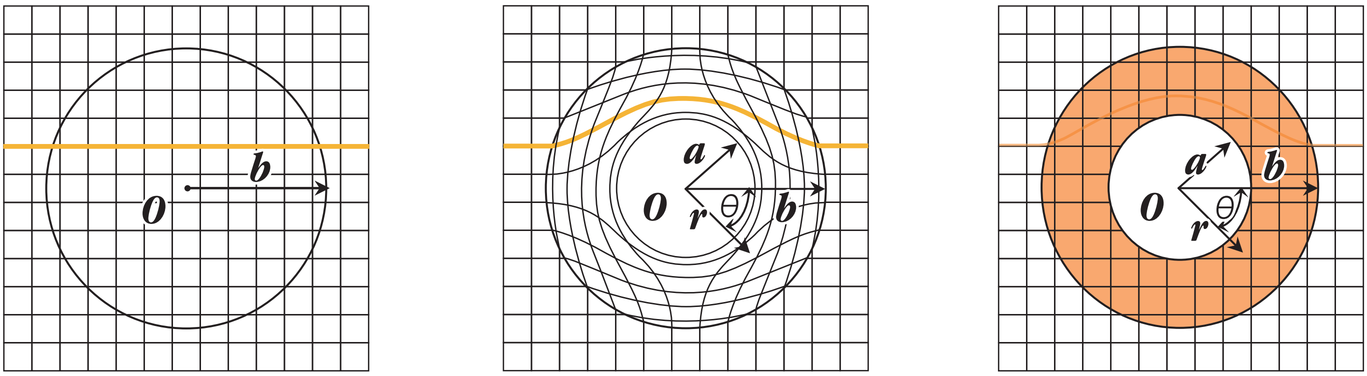
(Interviewed by Masataka Nikaido, URA)

Explanation: The coordinate transformation

A coordinate transformation is a conversion from one system to another, to describe the same space.
A single point P(x, y) on one coordinate is projected onto P' (x', y') on the other coordinate system,
(See Fig. T-1(a)). Generally, both of the original and transformed coordinates may not be the rectangular coordinates where the basis e1, e2 cross orthogonally (Orthonormal coordinate).
When Maxwell's equation is satisfied beyond the conversion, the rays of light will trace corresponding points on both coordinates.
If a circle of radius b, which is shown in Fig. T-1(b), is projected onto a donut-like region with inner diameter a and outer diameter b as shown in Fig. T-1(c),
and if Maxwell's equation is satisfied after the transformation, the ray of light shown as the yellow line in Fig. T-1(b) will bend by following the yellow line in the transformed coordinate Fig. T-1(c).
In this case, the inner area of the circle of radius a (0<r' <a) in Fig. T-1(c) does not have a corresponding area in Fig. T-1(b). Therefore, no reflection and scattering of electromagnetic wave appears. This means an object in this area becomes invisible.
The invisible cloak can be realized by placing heterogeneous anisotropic materials (i.e. metamaterials) in the donut-like orange colored area of a<r' <b in Fig. T-1(d).

(a)



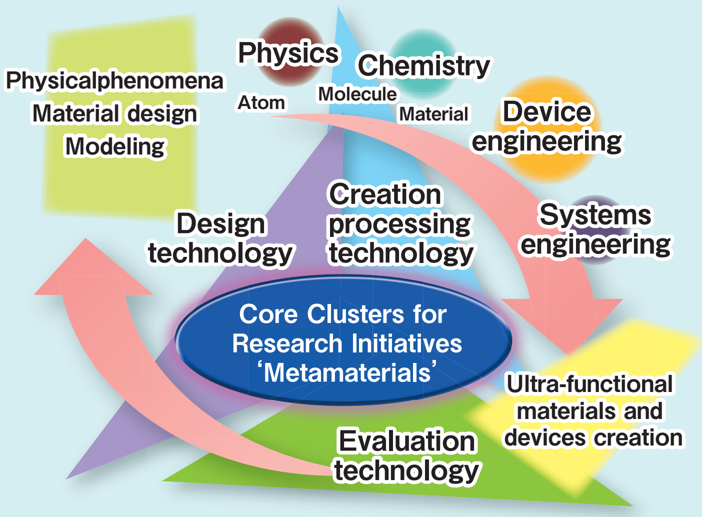


(b) (c) (d)

Research Area: to develop technology that will contribute to realizing a low-carbon and sustainable society.

Exploring hyper functional materials and devices based on metamaterials

This research initiative aims to establish basic theories for super-functional artificial materials which have specific physical properties and the fundamental technologies to design, fabricate and evaluate those artificial materials.
Evaluation and monitoring of the materials, large scale simulation, design of waveguides/devices, nano-fabrication, and chemistry-based fabrication technologies are promoted by a network of six researchers with Dr. Sanada's leadership.



Unraveling the secrets of microbes

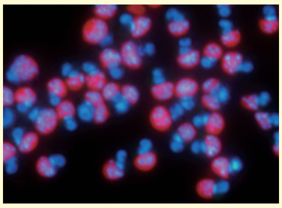
The world around us is filled with microbes that cannot be detected by the naked eye. Microbiologists have been studying microbes from different perspectives, including technology, ecology, and pathology. What will happen when these different approaches loosely collaborate?

Sharing common interests in target microbes

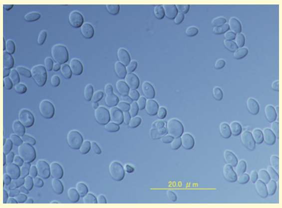
Nowadays where research disciplines and methods have been highly segmented, researchers require various motivations to form alliances, including launching large-scale projects, furthering research, increasing efficiency by dividing tasks, and brainstorming ideas through interaction between different research fields. In the field of life sciences, sharing a common interest in target microbes could be added to the list. The Core Clusters for Research Initiatives "Microbial evolution in function and their environmental adaptation" group was originally founded in 2005 and is a loose-knit community of researchers who actively participate in research exchanges. A total of 32 researchers studying viruses, bacteria, fungi, and protozoa, come together from various departments, including medicine, science, agriculture, engineering, and veterinary medicine.

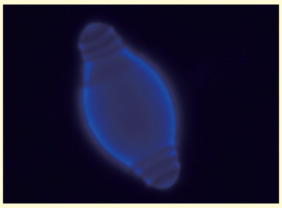
Just as the word "microbes" encompasses a broad spectrum of species, there is a wide range of research targets for this initiative (Photo 1). The research topics are very extensive, ranging from basic science to applied science, for example from trying to discover various aspects of the phenomenon of life by understanding microbial life, trying to exploit microbes' abilities for industrial applications, to fighting microbial infections in both humans and plants. So what draws them together? It is their interest in microbes and the universality that is evident through their research. Figure 1 shows the processes of Holospora infection in Paramecium cells, and Listeria infection in mammalian cells. In comparison, there are surprising degrees of commonality including the host uptake process through endocytosis, and the invasion into host cytoplasm mediated by cell membrane-surface protein interactions. The unique nature of the respective research targets and the universality of the microbes that sometimes presents itself are an integral part of what makes this research fascinating, and the academic conference held annually at Yamaguchi University allows researchers to share their fascinations and interests. From the breadth of the initiative's diverse research activities, we take this opportunity to share the researches on Paramecium and heat-resistant fermentation.

Photo 1: Various microbes as research materials


Cyanidioschyzon merolae


Colletotrichum gloeosporioides

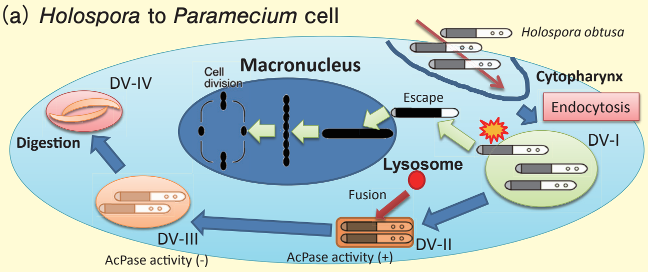

Kluyveromyces marxianus


Saccharomyces cerevisiae


Paramecium caudatum

Figure 1: Comparison between the infection processes of bacteria to eukaryotic cells

(a) *Holospora* to *Paramecium* cell



Core Clusters for Research Initiatives | Research Area: to create innovation in the fields of life science and medicine

Microbial evolution in function and their environmental adaptation

In this initiative, different microbial research groups within Yamaguchi University that are investigating fermenting microbes, parasitic and symbiotic microbes, and environmental microbes, come together to form an integrated inter-departmental microbial research group. It consists of three research groups. Each research group shares their cutting-edge technologies through workshops within the research initiative, and with other young researchers at Yamaguchi University and in Southeast Asia. In the research conference held annually in December, more than 150 researchers attend and over 100 research projects are presented every year. In addition, this research initiative actively collaborates and interacts with research institutions outside of Yamaguchi University, as well as private industries.

Research Groups

- Functional analysis of microbes
- Parasitism, symbiosis and environmental adaptation of microbes
- Maintenance and repair of the ecosystem by microbes

Collaborating institutions

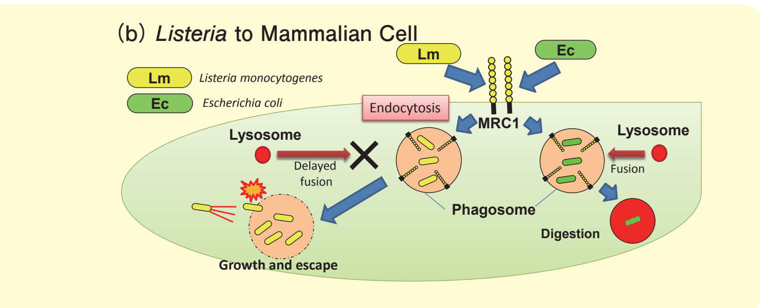
- ○International and domestic affiliated universities
- ○Neighboring universities, research institutions and museums etc.
- ○Domestic corporations

http://accafe.jp/microorganisms_yu/

Rediscovering Paramecium as a bioresource

Paramecium is a ciliated protozoon commonly found near human living spheres such as in ponds, sewers and irrigation channels. Their cell size is large, ranging from 100 to 250 μm, they possess characteristic organelles such as cilia, contractile vacuole, macronucleus, and micronucleus. They have been widely used as a model organism in cell biology. Furthermore, there is a large body of research into their morphology, reproduction, and behavior, and they have a long history of being used as research material in the study of genetics. For example, the fact that we can easily distinguish most mutations of paramecia under the microscope is a characteristic not found in other microbes. Recently Paramecium has been chosen as part of the National BioResource Project* by Ministry of Education, Culture, Sports, Science and Technology of Japan, and Prof. Masahiro Fujishima is serving as the center representative. This project maintains Paramecium resources of international standards and provides any researchers who have an interest in Paramecium with their desired strains. Collections of strains donated by researchers or sampled from the nature are maintained in a database along with the sampling location, and genetic and morphological characteristics. Strains used for genome and transcriptome studies, progeny from the cross in the laboratories and mutant strains are also available. In addition, strains which have endosymbiotic bacteria or algae and monoclonal antibodies (mAbs) for both host Paramecium and their symbionts developed through the research are also available.

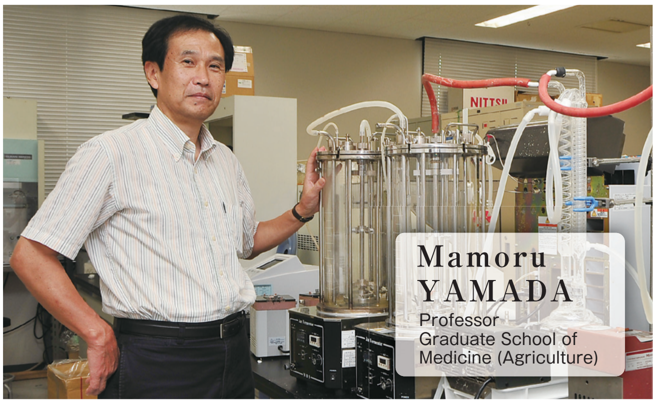
Masahiro FUJISHIMA
Professor
Graduate School of Science and Engineering



The purpose of this project is to systematically collect, preserve and provide bioresources such as experimental animals, plants and microbes that are important for the nation to strategically organize. Research institutions with advanced infrastructures and resources are chosen as core facilities to carry out collection, preservation, and provision of bioresources.

Heat-resistant microbes: promoting new concepts and returning research results to society

Achieving unprecedented research results and establishing new concepts in academia is one of researcher's dreams. The research group headed by Professor Mamoru Yamada is promoting the concept of "thermotolerant microbes," whereby microbes that are traditionally used in fermentation industries are modified so that their optimal fermentation temperatures shift 10 to 20 °C upward. Using cutting-edge technologies in genomics and metabolomics, the research group is starting to acquire evidence that supports their concept. In the heat-resistant ethanol fermentation project Prof. Yamada is currently working on, heat-resistant yeast is collected from natural environments in collaboration with Southeast Asian research institutions in Thailand, Laos, and Vietnam, and improved using selective breeding. Prof. Yamada is also collaborating with researchers from the Department of Engineering to design fermentation systems at "thermotolerant" temperature ranges. Collaborations are not limited to academia, but also extend to commercial industries to promote fermentation industry in tropical regions where such industrial infrastructure is relatively weak. As the Convention on Biological Diversity affects the academic research, international cooperation in the search and utilization of natural resources is highly sought after. Prof. Yamada's efforts in forming academic collaborations and returning research results to society is receiving attention as a case model for research expansion.
(Reported by Yuki Tonooka, URA)



Mamoru YAMADA
Professor
Graduate School of Medicine (Agriculture)

TOPICS The initiative welcomes a new researcher specializing in soil chemistry

In December 2013, Assistant Prof. Yukiko Yanagi from the Department of Agriculture, who specializes in soil chemistry, joined this research initiative. While soil organic matter is the largest reservoir of carbon in terrestrial ecosystems, the decomposition process of humic substances, the main constituent of soil, is not fully understood. Assistant Prof. Yanagi has conducted research into the biodegradation of humic substances using microbes and enzymes, and has demonstrated that biodegradability depends on the specific characteristics of the substance, and that the abundance of degrading microorganisms differs between soil environments. In the future, she plans to focus on enzymatic microbes in order to study the degradation characteristics of humic substances and analyze the mechanisms of degradation. This research into "loose symbiosis," achieved by investigating the cycling of nutrients and biologically active substances within the soil biome, is receiving attention as a new approach in the research initiative.

Soil investigation on the Alps in Italy

Overcoming intractable disease by uncovering the molecular mechanisms underlying the stress response

Considering homeostasis as a cellular response to stress, and uncovering molecular mechanisms to discover treatments for cancer and other intractable diseases

Heat-shock response: The key to sustaining life

The word "stress" is often associated with psychological factors. However, the cells in our bodies are constantly exposed to a variety of stressors, including extreme temperatures and low oxygen levels. Organisms maintain homeostasis by accurately monitoring and adjusting to ever-changing internal and external environments. When exposed to stress levels exceeding the capacity of the homeostatic mechanism, or during failures of the homeostatic mechanism itself, stress can lead to neuronal, metabolic, cardiovascular, and immunological disorders, and cancer.

Biochemistry and Molecular Biology of The Graduate School of Medicine, led by Professor Akira Nakai, has consistently demonstrated the importance of the mechanism that adjusts for elevated temperatures, called the "heat-shock response." This universal adaptive mechanism is one of the key processes used by living organisms to repair damaged proteins and is integral to human health. In the past decade, protein homeostasis, through the heat-shock response, has been established as a significant mechanism for suppressing aging and preventing age-related pathological conditions, such as neuronal disorders. A relationship between this response and the pathogenesis and growth of cancers has also been reported. Consequently, this mechanism is now attracting attention as a new therapeutic target.

Heat-shock proteins: Key factors in the heat-shock response

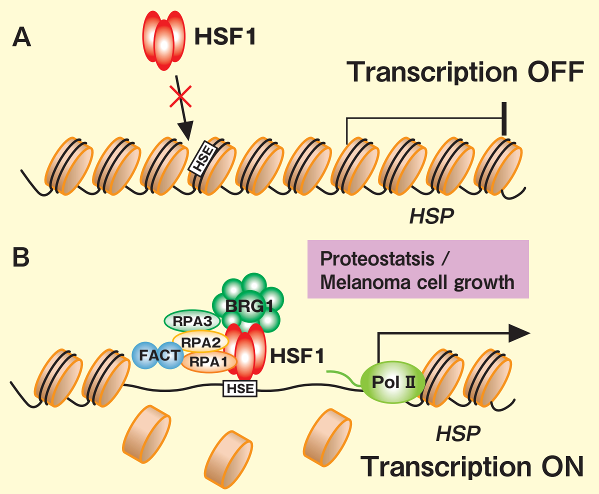
Proteins consist of amino acids, strung together in a chain, and their function depends on the correct folding of this chain. However, misfolding can occur due to external stress and genetic factors. In the case of misfolding, repair mechanisms, which refold or break down the proteins, are activated; among the most important of these is the mechanism called the heat-shock response. When cells are exposed to proteotoxic stress, including heat shock, a set of proteins known as heat-shock proteins (HSP) are produced, and the correct molecular protein structures are restored.

"Heat-shock factors" regulate the production of HSP

DNA, which contains genes, exists in nucleosome structures where DNA is wound around histone protein cores. Under normal conditions, this prevents transcriptional regulators from binding to the DNA. However, heat-shock factor I (HSF1) is able to bind to genes that code for HSPs to induce transcription. The mechanism behind this seemingly puzzling phenomenon was first discovered by Prof. Nakai and colleagues.

HSF binds to replication protein A (RPA), which is involved in DNA replication, to form the HSF1-RPA complex. The HSF1-RPA complex opens the nucleosome structure by recruiting components other than histone proteins from the DNA, thereby allowing HSF1 to bind to genes coding for HSP (Fig. 1). This induces the production of HSPs and activates the heat-shock response.

Figure. 1 HSP-coding gene and HSP1-RPA complex



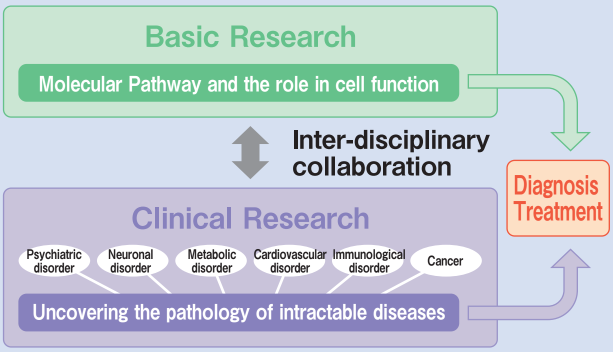
Core Clusters for Research Initiatives

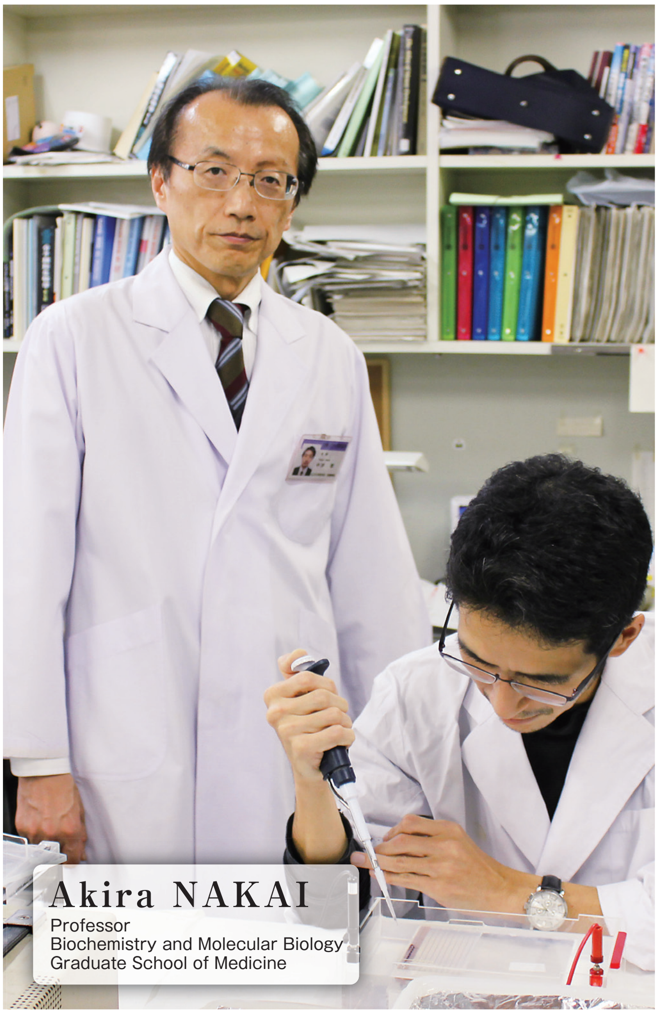
Research Area: to create innovation in the fields of life science and medicine

New approaches to understand and treat stress-related diseases

This research initiative consists of basic medical researchers, including Prof. Nakai, and clinical medicine researchers specializing in intractable diseases. Collaboration between basic researchers, investigating the cellular mechanisms of the stress response through epigenomic control (called "epigenomic adaptive mechanisms"), and clinical researchers, investigating the pathology of intractable diseases from the perspective of epigenomic adaptive mechanisms, is expected to greatly accelerate this research.

URL: http://ds22.cc.yamaguchi-u.ac.jp/~seika2/kennkyuusuishin/Kenkyuusuishin-2.html





Akira NAKAI
Professor
Biochemistry and Molecular Biology
Graduate School of Medicine

Melanoma cell proliferation and stress response

Melanoma cells are known to induce strong adaptive mechanisms during the stress response to achieve greater stress tolerance, and are even able to proliferate in inferior environments. According to research by Prof. Nakai and colleagues, when formation of the HSF1-RPA complex is inhibited in mice, suppressed levels of carcinogenesis are observed, suggesting that the HSF1-RPA complex plays a key role in melanoma cell proliferation.

Aiming to overcome intractable diseases

In 2014, this research project, led by Prof. Nakai, was awarded a research grant from the Takeda Science Foundation*. Further research developments are eagerly anticipated.

Building on his achievements in stress response research to date, Prof. Nakai has shifted his focus to understanding the mechanisms of epigenomic control, and is aiming to uncover the pathology of disorders related to epigenomic adaptive mechanisms. Since failure of the stress response can result in dysregulation of gene expression through reprogramming of the epigenome, which can lead to Alzheimer's disease, Parkinson's disease, cancer and other intractable diseases, Prof. Nakai is devoting his research to discovering new therapeutic targets associated with the stress response.

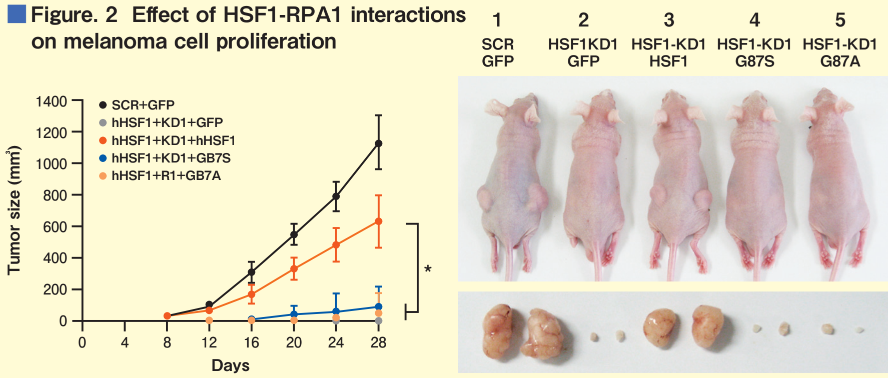
(Reported by Kumiko Tanaka, URA)

*Takeda Science Foundation Special Project Research
Research grants supporting the advancement of medicine in Japan. This grant is for research institutions and is awarded to collaborative research projects (both internally within an institution and inter-institutionally) that are supported by the respective institutions.

◀**Fig.1** Heat-shock factor 1 (HSF1) alone is unable to bind to DNA organized in nucleosome structures (A), but is able to bind successfully by forming a complex with replication protein A (RPA) and recruiting components other than histone proteins (FACT, BRG1). Consequently, proteostasis is achieved by controlling heat-shock protein (HSP) production. Melanoma cells utilize this mechanism to facilitate growth.

▶**Fig.2** Athymic nude mice were injected subcutaneously, in two locations in the lower back, with HMV-1 cells, where endogenous heat-shock factor 1 (HSF1) was replaced with green fluorescent protein (GFP), wild-type HSF1 (hHSF1-HA), or interaction mutants (G87S-HA, G87A-HA) (n = 8). In HMV-1 cells where HSF1-replication protein A formation was inhibited (2, 4, 5), tumor formation was significantly reduced.

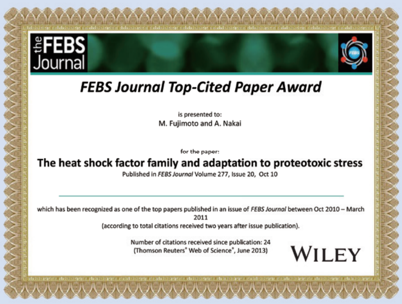
Figure. 2 Effect of HSF1-RPA1 interactions on melanoma cell proliferation



TOPICS

FEBS Journal Award for Top-Cited Paper Received By Members of the Core Clusters for Research Initiatives

Associate Prof. Mitsuaki Fujimoto and Prof. Akira Nakai, who are members of Core Clusters for Research Initiatives, won the FEBS Journal of Top-Cited Paper Award for their review article titled "The heat shock factor family and adaptation of proteotoxic stress", published in FEBS Journal in October, 2010. This distinction is awarded to an article that receives a high volume of citations in the two years following its publication in FEBS Journal, and is presented by the FEBS Journal Editorial Board. This review article details the research history of the HSF gene family, its proteostatic regulation, and its role in aging and age-related pathological conditions, to which the authors greatly contributed. The award indicates the high level of international interest in this research.


the FEBS Journal

FEBS Journal Top-Cited Paper Award

is presented to:
M. Fujimoto and A. Nakai

for the paper:
The heat shock factor family and adaptation to proteotoxic stress
Published in *FEBS Journal* Volume 277, Issue 20, Oct 10

which has been recognized as one of the top papers published in an issue of *FEBS Journal* between Oct 2010 – March 2011
(according to total citations received two years after issue publication).

Number of citations received since publication: 24
(Thomson Reuters' Web of Science®, June 2013)

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The United Graduate School of Agricultural Science, Tottori University	http://rendai.muses.tottori-u.ac.jp/english/index.html

Research Institute	URL
The Research Institute for Time Studies	http://www.rits.yamaguchi-u.ac.jp/?page_id=33

YAMAGUCHI UNIVERSITY

1677-1 Yoshida, Yamaguchi-shi, Yamaguchi 753-8511

http://www.yamaguchi-u.ac.jp/english.html

■ For Research enquiries:

Organization for Research Initiatives

http://kenkyu.yamaguchi-u.ac.jp/index.html (Japanese)

■ For International Exchange enquiries:

Office for International Affairs Strategy

http://www.iassc.jimu.yamaguchi-u.ac.jp/en/index.html

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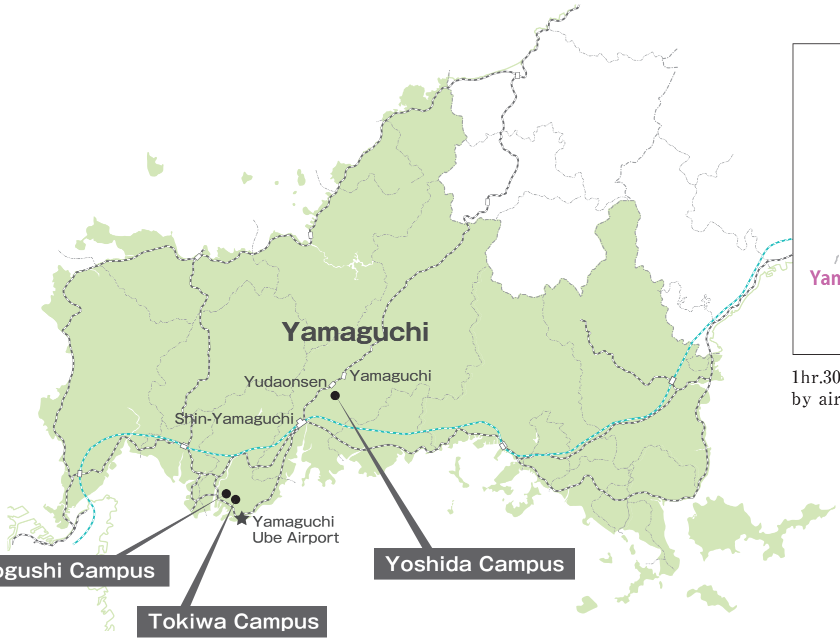
Location



1hr.30min to Yamaguchi Ube Airport by airplane

Yoshida Campus

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Graduate School of Humanities, Graduate School of Education, Graduate School of Economics, Graduate School of Medicine (Science, Agriculture), Graduate School of Science and Engineering (Science), Graduate School of Agriculture, Graduate School of East Asian Studies, United Graduate School of Veterinary Science, The United Graduate School of Agricultural Science, Tottori University, The Research Institute for Time Studies

Kogushi Campus

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Graduate School of Medicine (Engineering), Graduate School of Science and Engineering (Engineering), Graduate School of Innovation and Technology Management

Yamaguchi University Research Activities

2014 vol.2

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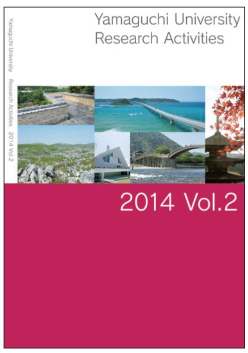

Cover design and art

The pictures show some of the famous sights of Yamaguchi Prefecture and present its long history and rich natural beauty. The vivid color along the bottom is a traditional Japanese color.

YAMAGUCHI UNIVERSITY

200th Anniversary YAMAGUCHI UNIVERSITY

Yamaguchi University Research Activities 2014 Vol.2

Designed by Kinoshita lab. 2014