

**Top: A chip bearing three different cantilevers for AFM imaging. The very sharp tip at the end of the cantilever scans the surface of the sample (Scale bar: 25µm).**

SEM image taken during a project in the group of Suzi Jarvis, Dublin. Image: Gillian Kaggwa.

**Bottom: High resolution AFM image of OmpF proteins reconstituted in a lipid bilayer and measured in buffer solution (Scale bar: 25nm).**

Patrick Frederix et al., Biophys. J. 2009

**Top: Radiolar**

Picture & coloration: Daniel Mathys, Center for Microscopy (ZMB), University of Basel

**Bottom: Metal islands on a cantilever, shortly before coalescence, serve as an experimental model system to understand micromechanical biosensing.**

Raphael Grüter, Rachel McKendry & Bart Hoogenboom, London Centre for Nanotechnology, University College London

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# master's program in nanosciences

## Nanosciences

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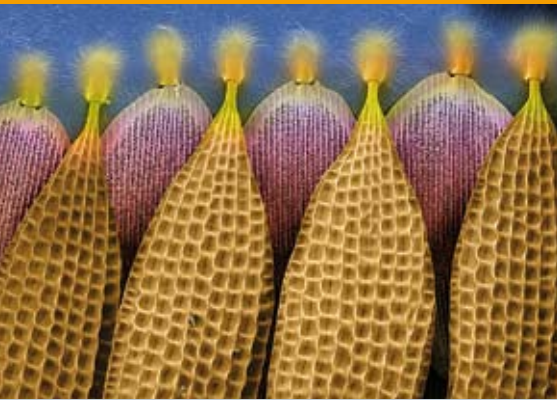
[www.nanostudy.unibas.ch](http://www.nanostudy.unibas.ch)



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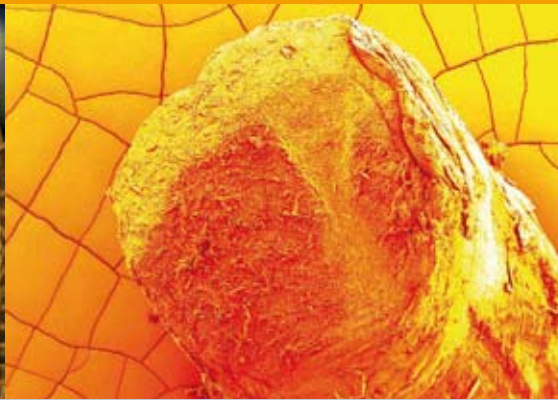
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**Detail from a Butterfly Wing.**

Picture & coloration: Daniel Mathys, Center for Microscopy (ZMB), University of Basel

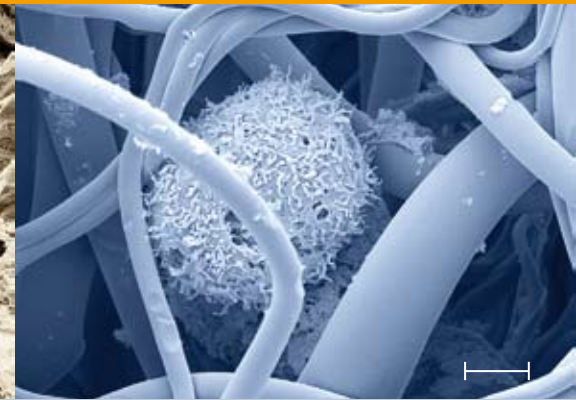


**Biopsy of human osteoarthritic knee joint cartilage (grade 3, Outerbridge scale) prepared for Scanning Electron Microscopy (SEM). Specimen is artificially colored.** Marcel Düggelin and Martin Stolz. Image ZMB.



**Mesenchymal stem cells on a three dimensional scaffold. Cells spread over a groove in the scaffold (Scale Bar: 5µm).**

Sample: Géraldine Guex. Image taken at the ZMB.



**Mesenchymal stem cells embedded in a meshwork of electrospun fibres of polyactive (Scale Bar: 5µm).**

Sample: Géraldine Guex, during Master Thesis in the group of Ivan Martin, ICFS, University Hospital Basel. Images taken at the ZMB (Evi Bieler), University of Basel.

**Master of Science in Nanosciences**

Since autumn 2002, the University of Basel has offered an interdisciplinary study course based on biology, chemistry and physics. This course in nanosciences is unique in Switzerland. For students holding a Bachelor in Nanosciences or a comparable degree, the University of Basel offers a Master's Program to obtain a Master of Science in Nanosciences. The Master's course usually lasts three semesters.

To achieve a Master's degree, students not only follow lectures and seminars, but complete two different elective projects and a Master's thesis. The projects provide students with the important skills needed to carry out their own independent scientific research and will be completed in two different research groups.

The Departments of Biology, Chemistry, Physics and Mathematics all offer lectures and seminars for the Master's students, enabling interdisciplinary studies. Due to the broad range of courses on offer and the large freedom of choice, Master's students can individually schedule their studies to a large extent. A major subject, with at least 16 ECTS, in which the Master's thesis will be completed (i.e. biology, chemistry or physics) has to be chosen. In a minor subject, lectures accredited with 14 ECTS have to be attended. During the six months dedicated to the Master's thesis, students follow their own research project and gain a broader insight into what working in science involves.

After an examination and a short presentation of the Master's thesis at the end of the course, students will obtain the degree of a Master of Science in Nanosciences.

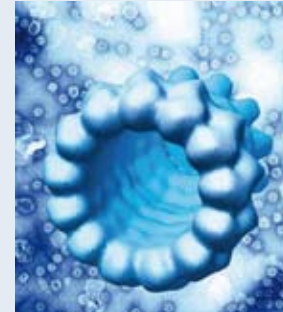
**Major Biology**

The Biozentrum offers a large variety of courses covering several subjects, ranging from immunology to proteomics: *Advanced Immunology, Recent Advances in Systems Biology, Neurological Diseases, Cellular Signalling, Proteomics* and *Drug Discovery Research* to mention a few only. Research groups examine the structures of biomolecules, as well as the quantum mechanics of nanomachines such as molecular motors and energy converters (ATPase). Other projects focus on cancer research and the investigation of human (cancer) cells using an Atomic Force Microscope (AFM). Tissue engineering and biodegradable materials (at the University Hospital of Basel) form an additional branch in the field of Nanobiology.



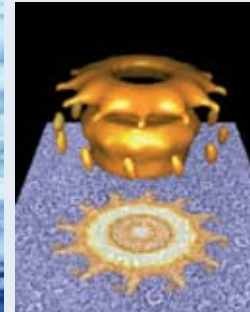
**Student operating an optical microscope with an integrated AFM. A cantilever (between the tweezers) is mounted on a glass block to perform AFM on biological samples immersed in liquid.**

Picture: Annette Roulier



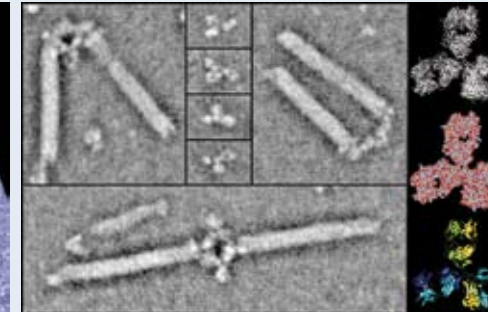
**3D model of a pore forming toxin ClyA from *Escherichia coli* obtained by low dose cryo-electron microscopy.**

Nora Eifler et al. The EMBO Journal 2006



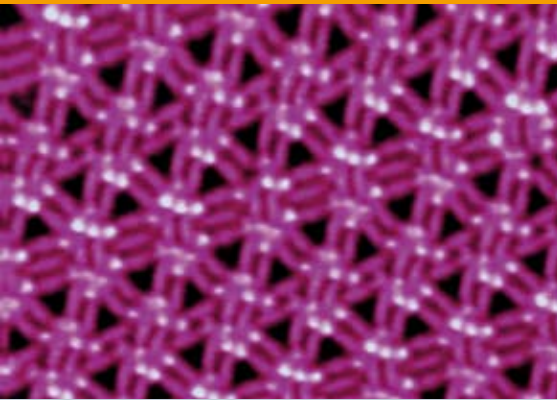
**3D model of the channel forming outer membrane secretin PulD from *Klebsiella oxytoca* determined by low dose cryo-electron microscopy.**

Mohamed Chami et al. J. Biol. Chem. 2005



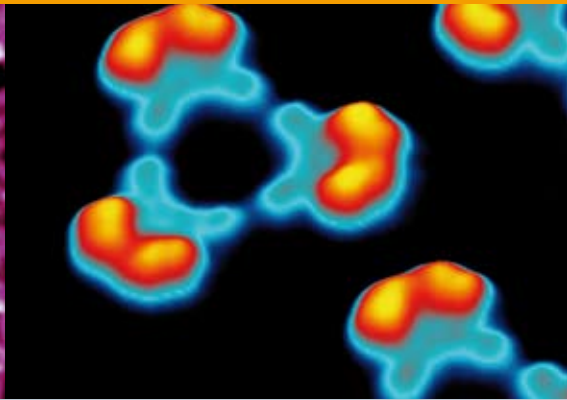
**The tip of the injectisome needle complex of pathogenic *Yersinia enterocolitica* is labeled by specific antibodies known to protect against the plague. The negatively stained sample was imaged at 500,000x magnification in Scanning Transmission Electron Microscope (STEM).**

Catherine A. Mueller et al., Science 2005



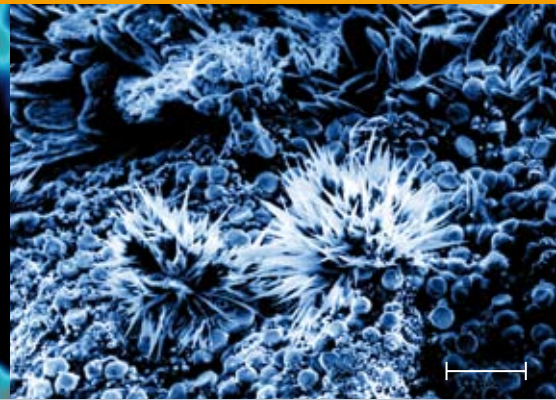
**STM image of a BOC protected phenyl derivative on a Cu(111) surface.**

Serpil Boz, in the group of Thomas Jung and Meike Stöhr.



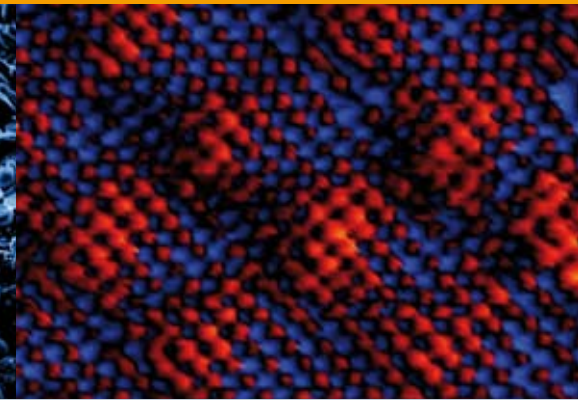
**Porphyrins on copper (111). 3 Porphyrins forming a trimer.**

Meike Stöhr / Hans Joachim Güntherodt



**SEM picture of tungsten oxide crystals on EPOXY glue. These nice structures were found while examining etched tungsten AFM/STM tips (Scale Bar: 20µm).**

Christian Held



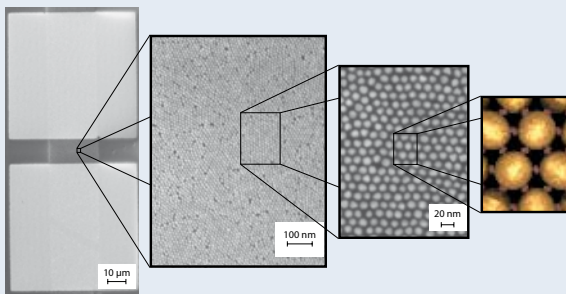
**Lateral force map of the superstructure formed by an ultrathin KBr film deposited on NaCl (Frame size 10nm).**

Enrico Gnecco / S. Maier et al., Phys. Rev. 2008

## Major Physics

Nanophysics aims to unravel the physical principles that are unique to nanosized objects and processes occurring specifically at the nanometer scale. Examples are quantum phenomena in quantum dots, the microscopy and manipulation of single atoms, atomic assemblies and molecules.

Lectures in *Electronic Structure* and *Atomistic Simulation*, *Quantum Mechanics* and *Superconductivity* contribute to the package of lectures from the Departement of Physics. Projects and experiments in Nanophysics are concerned with the production, manipulation and examination of nano structures such as molecular wires and transport properties of molecular junctions. Other projects focus on topics in *Quantum Computing and Quantum Coherence* such as manipulation of single spins, decoherence of spin-qubits and the study of entanglement in nanostructures.



**A monolayer of gold nanoparticles serves as a test platform for characterizing the electrical properties of molecules. The active elements in the device are single molecules (red) connecting neighboring nanoparticles (yellow).**

Michel Calame / Christian Schönberger



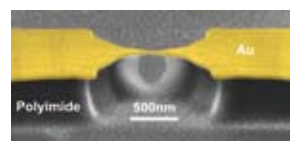
**Dilution refrigerator capable of cooling samples to the milli-Kelvin temperatures, required to observe novel quantum effects in nanostructured samples.**

Dominik Zumbühl

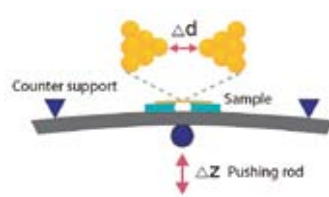


**Cartoon double quantum dot containing two electrons, formed by surface Gold gates (bright areas) on a GaAs 2D electron gas, fabricated in the Basel cleanroom facilities. We investigate the electron spin (red arrows) for storage and manipulation of quantum information.**

Dominik Zumbühl



**Microfabricated metallic bridge.**



**Mechanically controllable junctions are used to study the charge transport through single molecules. The junction is tuned on the sub-nanometer scale by bending.**

Michel Calame / Christian Schönberger

**Left: Samples with nanostructures are bonded onto a chip-carrier and measured at low temperatures.**

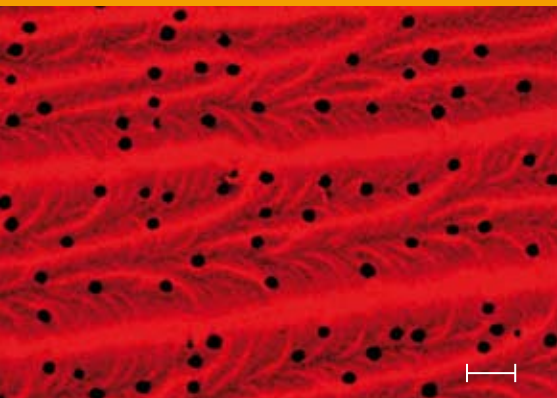
**Middle: Dark field image of a sample that consists of a carbon nanotube Josephson junction in an engineered electromagnetic environment.**

Markus Weiss / Christian Schönberger

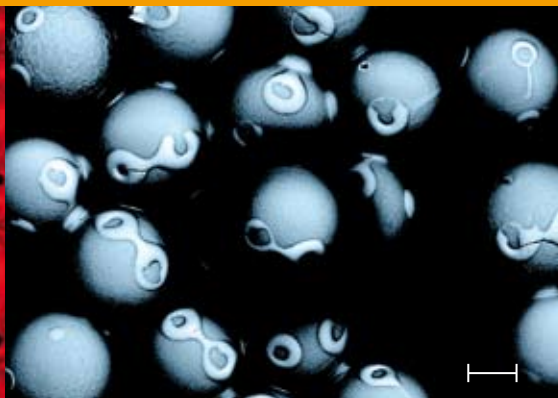
**Nanowires provide a unique platform to create quantum electronic devices.**

**Picture: InAs nanowire double quantum dot.**

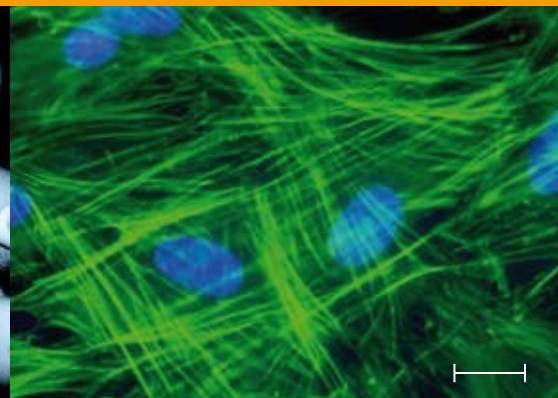
Szabolcs Csonka / Christian Schönberger



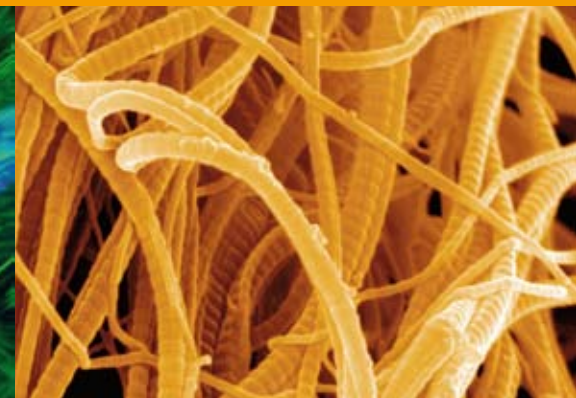
**Lipid stars on the water surface, surrounded by a fluorescent polymer (fluorescence scanning microscopy, Scale bar: 10µm).**  
Katarzyna Kita / Wolfgang Meier



**Silver nanoparticle formation in the form of "Nano-Glasses" on polymer beads (Scale bar: 50µm).**  
Tünde Vig Slenbers / Katharina M. Fromm et al., Angew. Chem. 2009. Image ZMB.



**Mesenchymal stem cells stained for actin stress fibres (green). Nuclei are stained blue (Scale bar: 20µm).**  
Master Thesis (Géraldine Guex) in the group of Ivan Martin, ICFS, University Hospital Basel.



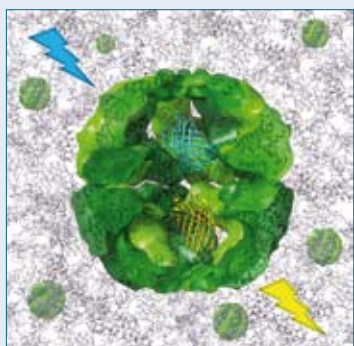
**SEM image of human osteoarthritic knee joint cartilage (grade 3, Outerbridge scale). The image reveals extensive meshwork disarrangement such as collagen fibril tangling and splitting of collagen fibrils into thinner fibrils.**  
Daniel Mathys and Martin Stolz. Image ZMB.

## Major Chemistry

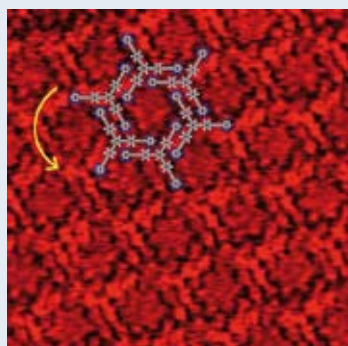
The Department of Chemistry offers courses covering topics such as *Macromolecular Chemistry*, *Supramolecular Chemistry*, *Synthesis and Physical Properties of Nanoscale Systems* or *Quantum mechanical Aspects of Computational Chemistry*. Experimental projects in Nanochemistry concentrate on the generation and examination of self-organized structures, as well as surface chemistry and the observation of reactions on single molecules. Several projects are strongly linked to molecular electronics, where previously synthesised nanowires are examined.

## Studies abroad

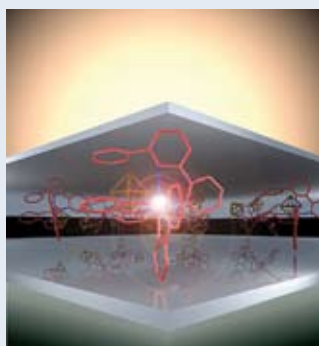
Projects as well as the Master's thesis can be performed at a University abroad. The University of Basel offers students applying to a different university, a scholarship to cover additional expenses. Several students have taken advantage of this and carried out their project work in Denmark, Ireland, Great Britain or even in the USA. An international nanostudents conference has been held every year since 2007 giving students the opportunity to meet other nanostudents. Exchange programs are strongly supported from different universities. The Nanosciences Curriculum offers great opportunities to gain expertise abroad.



**Protein-polymer hybrid material in which the biomolecule detects damage of the polymer.**  
Nico Bruns et al., Angew. Chem. 2009

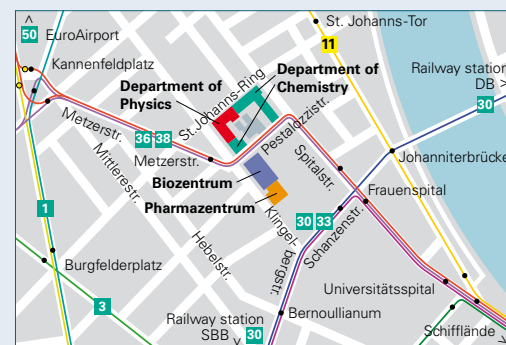
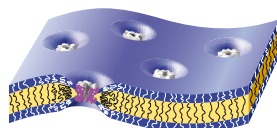


**Mercedes-star type molecules forming chiral porous networks based on Ar-F...H-Ar hydrogen bonds.** Marcel Mayor



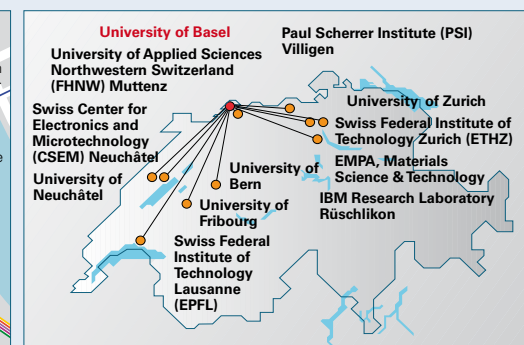
**Schematic representation of a light-emitting electrochemical cell.**  
Henk Bolink / Rubén Costa / Ed Constable

**Right: Biomimetic membrane with embedded Aquaporins can be used to create highly efficient water filters.** Wolfgang Meier



**Center of Nanosciences, University of Basel**

**Useful Links:**  
<http://www.unibas.ch/>  
> Studium > Uni Leben  
> Rubrik: Wohnen



**The partners in the network of the Swiss Nanoscience Institute (SNI)**

**Coverpicture:**  
**The compound eye of *Drosophila melanogaster* (Detail)** >  
Picture: Daniel Mathys, Center for Microscopy (ZMB), University of Basel; Coloration: Annette Roulier, Photo & Digital Imaging, Bio-Pharmazentrum, University of Basel