Yamaguchi University Research Activities

Yamaguchi University Research Activities 2015 Vol.3

2015 Vol.3

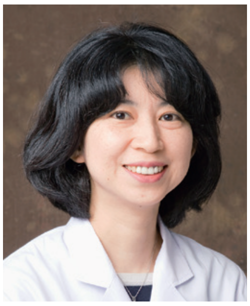
Masaaki OKA
President

In the third phase of Yamaguchi University's medium-term goals and planning, we have set the basic goal of advancing research, and we are supporting competent young researchers and female researchers with the aim of continuously improving our research capability. In 2014, our efforts in terms of improving the research capability of female researchers and the research environment were recognized and adopted by the "Program for Supporting Research Activities of Female Researchers (Organizations)" supported by the Funds for the Development of Human Resources in Science and Technology from the Ministry of Education, Culture, Sports, Science and Technology. Today, we are publishing Yamaguchi University Research Activities Vol. 3 , which focuses on the women working on interesting research at our university. I hope that their research activities will be introduced to people in Japan and overseas through this journal and will thus strengthen the interactions among researchers, local communities, and students.

Contents

Development of high-precision radiotherapy

Radiation technology has been advanced along with developments of IT (Information Technology). Prof. Shibuya is developing the leading-edge tumor-tracking radiotherapy systems, and which an early prototype was introduced to Yamaguchi University. She is now working on the research field of new development strategies for lung and abdominal tumors, by using the latest real-time tracking radiotherapy system.



Department of Therapeutic Radiology,
Graduate School of Medicine

Professor

Keiko SHIBUYA

2011: Assumed the position of Professor at the Department of Radiation Oncology , Graduate School of Medicine, Yamaguchi University upon the establishment of a new Department of Radiation Oncology

2010: Lecturer at Graduate School of Medicine, Kyoto University

2002 to 2004: Assistant Professor at MD Anderson Cancer Center, USA

2001: Assistant Professor at Graduate School of Medicine, Kyoto University

1991: Graduated from Faculty of Medicine, Kyoto University

Introduction: What is therapeutic radiology?

Therapeutic radiology is an academic field in which cancers are treated on the basis of the rationale of radiation oncology, which can target almost all malignant tumors in systemic organs. Novel treatment methods are being developed and researched.

The history of radiotherapy began with the discovery of X-rays by Roentgen in 1895. Surprisingly, only 1 year after this discovery, X-ray treatment was attempted. Thereafter, radiation biology and radiation physics were developed separately on the basis of the characteristics of radiation. These two academic fields were then integrated with oncology, resulting in a single academic system, namely radiation oncology.

Radiation technology has advanced along with the development of information technology, and today, radiotherapy has become indispensable as part of the cancer treatment triad (i.e., radiotherapy, surgery, and chemotherapy). In addition, radiotherapy plays an important role, not only as monotherapy but also as part of multimodal treatment, and is involved in a wide range of cancer treatments, from radical to palliative.

Novel radiotherapy techniques need to be researched and developed from the perspective of both radiation biology and radiation physics. We must have a thorough basic and clinical knowledge of tumors and radiation characteristics, and at the same time we must be capable of accurately assessing the characteristics of each tumor and the pathological conditions of patients.

Cancer radiotherapy

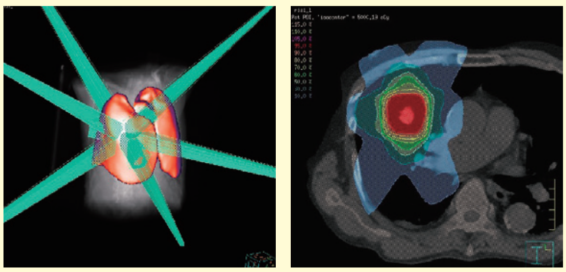
In radiotherapy, the use of three-dimensional conformal radiotherapy (3D-CRT), which can selectively target tumors both three-dimensionally and multi-directionally, has greatly improved therapeutic effects and reduced side effects.

Furthermore, the development and introduction of high-precision radiotherapies such as stereotactic body radiation therapy (SBRT) (Figure 1) and intensity-modulated radiation therapy (IMRT) (Figure 2) have improved prognosis and reduced adverse events in patients with early lung, prostate, or head and neck cancers. IMRT is very useful for ensuring tumor selectivity, because it can be used to achieve dose distributions with complex shapes by changing the shape of the radiation field little by little during irradiation.

However, higher accuracy is required because of the complexity of SBRT and IMRT; especially in treating tumors such as those of the lung or liver, the positions of which constantly change with respiration during irradiation, we must fully understand that dose distributions to such tumors can be inaccurate, and accordingly we need to take appropriate measures.

Figure 1 Stereotactic body radiation therapy (SBRT)

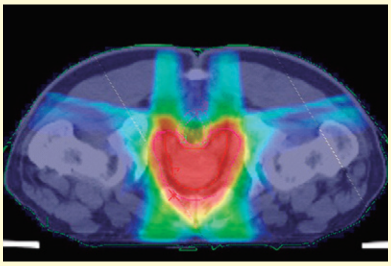
SBRT can target tumors three-dimensionally and multi-directionally within 5-mm accuracy; it is also called "pinpoint irradiation".



SBRT for early-stage lung cancer. SBRT can be used to deliver a high dose of radiation concentrated on a small area. This results in a strong biological effect (antitumor effect), resembling sharp excision with a scalpel.

■**Figure 2 Intensity-modulated radiation therapy (IMRT)**

IMRT yields dose distributions with more complex shapes. This method can be used to deliver high doses of radiation to a tumor safely, while sparing the adjacent normal organs and thus minimizing the risk of adverse events (i.e. side effects).



Radiotherapy for prostate cancer: IMRT can be used to deliver a high dose of radiation selectively to the prostate gland while sparing the rectum, thus achieving treatment outcomes similar to those of surgery. When the tumor is medically treatable by either surgery or radiotherapy, patients are, in principle, free to choose one of these alternatives.

In recent years, research and development have been conducted on a four-dimensional irradiation system capable of dealing with tumors that move with respiration.

Real-time tumor-tracking radiotherapy (RTRT) delivers radiation during the observation of tumor motion three-dimensionally. Yamaguchi University Hospital introduced this technology to Japan early on and has so far treated many patients by SBRT using the RTRT system.

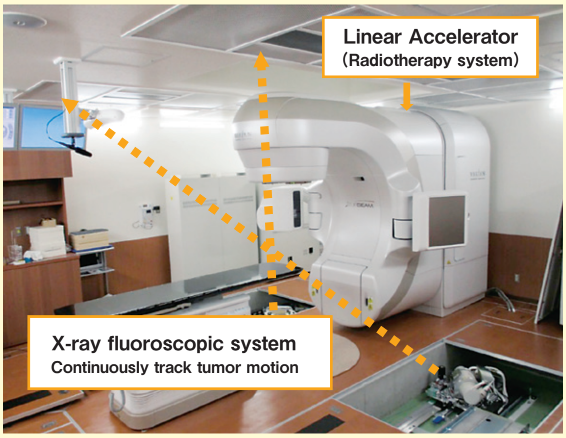
We have applied craniocaudal positional information on tumors to an existing dynamic phantom and have developed a quality assurance program for four-dimensional radiotherapy. We confirmed that the accuracy in tracking mobile tumors 3 cm or less in diameter was within 2 mm. High-precision treatment was able to be provided with high dosimetric and geometric accuracy equivalent to those in the treatment of immobile tumors.

Furthermore, in 2015, we started the world's first radiotherapy system (Figure 3) that uses a real-time tracking system (SyncTrax) and a radiotherapy system (TrueBeam) to deliver radiation up to about 10 times faster per unit time than conventional systems.

The IMRT irradiation method is more complicated than that of SBRT; therefore, it is still difficult to use IMRT on mobile tumors. We analyzed the motion of the pancreas and developed an IMRT method during which the breath was held at expiration. By using this method, we conducted dose-escalation studies in pancreatic cancer and recognized good therapeutic outcomes. In addition, we are now studying the application of the above-mentioned latest real-time tracking system to IMRT. Because verification is very important for securing accuracy, in collaboration with the Faculty of Engineering, Yamaguchi University, we are developing a new system of verification.

■**Figure 3 Real-time tracking radiotherapy system: TrueBeam (Varian, USA) and SyncTrax (Shimadzu, Japan)**

Gold markers are placed close to the tumor in the body, and biplane fluoroscopy is used to identify the three-dimensional position of the markers and track them continuously. In this way, tumor motion during respiration is recognized in real time, and radiation can therefore be delivered accurately in synchrony with respiration.



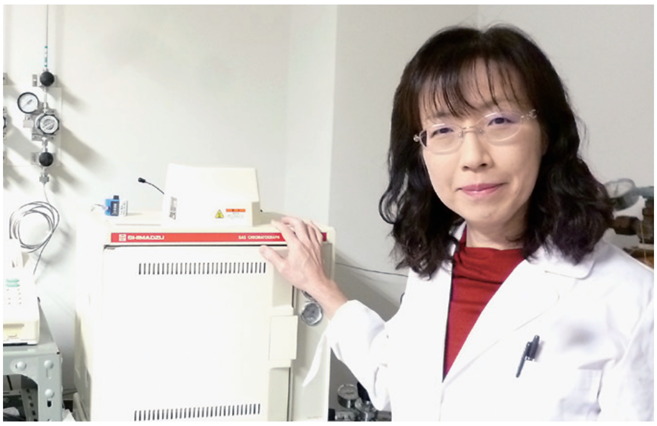
Future goals of radiotherapy

In the US, two-thirds of cancer patients receive radiotherapy. Curerently, half of all Japanese will develop cancer. From this perspective, developing human resources involved in radiotherapy should be regarded as a mainstay of cancer control. Furthermore, in Japan, which faces an aging population and declining birth rate, developing and providing cancer treatments for those who continue working, as well as elderly-friendly cancer treatments, are top priorities. Therefore, experts in all fields, including surgeons, physicians, radiotherapy physicians, palliative care physicians, nurses, and pharmacists, must get together to work on cancer treatment. With the aim of creating forward-looking clinical, research, and educational environments, I would like to continue to provide new information on cancer treatment from Yamaguchi.

We have successfully developed the world's first treatment system using the latest real-time tracking radiotherapy system (TrueBeam and SyncTrax). The photo shows staff involved in the system's development and treatment.

Challenging Energy and Environmental Problems by using Photochemistry

When Prof. Yamazaki worked on the research theme of the photocatalysis of tungsten trioxide nanoparticles, her labo's postgraduate student discovered new phenomena by chance, which has led to the developments of the photochromic film.



Environmental Science and Engineering,
Graduate School of Science and Engineering
Professor

Suzuko YAMAZAKI

2010 to 2011 : Director of the Japanese Photochemistry Association

1999 : Invited to present a paper at the 14th Special Lectures by the Younger Generation, the Chemical Society of Japan

1996 : Awarded the 1996 Corning Research Award

1994 : "Chemical Frontier X" adopted by the Energy and Environment Division of the Chemical Society of Japan

1993 : Lecturer at Faculty of Liberal Arts, Yamaguchi University

1991 : Postdoctoral fellow at University of Wisconsin, USA

1990 : Part-time lecturer at Faculty of Integrated Arts and Sciences, Hiroshima University

1988 : Research Fellowship for Young Scientists, Japan Society for the Promotion of Science

1988 : Completed PhD at Graduate School of Humanities and Sciences, Nara Women's University

Present: Professor at Graduate School of Science and Engineering (Science), Yamaguchi University. Director of the Support Office for Female Researchers, established in August 2014 at Yamaguchi University.

Regular member and Chief of the Shikoku-Chugoku branch, the Chemical Society of Japan. Associate editor of the Journal of Photochemistry and Photobiology C: Reviews

I specialize in photochemistry and develop functional materials by using light energy. I study photocatalytic materials that degrade and detoxify persistent environmental pollutants and volatile organic compounds that cause chemical sensitivity; dye-sensitized solar cells that convert light energy into electrical energy by using dyes; and film materials colored by photoirradiation.

Photocatalysts for environmental cleanup

During my days as a postdoctoral fellow in the US, I obtained funding from the US Department of Energy and served as the leader of a project to remediate soils contaminated with volatile chlorinated organic compounds (VCOCs). Together with Prof. M. A. Anderson, I developed porous titanium dioxide pellets that at the time had the world's largest specific surface area. By using the pellets, I elucidated the degradation reaction mechanism in the laboratory, optimized the reaction conditions for detoxifying VCOCs, made degradation equipment, and conducted demonstration experiments in the field setting. As a result, I successfully developed equipment capable of completely degrading VCOCs retained in the soil into carbon dioxide. Subsequently, I fell in love with photocatalysts that can degrade persistent substances by light irradiation alone, and research on photocatalysts became my lifework. My laboratory synthesizes not only a typical photocatalyst—titanium dioxide—but also tungsten oxide, bismuth tungstate, and bismuth vanadate by using a sol-gel method or a hydrothermal technique. To date I have developed, for example, glass coated with photocatalytic materials (Figure 1) used to trap and recover heavy metal ions; photocatalytic membranes that require no support structure because they are hardened by low-temperature firing; and composite photocatalysts that use two or more semiconductor photocatalysts. Although titanium dioxide is an efficient photocatalyst, it can absorb only ultraviolet light. In light of this, I doped various metal ions and successfully synthesized titanium dioxide capable of being operated by visible light; its photocata-

Glass coated with TiO_2

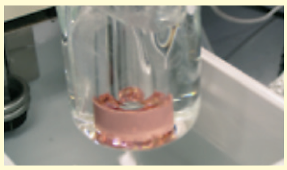


Figure 1 Removal of Cu (II) ion from aqueous solutions by the photoreduction on TiO_2 film.

lytic activity is currently being studied (Figure 2). I also conduct physicochemical research to elucidate the factors determining the reaction rates of photocatalytic water-splitting.

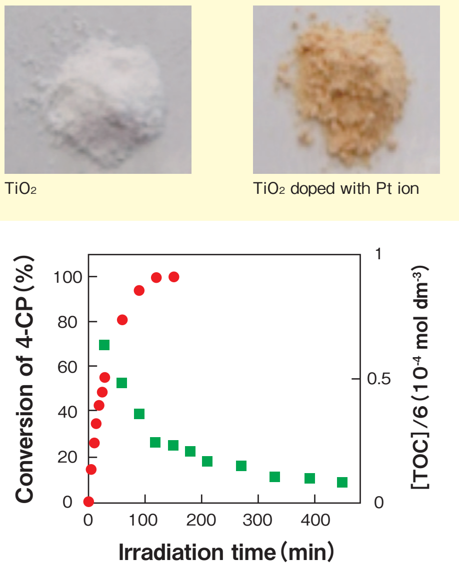
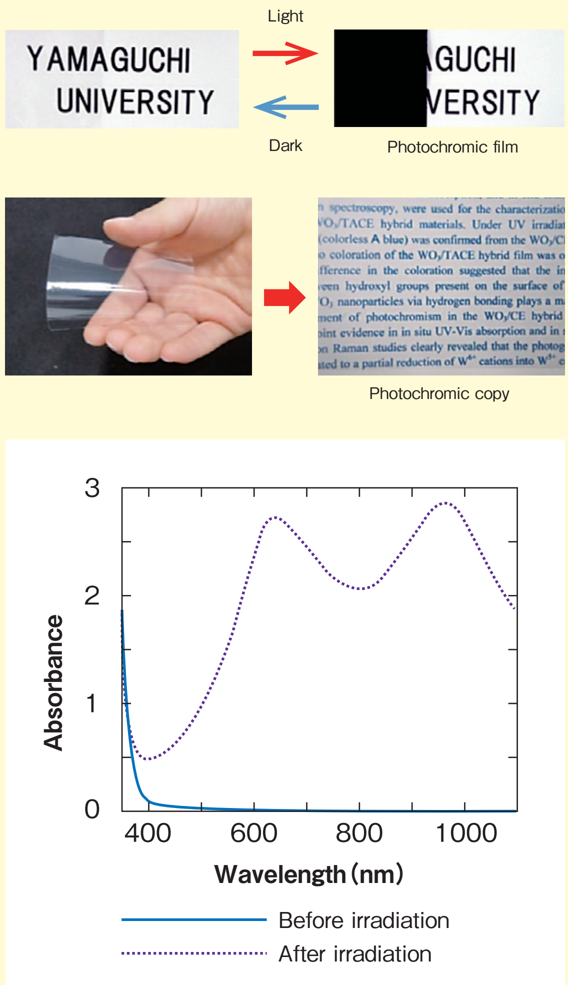


Figure 2 Mineralization of 4-chlorophenol on Pt-ion-doped TiO_2 under visible light irradiation.
(●: Conversion of 4-CP, ■: Total organic carbon concentration)

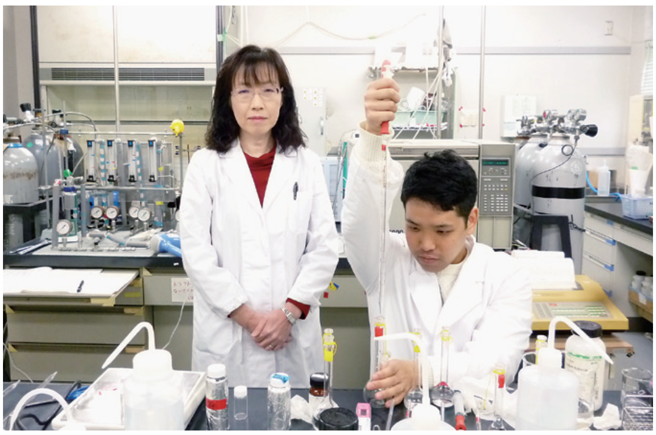
Films colored by sunlight

A decade ago, during research on the photocatalysis of tungsten oxide nanoparticles, I found a phenomenon by which a colloidal water solution was colored blue by ultraviolet irradiation. I then elucidated the mechanism of this phenomenon. Unfortunately, because it does not occur in the presence of oxygen, I underestimated its applicability. However, a graduate student who was conducting an experiment reported to me that the dialysis membrane used to purify the colloidal water solution was colored deep blue in air. Therefore, I collected information on the components of dialysis membranes and, as a result of trial and error, I finally succeeded in developing a transparent film that was colored by near-ultraviolet irradiation and discolored by stopping irradiation in air (Figure 3). This film is colored blue, even in sunlight. When colored, the film absorbs light in the range of infrared wavelengths, so that it can be placed on the surface of window glass to cut out the infrared light coming into a room. In the US, a smart window technology has been developed; this technology uses electrical instead of light energy to color conductive glass containing tungsten oxide. When our film is simply placed on existing window glass, it is colored by sunlight and then returns to a transparent state overnight. Most of the film consists of biodegradable polymers; it is therefore easy to dispose of. In addition, this phenomenon is applicable to wipe-off display media in which only the area irradiated by light is colored. With stronger irradiated light energy, the film is colored dark blue to blackish and the time



Absorption spectra of the photochromic film before and after UV irradiation.

Figure 3
Photochemical properties of the photochromic film.



taken for it to return to transparency—the color retention time—becomes longer. I have found that changing the types of dispersants added during film production can control the color retention time; therefore, I expect to expand the applications of the film to a wide variety of products.

Thoughts as a faculty member : conveying the importance of meekly accepting inspiration from someone you have met

In my first-year analytical chemistry class in college, the professor talked about his research experiences abroad; this experience made me decide to join his laboratory. When I was a senior student, I was assigned to the long-awaited laboratory and given a research project on photochemistry using metal complexes. The professor was in fact a great educator; I was allowed to study without detailed instructions or any restrictions, and I was corrected only when I was heading in the wrong direction. The professor told me, "If you want to get a PhD, don't be a big fish in a small pond: become a researcher who can create an idea out of nothing, and write papers for major international journals." Therefore, I proactively participated in conferences since I was in the Master's course, and I did experiments at other universities. With a view to researching abroad, I studied English conversation for 5 years during my Master's and Doctoral courses. I had a quiet nature in those days, and I put a lot of effort into following the professor's words. I participated in a summer school of the Young Coordination (called at the time "Complex Salt") Chemist's Association of Japan every year and established a division for young researchers in the Kinki region. Many of the researchers I met there have become university professors and play active roles in this field.

A female professor who taught physical chemistry at college once told me, "You only live once. When you are faced with a decision, make the decision that you won't regret." Since then, her words have been my personal motto in life. In the laboratory where I worked in the US there were many postdoctoral fellows from Europe and Asia, and the male-to-female ratio of students and staff, including postdoctoral fellows, was almost equal. Some female researchers left the laboratory at 17:00, took care of their children, and came back to the laboratory at 22:00. I witnessed many female researchers who successfully balanced motherhood with research, and this greatly influenced my later life. To realize a Japanese society in which both men and women can play active roles, it would be very effective to increase the numbers of competent female faculty members who can be role models to the students who will be responsible for the next generation.

To successfully complete the project of the Department of the Energy that we were working on, Prof. Anderson always put pressure on me, but at the same time he supported me. His carrot-and-stick approach was wonderful. Not only did he lead me to grow as a researcher; he also taught me that to develop human resources we need to have both rigor and warmth and to use these two attitudes differently according to the situation. Now, as a faculty member, I hope to be a role model who can share research know-how and experience with my students and inspire them.

Exploring the Possibility of Membrane Separation

Associate Prof. Kumakiri is working on the research field of the separation technology by using zeolite and carbon membranes. She aims at the developments of the unique and innovative technology by the combination use of the chemical reaction and the film separation methodology for hydrogen which is eco-friendly energy.

Environmental Science and Engineering,
Graduate School of Science and Engineering
Associate Professor

Izumi KUMAKIRI

Education and professional experience

2014 : Associate Professor at Graduate School of Science and Engineering, Yamaguchi University

2011 : Assistant Professor at Graduate School of Science and Engineering, Yamaguchi University

2006 : Visiting scientist at Arizona State University, USA

2004 : Full-time researcher at SINTEF, Oslo, Norway

2004 : Visiting scientist at University of Cincinnati, USA

2002 : Project researcher at SINTEF, Oslo, Norway

2000 : Research fellow at Centre National de la Recherche Scientifique, Institut de Recherches sur la Catalyse (CNRS-IRC, IRCELYON), Villeurbanne, France

2000 : Ph.D., Department of Chemical System Engineering, Graduate School of Engineering, the University of Tokyo

1994 : Graduated from Faculty of Engineering, the University of Tokyo

I studied chemical engineering at university. My main research area is membrane science and technology. Membranes can separate mixtures by e.g. a sieving mechanism. Among various types of membranes, in particular I' ve been working on nanoporous inorganic membranes, such as zeolite membranes and carbon membranes.

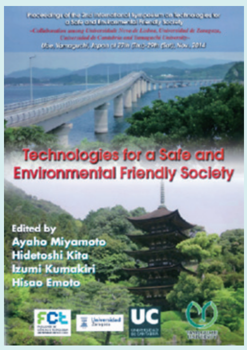
Zeolite membranes and carbon membranes contributing to the green technology

Our group (Prof. Kita, Prof. Tanaka, and I) has been involved in national research and development projects targeting to develop a hydrogen carrier system and an artificial photosynthesis system by applying hydrogen-selective membranes. Although hydrogen has attracted attention as an environmentally friendly energy source, stable supply of large amount of hydrogen is one of the major challenges. Electrolysis of water using renewable energy is one way of producing hydrogen. Some companies are considering using cheap renewable energy in abroad, e.g. solar power generation in Australia and wind power generation in Chile, to produce hydrogen, and transporting hydrogen in the form of methylcyclohexane—a liquid chemical substance at room temperature—by tankers or other vessels. At the end-users, e.g. at hydrogen stations, methylcy-

Column

Agreements between Yamaguchi University and the University of Zaragoza, Universidade NOVA de Lisboa, and the University of Cantabria have been signed.

These agreements allow students to take classes at partner universities. We also organized international symposiums with these partner universities. In 2014, the second symposium was held in Ube, where Tokiwa campus is located. In 2016, we will have third symposium in Lisbon.



clohexane is decomposed to hydrogen and toluene by dehydrogenation reaction, followed by a separation process to take out hydrogen. Membrane separation is a promising innovative technology due to its simple operation, small footprint of the unit and low energy-requirement. We are working on the development of new types of membranes for hydrogen separation. In artificial photosynthesis, photocatalysts split water into hydrogen and oxygen gases. However, a mixture of these two kinds of gas is explosive under a certain composition range. As membranes can separate hydrogen at room temperature continuously, combination of photocatalysis and membrane separation will reduce the risk of explosion. As shown above with two examples, we believe membrane technology is one of the key processes in the realization of a hydrogen society.

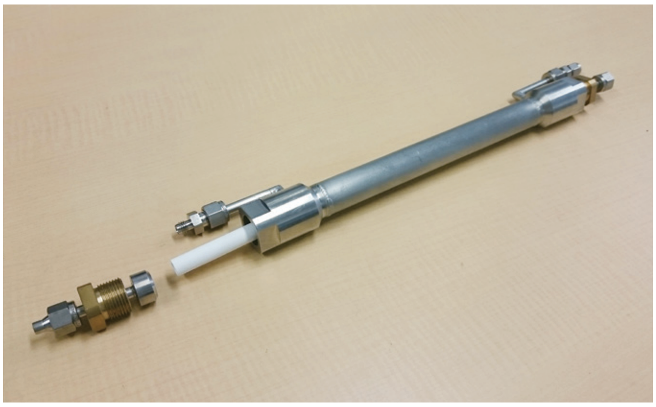
Research collaborations with the Faculty of Agriculture

Prof. Mamoru Yamada of the Faculty of Agriculture at Yamaguchi University is studying fermentation using unique medium-to-high temperature–resistant microorganisms. Fermentation broth contains a variety of substances, therefore separation process is required to take out the substance required. For example, bioethanol is regarded as a green fuel and replacing gasoline in some countries. Generally the ethanol concentration in the fermented broth is about 5-10%. The ethanol concentration should be over 99.5% to use bio-ethanol as a fuel additive. Conventional distillation process has a high energy demand, especially to overcome the azeotrope. On the contrary membrane separation process has no limitation of azeotrope and can drastically reduce the energy required for separation. Collaboration with the Faculty of Agriculture is expected to bring ideas of new technologies, such as simultaneous fermentation and separation for higher efficient reactors.

Increasing chemical reaction efficiency by using membrane separation technology

Membrane reactors are new concepts where membranes and chemical reactions are combined. This innovative concept is expected to reduce the size of a reactor, improve conversion, and lower the temperature/pressure of the reaction. Therefore, research on membrane reactors has been accelerating. The advantage of this concept is demonstrated with thermodynamically dominated reactions. As membranes can take out one (or more) of the products from the reaction field, higher conversion than the equilibrium limited value can be achieved.

For example, combining a zeolite membrane to an esterification reaction improves the conversion, as the membrane removes produced water simultaneously from the reaction field that sifts the equilibrium. Water gas shift reaction is another thermodynamically limited reaction. In this case, removing either hydrogen or carbon dioxide shifts the reaction. However, high temperature over ca. 500 °C is required. We are working on inorganic sorbents and membranes to separate carbon dioxide at high temperature.

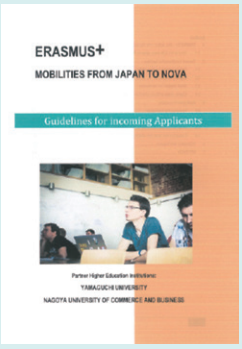


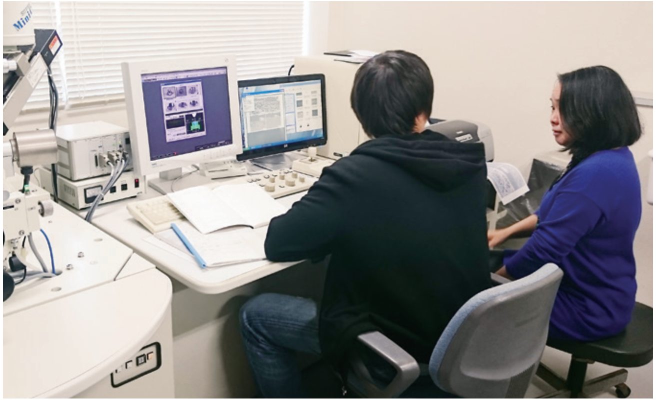
A tubular inorganic nanoporous membrane and a membrane module

Column

ERASMUS+

ERASMUS+ is an EU programme to support education, training, youth and sport (https://ec.europa.eu/programmes/erasmus-plus/) . Yamaguchi University is a member of an ERASMUS+ programme coordinated by Universidade NOVA de Lisboa, Portugal. Through this program, mobilities of students, professors and administration staff are planned between Yamaguchi University and Universidade NOVA de Lisboa.





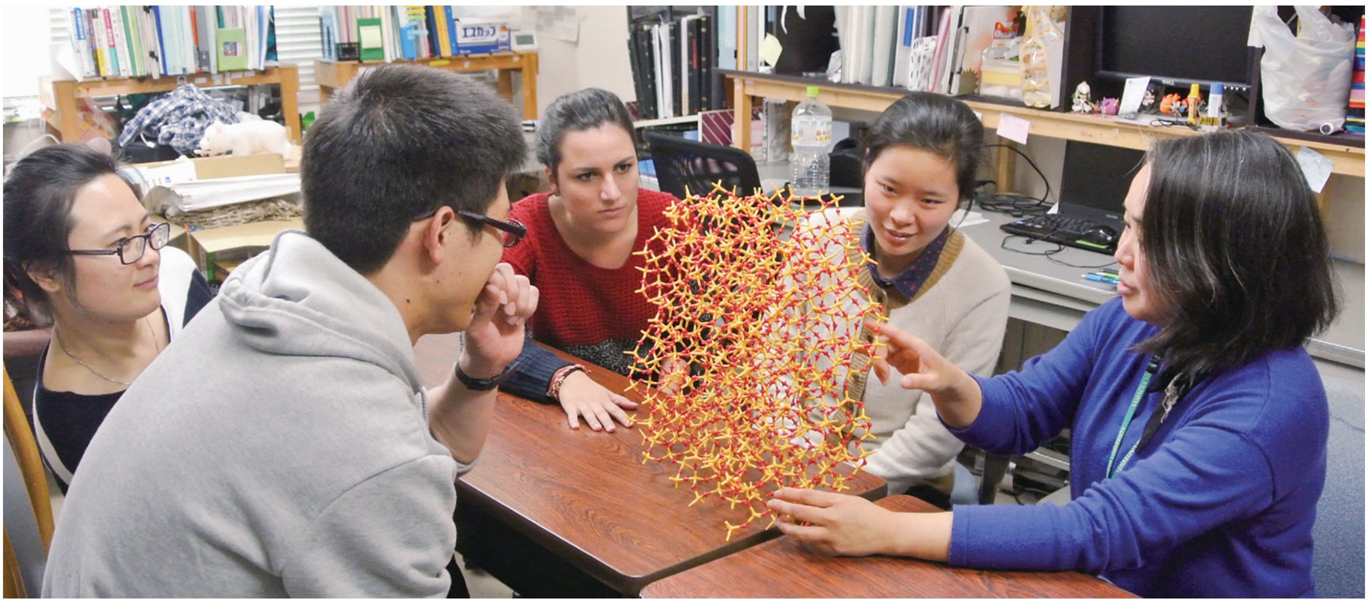
Observation of membrane structure through a scanning electron microscope (FE-SEM, JEOL JSM 6335F)

Thoughts as a faculty member

When I was a high school student, I attended a lecture given by a professor of Chemical Engineering Department. I learnt that both an evaluation of environmental pollution and a size estimation of supermarket parking lot can be treated with a same approach. I got interested in studying chemical engineering. My research in membrane science started with polymeric membranes for seawater desalination. From Master course, I started working on zeolite membranes, which was a very new membrane material at that time. I met Professor Kita of Yamaguchi University at several conferences. This encounter with him led me to my current employment. In my Doctoral course, I continued to study zeolite membranes.

I had a dream of working and living abroad. That is one of the reasons why I went to the Doctoral course. I spent a few months in France during my Master course as a trainee. After receiving my PhD, I worked on an European project in France for 2 years. I then obtained a permanent position in Norway where I did several project managements and participated in EU, international, national and industrial projects. At Norway, I worked not only on membrane separation technologies but also on nanomaterials and coating technologies. The institution I belonged to is a non-profitable organization which is operated mostly by external funds. Accordingly, my work included applying projects, managing financial, intellectual properties, human resource and other issues, controlling the safety of laboratories, besides performing research. I spent 9 years coordinating projects and conducting research. During this period, we offered summer internship programs and received university students from various countries (not only from Europe, but also from Pakistan, Iran, China and other Asian countries). Surprisingly, there were very few applications from Japan. It made me think the importance of encouraging Japanese students going abroad.

For us, Japanese, visiting abroad is physically going overseas. In contrast, in Europe, people easily visit other countries by train, just as visiting neighboring towns. We often hear Japanese cannot speak English, which, I think, is not true. Even if we cannot speak English perfectly, we can communicate to some extent, like we say "where there's a will, there's a way". I would like to support students experiencing new environment, different ways of thinking and living. English is a tool opening many opportunities in front of us. We have applied for ERASMUS+ programs and exchanged agreements with overseas universities to support the mobility. So far we have sent 10 students from our laboratories to universities in EU using my network. There are also some international students in our laboratory. I hope these pioneer students will share their experience with others and motivate them trying something new.



Prospects for Creating Innovation through Women's Career Advancement in Society

We are in the era where technology fusion in various fields is starting to change the society. Participation of women resulting in diversity could create an opportunity for further innovation. How can parents raise daughters who are interested in STEM (Science, Technology, Engineering and Mathematics) area where ratio of women is lower now?

Graduate School of Innovation and Technology Management
Professor

Yuko HAYASHI

Joined IBM Japan Ltd. after graduating the University of Tokyo.

1994 : Completed the Technology and Policy Program at Massachusetts Institute of Technology (Master of Science).

2006 : Completed the doctoral course at the Graduate School of Engineering, the University of Tokyo (Ph.D.).

Present:

Professor at Graduate School of Innovation and Technology Management, Yamaguchi University.

Intellectual member of the Liaison Conference for the Promotion of Gender Equality, the Cabinet Office.

External committee member of the Diversity Promotion Committee, the Japan Association of Technology Executives.

Empowering women once meant gender equality or relief of the weak, but today the meaning involves economical aspects and diversity management. From the point of view of the management of technology, entry of women into the labor force will create diversity which would stimulate innovation. At present, there is a tendency that more investments are made to companies that utilize more women. The average stock price of Nadeshiko Brand designated by the Ministry of Economy, Trade, and Industry's is higher than the Tokyo Stock Exchange Stock Price Index (TOPIX), making the Nadeshiko Brand an investment asset. From this perspective, my research focuses on women playing more active role in society from the viewpoint of the MOT.

Why is diversity necessary?

The way technology is created has changed gradually. Technological development automatically led to social development (Linear Model) in post war era. For example, development of technology such as lasers, nuclear power generation, and early computers had brought drastic changes to society. In recent years, however, fusion of technology in various fields are changing society (Technology Fusion Model). In Japan, innovation was interpreted as 'gijutsu kakushin', as technological revolution, while, nowadays, innovation is interpreted as more broad meaning like revolution in various systems of society. Thus the point of view of innovation is changing and expanding. In order to develop the emerging and unmet markets, it will be necessary to promote diversity by involving people from various backgrounds. In successful start-up businesses, there are 35% more entrepreneurs with some kind of experiences abroad than entrepreneurs without any kind of overseas experience. Somethings that are common in Japan are very uncommon when seen by foreigners. Some people start their businesses by discovering things that people around them have never thought of before, using perspectives obtained from their experiences abroad. In order to succeed in this, it is important to figure out ways to manage variety of people with different points of views. At the same time, increase in diversity by incorporating women will be an advantage, and some companies disclose data about female employers in order to invite more investments. However the percentage of women being hired is still small. Only 12% of women who studied in college graduated engineering department, and these small number of people are, right now, being one of the bearers of innovation. Here is where I would like to focus.

Why do only small numbers of female students take STEM related courses?

With a focus on mothers, who of course have a substantial impact on their children, I conducted a questionnaire survey of graduates of Ochanomizu University. The results showed that the most popular departments differed among the genders: the Department of Pharmacy for daughters and the Department of Engineering for sons (Figure 1). Mothers chose pharmacy for their daughters because they thought that it was a field in which they would be able to obtain a license (source: Report on Research and Analysis on the Impact of Awareness of Parents in Science Course Selection of Women, March 2015). Since parents' advice has a large impact on their children, to change a parent's mental attitude it is important to supply the parents with the correct information. Definitely, parents regard their children's desires as very important. Among STEM related courses, mothers tend to have a clear image of medicine or pharmacy, but only a vague image of the department of engineering. There are various ways of working in the engineering field: many who graduated engineering fields do interesting work, and some move up the ladder to work in managerial positions. Therefore, we need to demonstrate these role models and inform not only children but also their parents that there are many job opportunities in the engineering field.

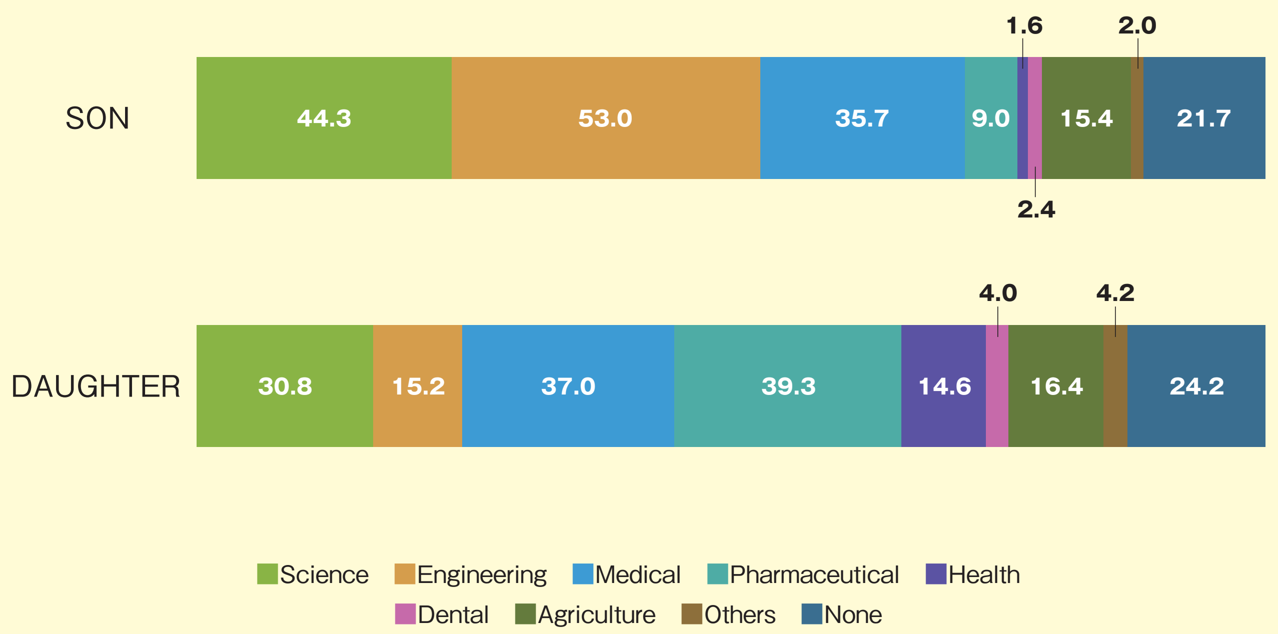
Influence of parents on their children's choice of courses : STEM related or non-STEM

I investigated the ways in which fathers and mothers were involved in their children's education. In all items, mothers were more involved than fathers (Figure 2). In the case of science-related items such as natural observation, I performed a cross-tabulation between mothers from STEM and from non-STEM courses. The results showed that mothers who had graduated non-STEM courses were less involved than those from STEM courses. In addition, fathers did not follow science-related topics. These results suggest that, from early childhood onward, children with mothers from non-STEM courses have fewer opportunities to come into contact with science-related topics.

Do mothers' courses (STEM or non-STEM) affect their children?

An investigation of the departments in which children had enrolled showed that children tended to enroll in the same department as their mothers. To increase the numbers of women in STEM courses, informing mothers who are graduates of non-STEM courses about STEM courses, and encouraging children to participate in scientific events which enable them to come into contact with science, can be used as triggers for children to become involved in science-related activities. Furthermore, fathers need to become involved in their children's education. The questionnaire results show that even education-minded fathers are not very involved in events such

Figure 1 University departments in which mothers want their children to enroll (by children's sex)



as playing with their children or taking their children to museum. Changing work-life balance is needed for fathers to make time to get involved in their children's lives, that it is likely to affect their children's future.

What changes when females participate in the workforce?

First, the household economy becomes stable. Among member countries of the Organization for Economic Cooperation and Development, those with higher female employment rates tend to have higher birth rates. This is because an environment that allows women to work is friendly to child-rearing, and even if one parent quit his/her job for any kind of reasons, the other working parent can cover the money for raising their child. Second, in terms of work-sharing, the Netherlands adopted work-sharing policies when it suffered from high unemployment rates. Its current female employment rates and gross domestic product (GDP) are both higher than those of Japan. The Womanomics 4.0 report of Goldman Sachs estimated that if gender gap is solved, the GDP will increase by 13%. Third, women's workforce participation will likely to create new markets in, for example, babysitting, food catering, and nursing care. From the perspective of MOT, a new market of housework support provided by robotics or the Internet of Things (IoT) may be created.

A vision and the direction of future research

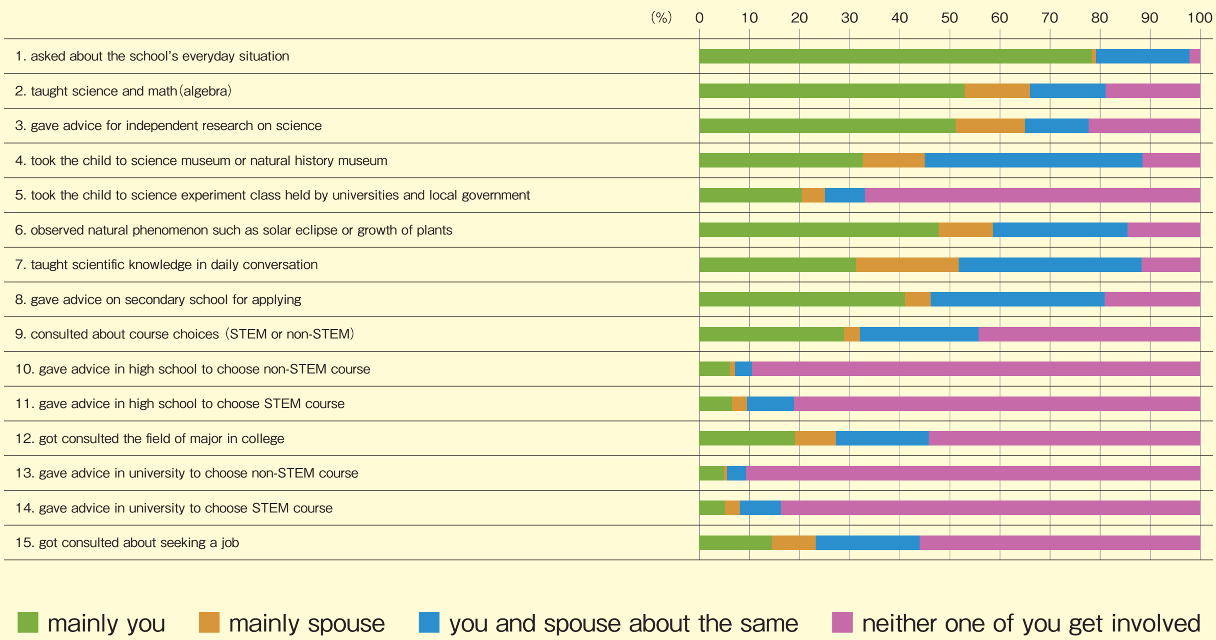
In future, I intend to investigate places where students in STEM courses can work. For example, the field of bioinformatics has been developed considerably in the area of life sciences; at the Broad Institute of MIT and Harvard, human resources involved in bioinformatics account for 70% of all human resources. I want to find out how life science will change in future, and I want to understand the characteristics and current status of job-hunting.

The other alternative is medical care with regulations. Drugs cannot go on the market unless they are approved; therefore, there are always regulations. Contrary to the concept of the need to relax regulations, regulations promote innovation. Since, until now, novel drugs have often come from overseas, the drugs have become available only by modifying overseas guidelines. However, when an innovative technology is created in Japan, we need to develop a new regulation by ourselves. To do this we need research and data on regulations; further human resources are therefore required in this field.

In light of women's career advancement in society and the development of women's involvement in STEM fields, data creation has significance in itself, because few data regarding women have been collected. Long-term data-gathering by using the same form will bring us new and exciting results.

Figure 2 Results of a questionnaire on parental involvement in children's education

Parents' involvement in child's education



Contact

［As of March, 2016］

Graduate Schools	URL
Graduate School of Humanities	http://www.hmt.yamaguchi-u.ac.jp/?lang=en
Graduate School of Education	http://www.edu.yamaguchi-u.ac.jp/english
Graduate School of Economics	http://www.econo.yamaguchi-u.ac.jp/gs_e.html
Graduate School of Medicine	http://www.med.yamaguchi-u.ac.jp/graduate/ (Japanese)
Graduate School of Science and Engineering	http://www.gse.yamaguchi-u.ac.jp/EN/
Graduate School of Agriculture	http://www.agr.yamaguchi-u.ac.jp/index_e.html
Graduate School of East Asian Studies	http://www.eas.yamaguchi-u.ac.jp/
Graduate School of Innovation and Technology Management	http://mot.yamaguchi-u.ac.jp/ (Japanese)
United Graduate School of Veterinary Science	http://ds22.cc.yamaguchi-u.ac.jp/~renju/e.html
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

※The United Graduate School of Veterinary Science was established through the cooperation of Tottori University, Kagoshima University and Yamaguchi University.
※The United Graduate School of Agricultural Science was established through the cooperation of Tottori University, Shimane University and Yamaguchi University.
※Graduate School of Science and Engineering was reorganized as the Graduate School of Sciences and Technology for Innovation in the 2016 academic year.

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

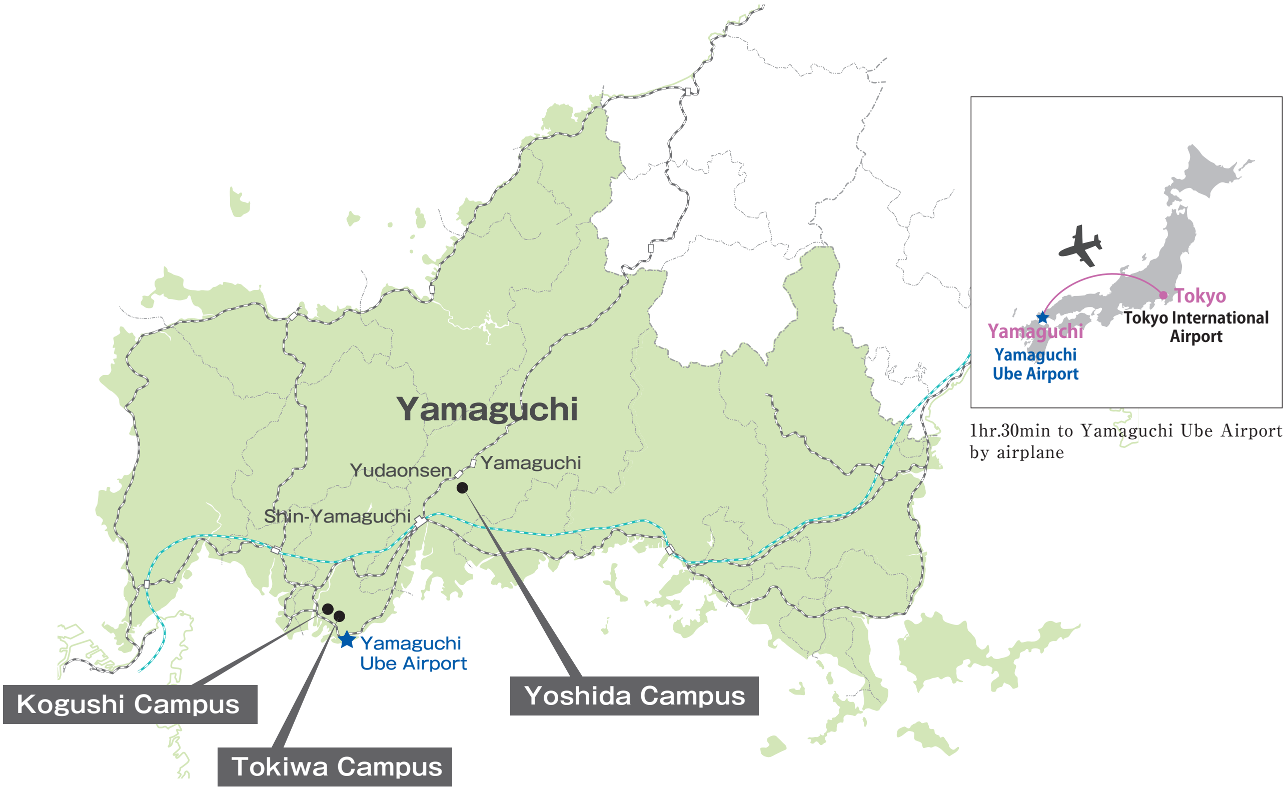
http://www.iassc.jimu.yamaguchi-u.ac.jp/en/index.html

■ For Studying at Yamaguchi University

International Student Center

http://www.isc.yamaguchi-u.ac.jp/english/top.htm

Location



1hr.30min to Yamaguchi Ube Airport by airplane

Yoshida Campus

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

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

1-1 Minami-Kogushi 1-chome, Ube-shi, Yamaguchi, 755-8505

Graduate School of Medicine (Medicine), Graduate School of Science and Engineering (Medicine)

Tokiwa Campus

16-1 Tokiwadai 2-chome, Ube-shi, Yamaguchi, 755-8611

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

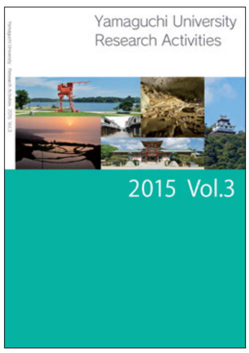
Yamaguchi University Research Activities

2015 vol.3

Published by the Organization for Research Initiatives, Yamaguchi University, June 2016
Edited by the working group for Yamaguchi University Research Activities
and Yamaguchi University Support Office for Female Researchers

Reports: University Research Administrator (URA) Office
Cover design and art: Associate Prof. Takeshi Kinoshita (Graduate School of Science and Engineering)

"Program for Supporting Reseach Activities of Female Researchers (Organization)" supported by the Funds for the Development of Human Resources in Sciense and Technology from the Ministry of Education, Culture, Sports, Science and Technology



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 2015 Vol.3

Designed by Kinoshita lab. 2015