### Faculty of Science Graduate School of Science

### $\equiv$ KOBE UNIVERSITY $\equiv$





### MESSAGE

**Faculty of** 

of Science

Science and

**Graduate School** 

# As dean of the Faculty of Science and Graduate School of Science, I would like to send a warm welcome to all international students, faculty members, and guests.

A Seat of Learning

Dean, Faculty of Science and Graduate School of Science

Katusi FUKUYAMA

The Faculty of Science was established in 1949 as one of the faculties at Kobe University. Now our Faculty of Science and Graduate School of Science consist of 5 departments: mathematics, physics, chemistry, biology, and planetology, which cover a wide range of natural sciences. Our staff-to-student ratio is a great advantage for students: we have more than 100 active faculty members for about 680 undergraduates and 330 graduates enrolled in 2018. We also have 36 international students enrolled.

Please visit our beautiful campus located at the foot of Mount Rokko as well as our website.

In the Faculty of Science, we conduct 4-year undergraduate education and research on fundamental issues in the natural sciences. The Graduate School offers 2-year Master's and 3-year Doctoral programs.

The Graduate School of Science collaborates closely with the following research centers: Kobe University Organization for Advanced and Integrated Research, Biosignal Research Center, Molecular Photoscience Research Center, Research Center for Inland Seas, Kobe Ocean Bottom Exploration Center Research Center for Urban Safety and Security, Center of Mathematial and Data Science and Research Facility Center for Science and Technology. The Center for also contributes to the Graduate School education.





Website http://www.sci.kobe-u.ac.jp/english/index.htm

## **Department of Mathematics**

Mathematics is both old and new. Traditionally, research in mathematics is the study of numbers, spaces and functions. From a modern viewpoint, one can argue that mathematics is still about these things, but then one would have to widen the interpretation of "numbers", "spaces" and "functions" to include the great variety of forms that numbers and spaces have recently evolved into. For example, to a set of numbers we may associate a "space", and a space is also an object for algebraic operations, or a space can even be a "function". In modern mathematics, they exist in such a wide variety of forms, and included in these forms are mysterious properties and intriguing principles.



We in the department of mathematics regard mathematics as a synthetic subject. We respect the independence of each research field, but at the same time we intend to impart graduate students with knowledge of a wide range of areas. We also regard it as important that students develop expertise in computation, logical thinking and abstract thinking. With this in mind, the goal of our graduate school is to turn out superior graduates who work as creative researchers and contribute to the development of society in various fields.

We cover a variety of research areas in both pure and applied mathematics. Students conduct their own research in an independent environment, under the supervision of their advisors. The members of our department include about 20 faculty members and 10 post-doctoral fellows. Students have free access to our various facilities, including the library, offices, seminar rooms, computers and internet-based communication tools related to mathematics.

#### Research Topic Rossman Wayne / Professor Geometry



I find doing research very satisfying, shedding light on how objects such as soap films bend the way they do. I work in the geometry group in the Kobe University mathemat-

ics department, and I greatly enjoy the research vitality and friendliness of this department. Our geometry group includes three other faculty members. One figure here is from my own research, showing a soap film, and another is from our fellow geometer Kentaro Saji in our group, showing a connection between geometry and singularity theory. Our research goals are to create a better understanding of purely geometric objects and to connect with other fields. One connection is between curvature properties in geometry and some types of integrable systems (which are particularly elegant partial differential equations). A number of our faculty focus on integrable systems research. Another faculty member, Naotaka Kajino, connects geometry with analysis and probability theory, and one figure here of a fractal is from his research. A further connection is between discretization of surface theory and structures in architecture that bend in a segmented way (segmented bending can be seen in the soap film figure), and also to computer graphics.

#### Research Groups

Analysis
 Partial Differential Equations
 Integrable Systems
 Mathematical Physics

- Algebra and Geometry
   Algebraic Geometry
   Number Theory
   Differential Geometry
   Knot Theory
- Applied Mathematics
   Probability Theory
   Computer Algebra System
   Fractal Analysis

#### Curriculum (undergraduate)

- Freshman
   Calculus
   Linear algebra
   Set theory
   Liberal arts classes
- Sophomore/Junior
   Advanced linear algebra
   Multivariable calculus
   Complex function theory
   Topology
   Algebra I-IV
   Geometry I-IV
   Analysis IV-VIII
   Probability theory
   Representation theory
   Computational mathematics
- Specialized seminar Intensive short-term courses Advanced courses



A non-Euclidean soap film (left), a "swallow tail" singularity (middle), a planar fractal (right)

## **Department of Physics**

Physics is a field of study which explores the truth of nature. It is an important academic field that provides the foundation for many applied sciences. The research subject extends over a very wide range: from the most basic particles constituting matter (elementary particles), to atoms, to molecules, to liquids/solids which is a population of atoms and molecules, and to the structure of the universe.



A physics experiment at Kobe University

There is close cooperation between theoretical and experimental studies. The meaning of phenomena discovered by experiment is studied by theory. In addition, the predictions from the theory are tested by experiment. This close relation has been very important in the development of physics. Our department has both theoretical and experimental research groups.

In the Department of Physics of the Faculty of Science, we have been doing small-group education, taking advantage of our small class sizes. Through the third year of undergraduate, we focus on thinking of physics problems using math, then we move from classical physics to modern physics. At the same time, a curriculum of basic physics experiments is provided. In the fourth year of undergraduate, you will learn that there remain many unresolved issues, and you will study one of those problems as graduation research. will learn more advanced research topics through lectures and seminars. Then you will work on a current physics research subject. For this purpose, we are in cooperation with research centers in our university, and research institutions with large experimental facilities in Japan and overseas.

The Department of Physics welcomes students who plan to pursue careers outside of physics as well as those who will continue in physics after graduation.

#### Research Topic

Cosmology (Jiro Soda / Professor)



(Illustration courtesy of Chris Blake and Sam Moorfield) Cosmology has become precision science due to rapid developments of observational techniques. In particular, WMAP and Planck satellites have provided us with high precision data of temperature fluctuations of the cosmic microwave background radiation, which reveal the universe just 0.4 million years after the Big Bang. From the statistical analysis of the temperature fluctuations, we can extract information about the very early universe, namely at 10<sup>-34</sup> seconds after the Big Bang, which enables us to know the physics of the microscopic world. Although there are a lot of interesting topics in cosmology, I am working on an inflationary scenario through which we can explore the microscopic world. The aim of my research is to find new physics through interdisciplinary studies of cosmology and elementary particle theory.

#### Research Groups

- Theoretical Physics
   Elementary Particle Theory
   Cosmology
   Condensed Matter Theory
   Quantum Solid State Physics
- Particle Physics
   Particle Physics
- Condensed Matter Physics
   Extreme Condition Condensed
   Matter Physics
   Low Temperature Condensed
   Matter Physics
   Correlated Electron Physics
   Quantum Dynamics

#### Curriculum (undergraduate)

Mechanics I\*, II\* Analytical Dynamics Modern Physics Wave Physics Electromagnetics I\*, II\* Electrodynamics Thermal and Statistical Physics Statistical Physics I\*, II\* Basic Mathematical Methods in **Physics** Mathematical Methods in Physics I\*, II\* Quantum Mechanics I\*, II\*, III Information Science for Physics The Theory of Relativity Astrophysics General Relativity Solid State Physics I, II Nuclear Physics **Elementary Particle Physics Experimental Physics** Physics Laboratories I, II, III (\*with exercises) Senior Graduation Research Seminar

In the Graduate School of Science, you

### **Department of Chemistry**

Chemistry is the basic study exploring the structures, properties, interactions, and transformation of matter in natural sciences. We seek to understand a wide variety of material characteristics according to the fundamental laws of chemistry, which allows us to provide direction for controlling chemical reactions and for preparing advanced functional materials. Recently, chemistry has evolved to incorporate various areas of science at an accelerated pace.



With the current trend of science, it is necessary to actively advance cutting-edge studies with the purpose of creating new concepts and interdisciplinary fields in science. It is crucial to make continuing effort in training students to become motivated for and capable of performing innovative work both in academia and in chemical companies. From the above viewpoint, our department has established a variety of research/education fields, including Molecular Structure and Dynamics, Material Physical Chemistry, Chemical Reaction Dynamics, Solid State Chemistry, Solution Chemistry, Physical Inorganic Chemistry, Organic Reaction Chemistry, Biomolecular Science, and Organic Molecular Structure and Function. In order to cultivate the spirit of academic inquiry of students for substances, we offer some specialized courses and lab training course. Although the scale of this department is relatively small, the small-group instruction system on a one-to-one basis has developed the abilities of students to recognize and solve unexplained issues with strong motivation and imagination. We think it is important to

use the small but highly capable organizations for the development of future human resources. In our research we focus on scientific fundamentals and aim to flexibly carry out research projects with high originality and big impact.

#### **Research Topic**



Photosynthetic organisms absorb solar energy and transfer it toward a reaction center as excitation energy of molecules (chlorophyll, carotenoid, and so on). Light-harvesting and excitation energy-transfer processes, which occur in 10<sup>-15</sup> second (fs) to 10<sup>-9</sup> second (ns), are modified with changes in environmental conditions, such as light, temperature, nutrient, and carbon dioxide. Associate Professor Seiji Akimoto and coworkers develop time-resolved measurement systems and examine response and adaptation of photosynthetic organisms to their environments. Recently, they found new mechanisms for a land plant Arabidopsis thaliana and a green alga Chlamydomonas reinhardtii to survive under high-light conditions.

#### Research Groups

- Physical Chemistry
   Molecular Structure and
   Dynamics
   Material Physical Chemistry
   Chemical Reaction Dynamics
- Inorganic Chemistry
   Solid State Chemistry
   Solution Chemistry
   Physical Inorganic Chemistry
- Organic Chemistry Organic Reaction Chemistry Biomolecular Science Organic Molecular Structure and Function

#### Curriculum (undergraduate)

Junior Physical Chemistry Chemical Thermodynamics Chemical Reaction Dynamics Surface Chemistry Quantum Chemistry Molecular Spectroscopy Inorganic Chemistry Analytical Chemistry Solid State Chemistry Solution Chemistry Organic Chemistry Structural Organic Chemistry Synthetic Organic Chemistry Biochemistry **Chemical Experiments** Computational Chemistry Senior

Laboratory Research Course

#### Message from a Foreign Student



Sanghun Kim

I came to Japan in 2016 from South Korea. Currently, I'm majoring in organic chemistry on a Master's course. Kobe University is in harmony with beautiful nature and scenery. Moreover, I can focus on my research with a well-organized system of education for foreign students. Especially, I have received plenty of help from the International Center to make my daily life here more comfortable, such as financial aid, Japanese classes,

home rental and others. Thanks to this help, I have been acquiring various chemical knowledge and analysis techniques through discussions with other international students and Japanese students. As well as cultural exchange, this will give me the skills to become a versatile chemist.

## **Department of Biology**

'What is life' is a fundamental, but still poorly answered question in Biology. Biological phenomena occur at various levels of organization, spanning from molecules to ecosystems. To better capture these multi-hierarchical phenomena, we aspire to approach various biological issues with modern tools of molecular, cellular, and developmental biology, as well as genetics. In addition to these approaches, our department has been studying proximate and ultimate causes of biodiversity with recently advancing methodologies of phylogeny and ecology. We believe that all of these approaches are mutually beneficial, and integration of these approaches will lead us to answer the fundamental questions in Biology.



[Expression of Lobe-less noncoding RNA in the Dorosophilla central nervous system]

Our department embraces many fields in Biology such as biochemistry, genetics, molecular and developmental biology, physiology, ecology, phylogeny, and so on. We offer a variety of lectures as well as experimental and practical courses to undergraduate and graduate students. Students are hence able to master not only fundamental skills to advance their own research but also presentation skills at scientific meetings and publication in scientific journals.

An outstanding feature of our department is that staff of various backgrounds regularly work together with students to answer both fundamental and integrated issues in Biology.



[Recreation room for students]

#### Research Topic

Dr. Kimitsune Ishizaki

Many plants generate clonal progenies directly from somatic cells of vegetative organs, however, little is known about the molecular mechanisms. The liverwort *Marchantia polymorpha* propagates



asexually via gemmae generated in the gemma cups.

Taking full advantage of molecular genetic resources in *M. polymorpha*, we have successfully identified several key genes for the gemma-cup development, which are both orthologous to regulatory genes for axillary buds in angiosperms. Our results suggest a common regulatory mechanism between vegetative propagation and axillary bud formation.



[Left: Gametophyte body of the liverwort *Marchantia polymorpha*; Right: Scanning Electron Microscopy (SEM) of gemmae in gemma cup.]

#### Research Groups

- Biomolecular Organization
   Molecular Physiology
   Cell Function
   Bioinformation
- Biosignal Transduction
   Gene Expression
   Gene Function
   Genome Integrity
- Biodiversity
   Evolution, Phylogeny
   Ecology, Speciation

#### Curriculum (undergraduate)

Junior Animal Ecology Development Environmental Biology Environmental Plant Cell Biology Functions of Genetic Information Genome Dynamics Marine Biology Molecular Biology Molecular Biology of Plant **Molecular Genetics** Molecular Physiology of Animal **Behavior** Neuroethology Neurophysiology Photobiology Plant Genomics Readings in Biology Field Biology Laboratory Exercises in Biology Senior Graduation research

### **Department of Planetology**

We have taken a new step forward since FY2015. The Department of Earth and Planetary Sciences has been renamed Department of Planetology, as planetology is a discipline that integrates earth sciences with planetary sciences. We are very keen to answer a primordial question, why this planet has evolved into the earth.



Since we are dealing with a wide variety of natural phenomena from the core of the earth to the edge of the solar system, we want our students not only to acquire wide knowledge and skills for planetology, but also to develop broad viewpoints, creativity, and originality, which are free from existing frameworks. To achieve this goal, we recommend that our students study mathematics, physics, earth science, chemistry, biology, etc. and become familiar with techniques and methods on field surveys, observations, experiments and theoretical analyses. It is difficult to achieve these goals with a passive attitude. Our diverse faculty members are available as guides for you.



We have a wide range of research fields on the origin and evolution of the earth and the solar system. For example, one researcher goes out for field work to hear sounds from stones or geological strata. Another researcher imagines the early stages of the solar system by doing impact experiments with ice and stones. A third researcher is trying to reproduce an atmosphere of a planet in a computer. And another researcher is exploring the origin of life from molecular motions. Curiosity is the engine to be enthusiastic about such things. Our department is full of people who enjoy research with whole-hearted enthusiasm and excitement. We believe this atmosphere is the key to make interesting studies possible. Why don't you come and join our paradise for intellectuals?

#### Research Topic

Minami Yasui / Assistant Professor Experimental Planetary Science



Ice creates some characteristic topographic features on the earth, such as ice sheets on Antarctica and glaciers on highlands. However, these features made of ice are also observed on other planets in the solar system. For example, there are polar ice caps and glaciers on Mars and furthermore, the satellites orbiting around giant planets have crusts made of ice.

I study the formation processes of unique topographic features observed on the surfaces of icy satellites. One of the key parameters that affect these surface features is strength. I measure the strength of icy materials simulating the crusts of icy satellites by laboratory experiments in a large cold room in order to discuss how these surface features were formed.

#### Research Groups

- Fundamental Planetology Geology
   Petrology and Mineralogy Solid Geophysics
   Fluid Geophysics
   Planetary Astrophysics
- Frontier Planetology
   Experimental Planetary Science
   Marine Geodynamics
   Computational Planetology
- Cooperative Division Applied Planetology Evolutionary History of the Planets and the Earth

#### Curriculum (undergraduate)

Planetology Fundamentals of Planetology Exercise of Fundamental Planetology Fundamentals of Planetary Physics Solid Earth Earth and Planetary Evolution Science Earth Material Science Planetary Material Science Fundamentals of Experimental Training in Planetology Experimental Training in Planetology Geology **Planetary Physics** Physics of Solid Earth Planetary and Space Science Fluid Dynamics in Planetology Atmospheric Science Field Exercise on Geology Graduation Research Colloquium

#### Number of international students (2017)

		Total	Country					
			China	Korea	USA	UK	Egypt	Others
Undergraduates		7		7				
Graduates	Master	22	17	3				2
	Doctor	11	5		2	1	1	2

#### **KOBE Summer School**

The annual science-focused international summer schoo will be held at Kobe University in July. At this school, all lectures will be given in English. Interested students (regular undergraduate and graduate students enrolled at universities which have academic exchange agreements with Kobe University) should consult with the appropriate sections of their home universities.

http://www.sci.kobe-u.ac.jp/international/pdf/1w\_experience2018.pdf





#### Faculty of Science, Graduate School of Science Kobe University

1-1 Rokkodai-cho, Nada-ku, Kobe 657-8501 Japan TEL : +81-78-803-5761 | FAX : +81-78-803-5770 Mail : sci-soumu@office.kobe-u.ac.jp | Web : www.sci.kobe-u.ac.jp/english/intro.htm

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