LANA-DSH:
Interdisciplinary research integrating chemistry, physics, biology, and medicine.
Synthetic epigenetics driven by a chemical catalyst recognizing a specific region of histones and acylating a specific lysine residue, as a basis for catalysis medicine—small molecular catalysts surrogating enzymes (i.e., histone acetyl transferase in this case).

Hybrid Catalysis:
Development of catalytic molecular transformations as a basis for sustainable society by merging functionally distinct catalysts and using earth’s environmental energy (here, visible light).
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The University of Tokyo’s Faculty of Pharmaceutical Sciences has a history spanning over 140 years, but the target of its scholarly pursuits has consistently been life science. It aims to create and apply a completely new realm of academia that combines the extremely high-level physical sciences needed to handle medicine that directly affects the human body and the bio-sciences to explain the mechanisms behind health and illness. The most unique aspect of our work lies in how, while retaining a focus on basic research, we constantly strive for the ultimate goal of overall human health.

Pharmaceutical sciences is an interdisciplinary field of academia, covering everything from basic science to the appropriate use of medicine in such fields as organic chemistry, structural biology, analytical chemistry, biochemistry, molecular and cell biology, genetics, immunology, pharmacology, pharmacokinetics, and more. In all the main fields of pharmaceutical sciences, the University of Tokyo’s Graduate School of Pharmaceutical Sciences has conducted advanced research activity on an international stage, backing our educational efforts to train and develop personnel who will become leaders in a wide range of academic pharmaceutical fields. The Graduate School and the Faculty have been producing particularly leading-level science as of late, with our faculty earning a litany of science awards (including the Japan Academy Prize, Order of the Purple Ribbon, and Uehara Prize) and our activities drawing attention from across the world. We boast an advanced and diversified position in educating personnel, turning out vital staff involved with drug discovery R&D at pharmaceutical companies and medical administration.

In addition, we are proceeding with the creation of brand-new, internationally-linked fields of research, from programs that go beyond graduate school/faculty frameworks, such as Graduate Program for Leaders in Life Innovation and World-Leading Innovative Graduate Study Programs, to our “Top Global University Project” to establish strategic partnership with the University of Cambridge and “Drug Discovery Initiative” to advance full-scale drug-discovery research. This has made the Faculty a popular department to advance to from the University’s College of Arts and Science, a place where highly talented graduate students from around the world gather together.

As our basic pharmaceutical science research continues to advance, the rise of sophisticated treatments and medical specialization in recent years has led to a need for expert pharmacists that can answer the social need for the suitable application of medical and pharmaceutical products. This led to the creation of a new six-year (Department of Pharmacy) curriculum in pharmaceutical education from the 2006 school year. Following a reorganization of this curriculum, the Graduate School of Pharmaceutical Sciences has established a specialized master’s course (2 years, capacity: 100 entrants) and doctoral program (3 years, capacity: 50 entrants) in pharmaceutical science on top of the four-year department curriculum, as well as a doctoral course (4 years, capacity: 10 entrants) on top of the six-year department curriculum. These two specialized doctoral courses provide a new and flexible framework for graduate-level education.

Going forward, the University of Tokyo’s Graduate School and Faculty of Pharmaceutical Sciences will continue to work as a leader in the pharmaceutical world, providing impactful scientific submissions and proposals that help blaze new eras. We hope you will join us and help develop the future of life science!

Hidenori Ichijo
Dean
Graduate School of Pharmaceutical Sciences
Faculty of Pharmaceutical Sciences
The University of Tokyo
The Department of Pharmaceutical Manufacturing was established in Daiichi-Daigaku-Ku Igakko (The First University District Medical School) in Kanda Izumicho, Tokyo.

Daiichi-Daigaku-Ku Igakko was renamed as Tokyo-Igakko (Tokyo Medical School).

Tokyo-Igakko was moved to Hongo, Tokyo.

Tokyo Daigaku, The University of Tokyo was established.

Tokyo-Igakko was renamed as the University of Tokyo Faculty of Medicine.

The organization of pharmaceutical education began with the establishment of Pharmaceutical Institute (later Department of Pharmaceutical Manufacturing in the Faculty of Medicine). For the first 10 years, instruction was given by foreigners and in particular a Dutch chemist Dr. J. E. Eijkman. He left a large amount of fine work in the study of components of various domestic medicinal plants.

The University of Tokyo was renamed as Imperial University and the name of the Department of Pharmaceutical Manufacturing in the Faculty of Medicine was changed to the Department of Pharmacy in the Imperial University Medical College. Japanese who had returned from studies in Germany took over the education of students, carried out valuable investigations of their own, and also established the ground for pharmaceutical organic chemistry in Japan.

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The Department of Pharmacy separated from the Faculty of Medicine and became an independent faculty as the Department of Pharmaceutical Sciences, the Faculty of Pharmaceutical Sciences.

The Department of Pharmaceutical Technochemistry was established.

The Graduate School of Pharmaceutical Sciences, The University of Tokyo was established. (Department of Pharmaceutical Sciences and Department of Pharmaceutical Technochemistry)

The Research Institute for Chemical Hazards was established.

The Experimental Station for Medicinal Plant Studies was established.

The Research Institute for Chemical Hazards was abolished, and instead the Department of Pharmaceutical Life-Science was established.

Two departments were unified into the Department of Pharmaceutical Sciences.

The graduate school was reorganized along with the new system, "Graduate School Priority System" and reformed into three Departments, that is Pharmaceutical Chemistry, Pharmaceutical Biology, and Pharmaceutical Technology. Although the Faculty’s emphasis of education is shifted from the Undergraduate Program to the Graduate Program, most of the faculty members also continue undergraduate education.

Clinical Pharmacy Course was established in the Master’s Program.

Pharmaceutical Sciences Research Building was constructed.

Following the revision of the School Education Act, the Faculty of Pharmaceutical Sciences started a new program with Department of Pharmaceutical Sciences (4-year program) and Department of Pharmacy (6-year program).

Department of Integrated Pharmaceutical Sciences was added to the Graduate School, which consists of total 4 departments.

Department of Integrated Pharmaceutical Sciences was added to the Graduate School, which consists of total 4 departments.

The former 4 departments in the Master’s Program were abolished and the Department of Pharmaceutical Sciences was established. Clinical Pharmacy Course was abolished.

The former 4 departments in the Doctoral Program were abolished. Department of Pharmaceutical Sciences and Department of Pharmacy were established in the Doctoral Program. Dual Speciality Course on Pharmacist Education was established.
### Number of Academic and Administrative Staff

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>10</td>
<td>8</td>
<td>27</td>
<td>3</td>
<td>5</td>
<td>1</td>
<td>14</td>
<td>86</td>
<td>47</td>
<td>19</td>
<td>20</td>
</tr>
</tbody>
</table>

### Number of Students

#### Undergraduates

<table>
<thead>
<tr>
<th>Year</th>
<th>3rd year</th>
<th>4th year</th>
<th>5th year</th>
<th>6th year</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2017</td>
<td>78</td>
<td>89</td>
<td>10</td>
<td>5</td>
<td>182</td>
</tr>
</tbody>
</table>

#### Graduates

<table>
<thead>
<tr>
<th>Year</th>
<th>Master’s Program</th>
<th>Doctoral Program (Pharmaceutical Sciences)</th>
<th>Doctoral Program (Pharmacy)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2017</td>
<td>87</td>
<td>106</td>
<td>193</td>
<td>386</td>
</tr>
</tbody>
</table>

### Number of Research Students, etc.

#### Undergraduate-level

<table>
<thead>
<tr>
<th>Year</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>10</td>
<td>5</td>
<td>12</td>
<td>8</td>
<td>27</td>
</tr>
</tbody>
</table>

#### Graduate-level

<table>
<thead>
<tr>
<th>Year</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>19</td>
<td>15</td>
<td>22</td>
<td>23</td>
<td>27</td>
</tr>
</tbody>
</table>

### Number of Doctoral Degree Holders

<table>
<thead>
<tr>
<th>Year</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>Cumulative Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thesis Doctorate</td>
<td>56</td>
<td>51</td>
<td>39</td>
<td>54</td>
<td>61</td>
<td>1,791</td>
</tr>
</tbody>
</table>

### Current Status of Graduates

#### Undergraduate-level Graduates

<table>
<thead>
<tr>
<th>Academic Year</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical industry companies</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Financial, insurance, &amp; trading companies</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Education, government, research institutes, etc.,</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Others</td>
<td>5</td>
<td>4</td>
<td>2</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Subtotal (Number employed)</td>
<td>3</td>
<td>5</td>
<td>1</td>
<td>7</td>
<td>4</td>
</tr>
</tbody>
</table>

### Number of International Students

<table>
<thead>
<tr>
<th>Countries and Regions</th>
<th>Undergraduate</th>
<th>Graduate School</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>2</td>
<td>11(1)</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>1</td>
<td>1(1)</td>
</tr>
<tr>
<td>India</td>
<td>1</td>
<td>1(1)</td>
</tr>
<tr>
<td>Korea</td>
<td>1</td>
<td>1(1)</td>
</tr>
<tr>
<td>Taiwan</td>
<td>1</td>
<td>1(1)</td>
</tr>
<tr>
<td>Nigeria</td>
<td>1</td>
<td>1(1)</td>
</tr>
<tr>
<td>United States</td>
<td>1</td>
<td>1(1)</td>
</tr>
<tr>
<td>Poland</td>
<td>1</td>
<td>1(1)</td>
</tr>
<tr>
<td>Total</td>
<td>3</td>
<td>15(2)</td>
</tr>
</tbody>
</table>

( ) Numbers indicate MEXT Scholarship Students
Pharmaceutical sciences is an academic field that covers development of pharmaceuticals and their applications. The field encompasses fundamental, life-related substances and their interactions with life; using organic chemistry, physical chemistry, and biochemistry as a base, upon which is built a wide range of research fields, including interdisciplinary areas. With these parallel 6-year and 4-year programs, the Faculty of Pharmaceutical Sciences not only provides traditional training in basic research for drug discovery but also offers some courses in advanced training for pharmacists. (Graduates of the Department of Pharmacy are qualified for the national examination for pharmacists.) No differentiation is made between the Departments of Pharmacy and Pharmaceutical Sciences from the College of Arts and Sciences until entering higher education, allowing students to gain an ample understanding of research content before deciding between the two departments in their fourth year.

Our doctoral program in the Department of Pharmaceutical Sciences, established in 2012, also provides a Dual Specialty Course on Pharmacist Education allowing students to be qualified for the national examination for pharmacists. (This is provided for students who enter the University of Tokyo by the 2017 school year and graduate from the Department of Pharmaceutical Sciences, Faculty of Pharmaceutical Sciences.)
Department of Pharmaceutical Sciences

Taking on the goal of the previous Department of Pharmacy curriculum, the Department aims to educate high-quality researchers, focusing on developing personnel in the fields of drug discovery and basic life-science research. With a capacity of 90 percent of all students, the Department offers graduates a two-year master’s program, then to a three-year doctoral program. The curriculum is nearly identical to the Department of Pharmacy until the third year, allowing students to experience on-the-ground medical treatment even if they intend to pursue research.

Department of Pharmacy

In response to the advancement of medical care, the purpose of the establishment of this department is to train and develop high-quality pharmacists. One large difference from the Department of Pharmaceutical Sciences is that the program includes six-month practical hospital/pharmacy training. The Department’s capacity is 10 percent of all students, providing high-quality pharmacy education to a small number of students, aiming to create personnel who will be able to lead this field. Six-year pharmacy departments are well over capacity across all of Japan; to avoid disruption, the University of Tokyo’s Faculty of Pharmacy will collaborate with the University of Tokyo Hospital and local pharmacies in order to provide smooth, uninterrupted practical training.

Faculty Curriculum

Lectures and practicums lie in the center of the education at the Faculty of Pharmaceutical Sciences. They are provided to students in order for them to acquire the broad knowledge and the perspectives of pharmacists, as well as to have a clear view when they decide which field of pharmacy they should enter as specialists. One can say that lectures provided to faculty students are the essence of pharmaceutical sciences. Furthermore, reflecting the diversity in research areas in the Faculty of Pharmaceutical Sciences, the pharmacy practicums encompass a wide range of training areas. It is efficiently designed in a way that students will be able to put organic chemistry, physical chemistry, biochemistry and clinical pharmacy into practice. When students enter into their fourth year, each student will be allocated to a class of his/her own choice and will have opportunities to get hands-on experience in the cutting-edge pharmacy through the participation in research projects.

<table>
<thead>
<tr>
<th>Department of Pharmaceutical Sciences</th>
<th>Department of Pharmacy</th>
</tr>
</thead>
<tbody>
<tr>
<td>80 credits</td>
<td>120 credits</td>
</tr>
<tr>
<td>(Compulsory: 62 credits, Elective: 18 credits or more)</td>
<td>(Compulsory: 109 credits, Elective: 11 credits or more)</td>
</tr>
</tbody>
</table>

2nd year: Autumn 1

<table>
<thead>
<tr>
<th>Course Title</th>
<th>Credits</th>
<th>Course Outline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physiological Anatomy of Human Body</td>
<td>1</td>
<td>Students will learn the structures and functions of each organ (i.e., anatomy and physiology) as the basic knowledge for them to understand pharmacotherapy and pathophysiology.</td>
</tr>
<tr>
<td>Pharmaceutical Affairs Law and Patent Law</td>
<td>1</td>
<td>Students will learn the basics of the Patent Act and pharmacy-related laws and regulations.</td>
</tr>
<tr>
<td>Pharmacology I</td>
<td>1</td>
<td>Students will learn the fundamentals of pharmacology in order to understand actions of drugs that affect the autonomic nervous system and the circulatory system.</td>
</tr>
<tr>
<td>Molecular Biology</td>
<td>1</td>
<td>Students will learn the fundamentals of molecular biology to understand the life sciences.</td>
</tr>
<tr>
<td>Pharmacokinetics</td>
<td>1</td>
<td>To achieve proper use of the pharmaceutical products, and contribute to the drug development, the lecture explains the pharmacokinetics, a theoretical scheme for quantitatively understanding the disposition of drugs in the body, and describes the factors that cause inter-individual variation in drug disposition and response.</td>
</tr>
<tr>
<td>Course Title</td>
<td>Credits</td>
<td>Course Outline</td>
</tr>
<tr>
<td>--------------</td>
<td>---------</td>
<td>----------------</td>
</tr>
<tr>
<td>Biostatistics</td>
<td>1</td>
<td>Students will receive lectures and practicums regarding statistical methods and experimental methods used for drug evaluations.</td>
</tr>
<tr>
<td>Immunology</td>
<td>1</td>
<td>Students will understand the immune system and the immune response to infections and allergies in the level of dynamic behaviors of tissues, cells and molecules.</td>
</tr>
<tr>
<td>Organic Chemistry I</td>
<td>1</td>
<td>Students will learn the fundamentals such as stereochemistry, structural chemistry, reduction and oxidation.</td>
</tr>
<tr>
<td>Physical Chemistry I</td>
<td>1</td>
<td>Students will aim to acquire the physicochemical concept by understanding quantum chemistry and spectroscopy.</td>
</tr>
<tr>
<td>Radiation Chemistry</td>
<td>1</td>
<td>Lectures pertaining to the fundamentals, applications and biological effects of isotopes and radiation (which are indispensable for the fields of medicine and pharmaceutical sciences) will be given.</td>
</tr>
<tr>
<td>Physical Chemistry II</td>
<td>1</td>
<td>Lectures are aimed to allow students to understand important concept of thermodynamics, acquire the physicochemical perspectives and learn methods that are important in pharmaceutical sciences.</td>
</tr>
<tr>
<td>Analytical Chemistry I</td>
<td>1</td>
<td>This course covers chemical equilibrium, qualitative and quantitative chemical analysis, and instrumental analysis.</td>
</tr>
<tr>
<td>Cell Biology</td>
<td>1</td>
<td>Students will learn the fundamentals of cell biology to understand the life sciences.</td>
</tr>
<tr>
<td>Introduction to Pharmaceutical Sciences</td>
<td>1</td>
<td>The outline, history and the future vision of pharmaceutical sciences will be explained in an easy to understand manner, allowing students to think about the relationship between pharmaceutical sciences and society in terms of industry and medical care. Moreover, students will learn some of the latest studies in the field of pharmaceutical sciences.</td>
</tr>
<tr>
<td>Organic Chemistry II</td>
<td>1</td>
<td>Fundamental organic chemistry which contains Acid and Base, Nucleophilic Substitution and Elimination Reactions.</td>
</tr>
</tbody>
</table>

2nd year: Autumn 2

<table>
<thead>
<tr>
<th>Course Title</th>
<th>Credits</th>
<th>Course Outline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pharmaceutics</td>
<td>1</td>
<td>In addition to drug delivery system, students will learn dosage forms, design/manufacturing methods and usability evaluation methods.</td>
</tr>
<tr>
<td>Microbiology and Chemotherapy</td>
<td>1</td>
<td>The basic biochemical and genetic methods will be outlined using microorganisms such as E-coli as materials. Students will also learn the mechanisms of action of antibiotics.</td>
</tr>
<tr>
<td>Physical Chemistry III</td>
<td>1</td>
<td>Students will learn the hierarchy of protein structure, various intermolecular interactions, enzyme structures and the theory of enzyme reaction.</td>
</tr>
<tr>
<td>Pharmaceutical and Medical Businesses</td>
<td>1</td>
<td>Students will learn the basics of strategic management to understand what exactly company/research institute management means. The structure and characteristics of medical care/pharmaceutical industry will also be explained.</td>
</tr>
<tr>
<td>Pathology</td>
<td>1</td>
<td>Pathological changes of cells and tissues, classification and treatment of diseases will be explained.</td>
</tr>
<tr>
<td>Molecular Structural Bio-Sciences</td>
<td>1</td>
<td>The fundamentals and actual examples of structural analysis of biomaterials will be explained using the nuclear magnetic resonance method or the X-ray crystal structure analysis method.</td>
</tr>
<tr>
<td>Functional Biology</td>
<td>1</td>
<td>Students will learn the fundamental of higher-order function cell to understand life sciences.</td>
</tr>
<tr>
<td>Organic Chemistry III</td>
<td>1</td>
<td>Students will learn chemical reaction theories such as substitution reaction, radical reaction, reduction/oxidation reaction and addition reaction, as well as the organic electron theory which is important for understanding chemical reaction.</td>
</tr>
<tr>
<td>Pharmaceutical Regulatory Science</td>
<td>1</td>
<td>Drug development and efficacy evaluation methods, domestic and overseas drug development environment and guidelines will be explained using specific examples.</td>
</tr>
<tr>
<td>Clinical Pharmacy</td>
<td>1</td>
<td>Aiming for understanding pharmaceutical sciences in medical care, the following subjects will be outlined: the medical system; drug development, and its efficacy and safety; diseases and their therapeutic agents; medical care and pharmacists; fundamentals of drug compounding/formulation; drug administration guidance and drug history management; and clinical pharmacokinetics.</td>
</tr>
<tr>
<td>Organic Chemistry IV</td>
<td>1</td>
<td>Students will learn the typical reaction of carbonyl compounds.</td>
</tr>
</tbody>
</table>
### 3rd year: Spring 1

<table>
<thead>
<tr>
<th>Course Title</th>
<th>Credits</th>
<th>Course Outline</th>
<th>Course Outline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pharmacology II</td>
<td>1</td>
<td>Students will understand drug actions that affect the central nervous system, endocrine system and immune system by learning the physical function and mental function.</td>
<td>4 6</td>
</tr>
<tr>
<td>Drug Informatics</td>
<td>1</td>
<td>Methods for constructing novel drug information effective in real-life medical care situations will be explained. These methods include methodology to standardize drug information and quantify drug reactions.</td>
<td>4 6</td>
</tr>
<tr>
<td>Clinical Pharmacology</td>
<td>1</td>
<td>Students will learn the fundamentals of pharmacotherapy and clinical development with the clinical perspectives from pathophysiology through pharmacokinetics, clinical pharmacology to clinical testing. Students will also learn diagnoses, treatment and clinical trials in real-life situations from experts in the departments of clinicopathology, internal medicine, surgery and radiology to understand the disease “cancer.”</td>
<td>*⑥</td>
</tr>
<tr>
<td>Interactive Organic Chemistry</td>
<td>1</td>
<td>The fundamentals of organic chemistry by practicum and group discussion will be outlined and reviewed.</td>
<td>4 6</td>
</tr>
<tr>
<td>Laboratory Works of Pharmaceutical Sciences I</td>
<td>5</td>
<td>To acquire fundamental experimental operations, and experience basic organic reactions and some practical synthesis of organic compounds.</td>
<td>4 6</td>
</tr>
<tr>
<td>Laboratory Works of Pharmaceutical Sciences II</td>
<td>3</td>
<td>Basic experiments in bio-organic chemistry (extraction, isolation, identification and biosynthesis of natural organic compounds; the fundamentals and applications of the extinction method and the fluorescence method; learning high-speed liquid chromatography; drug metabolism reaction experiments; enzyme kinetics; visits to the Experimental Station for Medicinal Plant Studies)</td>
<td>4 6</td>
</tr>
</tbody>
</table>

### 3rd year: Spring 2

<table>
<thead>
<tr>
<th>Course Title</th>
<th>Credits</th>
<th>Course Outline</th>
<th>Course Outline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic Chemistry V</td>
<td>1</td>
<td>Students will learn the chemistry of natural organic compounds having biological activity, as well as the fundamentals of biosynthesis.</td>
<td>4 6</td>
</tr>
<tr>
<td>Biophysics</td>
<td>1</td>
<td>Students will learn about the hierarchy structure of an organism (from molecules to an individual) as well as each level of the hierarchy.</td>
<td>4 6</td>
</tr>
<tr>
<td>Health Chemistry</td>
<td>1</td>
<td>The impact of environmental materials toward organisms will be explained.</td>
<td>4 6</td>
</tr>
<tr>
<td>Organic Chemistry VI</td>
<td>1</td>
<td>This is a class for learning metabolism of medical drugs, fundamentals of drug development, chemistry of carbohydrates and synthetic polymers. Enzyme induction, polymorphism, metabolic reactions, enzymes, reaction mechanisms of P-450 will be explained in molecular level. The fundamentals of drug development such as molecular design, chemical libraries and lead compounds, and polymers such as carbohydrates and synthetic polymers will be also explained.</td>
<td>4 6</td>
</tr>
<tr>
<td>Laboratory Works of Pharmaceutical Sciences III</td>
<td>3</td>
<td>Basic experiments in physico-chemistry (acquisition and analysis of drug disposition kinetic data, physicochemical analyses of proteins and structural biological analyses of protein interactions, analyses of molecular structures and understanding of the 3D structure using the X-ray diffraction)</td>
<td>4 6</td>
</tr>
</tbody>
</table>
### 3rd year: Autumn 1

<table>
<thead>
<tr>
<th>Course Title</th>
<th>Credits</th>
<th>Course Outline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medicinal Chemistry II</td>
<td>1</td>
<td>Students will learn organic chemistry of biologically active substances and pharmaceutical molecules, as well as that of molecular design.</td>
</tr>
<tr>
<td>Toxicological Pharmacology</td>
<td>1</td>
<td>Scientific proof of drug safety will be explained from the molecular biological, cell biological, pathophysiological and sociological perspectives, mainly focusing on the stress response of organisms.</td>
</tr>
<tr>
<td>Medicinal Chemistry I</td>
<td>1</td>
<td>Lectures pertaining to advanced level of organic synthetic chemistry, transition metal chemistry, heterocyclic ring and natural product synthetic chemistry will be given.</td>
</tr>
<tr>
<td>Molecular Physiological Chemistry</td>
<td>1</td>
<td>The latest knowledge regarding acceptance and transduction of extracellular signaling molecules such as hormones will be explained.</td>
</tr>
<tr>
<td>Special Lectures on Pharmaceutical Sciences I</td>
<td>1</td>
<td>Students will learn the ideal way of pharmaceutical sciences through bio/medical ethics.</td>
</tr>
<tr>
<td>Laboratory Works of Pharmaceutical Sciences IV</td>
<td>5</td>
<td>(1) Experiments in physiological chemistry: Regulation of blood sugar levels (physiological/metabolic experiments); proliferative response of culture cells (isotope experiments)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2) Experiments in molecular biology: Basic experiments in molecular biology using culture cells</td>
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<td>(3) Experiments in genetics: Basic experiments in molecular genetics using animal models</td>
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<td></td>
<td>(4) Experiments with microorganisms: Basic experiments with microorganisms and antibiotics; basic experiments on gene manipulation</td>
</tr>
<tr>
<td>Special Laboratory Works of Pharmaceutical Sciences I</td>
<td>1</td>
<td>Through the determination of genetic polymorphism of drug metabolizing enzymes, students will learn the significance and interpretation method of genetic polymorphism in consideration of future medical care. Furthermore, they will learn the appropriate process of research on human genome and genes, as well as the importance of compliance of ethical guidelines.</td>
</tr>
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### 3rd year: Autumn 2

<table>
<thead>
<tr>
<th>Course Title</th>
<th>Credits</th>
<th>Course Outline</th>
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</thead>
<tbody>
<tr>
<td>Medicinal Chemistry III</td>
<td>1</td>
<td>In lectures on organic chemistry (which is essential for drug development), the fundamentals of organic reaction chemistry, and chemistry of bio-related reaction and physiologically active substances will be explained. The fundamentals of chemical biology especially about photo-functional molecules will be explained.</td>
</tr>
<tr>
<td>Biological Basis of Cancer</td>
<td>1</td>
<td>Lectures pertaining to biology of cancer, clinic and treatment of cancer especially pharmacotherapy will be given.</td>
</tr>
<tr>
<td>Natural Product Chemistry</td>
<td>1</td>
<td>Students will learn the origins, ingredients, evaluations and applications of natural drugs (primarily those described in the Pharmacopoeia of Japan) as well as plant biotechnology.</td>
</tr>
<tr>
<td>Metabolism and disease</td>
<td>1</td>
<td>Metabolism and various diseases caused by metabolic failure will be explained.</td>
</tr>
<tr>
<td>Laboratory Works of Pharmaceutical Sciences V</td>
<td>3</td>
<td>Basic experiments in pharmacology using whole animals and organs, observation of pathology specimens, histochemistry, analysis of the mechanism of cell signaling, generic experiments using budding yeast</td>
</tr>
<tr>
<td>Special Lectures on Pharmaceutical Sciences II</td>
<td>1</td>
<td>Students will learn the ideal way of pharmaceutical sciences through voices of victims of harmful effects of drugs.</td>
</tr>
</tbody>
</table>

### 4th year (Department of Pharmaceutical Sciences)

<table>
<thead>
<tr>
<th>Course Title</th>
<th>Credits</th>
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<tbody>
<tr>
<td>Special Laboratory Works of Pharmaceutical Sciences</td>
<td>20</td>
<td>Students will be allocated to a laboratory in the Faculty of Pharmaceutical Sciences (including the Dept. of Pharmacy, the Univ. of Tokyo Hospital), and participate in frontline pharmaceutical research.</td>
</tr>
</tbody>
</table>
Pharmaceutical education experienced major changes beginning with students entering in the 2006 school year. As a result, the University of Tokyo's Faculty of Pharmaceutical Sciences established two new departments: The Department of Pharmaceutical Sciences, a four-year program designed to train researchers in basic drug discovery, and the Department of Pharmacy, a six-year program that qualifies graduates for the national examination for pharmacists. New graduate schools were also established based on student progression through their programs.

In April of 2010, we established a master's program in pharmaceutical sciences for graduates of the four-year Department of Pharmaceutical Sciences program. This research program unites the four departments that previously existed, creating a single department instead. In April of 2012, we established a doctoral program in pharmaceutical sciences for graduates of the master's program (duration of program: three years), along with a doctoral program in pharmacy for graduates of the six-year Department of Pharmacy program (duration of program: four years). The doctoral program in pharmaceutical sciences also offers a Dual Specialty Course on Pharmacist Education to qualify four-year doctoral graduates for the national examination for pharmacists.

The main part of graduate school curriculum is "special research" through participations in research conducted in each laboratory. At the Graduate School lectures are targeted at students in master's program/doctoral program(Department of Pharmacy). Those lectures are highly specialized, covering the latest information in the field, thus allowing them to be the world’s top class.

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<thead>
<tr>
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<tbody>
<tr>
<td>Laboratory Works of Pharmaceutical Sciences VI</td>
<td>20</td>
<td>Students will be assigned to a laboratory in the Faculty of Pharmaceutical Sciences and participate in frontline pharmaceutical research. They will also independently conduct research and study for practical hospital/pharmacy training.</td>
</tr>
<tr>
<td>Practice for Clinical Pharmacy II</td>
<td>4</td>
<td>To work as a pharmacist in the clinical practice of hospital and pharmacy, students will acquire basic requirements for drug treatment and team approach medical care/regional medical care from perspective of patients and living people. For Practice for Clinical Pharmacy III・IV, students will acquire basic knowledge, skills and attitude required for fulfilling pharmacists' duties within the University, such as preparation and formulation of drugs and drug administration guidance.</td>
</tr>
<tr>
<td>Practice for Clinical Pharmacy III</td>
<td>10</td>
<td>In order to understand duties and responsibilities of hospital pharmacists and be able to participate in team approach to medical care, students will acquire basic knowledge, skills and attitude required for fulfilling pharmacists' duties, such as preparation and formulation of drugs and drug administration guidance.</td>
</tr>
<tr>
<td>Practice for Clinical Pharmacy IV</td>
<td>10</td>
<td>In order to understand social roles and responsibilities of pharmacies and be able to participate in medical care in their local communities, students will acquire basic knowledge and skills regarding, and attitude toward, pharmacy services under health insurance, drug supply and management, information provision, health examinations and relationship with medical institutes and local communities.</td>
</tr>
<tr>
<td>Special Laboratory Works of Pharmaceutical Sciences</td>
<td>20</td>
<td>Students will be allocated to a laboratory in the Faculty of Pharmaceutical Sciences (incl. Dept. of Pharmacy, the Univ. of Tokyo Hospital) and participate in frontline pharmaceutical research.</td>
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</table>
### Department of Pharmaceutical Sciences

<table>
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<tr>
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<th>Course Outline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Special Studies for Pharmaceutical Science I</td>
<td>20</td>
<td>(Master’s course) To gain a foothold toward specialization; learn pharmaceutical modes of thought and logical, cutting-edge methodology; and develop advanced analytical skills through practice, seminars, and individualized laboratory research activities</td>
</tr>
<tr>
<td>Special Studies for Pharmaceutical Science II</td>
<td>20</td>
<td>(Doctoral course) To establish deep roots in a specialization; learn pharmaceutical modes of thought and logical, cutting-edge methodology; and develop advanced analytical skills through individualized laboratory research activities</td>
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</table>

### Department of Pharmacy

<table>
<thead>
<tr>
<th>Course Title</th>
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<th>Course Outline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Practical Studies for Clinical Pharmacy</td>
<td>4</td>
<td>To acquire the practical methodology, awareness of the issues, and independence to respond to the needs of society in sophisticated medical environments</td>
</tr>
<tr>
<td>Practical Studies for Social Pharmacy</td>
<td>4</td>
<td>To acquire the practical methodology, awareness of the issues, and independence to respond to the needs of society in medical administration environments</td>
</tr>
<tr>
<td>Practical Studies for Drug Discovery</td>
<td>4</td>
<td>To acquire the practical methodology, awareness of the issues, and independence to respond to the needs of society in drug discovery environments</td>
</tr>
<tr>
<td>Special Studies for Pharmacy</td>
<td>20</td>
<td>To learn—through practice, seminars, and individualized laboratory research activities—comprehensive methodology pertaining to the interaction of molecules and organisms for the purpose of discovering and appropriately using pharmaceuticals</td>
</tr>
</tbody>
</table>

*Courses are open every other year*
Laboratory of
Organic and Medicinal Chemistry

Synthesis of novel intelligent molecules which link chemical structures to biological functions in organic and medicinal chemistry

Research Topics

1. Synthesis of new compounds exhibiting characteristic structural features and properties, finally relevant to biological functions
2. New reactions to functionalize aromatic compounds based on designed superelectrophiles
3. Design and synthesis of intelligent molecules, which will have impacts on functions of membrane proteins
4. Computational modeling and simulations of organic and macromolecular systems

Our aims of researches emphasize on design and synthesis of structurally novel organic molecules, which are characteristic in terms of structural (bonding) features and intrinsic functions such as chemical reactivities and biological functions. Designs of such novel molecules are based on our finding new chemistry including ground-state stable non-planar amide peptides and nitrosamines, and structures of multiply positively charged molecules. We study nitrogen-pyramidal amides and related nitrosamines, i.e., molecules that take nonplanar structures, different from the common planar amides. We apply this chemistry to construction of molecules of highly ordered structures such as helix peptide mimetics stable in water. We also develop new chemistry involving dication or trication molecules and apply them as superelectrophiles to synthesize a variety of novel multi-functionalized aromatic compounds, which are pharmaceutically relevant. We are also creating chemical molecules, which will be useful to controlling biological events of membrane proteins such as ion channels, neurotransporters and G-protein-coupled receptors. These molecules also contribute to understanding the physiological functions of these membrane proteins. We combine all the experimental projects with computational chemistry, which will lead to deep understanding of the underling chemistry.
Laboratory of Synthetic Medicinal Chemistry

Total synthesis and functional analysis of biologically active natural products

Research Topics

1. Development of new synthetic methodologies for total synthesis
2. Total synthesis of highly oxygenated polycyclic natural products
3. Total synthesis and functional analysis of ion channel-forming molecules
4. Total synthesis and functional analysis of antimicrobial molecules
5. Synthesis of new artificial molecules by modification of natural products templates


Natural products have been tremendously important in biology and human medicine because of their power to modulate signal transductions of biological system. Since the removal of sub-structures of the natural products often leads to significant losses of their activity, total chemical syntheses of their entire structures with a precision at an atomic level are necessary to provide sufficient amounts of material required for biological and medical applications. Architecturally complex natural products with molecular weight over 1000 are capable of highly specific interactions with their target proteins. Therefore, they are powerful agents for selectively controlling intricate biological systems. The goal of our research program is efficient, practical and flexible syntheses of gigantic natural molecules, which include highly oxygenated polycyclic natural products as well as ion channel-forming peptides. At the core of this research program is the development of new strategies for assembling architecturally complex natural products in a concise fashion. These synthetic developments would enable unified synthesis of new artificial analogs by modification of natural products templates. The new synthetic methods for the natural products and the synthetic analogs will allow us to tailor and enhance their drug like properties, to gain control over diverse signal transductions thereby offering new research methods for the study of life science.
The main theme of our research is the development of revolutionary catalyses facilitating new drug design and synthesis. In this direction, we would like to promote human health based on the catalysis development. Chemical synthesis in 21st century should be clean, robust, and concise, no matter how complex the target molecules are. The “ideal synthesis” will be only possible by new catalytic methodologies. Moreover, new catalyses will expand the diversity of readily available building blocks, leading to structurally novel artificial drug design. Sustainability based on new catalysis is another direction of our research. Specifically, we are interested in catalytic activations of small molecules such as H2 and O2.

1. Development of new catalysis to facilitate complex molecule synthesis
2. Clean, robust, and concise synthesis of pharmaceuticals and their leads
3. Catalytic H2 and O2 activation
4. Conceptually new approach to promote human health

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Laboratory of Natural Products Chemistry

We establish the mechanisms of natural product biosynthesis as a science in their own right, to construct a rational system for the production of new and useful substances.

Research Topics

1. The biosynthesis and bioengineering of medicinal natural products (genome mining, engineered biosynthesis)
2. The enzyme biocatalysts (structure-function analysis, enzyme engineering, mechanistic studies)
3. The search for bioactive substances and isolation/structure determination

Natural organic compounds, prominent among which are antibiotics such as penicillin, are gifts from nature, and the benefits they have bestowed upon humankind as sources for the pharmaceuticals, etc., that maintain health is inestimable. In our laboratory, we study the process of biosynthesis of natural organic compounds produced by plants and microorganisms, using not only the foundation discipline of organic chemistry, but also incorporating the methods of biochemistry and molecular biology in an effort to understand the enzymes that catalyze each biosynthesis reaction and the functions and control mechanisms of the genes that govern their expression at the molecular level. In addition, we are expanding our research into “biosynthesis engineering,” by which rational systems for the biological production of new and useful substances can be designed and constructed, based on the mechanisms of biosynthesis that have been brought to light. We also are carrying out research on the mechanisms by which the bioactivity of natural products is expressed, while at the same time searching for natural products that are active in intracellular signaling.
Laboratory of
Advanced Elements Chemistry

Understanding of chemical phenomena at the atomic and electron levels and creation of a new science of materials through flexible construction of molecules

Research Topics

1. Development of advanced molecular transformation methods supporting materials science and life sciences (methodology development/synthetic chemistry)
2. Periodic table-traversing chemistry that transcends the frameworks of organic chemistry, inorganic chemistry, and metallic chemistry (elements chemistry)
3. Elucidation of the structural chemistry of intermediates and transitional states (physical chemistry, spectroscopy, theoretical calculation)
4. Design and production of materials founded on synthetic chemistry, spectroscopy, and computational chemistry (materials science/life sciences)

Our laboratory focuses on understanding the properties and phenomena of substances by “language of chemistry” such as molecules, atoms, and electrons (Seeing/Knowing); on developing reactions that manipulate the bonds between atoms completely in control (Designing); and on producing functional materials (Producing).

In our laboratory, we strive to develop technologies for the precise chemical conversion of tiny, tiny molecules less than 1 billionth of a meter in size (nanometer scale; nm). Thanks to recent advances in spectroscopy and theoretical calculation, it is getting possible to accurately predict and reproduce snapshots of the state of the electrons that form materials, as well as of reactions between molecules.

With the 3 methods, namely, synthetic chemistry, spectroscopy, and theoretical calculation as the pillars of our science, we expand upon elements chemistry in an interdisciplinary manner as we meet the challenges of elucidating life phenomena and creating a new materials science.

Developing new reactions and designing/producing new materials based on computational chemistry and theoretical chemistry (Adopted for the cover of Chemistry: A European Journal) Life sciences and materials science that open new frontiers in basic organic chemistry and elemental chemistry

Kanazawa, J., Maeda, K., Uchiyama, M.
Radical Multicomponent Carboamination of [1.1.1] Propellane.

Wang, D-Y., Kawahata, M., Yang, Z-K., Miyamoto, K., Komagawa, S., Yamaguchi, K., Wang, C., Uchiyama, M.
Stille Coupling via C–N Bond Cleavage.

Tezuka, N., Shimojo, K., Hirano, K., Komagawa, S., Yoshida, K., Wang, C., Miyamoto, K., Saito, T., Takita, R., Uchiyama, M.
Direct Hydroxylation and Amination of Arenes via Deprotonative Cupration.
Laboratory of Chemistry and Biology

"Chemical Biology" and "Chemical Medicine" in order to promote life science research and to develop novel medical tools

Research Topics

1. Fundamental photophysical and photochemical research to establish rational design principle for novel chemical tools
2. Theoretical design, synthesis and biological application of novel chemical tools, including sensor molecules and signal perturbation techniques for cellular signaling molecules, such as Ca^{2+} ion, reactive oxygen species, or various enzymes
3. Development of chemical tools, e.g., MRI probe and fluorescent probe, for diagnostic imaging and their in vivo application
4. Clinical use of our newly developed fluorescence probes for rapid imaging of tumor with human clinical fresh specimens
5. Research on drug discovery: Searching for novel lead compounds that control disease-related proteins, and development of high-quality screening systems

Our laboratory conducts research on the analysis and perturbation of dynamic living systems, using chemistry as a powerful tool. One of the important goals in modern life sciences is to elucidate the dynamic behaviors of biomolecules in situ in the living cells/organisms. So far, our laboratory has succeeded in developing bioimaging probes/other chemical tools including signal perturbation methodology and high quality screening systems by applying the probe design strategies that we established. Likewise, we utilize our probe design principle to establish chemical tools for clinical use, including a tumor-specific intraoperative fluorescence imaging methodology. On top of that, we are now conducting dozens of pilot clinical trial projects by utilizing above mentioned chemical tools with external collaborators in domestic hospital and abroad.

The above-described areas of research have attracted enormous attention in recent years under the name of "Chemical Biology", and we believe that they will open up new horizons in life sciences.

We are developing functional bioimaging probes, e.g., fluorescence, MRI, or bioluminescence probes, that are practically useful for live cell or in vivo imaging.

Our probes are commercially available all over the world.


We measure the functions of biomolecules at the level of a single molecule to elucidate vital functions

**Research Topics**

1. Research on the principles of action by which biomolecular machines such as molecular chaperonin and ribosomes operate
2. Single-molecule fluorescence imaging of intracellular mRNA processing and transport
3. Development of micro nanodevices for analyzing the functions and interactions of biomolecules

In order to understand living organisms, it is necessary to conduct research at a variety of different levels. The lowest level is that at which biomolecules such as proteins and DNA work. When these come together, biological supramolecules, cells, organs, and the like are created, while at the higher end, individual organisms, societies, and ecosystems are constituted. We focus on the level of the smallest unit, the “biomolecule,” together with the level of the “cell,” at which life functions are first expressed, to find answers to questions like “By what mechanisms do biomolecules function?” and “When they aggregate, what kinds of systems do they construct?” Concretely speaking, we bind a fluorescent dye to a single biomolecule and observe it with a sensitive fluorescence microscope. Some biomolecules can exhibit their functions even at the level of the single molecule. For example, the motor protein known as kinesin moves on rail proteins called microtubules. Humankind does not at this point in time possess the technology for creating this kind of molecular machine, but we believe that humankind will be able to make this kind of molecular machine in the near future through research on the motor protein. On the other hand, self-assembly of a variety of different biomolecules creates complex systems which differ greatly from manmade ones. By researching such biological systems, we close in on the mysteries of life.


Laboratory of Physical Chemistry

We develop original NMR methods for elucidating protein functions based on dynamical structure information

Research Topics

1. Elucidation of the functional dynamics of membrane proteins
2. Reconstitution of membrane proteins into lipid bilayer condition with tailored stable isotope labeling for in situ NMR analyses.
3. Analyses of protein-protein interactions involving intracellular signaling
4. Development of new NMR methods for analyzing the structure and dynamics of high molecular weight proteins
5. Real-time observation of the intracellular biological events using the in-cell NMR method

Membrane proteins play fundamental roles in many biological processes, and are recognized as the principal target proteins for drug development. Recently, accumulating evidence has suggested that membrane proteins are structurally dynamic, and exist in an intrinsic conformational equilibrium, such as between the active and inactive conformations.

We use NMR for obtaining dynamic structural information about the membrane proteins under physiological conditions. We have analyzed the relationships between the dynamical structures and the functions for biologically important membrane proteins: GPCRs, ion channels, and adhesion molecules (Figure 2). To achieve this goal, we are developing new methodologies, including the reconstitution of membrane proteins within lipid bilayer conditions, a sophisticated stable isotope labeling techniques, and NMR methods for analyzing the structure and dynamics of high molecular weight proteins.

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Laboratory of
Protein Structural Biology

Determining three-dimensional structures of proteins and nucleic acids, and elucidating their functions in living cells

Research Topics

1. Structural biology of proteins and nucleic acids using X-ray crystallography and small angle X-ray scattering
2. Structure and function relationship of proteins and nucleic acids
3. Structures of immune-system proteins and their complexes
4. Structures of nuclear proteins and their complexes
5. Structures of proteins in signal transduction and their complexes

Structural biology seeks to provide a complete and coherent picture of biological phenomena at the molecular and atomic level. Our laboratory aims at achieving a comprehensive understanding of structure/function relationships of key cellular components and processes, and roles in living cells. In the elucidation of three-dimensional structures, X-ray crystallography is extensively used since this method provides us with detailed structural information on the biological functions and roles. We also take an interdisciplinary approach, combined with methods of biophysics, biochemistry, molecular biology, genetic and protein engineering, and small angle X-ray scattering. With these structural biological approaches, we can obtain the information on three dimensional structures that are required for drug design and discovery.

We are now carrying out structural biological researches into immune-system proteins, nuclear proteins and proteins in signal transduction.

Crystal structure of innate immune receptor TLR8 in complex with the ligand.

Crystal structure of nuclear receptor VDR in complex with the ligand.
Exploration of new functions for biomembranes and their constituent lipids

**Research Topics**

1. Molecular mechanism of lipid biosynthesis and homeostasis
2. Molecular mechanism of membrane dynamics (e.g., endo/exocytosis)
3. Identification of new bioactive lipids and elucidation of their functions
4. Elucidation of functions of membrane lipids using *C. elegans* genetics

Biomembranes serve as barriers that segregate cells from the external environment. They also produce intracellular organelles, and are essential for cellular functions. The Laboratory of Health Chemistry aims to elucidate the physiological functions of lipids, essential constituents of biomembranes. Over 1,000 lipid species exist in biomembranes, and the appropriate balance among them is assumed to be fundamental to stability, activity, and localization of proteins, and regulation of gene expression. We focus on major components of cellular lipids, called phospholipids, and are trying to identify proteins involved in their biosynthesis and homeostasis. We also study the functions of lipids in the dynamic behavior of biomembranes, such as endo/exocytosis.

Various bioactive lipids are formed from membrane phospholipids, and affect a range of biological phenomena and diseases. Our study also focuses on “inflammatory response” which is the underlying condition of lifestyle-related diseases. To better understand the molecular mechanisms underlying inflammation, we are trying to comprehensively clarify when, where and how much lipid mediators are formed in the inflammatory sites using LC-ESI-MS/MS-based lipidomics system.

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Mechanisms of cell division and their application to drug development

**Research Topics**

1. Mechanisms of centrosome duplication and its theoretical model
2. Mechanisms of cell division regulated by divergent molecular machineries
3. Identification and characterization of non-coding RNAs that regulate cell division
4. Comparative cancer cell biology and its application to anticancer drug development
5. Forward genetic analysis of cell-cell communication with human cells

Our laboratory mainly focuses on understanding the mechanisms of cell division, with a particular emphasis on the molecular basis and theoretical model of centrosome duplication. We are also interested in elucidating how divergent molecular machineries, including a protein complex and protein-IncRNA complex, regulate somatic and meiotic cell division. Based on these studies, we then explore a new approach to develop a novel anti-cancer therapy. To this end, we currently use the combination of innovative and multi-disciplinary methods including molecular biology, biochemistry, biophysics, structural biology, genetics, computer simulation and cell biology.

Furthermore, to understand molecular mechanisms and basic principles underlying a wider range of biological phenomena *in vivo*, we are also trying to establish a forward genetic approach with *in vitro* reconstitution of human cell-cell communication.

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**Bipolar spindle formation in mitotic HeLa cells. Control (left panel) and a cell defective in forming a proper mitotic spindle and chromosome segregation (right panel).**

**Centriole duplication and structure. An image obtained by super-resolution microscopy: centriole wall in green, cartwheel structures in red.**

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Laboratory of
Molecular Biology

We investigate mechanisms regulating cell fate determination during development and homeostasis with an emphasis on neural stem cells and signal transduction.

Research Topics

1. Mechanisms regulating neural stem cell fate during brain development and in the adult brain
   - Roles of Polycomb group proteins and other chromatin modifiers in neural stem/progenitor cell fate during neocortical development
   - Signaling pathways that regulate the fate commitment and differentiation of neural stem/progenitor cells
   - Mechanisms that regulate the generation and maintenance of adult neural stem cells

2. Investigation of chromatin-level regulators of neuronal differentiation/maturation and activation

3. Dissection of signaling pathways regulating cell migration and metastasis

4. Dissection of signaling pathways regulating cell death and innate immunity

Our bodies have hundreds of cell types that each have distinct jobs, but they all contain the same genetic information. Our lab asks how the distinct fates of cells during development and homeostasis are determined by both cell-intrinsic programs and by environmental inputs.

Our first research goal is to understand the molecular basis of brain development with an emphasis on the regulation of neural stem/progenitor cell fate. Our second goal is to understand the intracellular signal transduction pathways that regulate cell proliferation, survival/death and migration, and the involvement of these pathways in tumorigenesis.

Please visit our HP for details.

Okazaki, T. ASK family in infection and inflammatory disease. Advances in Biological Regulation, S2212-4926(17)30144-6 (2017)


Research of cell and tissue communications for establishment and maintenance of cell society

Research Topics

1. Regulation and function of cell death in development, growth, regeneration and aging
2. Regulation of cell number and size of tissue via programmed cell death mechanism
3. Roles of dying cells as a signal center
4. Metabolic regulation of tissue regeneration and aging
5. Nutritional and gut microbial regulation of organismal homeostasis

Programmed cell death functions in dynamic tissue formation or remodeling. We have revealed that in the embryonic development, or aging process, caspases are activated by physiological stresses and exert regulatory functions. We aim to reveal how cell society is constructed and maintained during development, growth, regeneration and aging process with a particular focus on understanding the regulatory mechanisms and functions of cell death. We believe that our research would stimulate and encourage students and researchers to have the breadth of vision for life science research and provide new insights into the molecular logic underlying the formation and maintenance of cell society.

Dying cells act as a signal center, thus actively influence neighboring cells and tissues. Cell death is an instructive biological phenomena for establishment of cell society.
Laboratory

From signal transduction to drug discovery

## Research Topics

1. **Signal transduction and functions of ASK family proteins**
2. **Exploration of novel signaling molecules involved in cell death and stress responses**
3. **Molecular mechanisms of pathogenesis induced by dysfunction of stress signaling**

The Laboratory of Cell Signaling has been focusing on analyses of the intracellular signal transduction, through which we seek to elucidate molecular basis of human diseases and identify novel drug targets. Our current research mainly focuses on the pathophysiological roles of stress responsive signals in various diseases such as cancers, immune disorders, cardiovascular diseases and neurodegenerative diseases. In addition to molecular genetic tools such as mice, flies and worms as well as basic experimental techniques from molecular cloning to protein biochemistry, we always incorporate novel analytic technologies such as mass spectrometry-based proteomic analysis and genome-wide RNAi screening systems into our research exploring “target molecules and molecular mechanisms”. By taking advantage of such experimental approaches, we aim to open up new fields in pharmaceutical sciences with paying attention to whole body physiology, diseases and drug discovery.

**Stress Responses**

- **Physico-chemical Stress**: UV, Heat, ROS, Gravity
- **Biological stress**: Bacteria, Virus
- **Sensors & Receptors**
- **Cell Signaling**
- **Proliferation**
- **Differentiation**
- **Cell Death**
- **Cytokine**

**Cancer, Inflammation, Neurodegeneration, Diabetes**

- **Stress-induced formation of P-body**, green: Venus-Dcp1a, blue: Nuclei
- **Image analysis using a high-content image analyzer**, red: NFAT5, green: GFP, blue: Nuclei
- **Visualized Mitochondria by DsRed-Mito**, blue: Nuclei

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**Laboratory of Cell Signaling**

**Assoc. Prof. I. Naguro**

**Assist. Prof. T. Fujisawa**

**Assoc. Prof. I. Naguro**

**Assist. Prof. T. Fujisawa**

**Project Assist. Prof. S. Uchiyama**

**Project Assist. Prof. K. Watanabe**

http://www.f.u-tokyo.ac.jp/~toxicol/English/index-E.htm

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Laboratory of Protein Metabolism

Shedding light on the various biological phenomena controlled by proteolysis

Research Topics

1. The action mechanism of the proteasome, a multisubunit macromolecular complex responsible for regulated protein degradation in eukaryotic cells
2. Proteasome dysfunction in human diseases and aging
3. The mechanism of T-cell selection by the thymus-specific proteasome
4. The mechanism for the disposal of abnormal proteins by the ubiquitin-proteasome system

Laboratory of Protein Metabolism explores the regulatory mechanism of cellular functions by the ubiquitin-proteasome system, which is the major proteolytic machinery in eukaryotic cells. The lab’s main interest is the proteasome, which is an elaborate proteolytic enzyme that degrades ubiquitinated proteins and is a key regulator of physiological events. The questions we are interested in are, how is the proteasome regulated, how does it assemble, and how is it involved in human diseases. To this end, we make use of experimental techniques including biochemistry, molecular biology, cell biology, genetic engineering of the mouse, fly genetics, and yeast genetics. In recent years, there has been accumulating evidence indicating a close relationship between the ubiquitin-proteasome system and human diseases such as cancer, neurodegenerative diseases, immune disorders, and aging. The goal of our research activities is to provide new molecular bases for the development of drugs for such diseases.

1. The action mechanism of the proteasome, a multisubunit macromolecular complex responsible for regulated protein degradation in eukaryotic cells
2. Proteasome dysfunction in human diseases and aging
3. The mechanism of T-cell selection by the thymus-specific proteasome
4. The mechanism for the disposal of abnormal proteins by the ubiquitin-proteasome system

Laboratory of Protein Metabolism explores the regulatory mechanism of cellular functions by the ubiquitin-proteasome system, which is the major proteolytic machinery in eukaryotic cells. The lab’s main interest is the proteasome, which is an elaborate proteolytic enzyme that degrades ubiquitinated proteins and is a key regulator of physiological events. The questions we are interested in are, how is the proteasome regulated, how does it assemble, and how is it involved in human diseases. To this end, we make use of experimental techniques including biochemistry, molecular biology, cell biology, genetic engineering of the mouse, fly genetics, and yeast genetics. In recent years, there has been accumulating evidence indicating a close relationship between the ubiquitin-proteasome system and human diseases such as cancer, neurodegenerative diseases, immune disorders, and aging. The goal of our research activities is to provide new molecular bases for the development of drugs for such diseases.

Physiological roles of the ubiquitin-proteasome mediated protein degradation in eukaryotes

Proteasome dysfunction and human diseases
Laboratory of
Immunology and Microbiology

Understanding the principles of immunological tolerance and homeostasis

Research Topics

1. Mechanisms of immunological tolerance and homeostasis
2. Mechanisms of regulatory T cell development and function
3. Molecular mechanism of bacterial virulence

The immune system has evolved the ability to distinguish "self" from "non-self" to maintain homeostasis of the body. The immunological "self" is established in an adaptive and acquired manner through continuous interactions with changing internal as well as external environments. The ultimate goal of this laboratory is to elucidate, throughout multiple layers, from molecules, cells, cell populations, tissues, to individuals, the principles that govern the development of such immunological "self" and its transformation during diseases. Towards this end, we focus on a cell-extrinsic, dominant control mechanism of the immune system that depends on a subpopulation of T lymphocytes called regulatory T (Treg) cells. As one approach, we elucidate how mutations in the Foxp3 gene, encoding a transcription factor critical for Treg cell development and function, lead to a breakdown of immunological tolerance and homeostasis.

Fig. 1: Disintegration of immunological "self" underlies a variety of diseases

Fig. 2: Foxp3-expressing regulatory T (Treg) cells are indispensable for immunological tolerance and homeostasis
Elucidation of the mechanisms determining pharmacokinetic properties of drugs that contributes to drug design, and safe and effective utilization of drugs

**Research Topics**

1. Establishment of the methodologies for in vitro-in vivo extrapolation of drug pharmacokinetics and pharmacological effect
2. Elucidation of molecular mechanisms determining the intestinal absorption of drugs, clearance of drugs from liver/kidney and drug transport at the barrier organs such as blood-brain barrier
3. Prediction of the effect of genetic polymorphisms of metabolic enzymes/transporters on the inter-individual variations of drug pharmacokinetics
4. Establishment of the methodologies for the quantitative prediction of drug-drug interaction risks
5. Elucidation of mechanisms for the membrane trafficking of transporters
6. Development of transporter-based drug delivery system (DDS)
7. Elucidation of mechanisms of drug-induced toxicity

Pharmacological and adverse effects of drugs depend on their pharmacokinetic properties, which determine their exposure to the targets. Our laboratory aims to establish methods for quantitative and theoretical prediction of pharmacokinetic properties of new chemical entities in humans based on the molecular mechanisms. In particular, we investigate the impact of transporters on the elimination of drugs from the liver and kidney, the distribution of drugs into their target organs e.g., the brain, and drug absorption in the small intestine, in order to develop drug screening systems and to elucidate the mechanisms of drug-drug interaction, and interindividual variation in pharmacokinetics of drugs. We have also started research on the regulation of membrane trafficking of the transporters using low molecular weight compounds to cure transporter related-diseases. Research achievements in this laboratory contribute to predicting and evaluating rational pharmacokinetic properties in drug development, drug review and regulation, and in clinical use, and to developing medical therapy for transporter related-diseases.
Pharmacological approach toward the brain: from molecule to animal

**Research Topics**

1. Study on neuronal networks involved in learning and emotion using neuronal activity genetic markers
2. Study on brain network operation using functional imaging of multicellular activity
3. Studying on neuronal network formation during development

Pharmacology includes two aspects: 1) to analyze the biological action of drugs and 2) to search the strategies for developing treatments for diseases. We conduct our pharmacological research by taking advantage of state-of-the-art technologies and a wide range of knowledge from molecule to animal. We focus on the roles of the cerebral limbic system and cerebral cortex, in particular, the hippocampus and amygdala, which are involved in learning, memory, and emotion.

Our experimental techniques cover from genetics, biochemistry, and cell biology to electrophysiology, histochemistry, and behavioral pharmacology. Recent technical advances have allowed us to investigate the neuronal network dynamics on far larger scales than hitherto. Functional multineuron calcium imaging reveals the dynamics of network activity with single cell/synapse resolution (Upper Figure), through which we elucidate the structural and functional relationship that generates spatiotemporally organized spike patterns. We also address the mechanisms of learning and memory using in situ mapping learning-relevant neuronal circuits with immediate early genes with cellular and temporal resolution (Lower Figure).

We believe that these novel approaches open up a new avenue for our mesoscopic understandings of network function and malfunction associated with depression, stress-relevant disease, and epilepsy.


Laboratory of Neuropathology and Neuroscience

From understanding the molecular pathogenesis of neurodegenerative and psychiatric diseases to development of therapeutics and novel basic science

Research Topics

1. Understanding the molecular mechanisms of intramembrane proteolysis by γ-secretase
2. Research on Aβ metabolism (production, secretion and clearance) and its regulatory mechanisms
3. Elucidation of pathophysiological functions of risk factors for Alzheimer diseases
4. Molecular mechanisms of aberrant vesicular trafficking and diseases
5. Biological and pathological roles of synaptic adhesion molecules in psychiatric disorders
6. Elucidation of cellular pathology towards development of glial cells-targeting drugs
7. Understanding the molecular pathomechanisms of Parkinson disease

Aim of our laboratory is that understanding the molecular pathogenesis of neurodegenerative and psychiatric diseases to develop novel approaches to therapeutic, prevention and diagnosis. Also, we are pursuing novel basic science by understanding the molecular basis of diseases. Especially, we are studying Alzheimer disease, autism spectrum disorder and schizophrenia to identify the pathological mechanisms and therapeutic targets of these diseases at molecular levels. To understand the disease condition, we have to realize the basic mechanisms of cells and living organisms, and vice versa. We believe that this disorder-to-normal cycle in research is a basis of modern disease and basic biology, and bolsters both scientific areas by novel knowledge and technology. From this standpoint, we proceed disease-oriented molecular and cellular research in a multidisciplinary manner by mutual collaborations with organic chemists, structural biologists, physicians and pharmaceutical companies.
Establishing scientific drug evaluation

Research Topics

1. Advancing methods for rational drug evaluation
2. Analyzing drug development behaviors and policies
3. Evaluating drug regulation and guidelines
4. Developing systems to implement the above policies and guidelines

The goal of our research is to establish scientific principles and methods in drug evaluation with societal perspectives in mind. Pharmaceutical research and development (R&D), clinical development in particular, regulatory review and approval of new drugs, and post marketing activities are our research interests. We provide evidence on R&D efficiency, performance and outcomes of regulations, and public health impact through rigorous analysis based on economic models. Conflicts in global pharmaceutical R&D, including recent launch delay of new drugs in Japan and so-called ethnic differences, are always high on our agenda. Aside from the research activities, we also make efforts to develop human resources in both private and public sectors with up-to-date knowledge, ethics, and philosophy, and rationale in drug evaluation. We offer lectures for graduate and undergraduate students, and a half-year training course for industry and regulatory professionals. We aim to secure transparency and social responsibility on drug regulation through our research and educational programs.
Laboratory of
Medicinal Plant Chemistry
(Experimental Station for Medicinal Plant Studies)

An overall analysis is made of the old-yet-new drugs known as “medicinal plants” (crude drugs) to develop new ways of using them (utilizing the resources in the Experimental Station for Medicinal Plant Studies)

Research Topics

1. The cultivation of medicinal plants and tissue cultures
2. The production of useful secondary metabolites, using plant tissue culture technology
3. Chemistry and biosynthesis of plant-derived biologically active substances

Since prehistoric times, plants have been the principal material used as drugs by humankind. Many have fallen by the wayside through a long process of trial and error (human experiments), and the ones that remain can be considered the crude drugs of the present day. In recent years, the percentage of all drugs accounted for by antibiotics and biologics has increased, but the importance of plant-derived pharmaceuticals is by no means diminished and has led to the discovery of new drugs such as Taxol and vinblastine. Thus, the study of medicinal plants is by no means completed, and is continuing to evolve. The Experimental Station for Medicinal Plant Studies, formally established in 1973, is located adjacent to the Kemigawa Athletic Ground. The saplings transplanted there back then have grown large and now form a dense enclosure of trees around the garden.

At the research lab in Hongo, we conduct research on the production of useful secondary metabolites using plant tissue culture technologies (from the induction of culture cells to the production of substances). Some of the research topics we are currently pursuing are the biosynthesis of diterpene constituents from Gymnosperm plant cultured cells, the production and biosynthesis of diterpene alkaloids using cultured tissue of monkshood, the production and biosynthesis of phenylethanoids using cultured cells of olive, and the production of biologically active constituents of Egyptian medicinal plants by means of plant tissue culture technologies.
Laboratory of
Bioorganic Chemistry
(Institute for Quantitative Biosciences)

Discovery and production of bioresponse modifiers
directed toward an understanding of life phenomena

Research Topics

1. Discovery and production of molecules that control the spatio-temporally dependent expression and function of proteins
2. Medicinal chemistry of nuclear receptor ligands
3. Design and synthesis of bioresponse modifiers that control the topology and dynamism of proteins
4. Developing new methods of drug discovery, using the multifunctional thalidomide as a template
5. Developing novel strategies for improving aqueous solubility of drug candidates by their molecular modification

The aims of this laboratory are to discover and produce new bioresponse modifiers based on medicinal and synthetic organic chemistry, and to use them to gain an understanding of life phenomena. Many life phenomena are controlled by the expression, localization, and degradation of proteins. Thus far, research on chemical control of the expression of proteins has succeeded in discovering and producing various nuclear receptor ligands. At the same time, functional molecules that regulate life phenomena through modification of proteolysis have been designed and produced. By a method differing from siRNA, it has become possible to destroy target proteins at any time, and this is expected to serve as a new technique for the functional analysis of proteins within cells. [PROTEIN KNOCKDOWN APPROACH]

In addition, we are designing and synthesizing molecules that control the folding process of proteins. [PHARMACOLOGICAL CHAPERONES] These are compounds that control dynamic structure-based function of proteins, and they will open up new domains in medicinal chemistry of bioresponse modifiers. We are also producing bioresponse modifiers using multifunctional thalidomide as a drug discovery template.

Protein Knockdown Approach

Pharmacological Chaperones

Elucidating the intracellular signaling involved in disease development, with the goal of drug discovery

Laboratory of Cellular Biochemistry
(Division of Cellular and Molecular Biology, The Institute of Medical Science)

Research Topics

1. Transcription factor NF-κB activation signal mediated by TRAF family
2. Signal transmission by ubiquitination
3. Malignant progression of cancer and signaling
4. Bone metabolism disorders and signaling
5. Autoimmune diseases and signaling

The themes pursued in our laboratory are related to “cancer”, “immunity”, and “bones”, since TRAF6 and NF-κB, which we are interested in, are profoundly involved in tumorigenesis, immune regulation, and bone metabolism. Upon cytokine stimulation, TRAF6 acts as E3 ubiquitin ligase to generate Lys-63-linked polyubiquitin chains, which do not induce proteasomal degradation rather act as platforms for formation of active signal complexes leading to the activation of NF-κB. A number of serious human diseases are caused by various kinds abnormalities in bone metabolism and immunodeficiencies. We were able to reproduce diseases similar to these human diseases in TRAF6- or NF-κB-deficient mice, indicating that TRAF6/NF-κB signals are essential for normal bone formation and the establishment of immunity. Abnormal activation of NF-κB also plays a critical role in the onset and progression of leukaemias and many other cancers. We are trying to elucidate how dysregulation of the TRAF6/NF-κB signals leads to malignant transformation and serious diseases related to immune regulation, and bone metabolism at the molecular level and conducting numerous experiments on gene transfer into cultured cells, aiming to put the results to use in drug discovery and the diagnosis and treatment of diseases.

TRAF6 generates Lys-63-linked polyubiquitin chains, which act as the scaffolding for interactions of various proteins to form signal complexes to transmit signals. As a result, NF-κB and MAPKs become activated, which induces and regulates many important biological processes.

X-ray images of a normal mouse (left) and TRAF6 knockout mouse (right). The TRAF6 knockout mouse displays osteopetrosis because TRAF6 is required for formation of osteoclasts, which absorb bones. Dysregulation of osteoclastogenesis is involved in the progression of rheumatoid arthritis, osteoporosis, and bone metastasis of cancer cells.
Laboratory of

Clinical Pharmacokinetics
(The University of Tokyo Hospital)

Systems-pharmacological studies for drug development in the next-generation

Research Topics

1. Therapies for lifestyle-related diseases based on the comprehensive understanding of molecular mechanisms that control the transport of endogenous small molecules

2. Therapies for bone metabolism diseases based on the comprehensive understanding of the dynamic control mechanisms of signal molecules involved in bone resorption and formation

3. Quantitative understanding of the pharmacological and toxicological effects of molecular targeted anti-cancer drugs to establish clinical applications and new drug discovery techniques

4. Large-scale omics analysis to establish methods of preventing and treating adverse drug reactions based on the quantitative understanding of underlying molecular mechanisms

5. Clinical pharmacokinetics based on detailed quantification of related molecular functions

It has been recognized very well that we need to describe / predict the functions of cells, tissues and organisms from the function of each constituent molecule in a quantitative manner in order to understand the life activities. Although we have used such approach in analyzing and predicting the drug disposition in humans, it is quite important for us to expand the concept to the analysis of pharmacological / toxicological actions of drugs in humans. We are using such “systems-pharmacological” methods to solve many kinds of problems that remain great challenges in drug discovery, such as how to identify the most effective target molecules among numerous candidates, and how to comprehensively predict the adverse drug reactions in humans.

Prof. H. Suzuki

Lecturer M. Honma
Lecturer T. Takada

http://plaza.umin.ac.jp/~todaiyak/


Endowed Laboratory of
Pharmaco-Business Innovation

Developing a professional who Understand Both Life Sciences and Business

Prof. K. Imamura
Visiting Prof.
H. Kimura
Project Assoc. Prof.
E. Shimizu
http://www.f.u-tokyo.ac.jp/~pbi/index.html

Research Topics

1. Studies on industry dynamics in pharmaceutical/life science domain: Analysis of factors driving the reorganization of the industry
2. Studies on strategy and management issues in pharmaceutical/life science domain: Finding solutions for management issues of companies, universities, and medical institutions
3. Studies on industrial policy in pharmaceutical/life science domain: Making recommendations on social infrastructure for the development of the industry
4. Research on R&D related issues and talent development by global standards

While Japan aims at sustainable development for the future as a world leader in science and technology, pharmaceutical/life science domain occupies an important position in the national strategy. On the other hand, in a globalizing pharmaceutical industry, the presence of Japan as a market has relatively been declining little by little.

Under such circumstances, the objective of PBI course is to contribute to a sustainable development of the Japanese pharmaceutical industry by 1) conducting multilateral research on managerial issues of rapidly evolving pharmaceutical/life science industry for its long-term growth, such as those related to innovation, public health, global competition and harmonization, 2) fostering a new generation of industrial leaders capable of taking advantages of the new opportunities that are being created, and 3) developing a social infrastructure for drug discoveries including regulations.

PBI’S AIM AND PURPOSES

- Development of multi-disciplinary talents to lead the industry
- Contribute to talent & resources for innovation
- Practical industry-oriented research
- Development of multi-disciplinary talents to lead the industry
- Contribute to infrastructure development for industry
- Policy recommendations on regulation and social system
- Presenting Industrial insights

Figure: Basic concept of PBI
Endowed Laboratory of Drug Lifetime Management

Drug lifetime management for development of excellent drugs, proper use of drugs, and evolution of drugs

Research Topics

1. Development and practice of methodologies for the collection, evaluation, analysis, and distribution of drug post-marketing information
2. Creation of programs for promoting proper use and evolution of drugs in community healthcare
3. Development of new features in the community pharmacy to practice the above-mentioned 2
4. Specification, standardization, and digitization of drug information, and their clinical applications
5. Quantitative prediction of the effects of biodisturbance factors on pharmacokinetics and drug effects

Our university’s Faculty of Pharmaceutical Sciences bears the social mission of promoting drug discovery and the proper use and evolution of drugs while improving the quality of drug therapies. To these ends, this course in Drug lifetime management pursues various research to ensure that the developed drugs can amply exhibit their effects and lead a substantial “drug life.”

The research topics of this course are that (1) the proper collection of drug information (DI), (2) evaluation/analysis of DI based on pharmacokinetics and pharmacodynamics and quantitative prediction of changes in pharmacokinetics and drug effect due to various risk factors, (3) Qualitative evaluation and analysis of the individual cases, (4) Creation of archive based on the optimal specification/standardization/digitization of DI, and (5) their proper provision to the clinical field. Concretely speaking, the content of our research is to seize drug post-marketing problems (including trouble and needs related with drugs), to make a proposal, to the pharmaceutical field, for evolving drugs and their information in order to solve the problems, and to feedback them to the clinical field.

The central dogma of pharmaceutical development consists of the cycle of drug discovery → proper use of drugs → post-marketing drug development → drug discovery and so on.

Collection of drug post-marketing information with appropriate method (from whom? from where? How?).
Endowed Laboratory of
Health Economics and Outcomes Research

Maximizing and evaluating true "value" of various medical interventions, not only its impact for health care budgets but for health outcomes, to maintain and improve public health care system.

Research Topics

1. Health Technology Assessment (HTA)
2. Health economic analyses for drugs / medical devises
3. Surveys on public healthcare system / reimbursement system
4. Research on QOL (Quality of Life) instruments

There are growing concern about the cost issue of medical care interventions, as the sustainability of universal health coverage system is threatened with the increase of health care budget, in particular with introduction of expensive medications, such as drugs for cancer, hepatitis or life style diseases. Many stakeholders in Japan, not only health economists but also physicians, governmental decision makers, and industry officers have keen interest on health economics and outcomes research (HEOR), including QOL survey.

Efficiency data, or cost-effectiveness data, would play more role in decision making process, as well as efficacy and safety data would do.

We define the word "HEOR" with broader definition; any kind of researches which can maximize/quantify the value of particular medical interventions and/or disease area. Then, our research topics would range from narrower ones, like cost-effectiveness analyses of particular products to broader ones, like conceptual research for QOLs and the analytical methods.
Establishment of efficacy and safety models for drug discovery using human iPS-derived cells, such as neurons, cardiomyocytes, hepatocytes, etc.

Research Topics

1. Studies on developing new translational assay systems for clinical drug efficacy and safety with human iPS-derived cells, culture systems and devices
2. Establishment of test methods to predict adverse effects of medicines on CNS and cardiac function
3. Physiological and pharmacological studies to predict and prevent adverse drug reactions on learning and memory using human iPS-derived neurons and astrocytes, and imaging technologies
4. Development of morphological image analysis frameworks for cell structure images using artificial intelligence
5. Educational activity of knowledge, technology and application of iPS cells

The recent problem of low success rate in drug discovery is a big issue that we should solve for human health. Technology of induced pluripotent stem cells (iPSC) is expected to offer solutions for the problem. The low success rate is due to uncertainty for efficacy and safety in clinical trials. Unpredictable adverse effects usually come from limitation of the predictability of preclinical tests using the laboratory animals. Usage of a human cell-based tool for preclinical tests will overcome the limitation of animal experiments. Our laboratory is focusing on establishment of new translational assay systems for efficacy and safety with human iPSC derived cells, new culture systems and newly developed devices. We have recently validated a new safety pharmacological method with electrophysiological using cardiomyocyte derived from human iPSC. We are seeking more precious methods for cardiac safety of anti-cancer drugs. We are developing immunocytochemical assay for drugs acting on synaptic function and structure. There will be many applications for drug discovery using human iPSC derived cells; clinical tests in a dish at the stage of preclinical test, establishment of disease models and precision medicines.

We are organizing the tripartite research team with donation companies. Our laboratory will be a hub of the network of the academia, industries and regulators.
Laboratory of
Brain and Neurological Disorders

Drug discovery research for development of innovative therapies against brain and neurological disorders

**Research Topics**

1. Understanding the role of intracellular trafficking in the pathogenesis of neurological disorders
2. Drug discovery research for accelerating the clearance of aggregated proteins in the brain
3. Development of innovative therapies for recovery of damaged neuronal circuits

We are facing super-aging society, and developments of diagnostics, prevention and therapeutics against brain and neurological disorders (e.g., dementia) have been required. However, to date, only a limited number of drugs for these diseases has been available. Our laboratory aims to understand the pathogenesis of brain and neurological disorders and identify key molecules that lead to development of prevention and therapeutics. At the same time, we seek biomarker molecules for early and specific diagnosis of the disorders. Our laboratory also conducts mutual collaborative researches between academia, industry and students. We believe that such collaborative approaches will lead to development of innovative therapies against these neurological diseases and help to establish the healthy super-aging society with multi-generational relationships. Also, advanced research experiences in our laboratory would cultivate next generation researchers for drug discovery.

In 1869, the Meiji government decided to adopt German medicine and asked the minister of the North German Federation to send 2 instructors. In 1871, Müller (chief Army physician/staff surgeon) and Hoffman (Navy physician/staff internist) arrived in Japan and assumed their duties at the University East Building (Tôkô) in Shitaya Izumibashi (precursor of the Faculty of Medicine, University of Tokyo).

Müller and Hoffman, who were under the direct supervision of the Meiji Minister of Education, had absolute authority over medical education in Japan. A new curriculum was established with 3 preparatory years (changed to 2 the following year) and a 5-year main program.

Müller and Hoffman regarded “pharmaceutical sciences” as an independent branch of the natural sciences that was closely related to medicine, and they proposed the establishment of a pharmaceutical institute. This took shape in 1873 as the Department of Pharmaceutical Manufacturing, established in The First University District Medical School. Müller returned to Germany in 1875. In October of 1895, upon the third anniversary of his death, a bust of Müller was erected to honor him as a benefactor of Japanese medicine and pharmaceutical sciences.

Dr. Shimoyama was born in Owari Inuyama in 1853. In 1873, after transferring to the Department of Pharmaceutical Manufacturing, The First University District Medical School (the precursor of the Faculty of Pharmaceutical Sciences, University of Tokyo), he graduated in 1878. He gave the “address in reply” at the first degree-conferring ceremony held by the Faculty of Medicine. In 1886, Dr. Shimoyama received the Doktor der Philosophie degree from Strasburg University in Germany and in 1899, he became the first person in Japan to be awarded a Doctor of Pharmaceutical Sciences degree.

Dr. Shimoyama became a professor of the Department of Pharmacy in the Faculty of Medicine in 1887, and a professor of a laboratory of Pharmacognosy, the Department of Pharmacy in 1893. While devoting great efforts to education and research, he also helped to cultivate successors through the establishment of the Pharmaceutical Society of Tokyo (the present Pharmaceutical Society of Japan) and the creation of a privately funded medicinal herb garden (Zekô Yakuen), etc.

Dr. Shimoyama died suddenly in February of 1912 while still in service as an educator. In remembrance of him, a bronze statue was erected beside the Pharmaceutical Sciences Building in 1913.
Graduates of Faculty of Pharmaceutical Sciences, who have acquired a comprehensive fundamental understanding and applied knowledge of the field, receive extremely high respect, resulting in relative easiness to find a job. Over 90 percent of graduates choose to move forward to Graduate School of Pharmaceutical Sciences, the University of Tokyo. An increasing number of applications from the University of Tokyo, other universities, and foreign universities take an annual entrance exam in August.

We have seen more and more of a social trend that prefers an individual with a researcher background and research experience higher than a Master's level. Our graduates who completed either undergraduate or graduate courses find positions in a wide array of fields, such as pharmaceuticals, chemical, and food related companies, universities, as well as government agencies.

Half of graduate students opt for the doctoral course. After acquiring a Ph.D., they find vast opportunities not only in the academic field, such as universities and public research agencies, but in researching departments of companies, as leaders of projects.
**Undergraduate**

There are roughly 80 students in each grade at the Faculty of Pharmaceutical Sciences, and this is one of the smallest faculties at the University of Tokyo. New students form close friendships in no time after starting their first year. They attend lectures and engage in pharmaceutical training, all the while maintaining close relationships with faculty members. Lectures encompass a broad range of academic fields closely related to real life medicine. Assistant professors and graduate students as teaching assistants also take part in the pharmaceutical training classes. Second-year students begin to attend lectures on specialized topics for three days at the Hongo campus in the fall after receiving liberal arts education at the Komaba campus. In the third year, students sit in on lectures in the morning and engage in pharmaceutical training in the afternoon. Lectures become more specialized, and during training sessions students work in groups of two to four. Fourth-year students work in the laboratory of their choice, and they begin to focus less on classes and more on their senior research project.

Students must choose either the four-year program of the Department of Pharmaceutical Sciences or the six-year program of the Department of Pharmacy in their fourth year. Students who choose the Department of Pharmaceutical Sciences must complete a year-long senior research project in order to complete their degree. Those who decide on the Department of Pharmacy begin to work in the laboratory while they receive laboratory training for clinical pharmacy. At the end of the fourth year, students are expected to go through the Pharmaceutical Common Achievement Tests for clinical pharmacy. In the fifth year, students receive training for clinical pharmacy, and work in their laboratories. In the sixth year, students dedicate their time to working on their senior research project until graduation.

**Postgraduate**

Each laboratory and related laboratories (Institutes) of the Graduate School of Pharmaceutical Sciences and the Department of Pharmacy of the University of Tokyo Hospital conducts leading research in their specialized areas of focus. Students at the start of their graduate studies begin their research career by attending seminars and conducting experiments in world-renowned laboratories which are equipped with state-of-the-art facilities.

**Campus Social Events**

All the members form close-knit friendships, and this is not just because it is a relatively small department. The department hosts a slew of social events that include but are not limited to sports events, and activities with international students and researchers. These events contribute to the growth of friendships and close bonds outside of academic life. The close bonds of the students and researchers in this department foster collaboration, and this leads to a wider spectrum of academic insights and new developments in research.
Before Japan, I was in Shenyang Pharmaceutical University in China. From that period, here (the Graduate School of Pharmaceutical Science in the University of Tokyo) attracts many students like myself, since many of our professors were graduated from here. I heard a lot of things from them including the beautiful campus, high-grade equipment, advanced technology and strong academic atmosphere. So I dreamed that I could come to study in person one day.

Fortunately, I obtained the opportunity to study in the Laboratory of Organic and Medicinal Chemistry under the supervision of Prof. Ohwada from 2010. One of the things that surprised me very much was that professor did experiments on his own. From him I felt the pureness of doing research just because of curiosity, and this is the image of a scientist whom I was looking forward to. Prof. Ohwada taught me with great patience and sometimes personally guides me in the experimental operation. Here, not only the organic and medicinal chemistry was learned, but more importantly, the rigorous but imaginative attitude for scientific research.

Besides the laboratory, the International Student Advising Room (ISAR) lead by Lecturer Kituchi, also helped me a lot for my life as a foreign student. They provide many opportunities for scholarship application, life consultation, organize various events for our foreign students to know each other, let us feel in a warm family.

After graduation, I entered Takeda Pharmaceutical Company, and worked as a researcher for drug discovery at Shonan Research Center for 2 years. The daily work is to design, synthesis and evaluate new anti-cancer drug candidate. What I learned from the graduate school is the foundation of my daily work. Then, I was transferred from drug discovery department to drug development department, which let me broaden my insight from laboratory to clinical setting, finally to patient. Currently I am working as a program manager for oncology drug development around the globe. And through the laboratory I also had the opportunity to do summer internship at the MD Anderson Cancer Center at the University of Texas in the US, as well as participating in conferences of Cancer Associations such as the AACR and the JCA. Upon returning to Indonesia and to Universitas Gadjah Mada, I was able to start with teaching obligations as well as various research demands. This opportunity allowed me to share all the skill and knowledge I acquired during my study at the Department of Pharmaceutical Sciences. Being alumnae of the University of Tokyo also opened more doors for my work and research.

I still remember vividly my excitement when I got accepted to do a PhD program at the Graduate School of Pharmaceutical Sciences at the University of Tokyo. The excitement of joining a laboratory at a world-renown university was matched with the anxiety of the prospects of living and working in a completely different setting than my familiar home in Yogyakarta, Indonesia. Although I had been working as a researcher and a lecturer for almost ten years, and no less important, a wife and a mother of a young daughter, I knew that relocating and starting my PhD program in Japan would not be an easy process.

The hardest part of setting oneself up in Japan, and especially in Tokyo, was of course arranging a place to live. In my case it was more difficult. I anticipated, correctly, that with such a work demand at the laboratory I would need a place with an easy access to Hongo campus and I would need an arrangement for my family. I felt really fortunate that I had the International Student Advising Room (ISAR) who navigated me through the process. They gave me advises and recommendations that would allow me to chose the right arrangement. Much more beyond practical matters, ISAR also provided enormous support to me and to my family in adapting to our new life and new ways of living in Japan. They organized get-together events, trips to various fascinating places around Tokyo and other activities that would introduce us to different sides of Japan. And on personal level, Kikuchi-sensei in ISAR was always there to listen to my ups and downs as a student and a mother.

I spent most of my time in the Laboratory of Cancer Biology and Molecular Immunology under the kind and inspiring supervision of Professor Tatsuro Irimura on the development of a cancer vaccine. The work at the laboratory I would need a place with an easy access to Hongo campus and I would need an arrangement for my family. I felt really fortunate that I had the International Student Advising Room (ISAR) who navigated me through the process. They gave me advises and recommendations that would allow me to chose the right arrangement. Much more beyond practical matters, ISAR also provided enormous support to me and to my family in adapting to our new life and new ways of living in Japan. They organized get-together events, trips to various fascinating places around Tokyo and other activities that would introduce us to different sides of Japan. And on personal level, Kikuchi-sensei in ISAR was always there to listen to my ups and downs as a student and a mother.

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**Message from Student and Graduate**

**Xin Liu**  
M.S. completed in September 2013  
Laboratory of Organic and Medicinal Chemistry

**Retno Murwanti**  
PhD completed in March 2011  
Laboratory of Cancer Biology and Molecular Immunology
After graduating the six-year course at the Department of Pharmacy, I currently work as a newspaper reporter. In my fourth year on the job, I cover medicine, science, and city politics for our Yokohama bureau.

I think the Department of Pharmacy’s attractions lie in how it lets you tackle the latest in research while receiving on-the-floor clinical experience, providing a “true to life” education in pharmaceutics. Alongside my research, I worked with seven other Department of Pharmacy members to earn my required credits and pass my practical (OSCE) and written (CBT) examinations. From the end of year four to the summer of year five, I received on-the-job training at a hospital and pharmacy. Upon passing the national exam in March of my sixth year, I acquired full accreditation as a pharmacist.

Even if I may not work as a pharmacist in the future, my training at the University of Tokyo Hospital was a valuable, unforgettable experience. During the three months of training, I worked together with pharmacists in hospital wards and compounding rooms, letting me study general drug treatment. Gaining experience in a wide variety of work gave me a real feeling for how research is applied at the clinical stage. My pharmacy training, held nearby the University, was an opportunity to learn the importance of regional treatment in an aging society. Through my training, I saw the expectations and misunderstandings people in my town have for medicine. It made me think that I wanted to teach people about the latest in medicine and science, providing the inspiration for my current career choice.

At the Laboratory of Molecular Pharmacokinetics, which I joined as a fourth-year student, I did analytical research on drug interaction mechanisms in the kidneys. Through experiments on cultivated cells and lab animals, along with analysis using high-quality equipment, I spent every day going through a trial-and-error process. From my teachers, all leaders in their research field, I learned about the multiple profound observations I could make from my experimental results.

Now that I am on the job, I’ve been glad to find that the core education and thinking skills I learned during my Department of Pharmacy years are helping me greatly. Although I did not take a research position, I am still inspired by many former classmates continuing their front-line research. It is my hope that students entering the Department of Pharmacy can find the challenges they’re looking for and open up new fields to explore.

Ever since my junior high school years, I, for some reason or another, aspiring to join the Faculty of Pharmaceutical Sciences. I always had an interest in how they made those little pills that tackle a disorder and turn it back to normal, and how exactly they affect the body. That aspiration never faded once I joined the University, and I wound up advancing into the Faculty later. Immediately after, I thought I would be learning about nothing but biology at the Faculty, but once I joined in, I realized you actually study a wide range of subjects. The development and dissemination of medications takes advantage of a wealth of knowledge, from physics and chemistry to biology, mathematics, economics, and more. I was captivated by how fascinating the pharmaceutical sciences were, making full use of all these fields.

Advancing to graduate school allows you to take this knowledge and boost your own specialization. My greatest interest was in what exactly happens in your head while you’re considering a thought, so I asked to join the school’s Laboratory of Chemical Pharmacology. Studying under Prof. Norio Matsuki (now professor emeritus) and Associate Prof. Yuji Ikegaya (now professor), I took in all the difficulty, excitement, and fun of the neurosciences. It didn’t go perfectly all the time, but looking back, the research life was a great deal of fun. This experience has encouraged me to remain in academia in neuroscience even after obtaining my degree with my electrophysiological research on hippocampal neurons.

In addition to being so fascinated by the fun of research, I was also attracted to being a pharmacist, a professional in medicine. I had originally graduated from the four-year program and moved on to my masters and doctoral course, which basically made obtaining pharmacist accreditation impossible. However, starting from the third year of my doctoral course, I was admitted into the Dual Specialty Course on Pharmacist Education, changing my major subject to the pharmacy doctoral program and earning the right to take the national examination for pharmacists.

There are many international students in our Faculty and Graduate School. In fact, I discussed latest topics in our research field countless times with them in my laboratory. The Graduate School of Pharmaceutical Sciences makes you broaden your horizons and do further research. The Faculty and the Graduate School always welcome anyone who comes to Japan. I am sure that you will have an incredibly exciting time in U-Tokyo. Enjoy!
The International Student Advising Room (ISAR), established in 1994, provides a variety of services to support international students and researchers. http://www.f.u-tokyo.ac.jp/~israr/en/isar/index.html

ISAR offers:
- Advisory assistance and a counseling service
- Information for prospective international students
- Event planning
- Inter-university academic exchange program
- Information services

Japanese Language Class
The Japanese Language Class provides an opportunity to learn Japanese language to international students, researchers and their spouses. It also deals with a broad range of topics on Japanese society, culture, history, etc. There are a variety of courses offered from elementary to advanced level.
International Activities

International Training Program to Establish World Premier Research Center of the Pharmaceutical Sciences
University of Cambridge, University of Oxford, University of Bonn, LMU Munich

Rikejo Initiative
A training tour in US including Johnson and Johnson, Stanford University to meet with female professionals and explore careers and activities in STEM2D fields

Academic Exchange Agreements between Universities

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<th>Germany</th>
<th>P.R.China</th>
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<td>The University of Texas M. D. Anderson Cancer Center</td>
<td>The Sahlgrenska Academy, University of Göthenburg</td>
<td>Research Training Group 1873 The University of Bonn</td>
<td>Shenyang Pharmaceutical University</td>
<td>School of Pharmacy, Sungkyunkwan University</td>
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Thailand
Chulalongkorn University

The Netherlands
Leiden University

Sweden
Uppsala University
Experimental Station for Medicinal Plant Studies

Hanamigawa-ku, Chiba-shi, Chiba

The Experimental Station for Medicinal Plant Studies is located about 30 km east of the Hongo Campus. Its 6,123 m² plant specimen garden includes the medicinal plants that are considered important for the students’ education. This garden serves a variety of purposes, including maintenance of plant lineages; research on plant breeding and cultivation; collection and cultivation of medicinal plants native to Japan as well as introduced from overseas; research on medicinal plant ingredients from the standpoints of chemistry, pharmacology, biosynthesis, plant physiology, and pharmacognosy; and research on the medicinal plant cultivation and maintenance. The grounds of the Experimental Station also encompass a greenhouse, administration building, and laboratory building.

At present, about 250 varieties of plants are under cultivation. Each year, 3rd-year students receive practical training in the plant specimen garden during the summer session. In 1982, the laboratory for medicinal plant studies was set up within the building in Hongo Campus and have continued research until now.

The University Museum, The University of Tokyo (Hongo Campus) houses a Pharmaceutical Sciences Division on its first floor, where a large number of specimens – mainly crude drugs and medicinal plants – are stored and managed.

In October 2004, the first rooftop herb garden, with an area of approximately 100 m², was created on the rooftop of the auditorium of Pharmaceutical Sciences Research Building for enabling the students to come into close contact with medicinal plants. Several dozen varieties of medicinal plants are cultivated in light soil with a depth of about 60 cm, equipped with an automatic irrigation system.

Pharmaceutical Sciences Library

<table>
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<tr>
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LANA-DSH:
Interdisciplinary research integrating
chemistry, physics, biology, and medicine.
Synthetic epigenetics driven by a chemical catalyst recognizing
a specific region of histones
and acylating a specific lysine residue, as a basis for catalysis medicine
—small molecular catalysts surrogating enzymes
(i.e., histone acetyl transferase in this case).

Hybrid Catalysis:
Development of catalytic molecular transformations
as a basis for sustainable society by merging functionally
distinct catalysts and using earth’s environmental energy
(here, visible light).