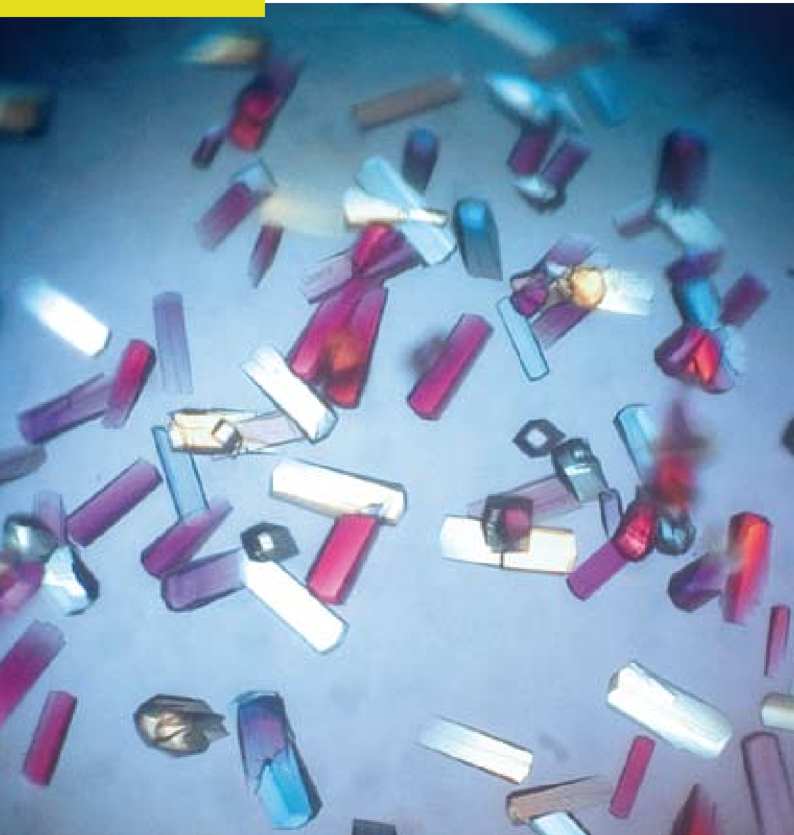
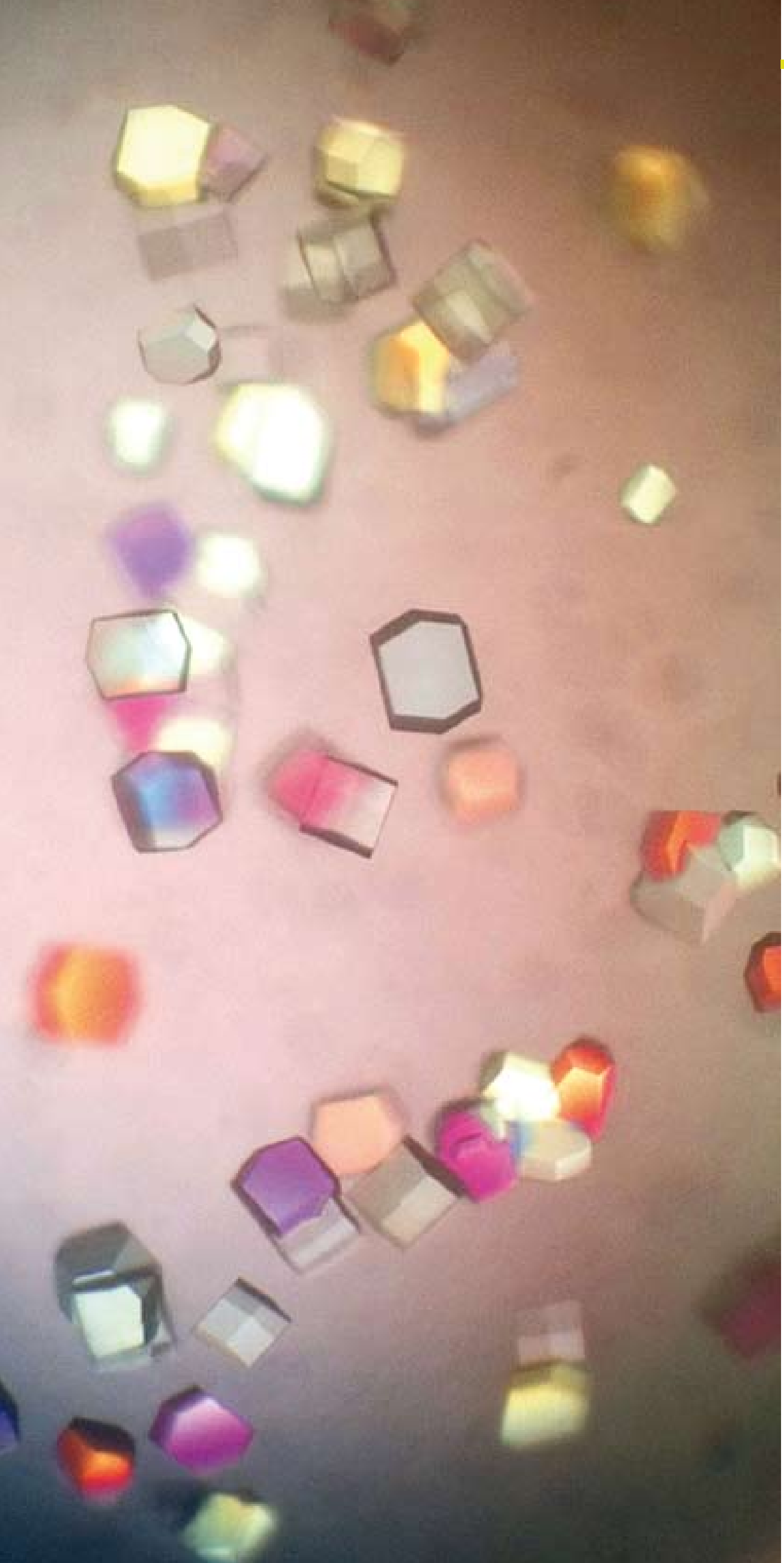
Freie Universität Berlin

Department of Biology, Chemistry, Pharmacy

Institute of Chemistry and Biochemistry





Content

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Crystals of the enzyme lysozyme, prepared in the lab course “protein crystallography” (RG Saenger

Department of Biology, Chemistry and Pharmacy

The three Institutes in the Department of Biology, Chemistry and Pharmacy offer excellent research opportunities, a wide range of study programs, and post-graduate training as well as further education courses. This booklet provides information about research and teaching programs at the Institute of Chemistry and Biochemistry.

The Institute of Biology specializes primarily in molecular botany, microbiology, neurobiology, ecology, biodiversity and plant and animal evolution. In addition to the classical fields of drug development and testing, the Institute of Pharmacy focuses on alternative testing methods and innovative carrier systems. For detailed information about the Department, please visit us at *www.bcp.fu-berlin.de*.

The Institutes enjoy a high reputation in the scientific world on account of outstanding their excellent, enthusiastic scholars and the wider creative environment of the Berlin research landscape. The Department collaborates in numerous projects not only with the Humboldt-Universität zu Berlin, the Technische Universität Berlin and the Universität Potsdam, but also with leading non-university institutions. The latter network includes the Federal Biological Research Centre for Agriculture and Forestry (BBA), the Federal Institute for Materials Research and Testing (BAM), the Robert Koch Institute, the Leibniz Institute for Molecular Pharmacology (FMP) and the Max Delbrück Centre for Molecular Medicine in Berlin-Buch, the Max Planck Institute of Molecular Genetics, the Fritz Haber Institute, the Max Born Institute, and the Helmholtz Centre Berlin for Materials and Energy. Over and above this, the Institutes cultivate close contact with companies in the private sector, such as Bayer Schering Pharma and Pfizer.

Institute of Chemistry and Biochemistry, Takustrasse

Chemistry in Dahlem

Emil Fischer in the laboratory © GdCh

It started with a vision, the vision of a "German Oxford", a unique research landscape in green fields not far from the Botanical Gardens in Berlin. In 1906, Friedrich Althoff, a powerful Prussian minister, succeeded in convincing a group of professors at the University of Berlin, including Emil Fischer, an organic chemist and one of the fathers of biochemistry to support his ambitious idea. Their efforts bore fruit: in 1911, Emperor William II founded the Kaiser Wilhelm Society for the Advancement of Science.

In the following years several research institutes were established on the grounds of the royal domain at Dahlem, including the Kaiser Wilhelm Institute for Physical Chemistry and Electrochemistry. Its first director was Fritz Haber (Nobel Laureate in Chemistry in 1918), who at the time was working on the thermodynamics of gas reactions and used his insights into chlorine and mustard gas to develop the poison gases deployed in trench warfare in World War I. Subsequent pioneering work at the Institute – e.g. on colloid and surface chemistry and crystal structure analysis – ceased abruptly in 1933, when the National Socialists came to power. Fritz Haber refused to dismiss Jewish staff and, like many of his colleagues, went into exile later that year.

Fritz Haber and Albert Einstein 1914 © MPG

The first director of the neighbouring Kaiser Wilhelm Institute (KWI) for Chemistry was Ernst Beckmann. The first head of the department of organic chemistry, Richard Willstätter, received the Nobel Prize in 1915 for elucidating the structure of chlorophyll. Otto Hahn was in charge of radiochemistry, and in 1938, together with Lise Meitner and Fritz Strassmann, discovered nuclear fission, for which he was awarded the Nobel Prize in Chemistry in 1944. In 1948 the building of the KWI for Chemistry and several other properties of the former Kaiser Wilhelm Society and the Max Planck Gesellschaft, its successor organization since 1946, were taken over by the recently founded Freie Universität Berlin.

Lise Meitner and Otto Hahn 1913 at the KWI for Chemistry © MPG

Many of the new research groups took up where their predecessors at the KWI had left off. In Inorganic Chemistry there is still a professorship for radiochemistry. The Institute for Physical Chemistry was founded in 1961. Although it initially focused primarily on electrochemical kinetics (Klaus Vetter), other fields subsequently came to the fore, such as quantum chemistry (Jaroslav Koutecký) and interfacial phenomena and heterogeneous catalysis (Wolfgang Hirschwald). Many research projects were and are carried out in conjunction with the Dahlem Institutes of the Max Planck Gesellschaft, whose scientific directors, including Gerhard Ertl, Nobel Laureate in Chemistry in 2007, often simultaneously hold professorships at the Freie Universität Berlin.

In organic chemistry, the Institute follows in the footsteps of Emil Fischer – an ardent champion of an Institute for Chemisty in Dahlem – in its focus on the synthesis of natural products, on carbohydrate and protein chemistry and on macromolecular chemistry. From 1957 onwards, Georg Manecke was the driving force in the latter field, pushing ahead with the synthesis of polymer gels, ion exchange materials, and reactive polymers, work that continues today in research on biopolymers and synthetic polymers – for applications in nanotechnology and nanomedicine.

Georg Manecke (1916-1990) © GdCh

As early as 1958 the Freie Universität established a chair in biochemistry, one of the first universities in Germany to do so. In 1989, the biochemists moved into a historic building, the former KWI for Chemistry, now known as the Otto Hahn Building. The scope of their work today includes peptide and neurochemistry, cell biology, RNA technologies and membrane research.

Kaiser Wilhelm Institute for Chemistry – today the Otto Hahn Building of the Freie Universität

Portrait of the Institute

Inorganic Chemistry building, Fabeckstrasse

The Institute's focus on the classical fields of chemistry and biochemistry provides the basis for, on the one hand, a sound, modern education and training for chemists, biochemists and chemistry teachers and, on the other, a solid reputation in interdisciplinary research projects, in particular cutting-edge advances in our understanding of the nature of matter and – in the field of applied chemistry – in medicine and technology.

Research covers a fairly broad range of topics: photosynthesis, bone regeneration, the pathogenesis of Alzheimer's disease and functionalized metal complexes for diagnostic applications are equally significant as fields of research as are nanoparticles, femtosecond chemistry, polymer synthesis, peptide design and the total synthesis of pharmacologically important natural products.

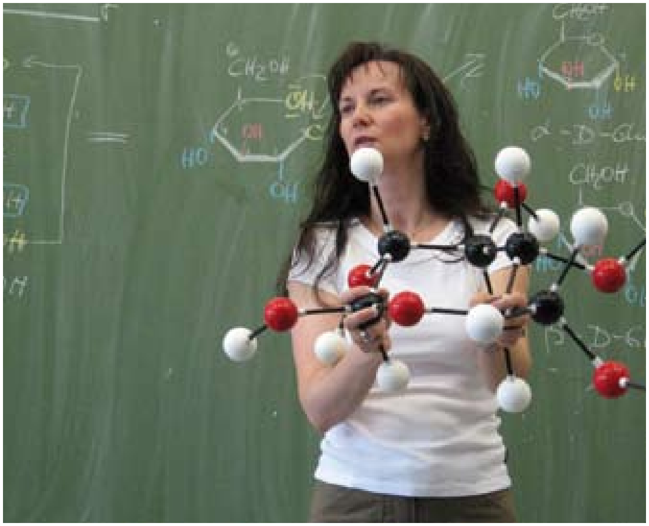
Sometimes fundamental scientific questions in one field raise points that can only be resolved with an interdisciplinary approach. In other cases, a particular technology – for instance crystal structure analysis – becomes the basis of a larger collaborative project in which chemists, physicists, biologists, medical scientists and pharmacists simultaneously do research on different aspects of one challenge. Both approaches offer good reasons for chemists and biochemists of the Freie Universität to establish close cooperation networks with colleagues in various fields at well-known institutions and universities around the world, and in particular at other Berlin universities, non-university research institutes and the Charité. This cooperation includes teaching – for instance in the master's program in Polymer Science –, individual research projects, and broader projects such as the different Collaborative Research Centres and the Cluster of Excellence UNICAT (Unifying Concepts of Catalysis).

Some research results are brilliant enough to deserve marketing – which is precisely what scientists are doing now. Many projects have already led to commercial campus start-ups that are developing innovative products and technologies for the market.

External evaluations repeatedly confirm the Institute's research performance and potential. According to the rankings of the Centre for Higher Education Development (CHE), the Institute is not only one of the best research institutions in Germany, but also a regular leader in third-party fund-raising and in the number of PhD theses per professor. In its 2007 pilot study of 77 chemistry institutes in Germany, the German Council of Science and Humanities (Wissenschaftsrat) gave the Institute the rating "excellent" for efficiency of research and the promotion of young researchers at the Institute.

Whether it is because of such assessments, or simply because of the range of exciting, cutting-edge research topics, or the international reputation of Institute professors, the Institute is a magnet for PhD students and guest researchers from Germany and abroad. Thus, the Institute provides DAAD, Marie Curie and Emmy Noether fellows, among others, the unique opportunity to work side by side. Between 2001 and 2005 alone there were 27 Alexander von Humboldt fellows and awardees doing research in the chemistry laboratories in Dahlem.

Female chemistry professors are no exception at the Freie Universität



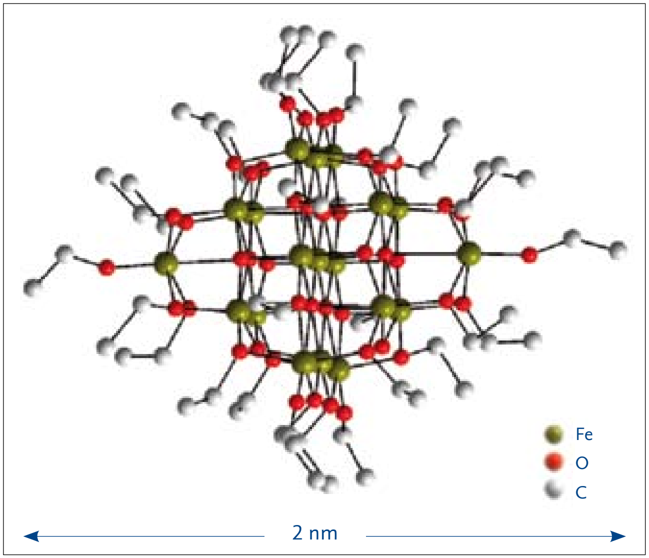
Inorganic Clusters and Nanostructures

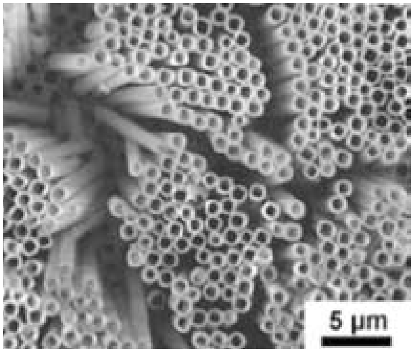
Inorganic clusters and nanostructures moved out of the laboratory and into our daily lives a long time ago: today they stabilize dyes in food and serve as the UV protection ingredient in sunscreen, as radio markers they enhance medical diagnostics and are responsible for the break-proof properties in sports equipment such as tennis rackets. But they have lost none of their fascination for purely scientific research: they continue to expand our understanding of chemical bonding in solids and liquids and of electronic and magnetic properties of solid bodies.

Basic researchers are particularly interested in structures in the 1 to 100 nm range because in this range scientists can observe the transition from the individual behaviour of single molecules to that of a body of solid matter whose properties are largely determined by the collective phenomena of periodically arranged building blocks. Besides the fabrication of inorganic nanostructures of various dimensions, important aspects include selected configurations in space and the customized control of their properties.

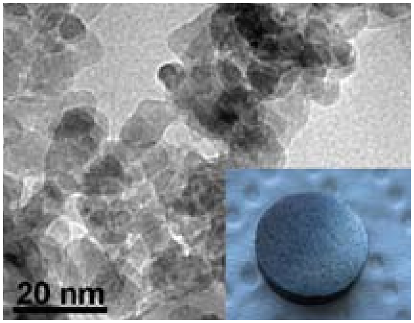
Inorganic Clusters and Nanostructures gives priority to the development of new methods of synthesis that allow selective control and enhancement of specific properties of target compounds. In cluster structures the focus is on the alkoxo compounds of the early and middle transition metals (such as titanium, vanadium, manganese, iron and cobalt). The use of small monodentate ligands favours, for example, the formation of compact highly aggregated clusters that strive towards sphere packing. This procedure has already led to the successful synthesis of alkoxo-oxo-iron compounds containing 19 iron atoms, which are among the largest iron-oxygen clusters ever synthesized. They are the only molecular compounds with an $\{Fe(\mu_6\text{-}O)_6\}$ nucleus, and exhibit previously unknown, very complex magnetic and spectroscopic properties.

Iron-oxo cluster with 19 iron atoms





Field of regularly arranged tin nanotubes



Nanoparticles and a pellet of ZnSb, a thermoelectric material

In the field of larger nanostructures the research focus is on regularly ordered wires and tubes made of metal and semiconductors. It is possible to modify their size and vary their composition with suitable design templates, producing, for example, nanowires made up of several components and exhibiting interesting optical properties.

Another field of research investigates inorganic nanoparticle powders that exhibit thermoelectrical properties, i.e. are able to transform heat into electrical energy. Nanostructured thermoelectrical materials have promise in energy recycling, where more efficient use of waste heat would make it possible to reduce, for instance, fuel consumption and CO_2 emissions.

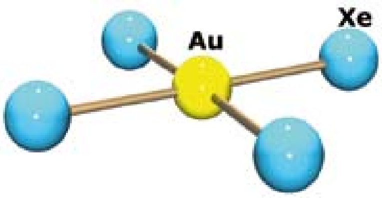
A joint interdisciplinary project with organic chemistry research at the Institute and the Charité – a project within the Collaborative Research Centre 765 (see p. 33) – investigates soluble nanoparticles. Shielded by a protective coating containing biologically active end-groups (e.g. carbohydrate mimetics), these particles are being tested as potential therapeutic agents against chronic inflammation.

▸ RG Schlecht | RG Spandl

Inorganic Molecule Chemistry

Novel noble gas and organometallic compounds

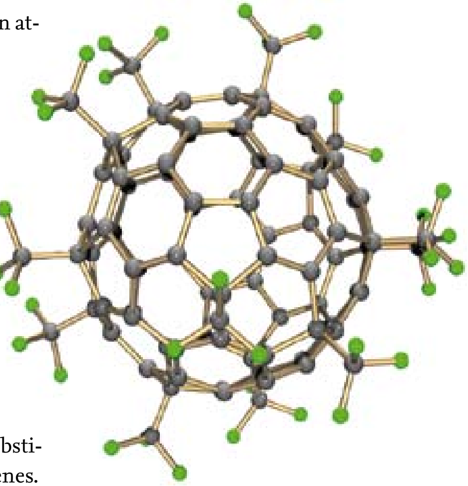
The synthesis of new molecules with previously unknown bonding patterns, unusual structures or remarkable properties is still one of the major challenges in synthetic chemistry. The diversity of possible combinations of elements and our ever-growing understanding of the nature of chemical bonding enables us to produce previously unrealizable compounds and study their properties. It has become almost routine in modern inorganic chemistry to use quantum chemical calculations to support such research.



$[AuXe_4]^{2-}$: The first compound with a noble gas-metal bonding

Stable compounds of the inert gas xenon and metals such as gold or mercury can be prepared in super acidic media and isolated in crystalline form. They contain metal-noble gas bonds determined primarily by single bonds between the 5d orbitals of the xenon and the d orbitals of the metals. Xenon in pure antimony pentafluoride (SbF_5) produces cations such as green Xe_2^+ or blue Xe_4^+. Such compounds are extremely interesting from the point of view of theoretical research: for example, experimental measurements and parallel quantum chemical calculations for the tetramer cation predict a linear structure with covalent bonds between the xenon atoms.

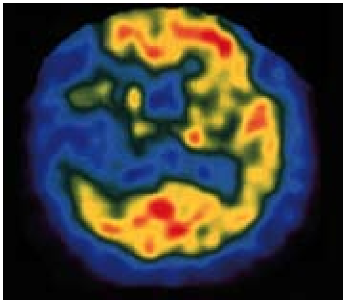
Further evidence of the value of theoretical chemists' predictions for synthetic chemistry is provided by experiments on trifluoromethylated fullerene molecules. Although there are billions of possibilities, scientists correctly predicted stable isomers of CF_3-substituted C_{74} and C_{78} fullerenes.



Experimentally determined structure of a CF_3-substituted fullerene

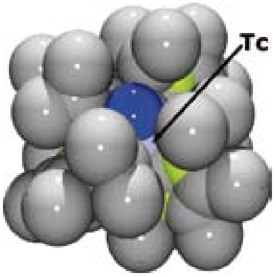
The experimental determination of the distribution of electron density enables us to directly evaluate controversial bonding concepts and provides a basis for further development of ideas about chemical bonding.

Molecular compounds containing radioactive rhenium and technetium complexes have medical applications. The β-radioactive rhenium isotopes ^{186}Re and ^{188}Re have potential applications in therapeutic nuclear medicine. On the other hand, complexes containing the metastable nuclear isomer ^{99m}Tc are already used in routine diagnostics to investigate a range of medical symptoms, e.g. cardiocirculatory disease, stroke and tumours, and to examine organ systems (e.g. lungs, liver and biliary tract or skeleton).



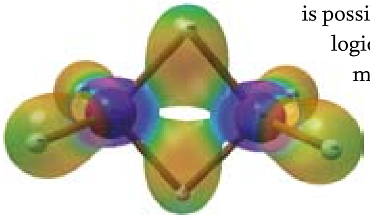
Cross-sectional image of the brain of a stroke patient (marker: technetium complex). Yellow-red: well supplied with blood; blue: poorly supplied with blood

To synthesize function-specific radioactive markers it is important to embed the metal atoms in a functional envelope of organic ligands. Recently, scientists at the Institute succeeded in producing air- and water-stable organotechnetium compounds with N-heterocyclic carbene ligands in which an envelope of carbon and nitrogen atoms almost completely shields the metal centre of the compounds. Hence, it is possible to selectively control the biological properties of the radioactive molecules by means of peripheral substituents.



Completely shielded technetium atom in a complex with four N-heterocyclic carbene ligands

Similar successes have also been reported using multidentate ligand systems that completely envelope the metal atoms and provide the marker molecules high thermodynamic stability because of their chelate effects. Coupling with biologically active peptides and proteins can produce function-specific bioconjugates.



Experimentally determined electron density in diborane (B_2H_6)

▸ RG Seppelt | RG Abram | RG Lentz

Stereoselective Synthesis and Bioorganic Chemistry:

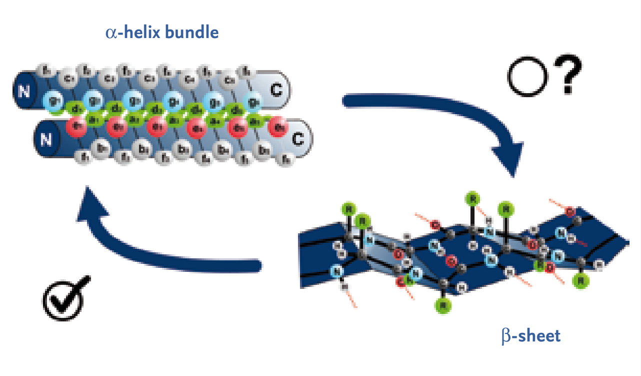
Natural products as models for drugs and materials

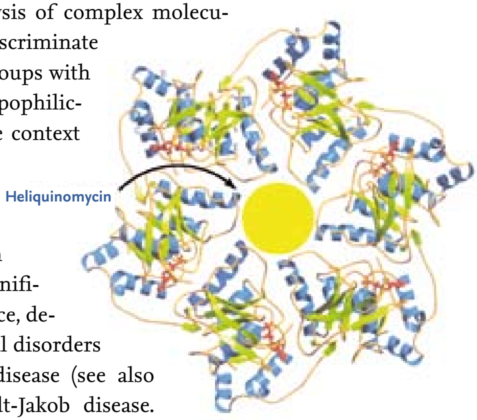
Chemists often take inspiration from natural products for the development of biologically active compounds and new materials. Typically however, only small quantities of the molecule of interest can be isolated from natural sources. For this reason, the elucidation of biosynthetic pathways, the determination of three-dimensional structure, and the analysis of how structure relates to property are predicated upon large-scale laboratory synthesis. Studies of this nature provide clues to the development of more effective drugs.

One very promising strategy for the pharmacological optimization of peptides and proteins is the introduction of non-natural amino acids. Modification of the structures of proteinogenic amino acids can enhance the resistance of proteins to protease-mediated degradation and can influence their transport across membranes. Indeed, the pharmacological efficacy of many peptides was made possible only as a result of this process.

Researchers in the fields of synthetic chemistry and bioorganic chemistry are developing new classes of non-natural amino acids. Heterocyclic amino acids are one example. By simulating a dipeptide unit, these scaffolds produce novel structures and biological properties – for instance, as protease inhibitors. Fluorine has also proved to be a useful tool in modulating the properties of peptides. In one project, the focus is on developing peptide models which, for the first time, enable the analysis of complex molecular interactions that discriminate between fluoroalkyl groups with differing steric sizes, lipophilicity, and polarity in the context of a native protein environment.

Peptide models used to study the conversion of helically structured peptides into amyloids. The conversion process is thought to be triggered by changes in environmental conditions, including pH value, salt content, metal ions, and spatial proximity to membranes. The conditions under which this conformational change can be reversed are still undefined.

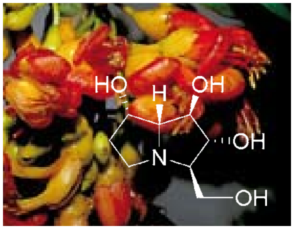




The spatial structures of proteins can vary. This plays a significant role in, for instance, degenerative neurological disorders such as Alzheimer’s disease (see also p. 28) and Creutzfeldt-Jakob disease. Changes in structure cause the formation and deposition of plaques, which irreversibly destroys the nerve tissue. Peptide-based model systems are being developed to improve our understanding of these phenomena.

Other research projects are also concerned with the interaction between natural products or synthetically available active compounds and proteins. To date, only minute quantities of the natural product heliquinomycin have been isolated from the fungus *Streptomyces sp* MJ 929-SF2. It is an antibiotic and one of the few known helicase inhibitors – substances that prevent unwinding of the DNA double helix. This property is viewed as very promising in the context of new disease treatments, including cancer. At this time, however, we lack adequate quantities of these inhibitors and their analogues, lending urgency to efforts to synthesize them.

In other projects carbohydrate and carbohydrate-like compounds such as glycosidase inhibitors or compounds such as pyridine derivatives are studied. Their suitability as multivalent ligands is currently being investigated by several cooperations working in the Collaborative Research Centre SFB 765 (see p. 33).



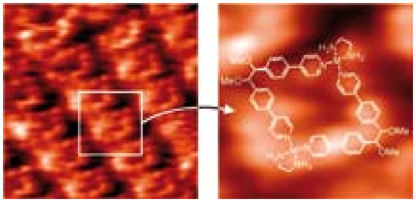
Australin, a glycosidase inhibitor from Castanospermum australe

Natural products and their organizational principles also serve as models for the development of new materials, which requires sophisticated synthetic tools and suitable methods for structure elucidation. In cooperation with the colleagues of Inorganic Chemistry, we are studying peptide models and heterocyclic compounds that can engage in multivalent binding interactions with the goal of achieving the reversible organization of functionalized nanoparticles in networks.

► RG Koksch | RG Reissig

Supra- and Macromolecular Chemistry

The powerful chemistry of weak bonding

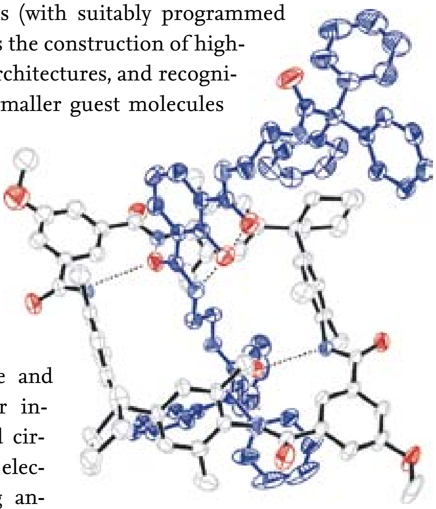


Macrocycles, highly ordered, precipitated on a copper surface (STM image; right 2 x 2 nm)

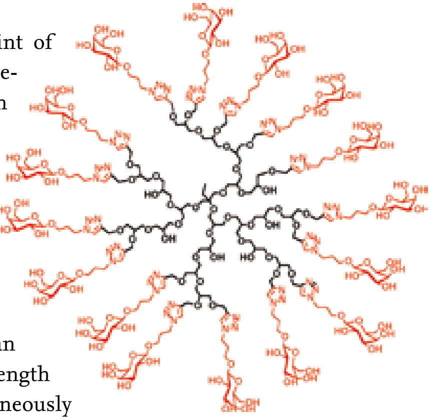
Life is vital and dynamic because it is constantly changing. This would be inconceivable if strong covalent bonds were all there was to hold atoms together in molecules. Without the hydrogen bridges between water molecules, water would not be liquid at room temperature. Weak forces between the components of cell membranes provide the elasticity that allows cells to change their shape. Without non-covalent forces, heredity – through the separation of the two DNA strands – would be next to impossible because it would not be fast enough. The human metabolism would collapse in chaos if enzymes were unable to recognize the molecules for whose reactions they are responsible.

Weak bonding interactions became a separate field of research for chemists only in the late 1960s. Since then, supramolecular chemistry has built up an almost uninterrupted chain of innovation. What began with the detailed investigation of individual weak forces now uses chemical templates to control reactions. Self-organization of molecules (with suitably programmed bonding sites) facilitates the construction of highly complex molecular architectures, and recognition and inclusion of smaller guest molecules in larger hosts makes possible the selective development of sensors.

Function-specific molecules are fashionable and developed with an eye to applications in the life and material sciences – for instance, on switches and circuit paths for molecular electronics, light gathering antennae for converting light into chemical energy and miniaturized molecular motors.



Axis (blue) threaded through a ring-shaped molecule (black) with the help of a template



Dendrimer with carbohydrate units (red) as bonding sites

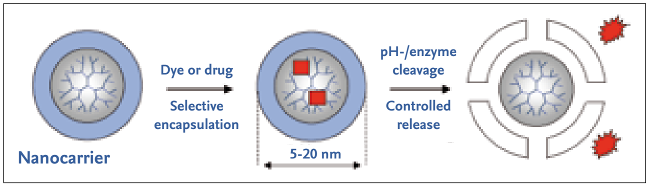
From a chemical point of view, numerous biomolecules are polymers with complex structures up to several nanometres in size. A length of this magnitude is big enough for a virus to dock with a cell, for example. At the same time, the virus can increase its bonding strength enormously by simultaneously bonding with a large number of docking sites. Chemists refer to this as multivalency. Selective intervention in such processes is only possible by applying the same strategy. Treelike, densely branched dendrimers fulfil the necessary requirements: a large diameter offering a dense cover with many bonding sites.

A number of aspects along this innovation chain are the subject of research at the Freie Universität Berlin. Mass spectrometers – ultra high precision balances to measure atomic mass – help to get investigate the nature of weak covalent bonds, because they make it possible to conduct high-vacuum studies of isolated complexes.

The focus is not limited to basic research; these weak forces also have practical applications: for instance, in the encapsulation of smaller molecules in the hollows of capsules, or controlling molecular movement through external signals that selectively influence non-covalent bonds. Such processes are used to study biochemical processes in synthetic model systems.

One process that has relevance in the material sciences is the selective structuring of surfaces through deposition of weakly bonded complexes. Scanning tunnelling microscopy makes it possible to view images of such surfaces down to the submolecular level. Thanks to the Collaborative Research Centre 765 „Multivalency“ (see p. 33) launched in 2008, supra- and molecular chemistry is firmly situated at the centre of research efforts.

▶ RG Schalley | RG Haag

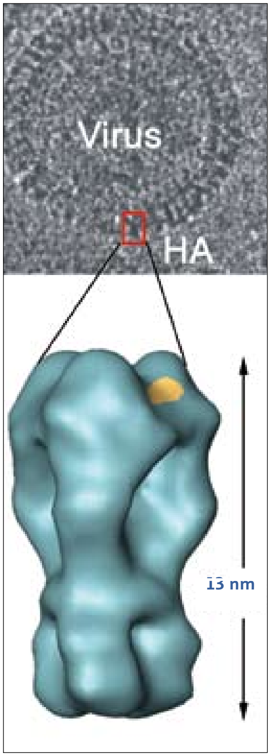


Electron Microscopy

Keyhole to the Nanocosmos

Many disciplines in chemistry require images of the exact structure of supra- or macromolecular architectures. This knowledge is necessary to understand how complex formations – proteins, say, or synthetic macromolecules used in nanotechnology – behave or function. These insights help chemists to answer questions such as the following.

How must certain polymers, so-called dendroamphiphiles, be arranged so that the stable aggregates they form in aqueous solution will always consist of the same number in the same order? In the interior of such structures guest molecules, for example drugs, can be "disguised" and safely transported. What is the process by which the addition of inhibitors that block certain macromolecular tools of viruses, so-called fusion proteins, efficiently prevent viral infections?



Above: Cryo-TEM micrograph of an influenza virus, red: a fusion protein (HA)
Below: 3D reconstruction of the HA; yellow: inhibitor binding site

Modern transmission electron microscopes (TEM) make it possible to carry out structural investigations on such objects, which are only a few millionths of a millimetre in size. However, a beam of electrons passing through biological and organic chemical materials may damage them. The cryo-TEM helps to reduce this problem: shock freezing embeds the objects in thin sections of vitreous ice of 100 to 200 nm thick, which can be observed under a microscope at -175°C.

Thanks to modern image processing techniques, even in low-contrast microscopic images full of interference it is in some cases possible to determine the three-dimensional structures of the objects. In this way, one can obtain information about the effects of modifications to individual molecules on the structure of their aggregates. With these insights, it should be possible in the future to construct selectively defined aggregates with specific size, structure and properties for nanotechnological applications.

▸ RG Boettcher

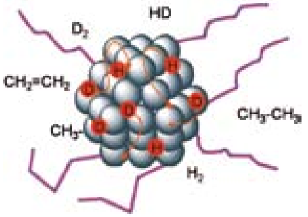
NMR Spectroscopy of Functional Molecules

Nuclear magnetic resonance, known as NMR, is an established technique for analysing the structure of chemical compounds. But it also lends itself to investigating many other important phenomena of molecular dynamics in different environments.

Systems	Phenomena
▸ Organic and organometallic model systems ▸ Liquids and solids ▸ Nanoparticles ▸ Drugs in solid excipients ▸ Polymers having acidic or basic groups ▸ Mesoporous solids ▸ Enzymes and enzyme models	▸ Hydrogen transfer and hydrogen bonding ▸ Isotope effects ▸ Acid-base theory ▸ Drug stability ▸ Confinement of molecules in pores ▸ Interactions of molecules in interfaces ▸ Catalytic processes

One example is ruthenium(Ru) nanocatalysts, which the Institute is investigating in cooperation with groups in Jena and Toulouse. Using different solid-state NMR techniques, mobile hydrogen atoms on the Ru surface and intermediate surface species generated by the catalytic hydrogenation of ethene were identified and characterized.

Aspartate aminotransferase, an enzyme found particularly in the liver, offers another example. Liquid and solid-state NMR spectroscopy was used to study its cofactor vitamin B6, which was marked in the active centre with the stable isotope ^{15}N. The geometry of the critical O-H-N hydrogen bond was characterized by comparison with model systems. The charge distribution, a function of the proximity of the protons to the nitrogen, is a prerequisite for initiating enzymatic catalysis.



Catalytic activity and hydrogen mobility of ruthenium nanoparticles (García-Antón et al., Angew. Chem. 2008)

Under physiological conditions in water neither the pyridine ring nor the aspartate side chain is protonated – in contrast to the active centre. Surprisingly, the dielectric properties of the active centre were found to be more typical of polar organic solvents than of aqueous environments.

▸ RG Limbach

Molecular Spectroscopy

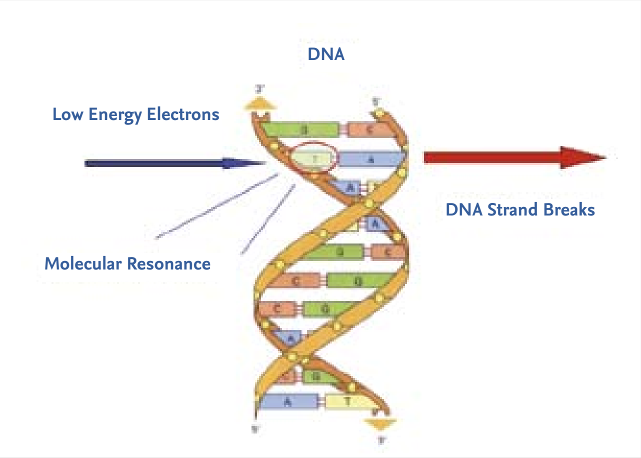
From model system to application

Size-dependent luminescence of semiconductor quantum dots (2-5nm): a sensitive diagnostic probe

Physical chemistry is one of the oldest interdisciplinary fields in the natural sciences. Fundamental physico-chemical research is the basis of a broad range of applications in the material, life and environmental sciences.

The progressive miniaturization of materials and their building blocks necessitates detailed investigations of the size-dependent properties of materials. These include studies of isolated atoms and molecules in the gas phase, the synthesis of clusters using molecular beam technologies and the preparation of organized molecular films. Nanoparticles can also be prepared and selectively structured by colloidal chemistry. Techniques used to study the systems' geometric and electronic structure include, among others, short pulse lasers, synchrotron radiation, free-electron lasers and the attachment of slow electrons (0 – 10 eV).

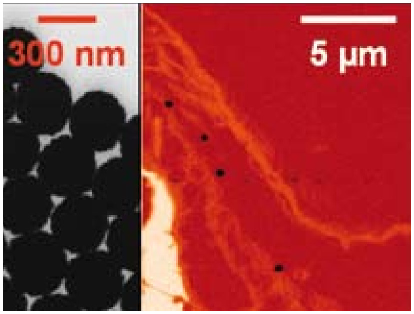
Damage to DNA as a result of the attachment of slow electrons



One focus of research is variable size clusters, as they are ideal model systems of nanoscopic building blocks of materials. Their size-dependent properties can be determined using soft X-rays and resonant electron attachment.

Using femtosecond laser pulses, researchers can optimize selective chemical-bond breaking and thereby control chemical reactions. Particle traps or nanoparticle beams make it possible to determine the intrinsic properties of individual nanoparticles without coming into contact with the substrate.

Because of their size-selective luminescent and magnetic properties, nanoparticles are also interesting as selective probes. Applications include the study of living cells and tissue – for both diagnostic and therapeutic purposes. The selective change in the particles' outer surface is an essential condition for their adsorption by the cell. Systematic investigations of these particles take account of their mono-, bi- and multivalent functionalities.



Nanoparticles (left) in living cells and tissue (right). Element-specific contrast using X-ray microscopy

Process studies on the atmospheric environment and on substances formed in astrochemical reactions are prerequisites for interpreting field measurements, besides improving modelling. Laboratory laser experiments simulate the photochemical decomposition of trace gases in the atmosphere, whereby stored single particles imitate the properties of the atmospheric aerosol and cloud particles. Kinetic experiments track the decomposition of non-volatile chemicals in the environment, for instance agricultural pesticides.

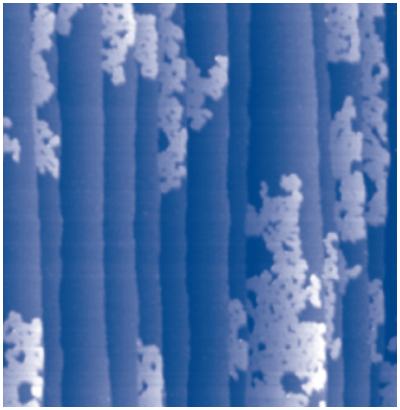
Innovative techniques are needed to enhance the sensitivity and selectivity of spectroscopic studies. Various collaborative projects are developing and experimenting with instruments applicable to synchrotron radiation and with free-electron lasers.

In the field of resonant electron attachment the research focus is on amplified resonance processes in biomolecular systems, in particular DNA and its building blocks. These experiments elucidate molecular processes in response to radiation damage in living cells or in the application of radio-sensitizers in tumour therapy. Such studies form the basis of more effective cancer therapies.

▸ RG Ruehl | RG Illenberger

Chemistry at the Surface

Our research focuses on chemical interactions occurring in model systems where (under ultra-high vacuum conditions) selected gases and metal vapours are brought into contact with well-defined single crystal surfaces of metals or oxides – also in the form of thin epitactic films.



[Detail of a] stepped rhenium surface partially covered with Ag atoms (STM image, 350Å x 350Å)

Current projects include the study of the interaction between hydrogen gas and metal surfaces with the object of understanding the processes that take place when hydrogen dissolves in storage materials. Analytical methods include low-energy electron diffraction (LEED), thermal desorption spectroscopy (TDS), vibrational loss spectroscopy (HREELS), photoelectron spectroscopy (XPS and UPS) and scanning tunnelling microscopy (STM).

For instance, as thin metallic films grow on metallic surfaces – either as flat layers or as 3D clusters – the thermodynamics and kinetics of growth are studied with LEED, TDS and STM. In a related project we investigate the co-adsorption of atoms of precious metals (gold or silver) and gases (for example, carbon monoxide CO) on a surface of a metal with a high melting point, such as rhenium. Under suitable conditions of pressure and temperature, the adsorbing CO molecules can, for example, reversibly compress adsorbed Ag or Au atoms into denser islands. This illustrates the structural dynamics of catalysts under the rigid conditions of technical catalysis – high pressures and temperatures.

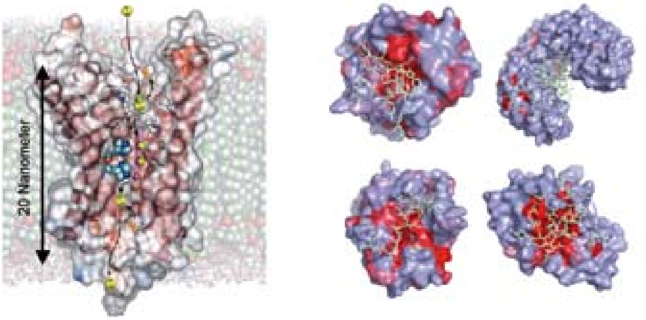
Another field of research concerns the catalytic activity of pure and gold-doped titanium dioxide films – e.g. of rutile(011)-(2x1). To give them the requisite properties, the films are prepared by epitaxy, after which their catalytic activity in the oxidation of carbon monoxide is studied. For the past 15 years it has been known that TiO_2/Au is an efficient catalyst for this reaction, although to date there is no satisfactory explanation for this behaviour. It is hoped that our research will contribute to a better understanding of the physical and chemical processes behind.

▸ RG Christmann

Macromolecular Modelling

Every biological cell contains a network of numerous interrelated processes – be they self-regulated or signal-controlled. Together they ensure the cell’s survival, growth and reproduction. Proteins, in their role as “molecular machines”, fulfil crucial tasks in this complex network. Despite their size – just a few nanometres (1 nm = 0.000000001 m) –, over the course of billions of years nature has endowed them with extremely precise structures and functions.

One of the most elementary processes in proteins is the transport of charge (in form of electrons and protons). In plants, for instance, such transfer processes are necessary to convert light energy into electrical energy – the first steps in photosynthesis. Practically all cells also use these processes to convert nutrients into own biomolecules. The formation and decomposition of numerous complexes, each made up of several proteins, sends out signals that turn various processes in the cell on or off. Many hereditary diseases are the result of problems that arise in the formation of such protein complexes. Another important group is channel proteins, which are found in cell membranes, where they regulate the flow of water or specific ions between different cell compartments.

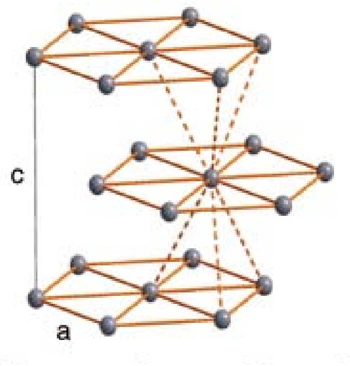


Left: ammonium channel protein © Science 2004
Right: four protein pairs as complexes; larger proteins complete, smaller proteins as rod-like model shown only in contact area

Theoretical studies contribute to a better understanding of the function of proteins in all these processes – in part with the goal of altering their course or mechanism. Thus, in the distant future it may be possible, for example, to solve the energy problem with artificial photosynthesis or to cure hereditary diseases. To this end, we conduct computer simulations of proton and electron transfer processes in photosynthetic proteins and ion conduction in channel proteins as well as computer-generated modelling of the spatial arrangement of proteins in their complexes.

▸ RG Knapp

Quantum Theories of Chemical Bonds and Reactions

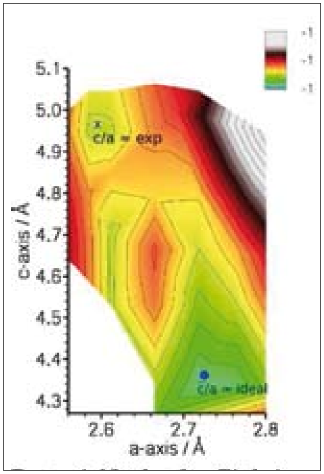


Hexagonal crystal structure of zinc

The application of physics with the help of mathematics and informatics to explain chemical phenomena: that is theoretical chemistry. It describes properties and phenomena of matter – from simple gas molecules to complex solids. It includes the quantum chemistry of molecular and periodic systems, quantum reaction dynamics and the theory of interactions between molecules and electromagnetic fields. The objective is always to explain and predict experimental observations, and for this purpose the continual development of theoretical methods is necessary.

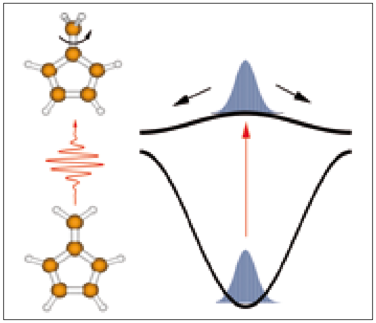
Quantum chemistry concerns the description of bonds between atoms in molecules and between molecules. Although the nature of chemical bonds is extremely diverse – from strong covalent or ionic bonds to weak hydrogen bonds and van der Waals interactions – the principle is always the same: a compromise between attraction of electrons to nuclei and repulsion among electrons and nuclei. Thus, methods need to be developed to describe ab initio the many electrons and their interactions in a condensed system – about 10^{23} in a cubic centimetre of matter – and to calculate material properties.

Potential energy surface for zinc vs. the two lattice constants



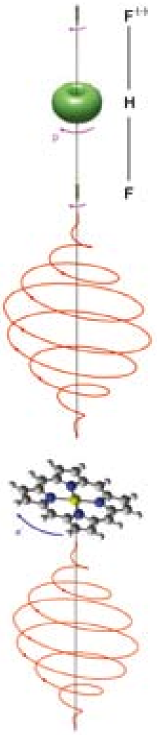
An important application of quantum-chemical methods is to the structure of metals. For example, one expects that metals with closed-shell atoms have a close-packed arrangement. Whereas magnesium does indeed have such a close-packed structure, zinc and cadmium are elongated along the c-axis.

Ab initio calculations of the potential energy surface enable us to explain the anomalous behaviour of zinc and to predict that zinc should also exhibit a closed-packed structure. Verification of this prediction presents a challenge to our colleagues in experimental chemistry.



Laser pulse excitation of molecular rotation described by wave packet dynamics

Another research priority is the theory of femtosecond chemistry, which is concerned with describing and controlling elementary chemical reactions in the femtosecond range (1 fs = 10^{-15} s). This is the time scale on which chemical bonds form and break. By using selective excitation, in particular ultrashort laser pulses, it is possible to control reactions in such a way that they result in a specific product. We simulate such processes by means of wave packets that describe the time evolution of bond lengths and angles. Produced by laser pulses, these wave packets move on the potential energy surfaces.



Excitation of the nuclear spin and electronic ring currents

The simulation and control of reactions of this nature requires a combination of methods used in quantum chemistry, quantum reaction dynamics and laser pulse optimization. Applications include the separation of nuclear spin isomers, controlled reactions in solids and the simulation of light-driven molecular rotors – a process that points in the direction of molecular engineering. Recently we have also extended these concepts to the control of electron movement, for instance, the induction of electronic ring currents. As electrons move a thousand times faster than atomic nuclei, the laser pulses must be 1000 times shorter. This requirement takes us into the uncharted territory of attosecond chemistry (1 as = 10^{-18} s).

▸ RG Manz | RG Paulus

Membrane and Structural Biochemistry

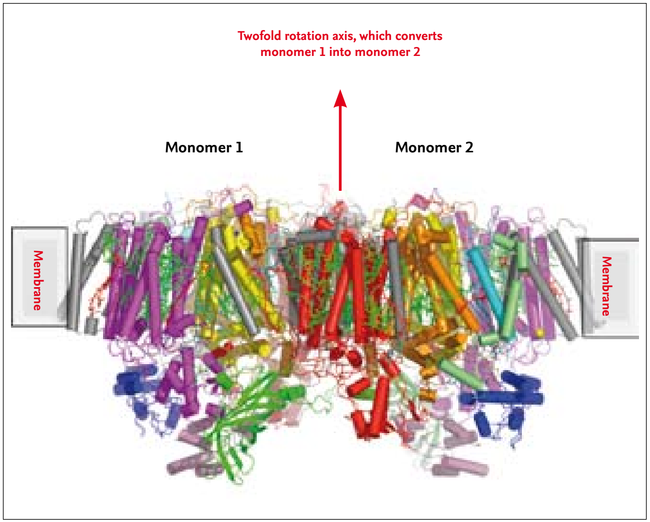
From intracellular membrane dynamics to protein structures

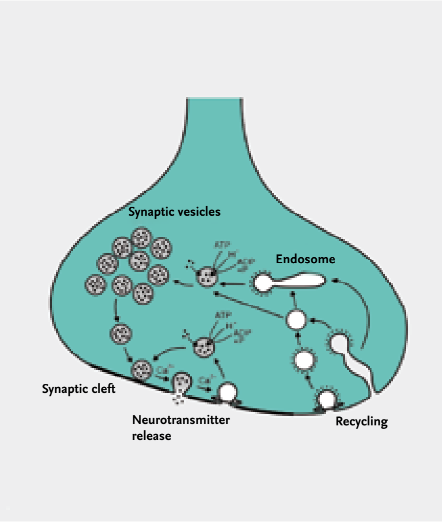
Anyone who has had the opportunity to view the almost endless tangle of membrane-encased organelles in a living cell under an optical or electron microscope inevitably asks the question: How on earth do you make sense of all this chaos? Yet, directed membrane traffic, following clear spatial and time patterns, is a necessary prerequisite for cells to perform their specific functions in tissue formation and signal transmission.

The investigation into the molecular rules governing intracellular membrane and protein dynamics, and the architecture of the protein complexes involved, is one of the main focuses of the Institute's work. These investigations, in turn, allow the study of the interactions between proteins and nucleic acids and membrane lipids.

Insight into the molecular architecture and dynamics of membrane-bound proteins is a prerequisite for an understanding of the central function of bioenergetic processes – such as the conversion of light energy into chemical energy in photosynthesis or physiological processes such as the transmission of chemical signals in the nervous system. These insights also play a fundamental role in the development of new drugs.

Structure of photosystem II (PSII), which is embedded in the thylakoid membranes of plants, green algae and cyanobacteria. PSII consists of two monomers, each of which contains 20 proteins (different colours) and 92 cofactors (green: chlorophyll; orange: carotenes; lipids). Cylinders: α-helices: arrows: β-strands





Membrane dynamics of chemical synapses. Once the small membrane-bound spheres containing messenger molecules (synaptic vesicles) have released the neurotransmitters into the synaptic cleft they are recycled

This research is supported by a constantly expanding range of molecular and cytobiological, biochemical and structure-biological methods. These include high-resolution optical and electron microscopic investigations of living or fixed cells and tissue and the development of biological model systems based on RNA technology and genetic methods. Multidimensional nuclear resonance spectroscopy and protein crystallography also play a key role. The last two reveal the atomic architecture of macromolecules – including detailed interactions between enzyme and substrate, receptor-ligand interactions and the complex interactions between biological macromolecules such as proteins, nucleic acids, carbohydrates and lipids. Knowledge of these structures permits the modelling of protein-protein dynamics or protein-ligand interactions using computer-aided techniques.

Important cooperation partners in these projects include the Berlin synchrotron BESSY, the Max Delbrück Centre for Molecular Medicine (MDC), the Leibniz Institute for Molecular Pharmacology (FMP) and the Charité Berlin. These research activities in membrane biochemistry form part of the "Neurocure" Cluster of Excellence.

Besides the sheer curiosity in deciphering rules and patterns of intracellular membrane dynamics and the molecular architecture of membrane-bound proteins and protein complexes, this research is also driven by the legitimate hope that the combination of functional and structural methods will result in new approaches to developing innovative drugs. At some point in the future these may form the basis of tailored therapies for neurodegenerative and hereditary diseases such as mental retardation or certain immune deficiencies.

▸ RG Haucke | RG Saenger

Biochemistry of Neurodegenerative Diseases

It is predicted that the rapid increase in the proportion of people suffering from dementia as the population ages will pose a major social challenge. Alzheimer's disease (AD) is the most common form of dementia and accounts for about 60 percent of all cases. The biochemistry of neurodegenerative diseases is a major field of research at the Institute and focuses on protein structure and function, signal transduction, and protein biochemistry.

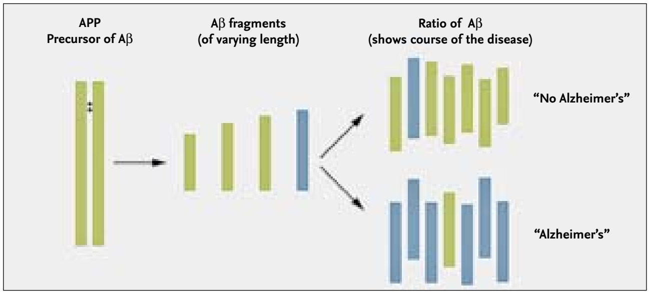
A characteristic feature of AD is protein deposits (so-called plaques and tangles) consisting primarily of the incorrectly folded proteins amyloid-β (Aβ) and tau, respectively. Efforts to explain their role in the pathogenesis of AD make use of biochemical models, including in vitro tests, cell culture systems and animal models, in conjunction with state-of-the-art techniques, such as MALDI-MS, NMR and EPR spectroscopy and crystallographic analysis.

One fundamental step in diagnostic and therapeutic advances is the identification and characterization of processes in the so-called amyloid cascade. The overarching goal of current projects – apart from discovering therapeutic target structures and lead substances – is the development of novel tools for the diagnosis and treatment of AD.

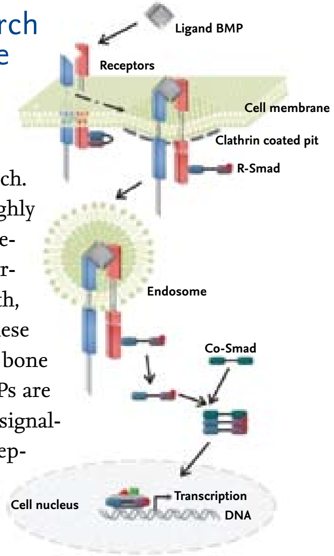
The therapeutic significance of basic research depends on the transferability of research results. Therefore, we cooperate closely with technology-transfer partners in industry and medical research institutions. For example, a test system patented for diagnostics is currently being further developed for screening and identifying compounds that can be used to target the cause of AD, i.e., toxic amyloid peptides.

Structural and functional analyses of key proteins that play a role in degenerative diseases are pursued within the framework of interdisciplinary research projects, in particular the Collaborative Research Centres (SFBs), postgraduate programs, EU initiatives such as NEURAD and and the BMBF-funded German network KNDD. ▸ RG Multhaup

An approach to Alzheimer diagnostics: the ratio of the Aβ forms (blue = symptomatic) gives an indication of the course or the onset of the disease.



Biochemical Basic Research of Regenerative Medicine



BMP signal transduction takes place when the ligand binds to the receptors, which are activated and phosphorylated Smad proteins. These migrate to the nucleus, where they control transcription of certain target genes.

The regeneration of damaged tissue and organs is a big challenge for both medicine and basic biomedical research. The body's own tissue repair is a highly coordinated succession of cell movements that resembles processes during embryonic development. In both, the embryo and the adult organism these events are stimulated by so-called bone morphogenetic proteins (BMPs). BMPs are growth factors that trigger specific signalling cascades through binding to receptors on their target cells – for example, embryonic or adult stem cells – eventually modulating the functions of these cells. For instance, this stimulus may cause stem cells to multiple or to differentiate.

The objective is to characterize these signalling cascades as precisely as possible so as to selectively develop therapeutic procedures for the regeneration of different tissues. The analyses include proteomics-based methods, modern microscopic techniques for visualization of signalling components in living cells, structure elucidation of central signalling components and production of novel, enhanced growth factors which will be analysed in functional test systems. These investigations will be undertaken in cooperation with experts from the fields of genetics, systems biology, structure biochemistry, biomaterial science and applied mathematics.

The intensity, duration and specificity of BMP-triggered signals in different species are coordinated by various but evolutionarily strongly conserved mechanisms – such as antagonists, co-receptors or nuclear co-repressors. However, in many genetically conditioned diseases precisely these components are defect, with the consequence that alterations in BMP signal transduction cause for example, vascular hypertension, bone diseases, fibrosis or cancer.

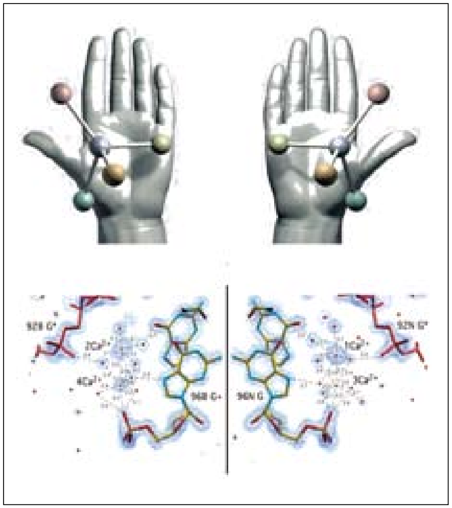
These projects are partly integrated into the Berlin Center of Regenerative Therapies (BCRT). As part of the excellence initiative BSRT was established as an interdisciplinary Graduate School, in which PhD students are educated also in biochemistry of tissue regeneration. ▸ RG Knaus

RNA Technologies

What makes RNA technologies so versatile is the structural and functional diversity of ribonucleic acid (RNA) and the ability to generate up to 10^{18} different RNA molecules within a few hours using methods of molecular evolution (SELEX method).

Moreover, “molecular scissors” developed from RNAs can be used to target and turn off other RNA molecules in living cells. The potential application of these so-called ribozymes is widespread and projects are under way to treat, among others, different types of cancer, hereditary diseases and virus infections.

In generating 10^{18} RNA molecules, one can also produce high-affinity RNA molecules, known as aptamers and spiegelmers. Similar to antibodies, these molecules have a wide range of potential for diagnostic and therapeutic applications in modern molecular medicine; in addition, they can also be used for the purification of, in principle, any biological substance. Over and above this, RNA technological procedures allow in vitro synthesis of natural and unnatural proteins – including incorporation of non-natural amino acids at specific sites in a protein.



Spiegelmers: structural details of a natural RNA molecule and its unnatural mirror image.

The Berliner RiNA Netzwerk für RNA-Technologien at the Freie Universität Berlin, founded in 1998 and funded by the Federal Germany Ministry of Education and Research, the Land of Berlin, and German industry, was the first institution of its kind in the world. An evaluation commissioned from the Fraunhofer Institute for Systems and Innovation Research on the occasion of the Netzwerk’s tenth anniversary came to the following conclusion: “The decision to invest in RNA technologies at an early stage was farsighted, innovative and courageous and – at the time the decision to initiate funding was taken – also unprecedented.”

▸ RG Erdmann

Making Chemistry Interesting

“PISA: German students top in chemistry!” – “Chemistry is ‘in’ at German schools!” – “Apprenticeships and university places in chemistry going like hot cakes!”.

German chemistry teachers can only dream of headlines like these. For, as international comparative studies regularly show, reality is another matter. Consequently, the Chemistry Education group is looking for ways to help German students get more out of chemistry.

What is it about school chemistry that puts off most young people? What can be done to give children from families in which education possibly plays little role a fair chance in class? Why is the public image of chemistry generally negative and what can be done to change this? To find answers to these questions and to make lasting improvements, we are concentrating on the following projects:

- Opportunities to promote competence in the natural sciences at primary school level
- Encouraging interest in the natural sciences – in particular chemistry – and motivating primary and secondary school students
- Providing career orientation and prototype – self-image comparisons and influencing them through special teaching projects such as Chemie (in) der Extra Klasse (= Chemistry in a Class of its Own), ParIS-Chemie (= Partnership between Industry and School) and WisA (= Know-How to Get Ahead)
- Analysing natural science and chemistry-related reading ability and identifying suitable teaching aids to improve it

Chemistry can be exciting as well as inspiring. To get this message across, the Chemistry Education group also organizes regular events for a broader public, e.g. Chemistry for the Whole Family, Nawi(e) FUntastisch (= Naturally FUntastic) and spectaculum (see p. 38).

▸ RG Bolte

Young Scientific Talent

The jump into the (not so) deep end

After a studying for a Master's and PhD, followed by postdoctoral research, not every chemist is interested in a career in the private sector. For many, becoming a professor at a reputable university with one's own working groups and choosing an exciting field for research is a very attractive proposition. The Institute of Chemistry and Biochemistry gives a number of young talented scientists the opportunity to realize this dream. This support is not purely altruistic: motivated scholarship holders and junior professors enrich the range of research topics, adding new accents and interesting approaches.

Take for instance Christian Hackenberger, who came to Dahlem in 2005 to work as Emmy Noether group leader in the unit of organic chemistry. He and seven research students are developing methods for chemoselective reactions with proteins and peptides. This allows, for example, residual phosphates or carbohydrates to be attached to glycoproteins without the need for complicated protecting group chemistry – exactly what happens in living cells. This is a trial period for Hackenberger, who has been coordinator of a research training group within the Collaborative Research Centre 765 since 2008. Equipped with generous research funding and, where necessary, the support of experienced colleagues, he has the opportunity to learn what a professorship involves besides his own creativity: independent teaching, raising third-party funds, supervising co-workers, budget management and much else.

Jens Beckmann has been gathering similar experience as a junior professor in inorganic chemistry. He joined the Institute in 2004 and works in the field of organometallic chemistry of main group elements, for example on hypervalent binary metaloxanes, which can absorb carbon dioxide, a greenhouse gas, and bind it as carbonate. What Beckmann, whose has a group of ten co-workers, most appreciates about junior professorships is the opportunity they offer for an early start to independent research and teaching. And, above all, he has had a much greater chance of building up a large research team that a colleague of the same age working on a habilitation thesis.

Collaborative Research Centres

To promote interdisciplinary work, the German Research Foundation (DFG) established its Collaborative Research Centres (SFB) program. Many scientists of the Institute are participating in SFBs being located in the Berlin area (SFB 448, 450, 498, 658, 740, 760 and the Transregio 19). At present, two SFBs are directly located at the Institute.

Perfect single crystals are the prerequisite for the structural analysis of proteins

SFB 449 brings together natural scientists, mathematicians and medical scientists working at the Freie Universität Berlin, the Humboldt Universität, FMP, the Max Delbrück Centre for Molecular Medicine and the Charité Berlin to study the "Structure and function of membrane-integral receptors". These complex proteins in the cell membrane are just as essential for the metabolism of each cell as they are for the effectiveness of drugs. Determining their functions will improve our understanding of the pathogenesis of many diseases and facilitate the development of causal therapies. When ligands dock to receptors, this triggers the transmission of extracellular signals to the cell interior, or signal transduction. SFB 449 analyses the processes at the relevant receptors at the molecular level. Atomic resolution macromolecular structural analysis plays a crucial role in this research.

Coordinator: Volker Haucke (until 2007: Wolfram Saenger)
www.chemie.fu-berlin.de/sfb449

SFB 765 – "Multivalency as chemical organization and action principle: New architectures, functions and applications" is a collaboration between researchers of the Institute and colleagues at the Humboldt Universität, the Zuse Institute Berlin, the FMP and the Charité Berlin. Drugs, viruses and the body's own messengers usually use multiple interactions with their target structures. They often have a choice of more than one "contact site" to dock to their receptors. (The same holds for the receptors.) Multivalency also plays a central role in the organization of small molecules to form larger units. The SFB investigates changes in the physical, chemical and pharmacological properties of molecules as a result of acquiring more than one binding site. It is hoped that this research will result in more effective drugs and new materials as well as suitable model systems that will advance the study and understanding the fundamentals of multivalency effects.

Coordinator: Rainer Haag
ww.sfb765.de

A Prize Achievement!

The Klung-Wilhelmy-Weberbank Award

Klung
Wilhelmy
Weberbank
Preis
chemie
physik

Excellent research deserves commensurate recognition – scientific and social. This is the objective of the Klung-Wilhelmy-Weberbank Award for outstanding young scientists in Germany. It is awarded annually, alternating between chemistry and physics. The prizewinner is chosen by a committee of experts in close cooperation with the sponsors: the Otto Klung Foundation at the Freie Universität Berlin, the Dr. Wilhelmy Foundation and the Fördergesellschaft der Weberbank gGmbH.

With a purse of € 100,000, the award is one of the largest privately financed prizes for natural scientists – and one of the most prestigious. The object of the sponsors is to support exceptionally qualified young scientists and their work.

The roots of the Klung-Wilhelmy-Weberbank Award go back to the Otto Klung Prize, which was first awarded in 1973. Until 1978, the Prize was reserved to students working on doctoral or habilitation theses in chemistry or physics at the Freie Universität. Apart from proven research ability, age is also a criterion: at the time of the award ceremony the prizewinner should not be much over 40 years of age.

Nominations for the award are submitted by selection committees made up primarily of professors of the Institute of Chemistry and Biochemistry or the Department of Physics at the Freie Universität, respectively. The final decision lies with the sponsors of the award. Committee and sponsors have amply demonstrated their keen sense of excellence. All of the awardees to date have made a name for themselves in their respective fields; five of them have won the Nobel Prize. Moreover, many of the winners in chemistry have subsequently been awarded the Leibniz Prize of the Deutsche Forschungsgemeinschaft, the “German Nobel Prize”.

Chemistry Award Winners

- Frank Neese, 2008
- Ingo Krossing, 2006
- Peter H. Seeberger, 2004
- Tom Tuschl, 2002
- Matthias Driess, 2000
- Michael Famulok, 1998
- Carsten Bolm, 1996
- Wolfgang Schnick, 1994
- Stefan Jentsch, 1992
- Klaus Rademann, 1990
- Gerhard Bringmann, 1988
- Hartmut Michel, 1986
- Martin Quack, 1984
- Wolfgang A. Herrmann, 1982
- Helmut Schwarz, 1980

Programs and Courses

The Institute of Chemistry and Biochemistry offers programs in chemistry, a program in teacher training in chemistry and a program in biochemistry. The programs in chemistry are Bachelor/Master (B/M) programs. Biochemistry is expected to replace its current diploma program with Bachelor/Master programs in the 2009/10 winter semester. In addition, the Institute is also responsible for some courses in the B/M program in bioinformatics, which is offered jointly by the Department of Mathematics and Informatics, the Department of Biology, Chemistry and Pharmacy and the Charité Berlin. Students can continue on to a PhD in all of these subjects.

As the chemistry programs switched to the B/M structure in 2002, the Institute already has a lot of experience in these programs. The Bachelor program takes six semesters and the Master’s program four semesters. In addition to a solid education and training in the classic disciplines – inorganic, organic, physical and theoretical chemistry – the two programs have a diverse offering that reflects current and future-oriented research topics.

The ensure that the program fulfils the professional qualifications expected of a Bachelor’s degree, course requirements include – apart from the mandatory university-wide general career skills modules – integrated practical work experience and a number of electives (e.g. in related fields of science, but also in, among others, journalism and business management).

About 25 percent of the courses in the Master's program are electives (subject to the approval of the Examination Committee), which allows students scope to pursue particular interests and react flexibly to current developments. To ensure that students acquire the necessary language skills at an early stage, the Master's program is bilingual, with some of the lectures offered in English and others in German.

Students with a Bachelor's degree have a choice of continuing with the Master's program in chemistry or a Master's program in another subject. At present the Freie Universität Berlin offers:

- Master of Science in Polymer Science (see p. 37), a joint program of the Technische Universität Berlin, the Humboldt-Universität zu Berlin and the Universität Potsdam.
- Master in Public and Private Environmental Management, a joint program of the Department of Law and the Department of Political and Social Sciences.

The chemistry program is certified as accredited, meets recognized standards of quality and, thus, the criteria of the Bologna Declaration.

As students may start the program in either the winter or the summer semester, almost all courses in the Bachelor program are offered every semester. This fact, and a complex coordination of class and examination timetables, enables all students, even those with individualized courses of study to complete their programs within the allotted time. Academic counselling is provided by three student advisors, a student office and a series of student-run counselling sessions. The Institute regularly assesses students' views on teaching quality and the organization of the programs of studies. For this purpose the Institute also conducts on-line evaluations of courses. Since 2004, the Department has awarded a Prize for Excellence in Teaching. The winners, one from each Institute in the Department, are determined on the basis of results of the student evaluations.

For further information please visit:
http://www.chemie.fu-berlin.de/lehre/studiengaenge.html

Master's Program in Polymer Science

Polymers have come a long way from cheap plastic bags, polystyrene packaging and another term for mountains of non-degradable rubbish. Whether Gore-Tex jackets, dialysis filters, biodegradable bone nails, dragée blister packaging or miniature building blocks for nanotechnologies, modern polymers are the state-of-the-art synthetics: high-tech materials that replace expensive natural resources in many areas and do things that even nature never thought of.

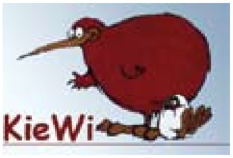
Polymer science is a diverse, interdisciplinary field at the interface of chemistry, physics, engineering and process engineering. It also has a huge on the material sciences. Thanks to multifarious existing and potential applications, polymers are playing an increasingly influential role in many areas of daily life. Hence, it comes as no surprise to learn that already 30 percent of all scientists in the chemical industry work in the field of polymers. To provide students an optimal education and training in the theory and practice of this promising discipline, the three universities in Berlin and the Universität Potsdam have bundled their competencies: since the 1999/2000 winter semester they have offered a joint Master's program in "Polymer Science" taught in English.

The Institute of Chemistry and Biochemsitry at the Freie Universität Berlin is responsible for polymer chemistry and polymer synthesis; physics and characterization of polymers are taught at the Humboldt Universität zu Berlin, polymer technologies at the Technische Universität Berlin, and properties of polymers and colloids at the Universität Potsdam.

The Master's program in Polymer Science is a two-year program, and students can start in either the winter or summer semester. For further information please visit *www.polymerscience.de.*

Chemistry's Guide to Nature

Our way of looking at the world is strongly coloured by the natural sciences. To understand the basic issues underlying the leading global questions of our time – energy supplies, food, bio-engineering, environmental pollution and climate change – and to contribute to solving them it is essential to have a solid knowledge of chemistry. But even apart from this, chemistry is fun: it stimulates our minds and arouses our interest and enthusiasm. For proof of this, we need look no further than the FU children's university, the FU Summer School and the packed events of Science Night, in which the Institute of Chemistry at the Freie Universität is heavily involved.



Spectacular public performances, demonstrations and presentations are only an introduction, a first contact with the field. To awaken children's lasting interest in natural science, instructors in the Chemistry Education group pin their hopes on a succession of concepts that build upon one another. For instance, since 2004 primary-school children (from the third class onwards) can enrol of a two-year program of weekly chemistry lessons. Successful KieWis graduate to Research Foxes and finally to Young Researchers – and at the end of the course receive the "Golden Test Tube with Ribbon". KieWi & Co. children themselves become guides and facilitators, passing on their knowledge and helping visitors to perform experiments at special events such as Chemistry for the Whole Family, Nawi(e) Funtastisch and spectaculum .

For older schoolchildren there are the "Chemistry in a Class of its Own" holiday courses. Here they have an opportunity to browse around the Institute for a week, meet professors and do experiments related to fundamental questions of bio-energy, biochemistry and climate change in the Chemistry Education labs. Some former participants have already returned to the Institute as chemistry students. Over and above this, colleagues at the Institute contribute to continuing education courses for teachers and educational offerings for school classes – whether in the didactics of chemistry or in the specially equipped Department NatLab.

▸ RG Bolte

Professorships, Junior Research Groups, Areas, Links

Inorganic Chemistry and Radiochemistry

The chemistry of radioactive metals
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Fluorine and Organometallic Chemistry
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Inorganic Nanostructures
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Noble Gas and Halogen Chemistry
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Organometallic Chemistry (JRG)
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Metal-Oxygen Cluster (JRG)
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Organic and Macromolecular Chemistry

Dendritic Polymers
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Amino Acid and Peptide Chemistry, Peptide Models and Folding
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Synthesis of Natural Products and Drugs, Heterocyclic Chemistry
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Mass Spectrometry and Supramolecular Chemistry
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Enantioselective Catalysis, Stereoselective Synthesis (JRG)
Constantin Czekelius (OC) | cczekeli@chemie.fu-berlin.de
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Multichromophoric Dye Systems on Functional Surfaces (JRG)
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Bioorganic Chemistry (JRG)
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Organometallic Chemistry, Catalysis (JRG)
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3D Electron Cryo-Microscopy
Christoph Boettcher | christoph.boettcher@chemie.fu-berlin.de
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“Chemistry in Our Daily Life” as Popular Science
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Physical and Theoretical Chemistry

Surface Physical Chemistry and Elementary Gas-Surface Interactions in Heterogeneous Catalysis
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Electron and Photon Induced Reactions in Free and Bound Molecules
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Macromolecular Modelling and Bioinformatic
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NMR Spectroscopy of Complex Systems
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Crystallography at Low and Ultra Low Temperatures, Charge Density Determination
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Theory of Molecular Reaction Dynamics
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Quantum Chemistry of Molecules and Solids
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Molecular Spectroscopy, Clusters and Nanoparticles, Life Science Applications, Environmental Process Studies
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Characterization and Synthesis of Nanoparticles (JRG)
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Theory for the Control of Molecules by Electromagnetic Fields
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Femtosecond Spectroscopy (JRG)
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Theory of Charge and Excitation Energy Transfer in Macromolecules (JRG)
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Hydrogen Bonds in Solids and on the Surface of Catalysts (JRG)
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Strong Hydrogen Bonding in Liquefied Gases (JRG)
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Biochemistry

RNA Technologies in Biotechnology and Molecular Medicine
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Membrane Biochemistry and Molecular Cell Biology
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Signal Transduction of Bone Formation and Regeneration
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Biochemistry of Neurodegenerative Diseases
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Protein Crystallography
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Molecular Cell Biology (JRG)
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Development and Function of Synapses (JRG)
Claudia Miech (BC) | cmiech@chemie.fu-berlin.de
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Didactics of Chemistry

Empirical Research on Science and Chemistry Education
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Associated Research Groups of the Institute

Medicinal Chemistry, Chemical Biology
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Chemistry and Biology of Carbohydrates, Vaccine Development, Microreactors
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NMR Spectroscopy of Proteins
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Protein Crystallography
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Photoelectrochemistry, Photocatalysis, Solar Energy Conversion
Helmut Tributsch (HZBME) | tributsch@hmi.de
www.chemie.fu-berlin.de/tributsch

T Cell Signalling, Protein Engineering (JRG)
Christian Freund (FMP) | freund@fmp-berlin.de
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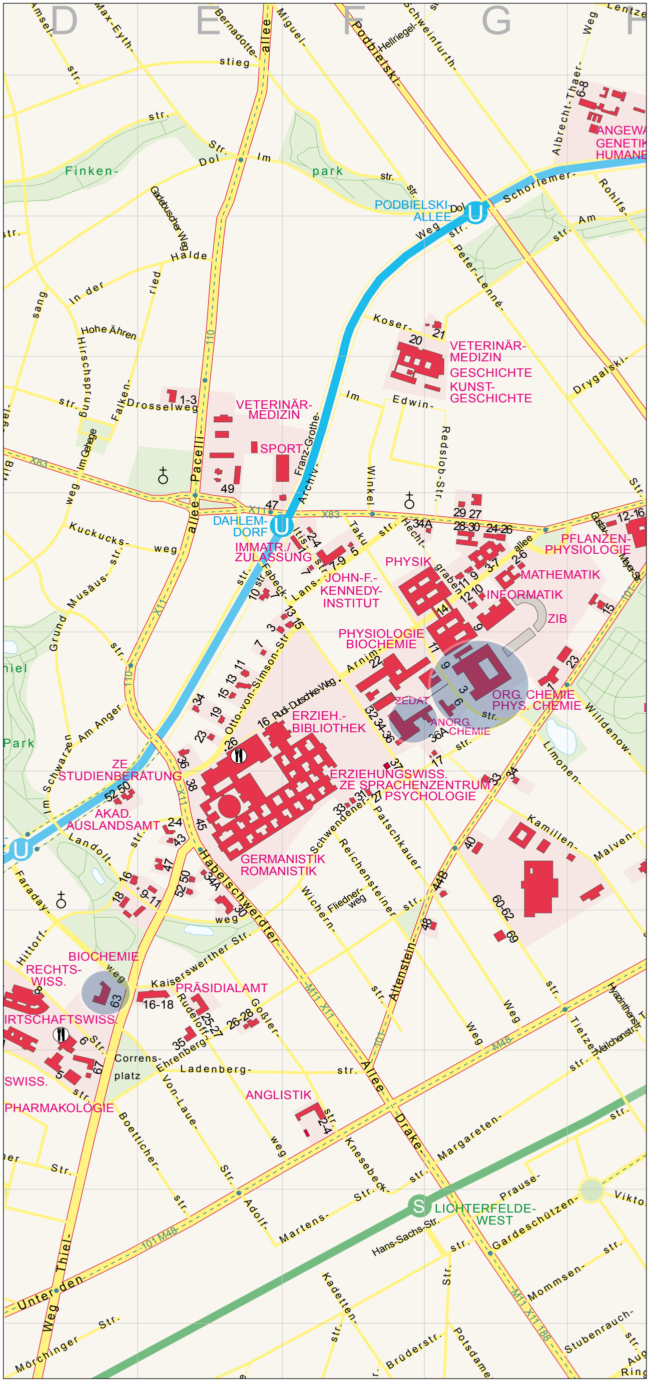
NatLab – Informal Hands-on Science Laboratory for School Students at the Department of Biology, Chemistry, Pharmacy
Petra Skiebe-Corrette | skiebe@zedat.fu-berlin.de
www.natlab.de



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Building Takustrasse 6, 14195 Berlin
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Biochemistry	Tel. +49 30 838-52938
Polymer Science	Tel. +49 331-9771229 (Uni Potsdam)

Library – Institute of Chemistry and Biochemistry

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www.bcp.fu-berlin.de/chemie/bibliothek/

Opening hours:
Mo-Fr 9.00-17.00 (lecture time)
Mo-Fr 9.00-16.00 (out of lecture time)

Information in Internet

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www.fu-berlin.de

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Institute of Chemistry and Biochemistry
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