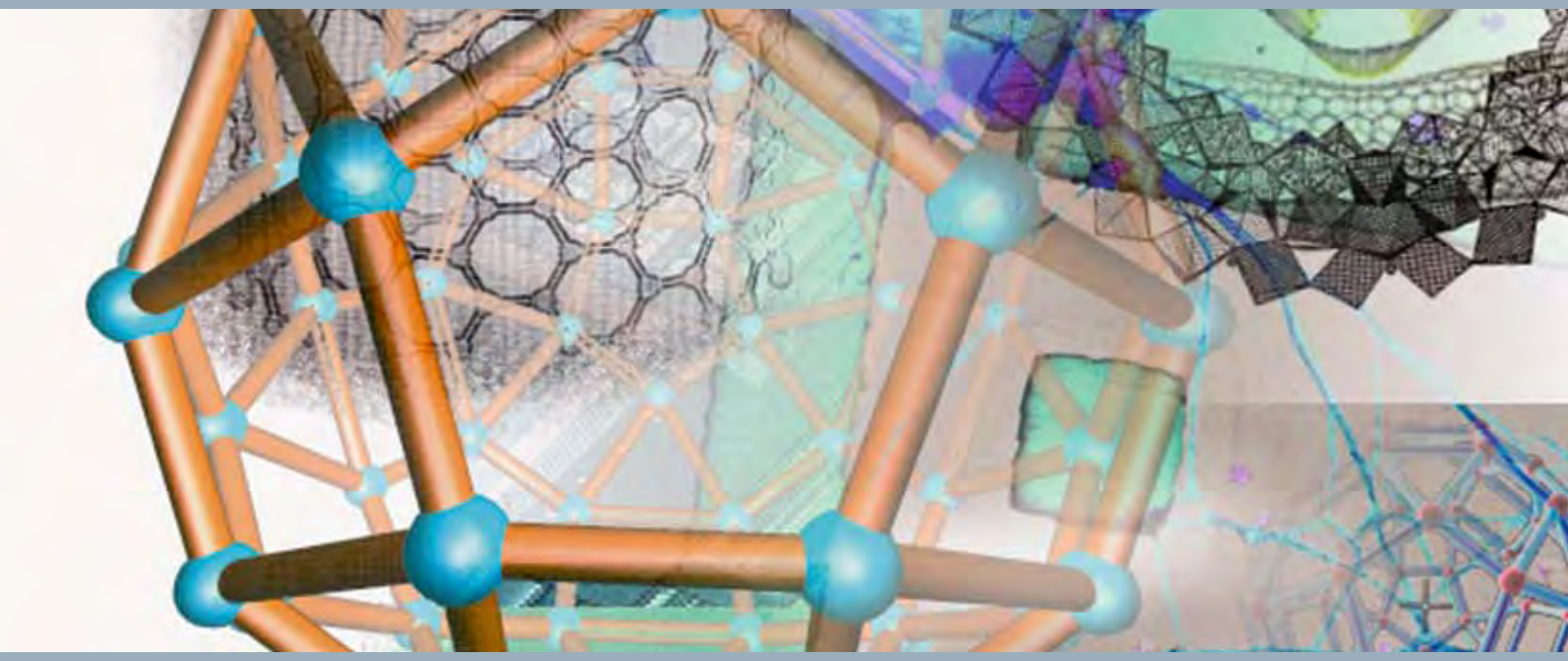
D-CHAB

Master's programs

Chemistry
Chemical and Bioengineering
Biotechnology
Pharmaceutical Sciences
Medicinal Product Development
Medicinal Chemistry
Interdisciplinary Sciences



Department of Chemistry
and Applied Biosciences

ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

About this brochure

The present brochure describes the master's programs offered by the Department of Chemistry and Applied Biosciences (D-CHAB) of the ETH Zurich, and gives an insight into the research done at the Department. It is mainly intended to provide information to students from abroad interested in pursuing advanced studies at ETH. More and detailed information is to be found on the Department website.

ETH Zurich

The Swiss Federal Institute of Technology Zurich (ETH Zurich) was opened in 1855 and was from the onset one of the most renowned universities in Europe focusing on technical and natural sciences. Education in chemistry and pharmacy was offered from the beginning. In its current mission statement ETH Zurich professes the following principles: advancement and support of high quality education and research at the highest international level, promotion of network and system-oriented thinking and acting, maintaining intellectual and cultural diversity as well as academic freedom for education and research.

The Department

The Department of Chemistry and Applied Biosciences of the ETH Zurich provides an environment for conducting high-quality teaching and research. Teaching is in the responsibility of an international faculty, which is engaged in research covering a wide range of topics. The faculty members are, therefore, qualified to disseminate advanced knowledge in their fields. We have 38 faculty members from 11 different countries, and about 400 PhD and 160 postdoctoral students from all over the world. Education is research-oriented. The Department has some of the finest research and teaching facilities with excellent equipment and infrastructure. Graduates meet the requirements and high standards of their chosen profession.

The Department is organized into five institutes and laboratories: Laboratory of Inorganic Chemistry, Laboratory of Organic Chemistry, Laboratory of Physical Chemistry, Institute for Chemical and Bioengineering, Institute of Pharmaceutical Sciences. We cultivate intensive cooperation, not only within the individual research groups, but also among scientists in all the institutes and laboratories. The D-CHAB has an interdisciplinary tradition and covers aspects from basic research to applied biosciences.
The strategic objectives of the Department include the synthesis, modeling and characterization of molecular systems. Research activities range from work on the structure and dynamics of molecules to the function of molecular complexes and beyond to the pharmaceutical and material sciences.

Admission

The programs are open to students with a bachelor's or equivalent degree in the respective field. Students with a degree in another field of study qualifying for a particular program may be considered for admission. Specific admission requirements may apply to the individual programs depending on the educational background of the applicant.

Applicants should consider that students are expected to regulate their studies on their own. For example, mastery of course material is independent, paced not by frequent examinations or papers but by self-discipline. Accustomed to external motivators such as course requirements, personal tutorials, and other checks on learning, many foreign students have difficulty in the absence of such intervention. Given this, successful applicants for the D-CHAB ETH Zurich master's programs are:

→ Graduated in the upper percentiles of their undergraduate programs
→ Strongly independent, self-motivating, and self-directed academically and personally
→ Experienced in completing tasks on schedule without supervision
→ Fluent in English and/or German
→ Self-financing with regard to school, travel, and living expenses

Application

Applications for the master's programs must be submitted to the Admissions Office of ETH. Please use the online application portal. Your application must include an essay in English of one to not more than two pages in which you explain why you have chosen the particular program of studies, and ETH as the institution for your master's studies, and which research area at our Department is particularly attractive to you.

If the formal requirements are fulfilled the application is examined by a departmental admission committee which proposes to the Head of the Department acceptance or rejection of the application. This committee also determines any individual admission requirements such as a request to collect additional credits in particular areas. The admission committee will not make a final decision before it has received a complete official record of the BSc graduation results. Please check the admission website for the submission deadlines that apply to applications to master's programs.

MSc in Chemistry

Students with an appropriate bachelor's degree can complete their studies in two semesters. The total number of 90 credits necessary to obtain the master's degree must be acquired within three years.

Categories of course units
Students have to obtain credits in the following categories:

Category	Credits
Core subjects	21
Optional subjects	14
Laboratory courses and research projects	33
Master thesis	20
Optional subjects in humanities, social and political sciences	2

Description of the categories

Core subjects
Core subject areas are «Inorganic Chemistry», «Organic Chemistry», and «Physical Chemistry». All students have to take at least one course from each of the three areas. If two courses are offered in a particular area students opt for one. Courses in this category are:

Inorganic chemistry

→ Bioinorganic Chemistry
→ Functional Inorganics

Organic chemistry

→ Organic Synthesis: Methods and Strategies
→ Advanced Methods and Strategies in Asymmetric Synthesis

Physical chemistry

→ Advanced Physical Chemistry: Statistical Thermodynamics
→ Advanced Magnetic Resonance (Compensatory subject)

Optional subjects
They cover a broad spectrum of advanced topics in chemistry, as well as topics from related areas. The list of courses in this category includes: Modern Concepts in Molecular Inorganic Chemistry, Reactive Intermediates, Advanced Optics and Spectroscopy, Analytical Strategy, Enzymes, Renewable Energy Technologies, Structure Determination, Biochemical Engineering and Biotechnology, Computer Simulation in Chemistry, Biology, and Physics, Advanced Quantum Chemistry, Introduction to Macromolecular Chemistry, Risk Assessment of Chemicals, General and Environmental Toxicology.

Students may also take as optional subjects:
a) core and compensatory subjects as long as they have not taken them as such, and b) optional subjects from the bachelor's program.

Laboratory courses and research projects
Students have to carry out either one laboratory course plus one research project, or two research projects in a core or optional subjects area chosen by the student.

Master thesis
The master thesis is carried out under the supervision of a professor in one of the core or optional subjects areas chosen by the student. Its duration is 16 weeks.

Optional subjects in humanities, social and political sciences
All students must collect credits in courses offered by the Department of Humanities, Social and Political Sciences.

Students with a bachelor's degree of the University of Zurich are admitted without any further requirements.

MSc in Chemical and Bioengineering

Students with an appropriate bachelor's degree can complete their studies in two semesters. The total number of 90 credits necessary to obtain the master's degree must be acquired within three years.

Categories of course units
Students have to obtain credits in the following categories:

Category	Credits
Core subjects	28
Optional subjects	17
Laboratory courses, research projects, and case studies	23
Master thesis	20
Optional subjects in humanities, social and political sciences	2

Description of the categories

Core subjects

Core subject areas are «Bioengineering», «Polymers», «Process Design», «Catalysis». All students have to take at least one course from each of the four areas. If two courses are offered in a particular area students opt for one.
Courses in this category are:

Bioengineering

→ Biological Engineering

Polymers

→ Polymerization Reaction and Colloid Engineering
→ Introduction to Macromolecular Chemistry

Process Design

→ Process Simulation and Flowsheeting
→ Planning and Process Development

Catalysis

→ Catalytic Reaction Engineering
→ Surface Science and Methods in Catalysis

Optional subjects

They cover a broad spectrum of advanced topics in chemical and bioengineering, process engineering, as well as topics from fluid dynamics, environmental sciences, energy production and conversion, and related areas.
The list of courses in this category includes: Bioprocesses, Biomedical Engineering, Computational Biology, Separations in Fine Chemistry and Biotechnology, Technical Electrochemistry, Renewable Energy Technologies, Turbulent Flows, Applied Fluid Dynamics, Risk Assessment of Chemicals, General and Environmental Toxicology.

Students may also take as optional subjects:
a) core subjects as long as they have not taken them as such, and b) optional subjects from the bachelor's program.

Laboratory courses and research projects

Students have to carry out a laboratory course in chemical engineering plus a research project in a core or optional subjects area chosen by the student.

Case studies in process design

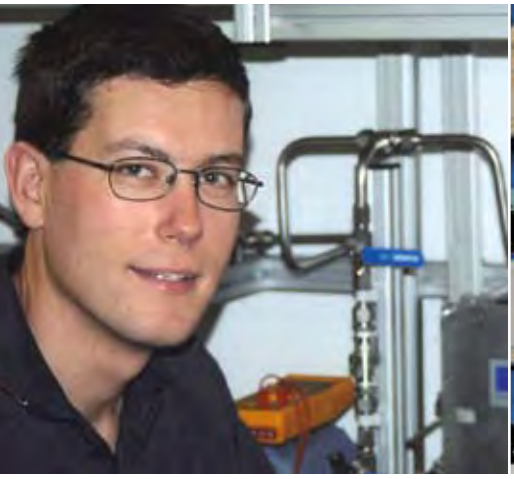
Groups of students investigate an industrial process.
The project involves the use of simulation programs, cost calculations, sensitivity analyses. Optimizations are conducted considering technical and, in particular, economic criteria.

Master thesis

The master thesis is carried out under the supervision of a professor in a research group of the Department chosen by the student. Its duration is 16 weeks.

Optional subjects in humanities, social and political sciences

All students must collect credits in courses offered by the Department of Humanities, Social and Political Sciences.



MSc in Biotechnology

Students with an appropriate bachelor's degree can complete their studies in two semesters. The total number of 90 credits necessary to obtain the master's degree must be acquired within three years.

Categories of course units
Students have to obtain credits in the following categories:

Category	Credits
Core subjects	14
Optional subjects	14
Research project	20
Master thesis	40
Optional subjects in humanities, social and political sciences	2

Description of the categories

Core subjects

Core subject areas are «Biotechnology» and «Biopharmaceutical Manufacturing». All students have to take at least one course from each of the two areas. If two courses are offered in a particular area students opt for one. Courses in this category are:

Biotechnology

→ Biological Engineering and Biotechnology
→ Bioprocess Engineering

Biopharmaceutical Manufacturing

→ Biopharmaceutical Manufacturing
→ Bioreaction Engineering

Optional subjects

They cover a broad spectrum of advanced topics in chemical and bioengineering, process engineering, and biotechnology. The list of courses in this category includes: Enzyme catalysis, Separations in Fine Chemistry and Biotechnology, Biocompatible Materials, Biopharmacy, Mycology, Development, Plasticity and Regeneration of the Nervous System.

Students may also take as optional subjects:
a) core subjects as long as they have not taken them as such, and b) optional subjects from the bachelor's program.

Research project

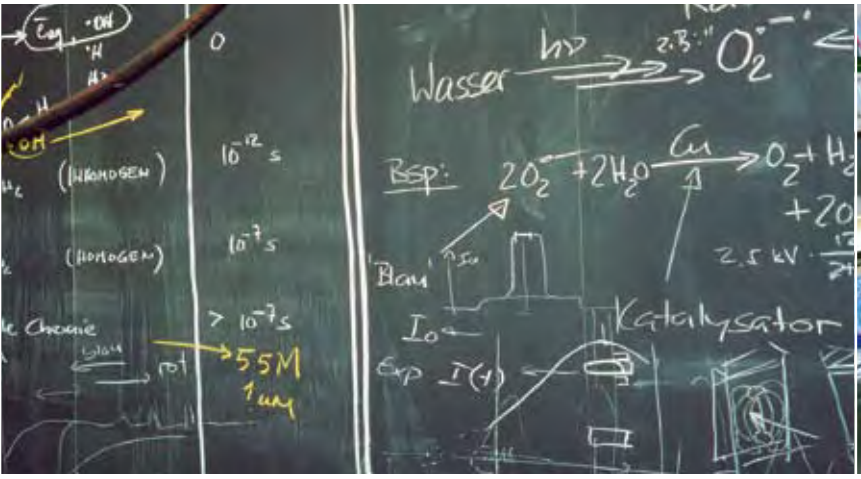
Students have to carry out a research project in a core or optional subjects area chosen by the student.

Master thesis

The master thesis is carried out under the supervision of a professor in a research group of the Department chosen by the student. Its duration is 32 weeks.

Optional subjects in humanities, social and political sciences

All students must collect credits in courses offered by the Department of Humanities, Social and Political Sciences.



MSc in Pharmaceutical Sciences

Students with an appropriate bachelor's degree can complete their studies in four semesters. The total number of 90 credits necessary to obtain the master's degree must be acquired within five years. The Federal Diploma in Pharmacy is subject to federal legislation.

Categories of course units
Students have to obtain credits in the following categories:

Category	Credits
Core subjects	14
Optional subjects	4
Research project	10
Master thesis	30
Optional subjects in humanities, social and political sciences	2
Year of professional training (Assistenzjahr)	30

Program
The two years of the master's program are structured as follows:
First year: Core subjects, optional subjects and research project in the first semester, master thesis in the second semester; courses mostly in English.
Second year: Professional training, consisting in preparatory and intermediate courses at the ETH. Eight weeks core subjects, 4 weeks optional subjects; internship of approximately 30 weeks in a community pharmacy or partly in a hospital pharmacy. Courses mostly in German, no legal title for instruction in English. The year is terminated by the Federal Pharmacists' exam. Students without admission to the federal medicinal examinations complete their studies with a master's degree ETH.

Description of the categories
Core subjects
Pharmacogenetics/Pharmacotherapy, Clinical Grade Pharmaceuticals, Pharmacoepidemiology/Evidence-based Medicine

Optional subjects
Broad spectrum of advanced topics in Pharmaceutical Sciences.

Research project
Students have to carry out one research project in the field of Pharmaceutical Sciences chosen by the student.

Master thesis
The Master thesis is carried out under the supervision of a professor in one of the core or optional subjects areas chosen by the student. Its duration is 22 weeks.

Optional subjects in humanities, social and political sciences
All students must collect credits in courses offered by the Department of Humanities, Social and Political Sciences.

Year of professional training
The concept of professional training is nationwide adopted by all pharmacy schools. It leads to competent health professionals. Basic subjects are knowledge about drugs, biologics, herbals, pharmaceutical technology, pharmaceutical care, health care, communication, social competence, ethics as well as economic and legal implications in the work of a pharmacist.

Students with a bachelor's Degree in Pharmaceutical Sciences of the University of Basel or of the Ecole de Pharmacie Genève-Lausanne are admitted without additional requirements.

Forthcoming master's programs

At the time of printing of this brochure three additional master's programs are in preparation.

MSc in Medicinal Product Development

The purpose of this master's program is to provide graduate level education in the most relevant areas of Industrial Pharmacy. Upon completion, graduates will have acquired a high level of understanding of the progression of medicinal product development from an industrial, regulatory and academic perspective, including aspects such as diseases and potential targets, drug finding, pre-formulation and formulation, preclinical and clinical studies, quality and safety aspects, registration, marketing and life-cycle management. Further, the graduates will have acquired good understanding and hands-on experience of procedures that enable and facilitate the aforementioned medicinal product development, including, e.g., professional communication with expert vocabulary, project management, information and documentation progression, ethical aspects.

The program is open to students with a BSc in Pharmaceutical Sciences, or with a BSc in a Pharmaceutical Sciences-related program complemented with additional credits from the BSc in Pharmaceutical Sciences program of ETH. Its launch is planned for the fall 2007.

MSc in Medicinal Chemistry

The purpose of this master's program is to provide graduate level education in the most relevant areas of Medicinal Chemistry and small molecule drug discovery. Upon completion, graduates will have acquired a high level of understanding of the essential issues and problems in chemical and pharmaceutical sciences, of the execution (including hands-on experience) of research projects combining organic synthesis and the evaluation of biological and pharmacological properties of chemical entities, of the essential mechanisms affecting bioavailability, distribution, metabolism, and excretion of chemical entities in an organism, of the problems of toxicity and drug-related side-effects, of pharmaceuticals and their formulation to ensure optimal efficacy, and of medical and legal aspects related to drug discovery and development. Graduates will have gained fundamental knowledge on methods and strategies of chemical synthesis, on physical and analytical techniques, on methods used in the evaluation of biological effects of chemical entities, and the integration of this knowledge for the invention of new medicinal agents taking into account pharmacokinetics, pharmacodynamics, galenics, patenting, law, and also ethical issues.

The program is open to students with a BSc in Chemistry or in Pharmaceutical Sciences, or with a BSc degree in a related program complemented with additional credits in the respective other area. Its launch is planned for the fall 2007.

MSc in Interdisciplinary Sciences

This master's program aims at providing students with a broad interdisciplinary training in the basic sciences physics, chemistry and biology as well as mathematics and computing. Its main feature is the great freedom students have in compiling their individual study program combining subjects ranging from chemistry, physics and biology to computer science, materials, earth and environmental sciences. Graduates acquire the skills necessary for interdisciplinary work in research, teaching, industry, business, and the civil service. Research in rapidly developing areas between the classical disciplines presents unique opportunities. Depending on the study program chosen the Master in Interdisciplinary Sciences is furthermore complemented by the specific major as selected by the students.

Examples for majors are: Chemical Physics, Biophysics and Chemical Physics, Analytical and Physical Chemistry, Biophysical Chemistry and Biology, Molecular Biology and Chemical Physics, Chemical Physics and Theoretical Physics, Biophysical and Organic Chemistry, and many more.

The program is open to students with a BSc in Interdisciplinary Sciences of ETH, or with a BSc in similar multidisciplinary programs or in the basic sciences physics or chemistry complemented with additional credits from the BSc in Interdisciplinary Sciences program of ETH. The program shall start in the fall semester of 2007.

Research at the Department

This page provides an overview of the research groups in the laboratories and institutes of the Department. Summaries of research topics are given on the following pages. For detailed information please consult the research website of the Department.

Laboratory of Inorganic Chemistry	
Main group element and coordination chemistry	Prof. Hansjörg Grützmacher
Analytical inorganic chemistry	Prof. Detlef Günther
Bioinorganic chemistry	Prof. Willem H. Koppenol
Solid state chemistry	Prof. Reinhard Nesper
Asymmetric catalysis, organometallic chemistry	Prof. Antonio Togni

Laboratory of Organic Chemistry	
Asymmetric catalysis, total synthesis	Prof. Erick M. Carreira
Physical organic chemistry, combinatorial catalysts development	Prof. Peter Chen
Advanced materials, molecular recognition	Prof. François Diederich
Chemical biology	Prof. Donald Hilvert
Asymmetric catalysis and synthetic methodology	Prof. René Peters
Bioorganic chemistry and synthesis	Prof. Peter Seeberger
Bioorganic chemistry of carbohydrates and organic synthesis	Prof. Andrea Vasella
Analytical chemistry	Prof. Renato Zenobi

Laboratory of Physical Chemistry	
Solid-state magnetic resonance	Prof. Beat H. Meier
Spectroscopy and photochemistry	Prof. Frédéric Merkt
Liquid state NMR, bio-NMR	Prof. Konstantin V. Pervushin
Molecular kinetics and spectroscopy	Prof. Martin Quack
Theoretical chemistry	Prof. Markus Reiher
Nano-optics	Prof. Vahid Sandoghdar
Computer-aided (bio)chemistry	Prof. Wilfred F. van Gunsteren
Associated Chair	
Computational science	Prof. Michele Parrinello

Institute for Chemical and Bioengineering	
Heterogeneous catalysis and reaction engineering	Prof. Alfons Baiker
Biotechnology and bioengineering	Prof. Martin Fussenegger
Safety and environmental technology	Prof. Konrad Hungerbühler
Chemical reaction and separation engineering	Prof. Massimo Morbidelli
Functional materials and catalysis	Prof. Wendelin Stark
Heterogeneous catalysis	Prof. Jeroen van Bokhoven
Chemical aspects of energy	Prof. Alexander Wokaun

Institute of Pharmaceutical Sciences	
Pharmaceutical biology	Prof. Karl-Heinz Altmann
Therapeutics technologies I	Prof. Andre Braendli
Pharmacogenomics	Prof. Michael Detmar
Drug formulation and delivery	Prof. Hans Peter Merkle
Biomacromolecules	Prof. Dario Neri
Molecular pharmacology	Prof. Ursula Quitterer
Therapeutics technologies II	Prof. Roger Schibli
Radiopharmaceutical science	Prof. August Schubiger
Biopharmacy	Prof. Heidi Wunderli-Allenspach
Clinical pharmacology	Prof. Hanns Ulrich Zeilhofer
Pharmaceutical chemistry	NN

Laboratory of Inorganic Chemistry

The laboratory covers a wide spectrum of the main teaching and research routes of inorganic chemistry. Research directions are Bioinorganic and Main Group Element Chemistry, Homogeneous Catalysis, General Element and Trace Element Analysis, Solid State Chemistry, New Materials and Chemical Nano Science. These fields are targeted primarily by synthesis of new compounds which are investigated through state of the art chemical analysis, NMR, Xray and Electron Microscope facilities as well as by other spectroscopic, thermal and electric investigations.

Trace Element and Micro Analysis applies inductively coupled plasma mass spectrometry and laser ablation techniques to determine element concentrations and isotope ratios at ultra trace levels and high spatial resolution. Fundamental and applied research is carried out using latest laser technology (femto second lasers and UV-nanosecond lasers) and a wide variety of different mass spectrometers (such as quadrupole, time of flight, sector field and multi-collector ICP-MS. Ionization process, ion transmission are studied in detail. Furthermore, the applied research includes single crystals, synthetic samples, catalyst materials, forensic applications and geological samples. Bioinorganic chemistry targets the reactivity of nitrogen monoxide and peroxynitrite, and their reactions with heme proteins in particular. Biological iron overload and the coordination chemistry of oral chelators with iron is being investigated through electrochemistry and the kinetics of the Fenton reaction. Other attempts focus on biological superoxide and peroxide removal, Cu/Zn superoxide dismutase properties, and, more recently, on the kinetics of peptide and protein oxidation and repair reactions. A unique combination of rapid kinetics techniques: flash photolysis, Special techniques being applied are stopped flow kinetics with optical detection, laser flash photolysis EPR with optional flow reactor, and pulse radiolysis.

The Main Group Element and Coordination Chemistry is concerned with polycyclic phosphiranes which carry unusual properties and with tropylidenyl phosphanes which are ligands for the stabilisation of unusual metal oxidation states. In addition synthesis of various new phosphorus radicals is being persued, i.e. use of organometallic precursors as source for various radicals, factors which are important to stabilise phosphorus radicals and the question on how -heteroelements stabilize a carbenium ion by compounds $[CX_nR_{3-n}]+$ in which X stands for a heteroatom from almost any group and period of the main group elements and R for H or an organic group. Especially, their reduction chemistry yields new main group element centered radicals.

Solid state and Nano Chemistry targets new solids and solid materials through syntheses, investigates their chemical and physical properties and works out theoretical understanding of solids by state of the art methods. New materials are being chased for energy storage and conversion (oxides, nano particles), for opto-electronic devices (nitrides), for high strength and high resistance applications (Si/B/C/N polymers) as well as new superconductors (MgB_2 and related phases). Through periodic nodal surfaces considerations phase transitions and regular structure formation are tackled on new routes. Band structure calculations and subsequent determination of electron localization functions allow for detailed analyses of chemical bonding in solids.

The research in the field of Organometallic Chemistry and Homogeneous Catalysis is focused on aspects of asymmetric catalysis with transition-metal complexes. The main research areas are 1) ligand and catalyst design, 2) the development of new catalytic reactions, as well as 3) mechanistic investigations, including computational studies. Coordination chemical aspects of asymmetric catalysis constitute an important area of study, thus complementing the synthesis oriented investigations and underlying the interests for fundamental features of homogeneous catalysis.

Research in the field of the **Coordination Chemistry** of the late transition metals, ruthenium, rhodium and palladium, is directed towards the use of diffusion and multidimensional NMR methods to understand a) how anions in catalytically active cationic complexes enhance reactivity, b) how to recognize and quantify ion pairing in solutions of non-polar solvents, c) unusual chelating olefinic bonding modes for selected chiral phosphorus ligands in metal complexes, and d) the source of the regio-selectivity in Ru(II) catalyzed allylic alkylation and amination reactions.

Creative Chemistry in the Internet (CCI) is a widely used system which supplies well prepared pictures and movies of chemical experiments together with a large amount of background information.

Laboratory of Organic Chemistry

Organic chemistry plays an integral role in science and society. It is the bridge between biology and medicine, providing the basis for understanding biological function through molecular structure and enabling both medical discoveries and development. It also opens doors to many advanced materials never seen in nature. Indeed, organic chemistry has given us countless new substances that benefit our everyday lives, including dyes and drugs, fabrics and fertilizers, plastics and pesticides – basically everything manmade that can be tasted, touched, and smelled.

Research in the Laboratory of Organic Chemistry (LOC) reflects this richness. The art of making molecules is the traditional heart of organic chemistry. Its importance is reflected in a wide range of projects to synthesize complex natural products, potent enzyme inhibitors, compounds with fleeting lifetimes, carbon-rich acetylenic materials, as well as diverse biopolymers, such as novel oligosaccharides, oligonucleotides and proteins, and biologically inspired but non-natural polymers. New agents for treating diseases like cancer and novel vaccines for combating malaria, AIDS and other major health problems are only some of the practical embodiments of such work. Efforts to understand how chemical transformations proceed – with the goal of controlling their outcome and optimizing their efficiency – is another major research focus in the Laboratory of Organic Chemistry, with practical applications in fields as diverse as drug discovery, homogeneous catalysis, and combustion chemistry. In this context, efforts to create organometallic and biological catalysts with tailored activities and selectivities are representative. Progress on all these fronts depends, of course, on the availability of powerful analytical tools. The development of new methods for detecting, characterizing and manipulating tiny amounts of material, from trace organic compounds in the environment to supramolecular complexes in biological systems, is another ongoing area of investigation in the institute.
Based on this broad palette of offerings, which extends from chemical synthesis, chemical biology, and materials science to analytical chemistry, the LOC affords young researchers exciting opportunities to pursue their imaginations in challenging projects at the cutting edge of research.

Medicinal Chemistry: structure-based design of nonpeptidic enzyme inhibitors; targets include thrombin, catechol O-methyl transferase, t-RNA guanine transglycosylase.

Advanced Materials: supramolecular nanosystems and materials based on carbon-rich acetylenic architectures as well as fullerenes.

Analytics: new techniques; probes sampling 50 nm at ambient conditions; the study of biomolecules using continuous flow probe interface for on-line coupling of liquid separation methods with MALDI-MS.

Catalysis and Natural Products: synthesis of biologically active, stereochemically complex, natural products; reaction innovation and design; synthetic methods; catalysis; stereoselective synthesis, organometallics.

Physical Organic: investigations of reactive intermediates using laser spectroscopy and computational chemistry; reactivity studies of high-molecular-weight complexes in the gas–phase; focus on C-H activation, olefin metathesis, Ziegler-Natta polymerization and hydrogenation; supersonic jet flash pyrolysis to study the spectroscopy and dynamics of radicals; multidimensional approaches to understanding molecular recognition in chemistry and biology using complexation studies, synthetic receptors, data base mining, computations, and crystallography.

Chemical Biology: Synthesis, characterization and biological properties of peptides, proteins, oligosaccharides, glycoproteins and glycolipids; synthesis and evaluation of pairing properties of novel DNA and RNA analogues, incorporating systematic structural variations; protein and enzyme design and laboratory evolution; catalytic antibodies; investigation of enzyme reaction mechanisms; mechanism of action of natural products.

Laboratory of Physical Chemistry

Research and teaching in the Laboratory of Physical Chemistry address a wide range of scientific topics in physics, chemistry, life sciences, and material science. The laboratory is recognized for its pioneering contributions to the development of various experimental and theoretical methods for the detection, characterization and description of the structure, dynamics, and function of molecular systems.

Nuclear Magnetic Resonance

Nuclear magnetic resonance (NMR) spectroscopy in liquid and solid phase is a key technology for the structural and dynamic characterization of non-crystalline materials. Our research is focused on the development of new methods and pilot applications in selected materials of biological, chemical and material-science interest. Important topics are the improvement of spectral resolution, detection sensitivity as well as hyperpolarization. Applications presently under investigation include the atomic structure of prions in their amyloid state, the structure-function relationship in spider silk, imaging on the nanometer scale by magnetic resonance force detection, and the structure-dynamics relationship in structurally disordered and membrane proteins.

Electron Paramagnetic Resonance

Electron paramagnetic resonance (EPR) spectroscopy can elucidate structural details around paramagnetic metal ions in inorganic and biological molecules and complexes. Both types of EPR spectroscopy, continuous-wave and pulse, are employed to obtain information on the nanoscale geometry and the electronic structure in such systems.

Molecular Kinetics and Spectroscopy

The primary quantum mechanical processes of molecular motion from the attosecond time scales to times of seconds, which are at the origin of all chemical reactions, are studied by infrared Fourier transform and laser spectroscopy at very high frequency resolution and by time resolved kinetic spectroscopy. A long term vision of this research is to introduce new ways of mode selective laser chemistry comparable to the «selective surgery» of molecules. The study of fundamental symmetries and their violation in chiral molecules provide deep insight into the physical laws governing molecular primary processes. Here, the interplay of experiment and theory is essential and we cross the borders between chemistry and fundamental high energy physics, with possible implications also for the evolution of biomolecular homochirality.

Nano-Optics

Laser spectroscopy and optical microscopy are combined with scanning probe technology to study light-matter interaction at the nanometer scale. The challenges in Nano-Optics include a variety of topics such as the development of efficient sources of single photons for quantum optical applications, novel methods for the detection and tracking of nanoscopic biological entities such as viruses or proteins, and pushing the limits of resolution in optical microscopy to the molecular level.

Photochemical and Photophysical Processes in the Gas Phase

Broadly tuneable short wavelength laser systems in the wavelength range 30-200 nm are developed and used to study photochemical and photophysical processes in the gas phase with relevance in astrophysics and atmospherical chemistry. The research topics include the study of highly excited electronic Rydberg states and their applications in atom and molecule optics and in photoelectron spectroscopy, the study of the structural and dynamical properties of molecular cations by photoelectron spectroscopy and the investigation of molecular photoionization and photodissociation dynamics.

Theoretical Chemistry

We investigate molecular aggregates that range in size from small molecules up to nanometer-scaled objects and macroscopic materials on the basis of the fundamental laws of quantum mechanics. These laws describe the motion of electrons and atomic nuclei and provide a framework for the description of chemical processes in chemistry, physics and biology. Furthermore we develop methodologies to simulate the behaviour of biomolecular systems and investigate their function at the atomic level. Currently the fields of research are biomolecular force field development, interpretation of CD, NMR and X-ray experiments using simulation, development of methods to compute binding free energies and entropies of protein-ligand complexes, simulation of peptide folding and association under different conditions, simulation of lipid bilayer membranes, development and distribution of software for biomolecular simulation. We also develop methods and distribute programs for the simulation of the dynamics of complex chemical processes, e.g. chemical reactions in condensed phases, the simulation of disordered systems, phase transitions, and the prediction of crystal structures.

Institute of Pharmaceutical Sciences

The Institute of Pharmaceutical Sciences performs research on the discovery, development and application of medicinal agents for the diagnosis, prevention and treatment of diseases, as well as investigations on the mode of action of pharmaceutical agents.

Research activities at the Institute of Pharmaceutical Sciences cover many areas of modern biomedical research, under the motto «From Concepts to Prototypes». A research focus at the Institute is represented by cancer research, which includes activities devoted to the identification and validation of tumor-associated markers, the study of molecular and biological mechanisms of tumor progression and invasion, the synthesis of novel anti-cancer chemotherapeutic agents, the engineering of novel-antibody-based therapeutic proteins capable of stimulating a strong immune response against tumor cells, and the development of innovative radiopharmaceuticals for the imaging of solid tumor masses. A number of pharmaceutical agents developed at the Institute are now in clinical development in the area of oncology, in collaboration with industrial partners.
Several groups at the Institute are actively involved in the development of innovative delivery systems (both ligand- and non-ligand-based), which allow the selective localization of bioactive agents at sites of disease. These research activities find an ideal complementation in the Center of Radiopharmaceutical Sciences, featuring state-of-the-art instrumentation for the production of radionuclides of biomedical relevance for SPECT and PET applications, as well as innovative technologies and instrumentation for the radiolabeling of disease-targeting agents and their use for in vivo imaging. Furthermore, research groups at the Institute are actively investigating the mechanisms of drug transport across biological barriers and membranes, and molecular and pharmacological aspects related to the treatment of heart and nervous pathological conditions.

Pharmaceutical Biology: chemical synthesis and biological and pharmacological profiling of biologically active natural products and their synthetic and semi-synthetic analogs

Therapeutics Technologies I: developmental biology, functional validation of target genes of pharmaceutical relevance, Xenopus laevis technology, organogenesis and angiogenesis

Therapeutics Technologies II: radiopharmaceuticals, development of novel Tc- and Re-precursors, bioorganometallics, target chemistry, radiolabeled nucleoside analogues, enzymatic modification of peptides

Pharmacogenomics: cancer biology, role of angiogenesis and lymphangiogenesis in cancer progression and chronic inflammation, genetic disposition for disease and for the response to specific therapies

Drug Formulation and Delivery: delivery of therapeutic agents across biological barriers, particulate vaccine delivery systems, drug delivery at the interface to tissue engineering, biodegradable drug delivery systems

Biomacromolecules: ligand-based vascular targeting, therapeutic antibodies, antibody engineering, DNA-encoded chemical libraries, chemical proteomics for target discovery

Molecular Pharmacology: research on the relationship between the diverse risk factors of vascular disease, disturbed signaling and end-organ damage

Radiopharmaceutical Science: development of radiopharmaceuticals for applications in nuclear medicine, radiopharmaceutical chemistry, biochemistry, molecular biology, pharmacy and pharmacology

Biopharmacy: drug partitioning in lipid bilayers, P-glycoprotein biology and pharmacology, tight junction proteins as targets, applied pharmacokinetics

Pharmacology: research on the cellular and molecular basis of chronic pathological pain in inflammatory and neuropathic diseases

Medicinal Chemistry: position currently being filled

Institute for Chemical and Bioengineering

Research at the institute is done in a variety of fields as described below.

Catalysis and Reaction Engineering

Research on catalysis is focused on the investigation of molecular processes occurring at catalytic fluid/solid interfaces and on the development of new catalytic materials and processes for fine chemical synthesis and environmental control. This goal is pursued by a combined spectroscopic, kinetic and theoretical approach. Various in situ spectroscopic techniques are applied, including ATR-IR, XRD and XAS to unravel the structure – performance relationships that assist in a rationally guided catalyst design. Main reaction types in focus are: enantioselective hydrogenation, oxidation with molecular oxygen, carbon dioxide and alkane activation, and several reactions relevant for the abatement of pollutants. Catalysis research is strongly supported by reaction engineering in which catalytic reactions in supercritical fluids are targeted. The aim is to gain a scientific basis for the beneficial use of supercritical fluids in catalysis.

Biotechnology

As a central therapeutic engineering discipline biotechnology covers all aspects from target to market. Biotechnology research impacting human therapy focuses on two major strategies: (i) *Products From Cells* capitalizes on the natural capacity of mammalian cells to produce therapeutic proteins at pilot and large quantities. This strategy involves genetic engineering of mammalian cell lines for production of a desired protein therapeutic, adaptation of production cell lines to serum-free suspension cultures, design of prototypic bioreactors, and bioreactor operation of engineered cells as well as purification, quality and safety controls known as downstream processing. The ultimate goal of this innovation process is a protein pharmaceutical, which complements compromised physiologic activities and provides successful treatment of severe diseases.
(ii) *Cells As Products* takes advantage of engineered cells to complement genetic deficiencies or replace pathologic tissues. Whereas gene therapy aims at replacing or complementing genetic defects in individual cells by expressing therapeutic transgenes at the right time and the right dose in the human body, tissue engineering focuses on genetic reprogramming of mammalian cells to produce organotypic structures, which could ultimately be used to replace diseased organs. Detailed molecular understanding of intracellular processes is instrumental to reprogram mammalian cells for human-therapeutic use.

Chemistry and Sustainability

Sustainable chemistry research aims at the design of resource efficient and inherently safe chemical products and processes. The goal is to develop experimental and theoretical methods to model, evaluate and optimize the resource efficiency and safety of chemical processes and the environmental performance of chemical products throughout their whole life-cycle. These methods support e.g. the choice of appropriate raw materials and reaction conditions and the identification of environmentally preferable chemical products.
A sustainable energy system provides societal access to energy services, while respecting the environment and minimizing resource consumption. To achieve this goal we render services with minimum energy input, increase the efficiency of energy conversion, and substitute fossil by CO_2-free primary energies. One pathway is the production of biofuels and their use in combustion engines with highest efficiency and near-zero emissions. The second route generates hydrogen by solar thermochemisty, for use in fuel cell cars for transportation.

Functional Materials

The most recent advances in nanotechnology and analytics have given us the possibility to better understand and even design molecular interactions between materials and their surroundings. Most of the fascination of working with functional materials comes from a close interaction between fundamental science, engineering and the real application of our research: Degradable medical implants, nano-sized electronic sensors, increasingly stable catalysts and novel polymer surfaces with no adhesion reflect the intense collaboration with medical clinics, industrial partners and researchers from most different backgrounds. Various techniques for producing dispersions of colloidal particles either in aqueous phase or in supercritical fluids are investigated. These can be used to produce very peculiar aggregates whose fractal structure can be exploited for adsorption, catalytic or drug delivery applications. The aggregation processes leading to such structures pose fascinating questions at the level of both fundamental science and engineering realizations.

General information

Academic year

Teaching is organized in two semesters. The Fall semester lasts approximately from mid-September to the end of the year, the Spring semester approximately from the end of February to the end of May. The academic year begins with the Fall semester. Examinations are held in examination terms during the last weeks of the semester breaks before the start of the new semester.
Students will normally enter the master's program in the Fall semester. However, entrance in the Spring semester is also possible and especially recommended to students who have to fulfill admission requirements such as a request to collect additional credits in particular areas.
Most of the courses in the master's program, especially lectures, are offered in the Fall semester. With the consent of the respective supervisors, laboratory courses and research projects may also be available in the Spring semester and during the semester breaks.

Credit system

The master's programs use a credit system which is based on the European Credit Transfer System (ECTS). Credits are a measure for the total labour required from the students to reach the educational goal. Calculations are based on a total of 1500 to 1800 working hours per year, equivalent to 60 credits. Therefore, 1 credit corresponds to 25 to 30 hours of total work.
Credits are allocated after the performance assessment according to the list of courses has been passed. Upon application by the student the master title is awarded when a total of 90 credits is reached.

PhD studies

A doctoral degree from the Department of Chemistry and Applied Biosciences is granted for participating in a PhD program under the supervision of a professor. Admission to a PhD program requires that you hold a diploma or a MSc degree with excellent grades. Furthermore, a professor of ETH has to accept you as a PhD student. Therefore, prior to submitting an application to the Admission Office, you should contact a professor of the Department.

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Detailed and actual information

Department website:	www.chab.ethz.ch/index_EN
Study programs offered by the Department:	www.chab.ethz.ch/lehre/index_EN
Research at the Department:	www.chab.ethz.ch/forschung/index_EN
Admission to studies at ETH:	www.admission.ethz.ch
Online application portal:	www.eapply.ethz.ch
Union of the Assistants at the Chemical Laboratories:	www.vac.ethz.ch
Scientific Staff Association of the Institute of Pharmaceutical Sciences:	www.pharma.ethz.ch/education/mab
Association of Scientific Staff at ETH:	www.aveth.ethz.ch/index_EN.html
Homepage for International Students:	www.international.ethz.ch

June 2006. Editors: Barbara Brauckmann, Otmar Dossenbach, Heidi Wunderli-Allenspach, Pia Wyrsch.
Illustrations, photos put at disposal by B. Brauckmann and various sources.