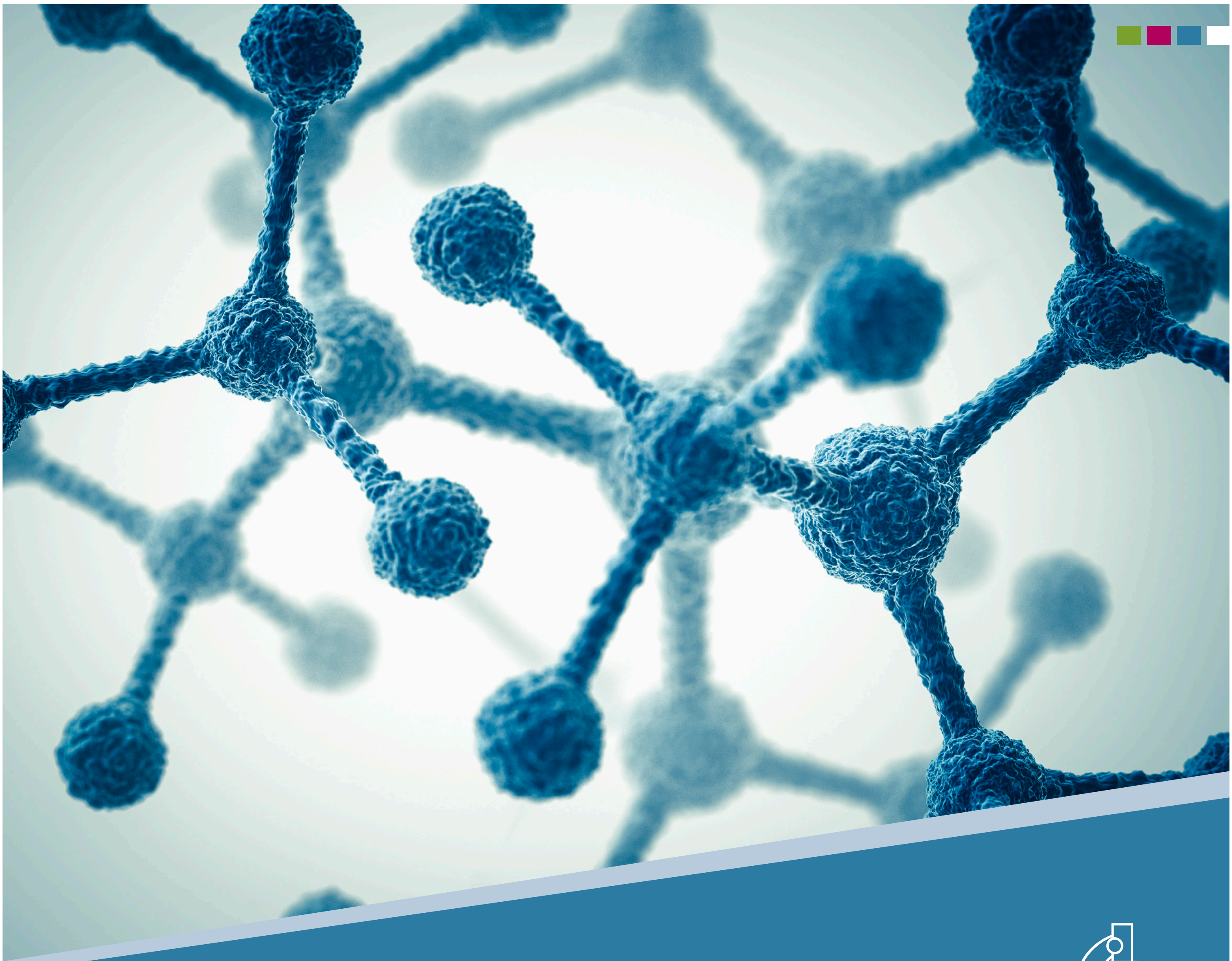

POSTGRADUATE DISTANCE STUDIES
SCIENCE & ENGINEERING

MODULE HANDBOOK · NANOBIOTECHNOLOGY

# MODULE HANDBOOK

TECHNISCHE UNIVERSITÄT
KAISERSLAUTERN

DISTANCE AND INDEPENDENT
STUDIES CENTER

Version: June 2016

# Preamble

Upon successful completion of the distance study programme the graduates, which are primarily composed of engineers, natural scientists and medical doctors, have acquired skills that enable them to strongly improve products and processes in the organizations in which they operate. Thus the study programme makes a contribution to the high demand for skilled workers in the field of nanobiotechnology.

The two on-campus weekends contribute to the acquisition of practical skills. In this context, the students apply their acquired knowledge with the help of experienced tutors. This is usually done in the context of topic-specific lab work which is carried out at the Department of Physics at the University of Kaiserslautern and at the Institute for Technical Chemistry of the University of Hannover.

An important secondary objective of the distance study programme is learning of working in an international environment. The fact that the study programme has a high percentage of foreign students helps to acquire these skills in parallel to the studies.

The **qualification objectives** are described below on the basis of **professional**, **methodological** and **social competences**, as well as in terms of **learning outcomes**.

**Professional competence** is the ability to cope with job-specific tasks and situations independently and responsibly meeting the theoretical requirements. **Methodological competence** is the ability to apply certain working methods. **Social competence** is the ability to deal with fellow men unprejudiced, constructively and easily in the work environment. Interacting and cooperating with others, as well as management skills play a major role.

The **overall qualification objective** is: Graduates have the technical knowledge, skills and competences to understand issues in the broad field of nanobiotechnology and to cope independently and responsibly with tasks set by the theoretical requirements by applying the work methods they learned, and deal fairly, constructively and confidently with their fellow men.

The following **competences** are derived from the overall qualification objectives:

- **Professional competence:** The graduates have acquired an extensive factual knowledge about the principles, general approaches and models in the field of nanobiotechnology. Moreover, they have the ability to raise, formulate and formalize issues at all abstraction levels, and can solve these problems through critical thinking and a pronounced judgement in a scientific way.
- **Methodological competence:** The graduates have the ability to combine knowledge from different fields of nanobiotechnology and apply methods and techniques learned in this study programme. Furthermore, they can apply the acquired knowledge to new innovative methods from the field of nanobiotechnology in their field of activity, and they have the ability to learn and to develop new technologies.
- **Social competence:** The graduates have the ability to carry out activities in the field of nanobiotechnology independently to introduce new technologies in organizations, and they have the ability to work in an interdisciplinary and international team.

The **learning outcomes** of this study program are:

- Knowledge of fundamental concepts of quantum physics
- Basic knowledge of molecular biology
- Insight into the concepts of a biosensor, linear and rotary molecular motors
- Knowledge of the different applications of nanoparticles in drug delivery and diagnostics
- Familiarity with the main characterization procedures on the nano-scale
- Insight into the principles of screening methods in biology
- Knowledge of the preparation of advanced materials like nanosized powders, coatings, ceramics, compacts, monoliths, and glasses.
- Insight in synthesis processes for nanoparticles in which the essential particle formation steps are the result of physical and chemical phenomena.
- Familiarity with coating materials on the basis of the sol-gel- and nanotechnology
- Knowledge of the interaction phenomena between biological entities and non-biological substrates
- Insight into basic concepts of biomaterials for implantation nanotechnological methods that are used to improve biomaterial interactions with biological tissue

| **Module name** | **Lecturer** | **Module coordinator** |
| --- | --- | --- |
| **Fundamentals of Quantum Mechanics** | apl. Prof. H.-J. Korsch<br>Fachbereich Physik,<br>Technische Universität Kaiserslautern | Prof. H.-Ch. Schneider |

| **Abbreviation** | **Work load** | **Credit points (CP)** | **Classification within the curriculum** | **Duration** |
| --- | --- | --- | --- | --- |
| NT0001 | 125 h | 5 | 1st semester basics | one semester |

| 1 | **Courses** | **Contact hours[1]** | **Self-study hours** | **Credit points (CP)** |
| --- | --- | --- | --- | --- |
| | Online-tutorial of 6 weeks | 35 h | 90 h | 5 |

2 **Content and targeted learning outcomes**

**Content:**

- Classical and quantum physics
- The Schrödinger equation
- One-dimensional systems
- Two- and three-dimensional systems
- Some advanced topics (facultative)

**Targeted learning outcomes:**

The objective of these lecture notes is to offer to students a brief introductory course in basic quantum mechanics. The plan is to present the fundamental concepts of quantum physics in a way that a clear understanding of the theoretical methods is possible without full mathematical rigor.

After studying the first four chapters of this module the students will be familiar with the Schrödinger equation and their applications to simple one-dimensional systems, the time evolution of wave packets, the expectation values of physical variables as well as the uncertainty relation. In the fifth chapter the students approach the description of real quantum objects in three dimensions and will have a detailed look at the structure of atoms, molecules, artificial atoms and quantum dots.

3 **Literature**

Bes, Daniel R.: Quantum Mechanics. Springer, 2004.

Merzbacher, Eugen: Quantum Mechanics. John Wiley, 1970.

Singh, Jasprit: Quantum Mechanics – Fundamentals and Applications to Technology. John Wiley, 1997.

Thaller, Bernd: Visual Quantum Mechanics. Springer, 2000.

4 **Teaching format**

Textbook for self-study, self-control assignments, online tutorial, lecture “Visual Quantum Mechanics” during kick-off. The participation in kick-off is not compulsive.

5 **Usability of the module in individual study programs**

Distance Study Program “Nanotechnology” (Master)

[1] The contact hours consist of the time in which the student is in contact with the tutor and her / his fellow students during the online tutorials and (if required) the time spent at the on-campus weekends.

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| 6 | **Prerequisites**<br>Formal admission requirements: none<br>Contentual prerequisites: Appendix A of the textbook has to be learned before the tutorial starts. |
| 7 | **Assessment**<br>Mail-in exercises |
| 8 | **Study achievements**<br>Solving the mail-in exercises |
| 9 | **Offered**<br>Yearly in winter semester |

<table>
<tr><td colspan="3">Module name<br>Fundamentals of Molecular Biology, Genetics</td><td colspan="2">Lecturer<br>Dr. Peter Reichmann, Employee in the publishing company Studienwelt Laudius<br>Dr. Angelika Roth, Research associate, Scientific Office DFG-Senate Commission on Food Safety Technische Universität Kaiserslautern</td><td colspan="2">Module coordinator<br>Dr. Angelika Roth</td></tr>
<tr><td colspan="2">Abbreviation<br>NT0002</td><td>Work load<br>125 h</td><td>Credit points (CP)<br>5</td><td colspan="2">Classification within the curriculum<br>1st semester basics</td><td>Duration<br>one semester</td></tr>
<tr><td>1</td><td colspan="2">Courses<br>Online-tutorial of 6 weeks</td><td>Contact hours[1]<br>35 h</td><td colspan="2">Self-study hours<br>90 h</td><td>Credit points (CP)<br>5</td></tr>
<tr><td>2</td><td colspan="6">Content and targeted learning outcomes<br>Content:<br>• Basics in chemistry<br>• DNA and RNA<br>• From amino acids to proteins<br>• The flow of genetic information<br>• Molecular biology of gene function<br>• Regulation of gene expression<br>• Alteration of genetic information<br>• Recombinant DNA technology<br>• Important techniques in molecular biology<br>• Genomics<br>• Biology in the computer age<br>Targeted learning outcomes:<br>This module provides the students with the basics knowledge of molecular biology, i.e. the structure of the nitrogenous bases, the details of the DNA double helix, RNA secondary structures, the general structure of amino acids, the properties of the 20 amino acids that build up proteins, primary, secondary, tertiary, quaternary structure of a protein, the basic principles of DNA replication, the definition of a gene, gene regulation mechanisms in prokaryotes and eukaryotes, the molecular basis of gene transfer and mutations, the basic techniques of molecular biology, the principle of Southern blotting, and the basic concepts of all genome analysis techniques.<br>The knowledge taught in this module forms the basis for the understanding of further subjects in this study program like screening methods in biology, nanotechnologically modified biomaterials and molecular nanosystems.</td></tr>
<tr><td>3</td><td colspan="6">Literature<br>Alberts, B., Johnson, A., Lewis, J., Morgan, D., Raff M., Roberts, K., Walter, P.; Molecular Biology of the Cell; Publisher: Garland Science, (2014) 6th edition.</td></tr>
</table>

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|---|---|
| | Goldstein, J. E., Kilpatrick, E. S., Krebs, S.; Lewin's GENES XI; Jones & Bartlett Learning; (2012) 11th edition.<br><br>Hartwell, L. H., Goldberg, M. L. Fischer, J. A., Hood, L.; Genetics: From Genes to Genomes; Publisher: McGraw-Hill, (2014) 5th edition.<br><br>Madigan, M. T., Martinko, J. M., Bender, K.S., Buckley, D.H.; Brock: Biology of Microorganisms; Publisher: Benjamin Cummings (2014) 14th edition. |
| 4 | **Teaching format**<br>Textbook for self-study, self-control assignments, online tutorial |
| 5 | **Usability of the module in individual study programs**<br>Distance Study Program “Nanotechnology” (Master) |
| 6 | **Prerequisites**<br>Formal admission requirements: none<br>Contentual prerequisites: none |
| 7 | **Assessment**<br>Written examination, 90 minutes |
| 8 | **Study achievements**<br>Passing the written examination at the end of the semester |
| 9 | **Offered**<br>Yearly in winter semester |

| **Module name**<br>**Applications of Nanotechnology** | **Lecturer**<br>Prof. Dr. Christiane Ziegler<br>Fachbereich Physik<br>Technische Universität Kaiserslautern<br><br>Prof. Pia Vogel<br>Department of Biological Sciences<br>Southern Methodist University<br>Dallas, TX, USA<br><br>Prof. M.N.V. Ravi Majeti<br>Faculty of Science<br>University of Strathclyde<br>Glasgow, UK<br><br>Prof. U. Bakowsky<br>Fachbereich Pharmazie<br>Philipps University Marburg<br><br>Prof. C.-M. Lehr<br>Naturwissenschaftlich-Technische Fakultät III<br>Universität des Saarlands | **Module coordinator**<br>Prof. Dr. Christiane Ziegler |
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| **Abbreviation**<br>NT0013 | **Work load**<br>125 h | **Credit points (CP)**<br>5 | **Classification within the curriculum**<br>1st semester advanced | **Duration**<br>one semester |
|---|---|---|---|---|

| 1 | **Courses**<br><br>Online-tutorial of 6 weeks | **Contact hours**[1]<br><br>35 h | **Self-study hours**<br>90 h | **Credit points (CP)**<br>5 |
|---|---|---|---|---|

2 **Content and targeted learning outcomes**

**Content of the textbook "Molecular Nanosystems: Sensors":**

- Sensors and Biosensors
- Nanoelectromechanical Transducers
- Biosensing Applications

**Content of the textbook "Molecular Nanosystems: Molecular Motors":**

- Importance of movement for living systems
- Kinesin, dynein and myosin: motors for linear, intracellular transport
- ATP synthase

**Content of the textbook "Nanoparticles as Therapeutic Drug Carrier and Diagnostics":**

- Features of polymeric nanoparticles
- Preparation and characterization of nanoparticles
- Recent developments in pharmaceutical nanoparticles technology

- Therapeutic applications of nanoparticular carrier systems
- Nanoparticles as diagnostics

**Targeted learning outcomes:**

After learning the first textbook the student will have become familiar with the concept of a biosensor. More precisely, he will know the advantages and disadvantages of acoustic and cantilever sensors. Furthermore, the student will have a basic knowledge of resonating beams and of the different possibilities to use cantilevers as biosensors.

After reading the second textbook the student will get a sense of the importance of movement for living systems. He will learn about linear and rotary motors, how they work and what are they for. The student will be able to compare the different molecular motors and their potential application in nanobiotechnology, and envision potential nanobiotechnological applications of the different motor types.

In the third textbook, some basic principles of polymer nanoparticles are discussed apart from their applications in the area of biomedical sciences. The students will get an idea of several parameters that one has to consider while dealing with nanobiotechnology for medical applications. After studying this lectures, the student should understand the features of polymeric particles, preparation and characterization techniques, different applications in drug delivery as well as the applications of nanoparticles as diagnostics.

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**Literature**

**“Molecular Nanosystems: Sensors”:**

Ch. Ziegler, “Cantilever-based Biosensors”, Review, Analytical and Bioanalytical Chemistry, Special Issue on “Nanotechnologies for the Biosciences”, Anal. Bioanal. Chem. 379 (2004) 946-959.

D. Then, Ch. Ziegler, “Cantilever-based Sensors”, Review, in: Encyclopedia of Nanoscience and Nanotechnology, H.S. Nalwa (Ed.), Vol 1, H.S. Nalwa (Ed.), American Scientific Publishers (2004) p. 499-516.

W. Göpel, J. Hesse, J.N. Zemel (Eds.), “Sensors – A Comprehensive Survey”, in particular Vols. 2 and 3, VCH, Weinheim 1992.

A.P.F. Turner, I. Karube, G.S. Wilson, “Biosensors: Fundamentals and Applications”, Oxford Science, Oxford 1987.

D.G. Buerk, “Biosensors – Theory and Applications”, Technomic, Lancaster 1993.

**“Molecular Nanosystems: Molecular Motors”:**

Brady, S.T., Nature 317, p. 73-75, 1975.

Allen, R.D., Metuzals, J., Tasaki, I., Brady, S.T., Gilbert, S.P., Science 218, p. 1127-1129, 1982.

Paschal, B.M., Vallee R.B., Nature 330, p. 181-183, 1987.

Gee, M.A., Heuser, J.E., Vallee, R.B., Nature 390, p. 636-639, 1997.

Burgess, S.A., Walker, M.L., Sakakibara, H., Knight, P.J., Oiwa, K., Nature 421, p. 715-718, 2003.

Mehta, A.D., Rock, R.S., Rief, M., Spudich, S.A., Mooseker, M.S., Cheney, R.E., Nature 400, p. 590-593, 1999.

Yildiz, A., Forkey, J.N. , McKinney, S.A., Ha, T., Goldman, Y.E., Selvin, P.R., Science 300, p. 2061-2065, 2003.

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| | Hua, W., Young, E.C., Fleming, M.L., Gelles, J., Nature 388, p. 390-393, 1997.<br>Stock, D., Leslie, A.G., Walker, J.E., Science 286, p. 1700-1705, 1999.<br>Sabbert, D., Engelbrecht, S., Junge, W., Nature 381, p. 623-625, 1996.<br>Noji, H., Yasuda, R., Yoshida, M., Kinosita Jr., K., Nature 386, p. 299-302, 1997.<br>Sambongi, Y., Iko, Y., Tanabe, M., Omote, H., Iwamoto-Kihara, A., Ueda, I., Yanagida, T., Wada, Y., Futai, M., Science 286, p. 1722-1724, 1999.<br>Yasuda, R., Noji, H., Yoshida, M., Kinosita Jr., K., Itoh, H., Nature 410, p. 898-904, 2001.<br>Finer, J.T., Simmons, R.M., Spudich, J.A., Nature 368, p. 113-119, 1994.<br>Svoboda, K., Schmidt, C.F., Schnapp, B.J., Block, S.M., Nature 365, p. 721-727, 1993.<br>**“Nanoparticles as Therapeutic Drug Carrier and Diagnostics”:**<br>Bala, I., Hariharan, S., Ravi Kumar, M.N.V.: PLGA nanoparticles in drug delivery: The state of the art. Crit. Rev. Ther. Drug Carrier Systems 21, p. 387. 2004.<br>Couvreur, P., Puisieux, F.: Nano- and microparticles for the delivery of polypeptides and proteins. Adv. Drug Deliv. Rev. 10, p. 141, 1993.<br>Kreuter, J.: Nanoparticulate systems for brain delivery of drugs. Adv. Drug Deliv. Rev. 47, p. 65, 2001.<br>Müller, R.H., Jacobs, C., Kayser, O.: Nanosuspensions as particulate drug formulations in therapy: Rationale for development and what we can expect for the future. Adv. Drug. Del. Rev. 47, p. 3, 2001.<br>Ravi Kumar, M.N.V.: Nano and microparticles as controlled drug delivery devices. J. Pharm. Pharmaceut. Sci.3, p. 234, 2000. |
| 4 | **Teaching format**<br>Textbook for self-study, self-control assignments, online tutorial |
| 5 | **Usability of the module in individual study programs**<br>As optional module in the Distance Study Program “Nanotechnology” (Master) |
| 6 | **Prerequisites**<br>Formal admission requirements: none<br>Contentual prerequisites: none |
| 7 | **Assessment**<br>Mail-in exercises |
| 8 | **Study achievements**<br>Solving the mail-in exercises |
| 9 | **Offered**<br>Yearly in winter semester |

<table>
<tr>
<td colspan="3">Module name<br>Analytical Techniques in Nanotechnology</td>
<td colspan="2">Lecturer<br>Prof. Dr. Christiane Ziegler<br>Fachbereich Physik<br>Technische Universität Kaiserslautern<br><br>Dr. Christine Müller<br>Fachbereich Physik<br>Technische Universität Kaiserslautern<br><br>Prof. Roland Ulber<br>Fachbereich Maschinenbau und Verfahrenstechnik<br>Technische Universität Kaiserslautern<br><br>Dr. Frank Stahl<br>Institut für Technische Chemie<br>Universität Hannover</td>
<td colspan="2">Module coordinator<br>Prof. Dr. Christiane Ziegler</td>
</tr>
<tr>
<td colspan="2">Abbreviation<br>NT0007</td>
<td>Work load<br>300 h</td>
<td>Credit points (CP)<br>12</td>
<td colspan="2">Classification within the curriculum<br>1st semester advanced</td>
<td>Duration<br>two semesters</td>
</tr>
<tr>
<td rowspan="2">1</td>
<td colspan="2">Courses<br><br>Online-tutorial of 8 weeks</td>
<td>Contact hours[1]<br><br>56 h</td>
<td colspan="2">Self-study hours<br><br>144 h</td>
<td>Credit points (CP)<br><br>8</td>
</tr>
<tr>
<td colspan="2">On-campus weekends in the 1st and 2nd semesters</td>
<td>14 h are designated for each on-campus weekend</td>
<td colspan="2">36 h are designated for each on-campus weekend</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td colspan="6">Content and targeted learning outcomes<br><br>Content Textbook “Characterization of Nanostructures”:<br>• Prerequisites for resolution on the nanometer scale<br>• Overview on experimental aspects<br>• Microscopic techniques<br>• Spectroscopic and spectrometric techniques: chemical composition<br>• Spectroscopic techniques: electronic structure<br>• Spectroscopic techniques: vibrational and magnetic structure<br><br>Content Textbook “Screening Methods in Biology, Chip Technologies”:<br>• Traditional screening of genes and gene expression<br>• High-throughput screening<br>• Chip technologies</td>
</tr>
</table>

- Gene expression analysis by RNA Seq
- Protein chip technologies
- Aptamer microarrays
- Cell and tissue microarrays
- Lab-on-a-chip

**Targeted learning outcomes:**

The aim of the first part of this module – “Characterization of Nanostructures” – is that the students get a comprehensive view of the main characterization procedures of any kind of nanomaterials, no matter if it is a particle or a very thin film of some nanometers thickness. In general the students learn about:

- How a characterization method does work in general?
- Which information can he clearly get from the output of the experiment?
- Which are the limits of the method?
- To which materials are the methods dedicated?

At the beginning the students learn the prerequisites for resolution on the nanometer scale, i.e. surface sensitivity and lateral resolution. Furthermore, they will get an overview on the most important experimental aspects like UHV, special requirements for biological samples etc.

Furthermore, students will get familiar with the most powerful tools in the field of nanomicroscopies: Scanning Electron Microscopy, Transmission Electron Microscopy, Scanning Tunneling Microscopy, Scanning Force Microscopy, Scanning Nearfield Optical Spectroscopy, and other scanning probe techniques.

The different methods of spectroscopy and spectrometry which are used to get information about the chemical composition of nanomaterials are a further learning outcome: X-ray Photoemission Spectroscopy (XPS), Auger Electron Spectroscopy (AES), Secondary Ion Mass Spectrometry, Atom Probe, Scattering Techniques.

Students will also become acquainted with methods which are used to look for the electronic structure of nanomaterials, these are spectroscopic techniques like e.g.: UV-photoelectron spectroscopy, inverse photoemission spectroscopy, Scanning Tunneling Spectroscopy, and Electron Energy Loss Spectroscopy (EELS).

Finally the students will get insight in the spectroscopic techniques which allow getting information about the vibrational and magnetic structure of nanomaterials: High Resolution Electron Energy Loss Spectroscopy, infrared techniques, Raman Scattering Spectroscopy, Brillouin Scattering, Spin-resolved Photoemission, and magnetic modes of Scanning Probe Microscopies.

Practical skills in this area will be acquired during the on-campus weekend at the end of the 2$^{nd}$ semester with the following targeted learning outcomes:

The students:

- know the necessary sample preparation for characterization of nanostructures,
- get hands-on experience in imaging by AFM, STM, SEM and EDS analysis,
- know how to interpret the information supplied by the different imaging techniques,
- are able to decide which of the imaging methods is appropriate for a specific sample or purpose.

The learning outcomes of the lecture “Screening Methods in Biology” can be summarized as follows:

The principles of traditional screening methods in biology should be understood. The students should become acquainted with the basic mechanisms in high-throughput screening systems. The main focus lies on the description of different chip technologies such as DNA and protein chip technology. It is the aim that the students based on this program will be able to perform their own chip experiments. As new concepts the principles of a lab-on-a-chip, aptamer-microarrays, cell microarrays and RNA-seq should be understood.

Practical skills in this area will be acquired during the on-campus weekend at the end of the $1^{st}$ semester with the following targeted learning outcomes:

The students

- know the molecular biology of gene expression,
- know the principles of traditional screening methods in biology,
- know the basic mechanisms in highthroughput screening systems,
- know different microarray technologies such as DNA, Protein and Aptamer microarray technology,
- will be able to perform their own microarray experiments based on this programme,
- will be able to perform the data anaylsis of an microarray experiment,
- know to use of bioanalytical systems to describe complex reactions in biotechnological processes,
- will know the principles of a lab on a chip as a new concept.

3 **Literature**

**“Characterization of Nanostructures”:**

Bhushan, Bharat (Ed.): Handbook of Nanotechnology. Springer, $3^{rd}$ ed. 2010.

Meyer, E., Hug, H.J., Bennewitz, R.: Scanning Probe Microscopy – Lab on a Tip. Springer, 2004.

Reimer, L.: Scanning Electron Microscopy – Physics of Image Formation and Microanalysis. Springer, $2^{nd}$ ed., 1998.

Bowker, M., Davies, P.R.: Scanning Tunneling Microscopy in Surface Science, Nanoscience and Catalysis. Wiley-VCH, 2010.

Wiesendanger, Roland: Scanning Probe Microscopy and Spectroscopy. Cambridge University Press, 1994.

Ertl, G., Küppers, J.: Low Energy Electrons and Surface Chemistry. VCH, 1985.

Czanderna, A.W. (Ed.): Methods of Surface Analysis. Elsevier, 1975.

Briggs, D., Seah, M.P.: Practical Surface Analysis, Auger and X-ray Photoelectron Spectroscopy. Wiley, 1996.

**“Screening Methods in Biology, Chip Technologies”:**

Quackenbush, J.: Computational analysis of microarray data. Nat. Rev. Genet. 2, p. 418-427, 2001.

Stekel, D.: Microarray Bioinformatics. Cambridge University Press, p. 100-110, 2003.

Hegde, P., Qi, R., Abernathy, K., Gay, C., Dharap, S., Gaspard, R., Hughes, J.E., Snesrud, E., Lee, N. and Quackenbush, J.: A Concise Guide to cDNA Microarray Analysis. BioTechniques 29, p. 548-562, 2000.

Spielbauer, B. and Stahl, F.: Impact of microarray technology in nutrition and food research. Mol. Nutr. Food Res. 49(10), p. 908-917, 2005.

Walter, J.G., Kokpinar, O., Friehs, K., Stahl, F. and T. Scheper: Systematic

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| | investigation of optimal aptamer immobilization for protein-microarray applications. Anal. Chem. 80(19), p. 7372-7378, 2008.<br><br>Stahl, F., Hitzmann, B., Mutz, K., Landgrebe, D., Lubbecke, M., Kasper, C., Walter, J., Scheper, T.: Transcriptome Analysis. Adv. Biochem. Eng. Biotechnol. 127, p. 1-25, 2012.<br><br>Schena M. and Davis R.W.: Genes, Genomes and Chips. In: DNA Microarrays: A Practical Approach (Ed. M. Schena). Oxford University Press, Oxford, UK, p. 1-16, 1999.<br><br>Schena M. and Davis R.W.: Parallel Analysis with Biological Chips. In: PCR Methods Manual (Eds. Innis M., Gelfand D., and Sninsky J.). Academic Press, San Diego, p. 445-456, 1999.<br><br>Lemieux B., Aharoni A., and Schena M.: Overview of DNA Chip Technology. Mol. Breeding 4, p. 277-289, 1998.<br><br>Schena M., Heller R.A., Theriault T.P., Konrad K., Lachenmeier E., and Davis R.W.: Microarrays: Biotechnology's discovery platform for functional genomics. Trends in Biotech. 16, p. 301-306, 1998. |
| 4 | **Teaching format**<br>Textbooks for self-study, self-control assignments, online tutorial, lecture “Introduction into Microarray Technology” and lab “Gene Expression under Heat Shock Conditions” during the first on-campus weekend, lecture “Seeing at the Nanoscale: Microscopical Methods with Atomic Resolution” and labs “Raster Force Microscopy, Scanning Tunnelling Microscopy, Scanning Electron Microscopy” during the second on-campus weekend. |
| 5 | **Usability of the module in individual study programs**<br>Distance Study Program “Nanotechnology” (Master) |
| 6 | **Prerequisites**<br>Formal admission requirements: none<br>Contentual prerequisites: none |
| 7 | **Assessment**<br>Written examination, 120 minutes |
| 8 | **Study achievements**<br>Passing the written examination at the end of the semester, participation in both on-campus weekends (1st and 2nd semester) |
| 9 | **Offered**<br>Tutorials are offered yearly in winter semester; on-campus weekend belonging to “Screening Methods in Biology, Chip Technologies” is offered yearly in winter semester; on-campus weekend belonging to “Characterization of Nanostructures” is offered yearly in summer semester. |

<table>
<tr><td colspan="3">Module name<br>Nanomaterials 1</td><td colspan="2">Lecturer<br>Prof. Rolf Clasen<br>ehemals:<br>Naturwissenschaftlich-Technische Fakultät III<br>Universität des Saarlands<br><br>apl. Prof. Einar Kruis<br>Fakultät für Ingenieurwissenschaften<br>Universität Duisburg-Essen</td><td>Module coordinator<br>apl. Prof. Einar Kruis</td></tr>
<tr><td colspan="2">Abbreviation<br>NT0009</td><td>Work load<br>175 h</td><td>Credit points (CP)<br>7</td><td>Classification within the curriculum<br>2nd semester advanced</td><td>Duration<br>one semester</td></tr>
<tr><td>1</td><td colspan="2">Courses<br><br>Online-tutorial of 8 weeks</td><td>Contact hours[1]<br><br>49 h</td><td>Self-study hours<br>126 h</td><td>Credit points (CP)<br>7</td></tr>
</table>

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**Content and targeted learning outcomes**

**Content of the textbook "Processing Ceramics and Composites and Their Applications":**

- Overview nanotechnology
- Synthesis of nanosized powders
- Characterization of nanopowders
- Dispersing
- Aerosols
- Shaping
- Drying
- Modification
- Sintering
- Characterization

**Content of the textbook „Physical Synthesis of Nanoparticles":**

- Nanoparticle movement and interaction
- Nucleation and growth
- Gas-phase synthesis
- Nanoparticle reactor design
- Nanoparticle formation on substrates
- Ball milling techniques

**Content of the textbook „Chemical Synthesis of Nanoparticles":**

- Basic mechanisms in liquid phase processes
- Reduction processes and coprecipitation
- Sol-gel nanoparticle synthesis
- Synthesis in confined volumes
- Synthesis of nanoparticles by means of diblock copolymers
- Templated-based synthesis
- Gas-phase methods

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| | **Targeted learning outcomes:**<br><br>The first part of this module focuses on the preparation of advanced materials like nanosized powders, coatings, ceramics, compacts, monoliths, and glasses. The students will also learn the characterization methods of the final material.<br><br>The second part provides the students with insight in synthesis processes for nanoparticles in which the essential particle formation steps are the result of physical phenomena. A major part of these techniques bases on the creation of a supersaturated vapor. In the first chapters students are provided with the theoretical background necessary to understand the formation processes. A large part of this course is dealing with vapor phase processes, which can be and are already scaled up by engineers into large industrial processes.<br><br>Students will also learn how to design a simplified gas-phase reactor. An extensive case study in one full chapter gives an insight in the methods used by engineers to design a nanoparticle reactor on the basis of the theory provided in the first chapters.<br><br>The third part of the module focuses on synthesis processes for nanoparticles in which the essential particle formation steps are the result of chemical phenomena. Examples are given of the main synthesis principles and most important chemical reactions. After having studied this course, students should be able to recognize a chemical reaction or chemical compound cited in the textbook and to write down analogous reactions. |
| 3 | **Literature**<br><br>**“Processing Ceramics and Composites and Their Applications”:**<br><br>Fendler, J.H. (Ed.): Nanoparticles and Nanostructures, Preparation, Characterization and Application. Wiley-VCH, Weinheim, 1998.<br><br>Wang, Z.L. (Ed.): Characterization of nanophase materials. Wiley-VCH, Weinheim 1999.<br><br>Lorenz, W.J. ,Pleth, W.: Electrochemical Nanotechnology. In Situ Local probe Techniques at Electrochemical Interfaces. Wiley-VCH, Weinheim, 1998.<br><br>Evans, D.F., Wennesström, H.: The Colloidal Domain, Where Physics, Chemistry and Biology meet. J. Wiley & Sons, Ltd., Chichester, 2$^{nd}$ ed., 1999.<br><br>Bimberg, D., Grundmann, M., Ledentsov, N. N.: Quantum Dot Herterostructures. J. Wiley & Sons, Ltd., Chichester, 1999.<br><br>Mitin, V., Kochelap, V., Stroscio, M.: Quantum herterostructures: Microelectronics and Optoelectronics. Cambridge University Press, 1999.<br><br>Ekardt, W. (Ed.): Metal Clusters. J. Wiley & Sons, Ltd., Chichester, 1999.<br><br>Edelstein, A. S., Cammarata, R. C.: Nanomaterials: Synthesis, Properties and Applications. Institute of Physics Publishing, London, 1996.<br><br>Fujishima, A., Hashimoto, K., Watanabe, T.: $TiO_2$ Photocatalysis, Fundamentals and Application. BKJ, Inc.,Tokyo, 1999.<br><br>Nalwa, H.S. (Ed.): Handbook of Nanostructured Materials and Nanotechnology. Vol. 1-5, Academic Press, 1999.<br><br>Gleiter, H.: Nanocrystalline Materials, Progress in Material Science. Vol. 33, p. 223-315, Pergamon Press, Oxford, 1990.<br><br>Harrison, P.: Quantum wells, Wires and Dots, Theoretical and Computational Physics. Wiley Interscience, 1999. |

Hackley, V. A., Texter, J.: Ultrasonic and Dielectric Characterization Techniques for Suspended Particulates. Am. Ceram. Soc., Westerville 1998.

Kodas, T.T., Hampden-Smith, M.: Aerosol Processing of Materials. Wiley-VCH, New York, 1999.

Rhodes, M.: Introduction to Particle Technology. J. Wiley & Sons, Chichester-New York, 1998.

Shaw, D.J.: Introduction to Colloid and Surface Chemistry. Butterworth, London, 1986.

Ring, T.A.: Fundamentals of Ceramic Powder Processing and Synthesis. Am. Ceram. Soc., Westerville (USA), 1996.

**„Physical Synthesis of Nanoparticles“:**

Edelstein, A.S.: Nanomaterials: Synthesis, properties and applications. IOP Publishing, Bristol, UK, 1996.

Friedlander, S.K.: Smoke, dust and haze – Fundamentals of aerosol dynamics. Oxford University Press, New York, 2$^{nd}$ ed., 2000.

Goldstein, A.: Handbook of nanophase materials. Dekker, New York, 1997.

Hinds, W.C.: Aerosol technology. Wiley, New York, 1982.

Ichinose, N., Ozaki, J., Kashu, S.: Superfine particle technology. Springer, New York, 1991.

Kodas, T.T., M. Hampden-Smith: Aerosol processing of materials. Wiley-VCH, New-York, 1999.

Rogers, B., Adams, J., Pennathur, S.: Nanotechnology - understanding small systems. CRC Press, Boca Raton, 2008.

**„Chemical Synthesis of Nanoparticles“:**

Baraton, M.I.: Synthesis, functionalization and surface treatment of nanoparticles. American Scientific Publishers, USA, 2003.

Bhushan, B.: Springer handbook of nanotechnology. Springer Verlag, Berlin, 2004.

Cao, G.: Nanostructures and nanomaterials -- Synthesis, properties and applications. Imperial College Press, London, 2004.

Caruso, F.: Colloids and colloid processing -- Synthesis, modification, organization and utilization of colloid particles. Wiley-VCH, Weinheim, 2004.

Edelstein, A.S., Nanomaterials: Synthesis, properties and applications, IOP Publishing, Bristol, UK, 1996.

Feldheim, D.L., Colby, A.F.: Metal nanoparticles - Synthesis, characterization and applications. Dekker, New York, 2002.

Friedlander, S.K.: Smoke, dust and haze -- Fundamentals of aerosol dynamics. Oxford University Press, New York, 2$^{nd}$ ed., 2000.

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Gonsalves, K.E., Rangarajan, S.P., Wang, J.: Chemical synthesis of nanostructured metals, metal alloys, and semiconductors. Chapter 1 from: Handbook of nanostructured materials and nanotechnology. Vol. 1, Nalwa, H.S. (Ed.), Academic Press, 2000.

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Klabunde, K.J., Mohs, C.: Nanoparticles and nanostructural materials. In: Chemistry

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| | of advanced materials. Interrante, L.V. and Hampden-Smith, M.J. (Eds.), Wiley-VCH, New York, 1998.<br>Kodas, T.T., Hampden-Smith, M.: Aerosol processing of materials. Wiley-VCH, New-York, 1999.<br>Poole, C.P., Owens, F.J.: Introduction to nanotechnology. Wiley-Interscience, Hoboken, 2003.<br>Rao, C.N.R., Müller, A., Cheetham, A.K.: The chemistry of nanomaterials. Wiley-VCH, Weinheim, 2004.<br>Schmid, G.: Nanoparticles - From theory to application. Wiley-VCH, Weinheim, 2004.<br>Schubert, U., Hüsing, N.: Synthesis of inorganic materials. Wiley-VCH, Weinheim, 2000. |
| 4 | **Teaching format**<br>Textbooks for self-study, self-control assignments, online tutorial |
| 5 | **Usability of the module in individual study programs**<br>Distance Study Program “Nanotechnology” (Master) |
| 6 | **Prerequisites**<br>Formal admission requirements: none<br>Contentual prerequisites: none |
| 7 | **Assessment**<br>Written examination, 120 minutes |
| 8 | **Study achievements**<br>Passing the written examination at the end of the semester |
| 9 | **Offered**<br>Yearly in summer semester |

| Module name | Lecturers | Module coordinator |
|---|---|---|
| **Processing Coatings and Their Applications** | Dr. Stefan Sepeur<br>Dr. Frank Groß<br>Dr. Nora Kunze<br>Dr. Stefan Goedicke<br>NANO-X GmbH, Saarbrücken | apl. Prof. Einar Kruis |

| Abbreviation | Workload | Credit points (CP) | Classification within the curriculum | Duration |
|---|---|---|---|---|
| NBT05 | 75 h | 3 | 2nd semester advanced | one semester |

| 1 | Courses | Contact hours[1] | Self-study hours | Credit points (CP) |
|---|---|---|---|---|
| | Online-tutorial of 6 weeks | 21 h | 54 h | 3 |

2 **Content and targeted learning outcomes**

**Content:**

- Basics of inorganic–organic nanocomposites
- Processing coatings
- Analytical methods for the characterization of the liquid sol
- Characterization of the cured coating

**Targeted learning outcomes:**

After completing this subject students will become familiar with coating materials on the basis of the sol-gel- and nanotechnology. The student learns the structure, the synthesis, the application and the use of coating materials based on chemical nanotechnology. The chemical and physical basic knowledge is provided where necessary, such that students learn to develop a synthesis and application process and further to examine and characterize the coated samples.

3 **Literature**

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Chung, H. Rack patent US 4478876 (23.10.1984).

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N. Gupta, T.J.M. Sinha, I.K. Varma, Indian Journal of Chemical Technology Vol. 4 (1997) 130-134.

C. Tronche, R. Jaria, C.P. Chawla, Proc. Rad. Tech. Europe Conference, Berlin, (1999) 719-724.

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R. Kasemann, H. Schmidt, E. Wintrich, "New type of a sol-gel derived inorganic-organic nanocomposite", in: Proceedings 1994 MRS Spring Meeting, Symposium "Better Ceramics Through Chemistry VI", April 1994, San Francisco / USA, Mat. Res. Soc. Symp. Proc. 346 (1994).

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| | Inorganic Materials, Château de Bierville / France, (November 1993).<br>D.A. Jones, “Principles and Prevention of Corrosion”, 2nd ed. Prentice-Hall, New Jersey (1996).<br>L.L. Shreir, R.A. Jarman, G.T. Burstein, (Eds.), Corrosion 3rd ed. Butterworth-Heinemann, Oxford, (1994).<br>R. Buchheit, J. Electrochem. Soc. 142 (1994) 3994.<br>G. Grundmeier, W. Schmidt, M. Stratmann, Electrochimica Acta 45 (2000) 2515.<br>R. Haneda, K. Aramaki, J. Electrochem. Soc. 145 (1998) 2786.<br>W. Lu, R.L. Elsenbaumer, T. Chen, V.G. Kulkarni, Mat. Res. Soc. Symp. Proc. 488 (1998) 653.<br>M. Guglielmi, J. Sol-Gel Sci. Tech. 1 (1994) 177.<br>D.C.L. Vasconcelos, J.N. Carvalho, M. Mantel, W.L. Vasconcelos, J. Non-Cryst. Solids 273 (2000) 135.<br>M. Simoes, O.B.G. Assis, L.A. Avaca, ibid. 273 (2000) 159.<br>M. Atik, S.H. Messaddeq, F.P. Luna, M.A. Aegerter, J. Mater. Sci. Lett. 15 (1996) 2051.<br>P. Neto, M. Atik, L.A. Avaca, M.A. Aegerter, J. Sol-Gel Sci. Tech. 2 (1994) 529.<br>C.J. Brinker, G.W. Scherer, “Sol-Gel Science: The Physics and Chemistry of Sol-Gel Processing”, Academic Press, San Diego, CA (1990).<br>A.C. Pierre, “Introduction to Sol-Gel Processing”, Kluwer, Boston, MA, (1998).<br>L.F. Francis, Mater. Manufacturing Process. 12 (1997) 963.<br>X.H. Han, G.Z. Cao, T. Pratum, D.T. Schwartz, B. Lutz, J. Mater. Sci. 36 (2001) 985.<br>C.M. Chan, G.Z. Cao, H. Fong, M. Sarikaya, T. Robinson, L. Nelson, J. Mater. Res. 15 (2000) 148.<br>J. Wen, G.L. Wilkes, J. Inorganic and Organometallic Polymers 5 (1995) 343.<br>J.S. Park, J.D. Mackenzie, J. Amer. Ceram. Soc. 78 (1995) 2669.<br>S.H. Messaddeq, S.H. Pulcinelli, C.V. Santilli, A.C. Guastaldi, Y. Messaddeq, J. Non-Cryst. Solids 247 (1999) 164.<br>M. Atik, F.P. Luna, S.H. Messaddeq, M.A. Aegerter, J. Sol-Gel Sci. Tech. 8 (1997) 517.<br>W. Barthlott, “Scanning electron microscopy of the epidermal surface in plants”, in: “Scanning electron microscopy in taxonomy and functional morphology”, D. Claugher (Ed.), Clarendon Press, Oxford, (1990) 69-94.<br>W. Barthlott, “Epicuticular wax ultrastructure and systematics”, in: “Evolution and systematics of the Caryophyllales”, H.D. Behnke, T.J. Mabry (Eds.), Springer, Berlin, (1993) 75-86.<br>W. Barthlott, C. Neinhuis, “Purity of the sacred lotus, or escape from contamination in biological surfaces”, Planta 202 (1997) 1-8.<br>C. Neinhuis, W. Barthlott, “Characterization and distribution of water-repellent, self-cleaning plant surfaces”, Annals of Botany 79 (1997) 667-677. |
| 4 | **Teaching format**<br>Textbook for self-study, self-control assignments, online tutorial |
| 5 | **Usability of the module in individual study programs** |

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| 6 | **Prerequisites**<br>Formal admission requirements: none<br>Contentual prerequisites: none |
| 7 | **Assessment**<br>Mail-in exercises |
| 8 | **Study achievements**<br>Solving the mail-in exercises |
| 9 | **Offered**<br>Yearly in summer semester |

<table>
<tr>
<td colspan="3">Module name<br>Interaction between Biological and Non-biological Devices</td>
<td colspan="2">Lecturer<br>Prof. Axel Blau<br>Department of Neuroscience and Brain Technologies<br>The Italian Institute of Technology, Genova, Italy</td>
<td colspan="2">Module coordinator<br>Prof. Eva Eisenbarth<br>Fachbereich Informatik und Naturwissenschaften<br>Fachhochschule Südwestfalen<br>Iserlohn</td>
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<tr>
<td colspan="2">Abbreviation<br>NBT09</td>
<td>Workload<br>75 h</td>
<td>Credit points (CP)<br><br>3</td>
<td colspan="2">Classification within the curriculum<br>$2^{nd}$ semester advanced</td>
<td>Duration<br>one semester</td>
</tr>
<tr>
<td>1</td>
<td colspan="2">Courses<br><br>Online-tutorial of 6 weeks</td>
<td>Contact hours[1]<br><br>21 h</td>
<td colspan="2">Self-study hours<br>54 h</td>
<td>Credit points (CP)<br>3</td>
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<td>2</td>
<td colspan="6">Content and targeted learning outcomes<br>Content:<br>• Types of interactions on atomic and molecular level<br>• Molecularly derived types of interactions between biology and biological as well as non-biological substrates<br>• How does nature make use of adhesive and anti-adhesive interactions? From microscopic to macroscopic scales<br>Targeted learning outcomes:<br>The aim of these lectures is to give the students a survey on most of the interaction phenomena between biological entities and non-biological substrates, that range from molecular mechanisms to all sorts of macroscopic interactions.<br>More precisely, after reading these lectures, the students will be familiar with the different types of chemical and physical interactions, with the properties and strengths of interactions, as well as with the factors that modulate their strength. They will know the various physical, chemical, and biochemical terminologies used in describing interactions. Further learning outcomes are the knowledge of the wide spectrum of cell and substrate adhesion phenomena, of the participants involved in cell adhesion, of the major proteins that mediate it, and of the similarities and differences of cell adhesion in vivo and in vitro. Students will get to know the strategies for exploiting cell adhesion factors in cell culture, the molecular and microscopic adhesion phenomena that manifest themselves on a macroscopic scale.<br>Finally, the students will be familiar with the range of 'non-classical' adhesion and anti-adhesive strategies used by nature, with the underlying molecular and microscopic adhesion mechanisms that manifest themselves on a macroscopic scale and with the extended range of parameters affecting cell adhesion exemplified in biofilms.</td>
</tr>
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|---|---|
| 3 | **Literature**<br>Beckerle M.C.: Cell Adhesion. Vol 39, New York, Oxford University Press, 2001.<br>Crawford N., and Taylor D.E.M., (Eds.): Interaction of Cells with Natural and Foreign Surfaces. New York, Plenum Press, 1986.<br>Kreis T., and Vale R., (Eds.): Guidebook to the Extracellular Matrix, Anchor, and Adhesion Proteins. Oxford, Oxford University Press, 2$^{nd}$ ed., 1999.<br>Stryer L.: Biochemistry. Heidelberg, Spektrum der Wissenschaft Verlagsgesellschaft mbH, 3$^{rd}$ ed., 1990.<br>Lewis R.: Sorting out the Science of Stickiness – Adhesion biology research crosses numerous disciplinary lines. The Scientist 16, p. 14, 2004.<br>Yamagata M.: Regulation of Cell-Substrate Adhesion by Proteoglycans Immobilized on Extracellular Substrates. The Journal of Biological Chemistry 264, p. 8012-8018, 1989. |
| 4 | **Teaching format**<br>Textbook for self-study, self-control assignments, online tutorial |
| 5 | **Usability of the module in individual study programs** |
| 6 | **Prerequisites**<br>Formal admission requirements: none<br>Contentual prerequisites: none |
| 7 | **Assessment**<br>Written examination, 60 minutes |
| 8 | **Study achievements**<br>Passing the written examination at the end of the semester |
| 9 | **Offered**<br>Yearly in summer semester |

| Module name | Lecturer | Module coordinator |
| --- | --- | --- |
| Nanotechnologically Modified Biomaterials | Prof. Eva Eisenbarth<br>Fachbereich Informatik und Naturwissenschaften<br>Fachhochschule Südwestfalen<br>Iserlohn | Prof. Eva Eisenbarth |

| Abbreviation | Work load | Credit points (CP) | Classification within the curriculum | Duration |
| --- | --- | --- | --- | --- |
| NT0010.1 | 75 h | 3 | 2nd semester advanced | one semester |

| 1 | Courses | Contact hours[1] | Self-study hours | Credit points (CP) |
| --- | --- | --- | --- | --- |
| | Online-tutorial of 6 weeks | 21 h | 54 h | 3 |

2 **Content and targeted learning outcomes**

**Content:**

- Biomaterials
- The interface biomaterial-biological system
- Nanotechnological aspects of biological systems
- Biomaterial properties control interactions with the biological system
- Nanotechnological tools improve biomaterials
- Nanosized materials for tissue engineering
- Nanotoxicology

**Targeted learning outcomes:**

This module focuses on biomaterials for implantation. Here the students learn how nanotechnological methods are used to improve biomaterial interactions with biological tissue, the properties of metallic, ceramic, and polymer based biomaterials. They will know several stages of the tissue regeneration process around an implant and how this process might be influenced by biomaterial properties. Further learning outcomes are the concept of biomimetic implants, the knowledge of the properties and factors which influence the biological response to an implant, the knowledge of the nanotechnological tools that are used to tailor biomaterials to their requirements, the impact of biomimetic materials for tissue engineering applications, and work safety aspects of nanotechnology. After learning this module the students will have the ability to decide which kind of biomaterial has to be used for which application.

3 **Literature**

Dee, K.C., Puleo, D.A., Bizios, R.: An Introduction to Tissue-Biomaterial-Interactions. Wiley-Liss, John Wiley & Sons, Hoboken, New Jersey, 2003.

Dee, K.C., Puleo, D.A., Bizios, R.: Handbook of Biomaterial Properties. Chapman & Hall, London, Weinheim, NY, Tokyo, Melbourne, Madras, 1998.

Helsen, J.A., Breme. J. (Eds.): Metals as Biomaterials. John Wiley and Sons, New York, 1998.

Brunette, D.M., Tengvall, P., Textor, M., Thomson, P.: Titanium in Medicine. Springer Verlag, Berlin, Heidelberg, New York, 2001.

Peters, M., Leyens, C.: Titanium and Titanium Alloys. Wiley-VCH, Weinheim, 2003.

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| | Science, 2002.<br>Guilak, F., Butler, D.L., Goldstein, S., Mooney, D.: Functional Tissue Engineering. Springer, New York, Berlin, Heidelberg, 2004.<br>Kasemo, B., Gold, J.: Biological Surface Science. Surface Science, Vol. 500, Elsevier, Netherlands, 2002.<br>Castner, D., Ratner, B.: Biomedical surface science: foundations to frontiers. Surface Sci. Vol. 500, Elsevier, Netherlands, 2002. |
| 4 | **Teaching format**<br>Textbook for self-study, self-control assignments, online tutorial |
| 5 | **Usability of the module in individual study programs**<br>As part of the optional module “Nanomaterials 2” in the Distance Study Program “Nanotechnology” (Master) |
| 6 | **Prerequisites**<br>Formal admission requirements: none<br>Contentual prerequisites: none |
| 7 | **Assessment**<br>Mail-in exercises |
| 8 | **Study achievements**<br>Solving the mail-in exercises |
| 9 | **Offered**<br>Yearly in summer semester |