MSc Biotechnology

The department of Biotechnology offers an international MSc programme in Biotechnology designed to enable those applicants who recognise the impetus of the global market to become active participants in and contributors to the field of biotechnology. All courses are held exclusively in English. The key features are:

- 1½ years (3 semesters) long
- Course starts every March (summer semester) and October (winter semester)
- Project-oriented teaching in small groups
- Intensive training programme in tutorials and seminars
- Application-oriented teaching and research
- Choice of two focuses
- Modular structure of the course programme based on ECTS
- Comprehensive student services and guidance

The MSc Programme in Biotechnology is intended for applicants who have successfully completed a first academic degree in a biological science. The admission requirements are:

1. First academic degree in a biological science (e.g. Biotechnology, Biological Chemistry, Biology, Microbiology, Bio-Engineering, Biomedical Sciences or Molecular and Cell Biology) - Bachelor of Science (German BSc or equivalent)
2. Solid knowledge and skills in microbiology, molecular biology and biochemistry (certified)
3. Solid knowledge and skills in mathematics, physics and chemistry (certified)
4. Very good skills in English (TOEFL: at least 92 (IBT), IELTS: at least 6.0) for applicants who have not studied in English). German applicants can have their English tested in an interview with the Course Coordinator, John Clear.
5. Proof of at least six months’ research-oriented practical experience
6. Resumée/curriculum vitae
7. Motivation letter
8. Two references from university professors and/or employees

The master programme offers two focuses: Biomedical Science and Technology (BST) and Bioprocess Development (BPD). The curricula include the following modules:

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<th>Biomedical Science and Technology</th>
<th>Bioprocess Development</th>
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<td><strong>1st Semester</strong></td>
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<td>• Biostatistics</td>
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<td>• From Research to Market</td>
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<td>• Biomedical Science</td>
<td>• Strain Development</td>
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<td>• Cell Based Assays</td>
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<td>• Drug Discovery</td>
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<td>• Genomics and Bioinformatics</td>
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<td>• Bioanalytical Sciences</td>
<td>• Protein Downstream Processing</td>
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<td>• Electives *)</td>
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<td><strong>3rd Semester</strong></td>
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<tr>
<td>• Master Thesis</td>
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* Electives: Immunology, Biochips and High-Content Screening, Clinical Chemistry, Plant Biotechnology, Transgenic Animals in Medicine, Pathophysiology, Environmental Biotechnology, Bioinformatics, Immunology, Modern Analytical Methods, Proteomics
For detailed module descriptions go to: www.biotech.hs-mannheim.de

The application deadline is 15 May for the winter semester and 15 November for the summer semester.

Mannheim University of Applied Sciences regrets that there is no financial support for students available at the moment. However students do not have to pay any fees to study at the university.

Students have to:
1. provide proof of sufficient health insurance (€54 monthly);
2. pay registration fees to the Students' Service (€101.50 per semester).

Students do not have to pay any tuition fees.

Single rooms are available in the student hostels with rent of between €190 and €250 per month. Furthermore a security of €385 has to be paid to the Students’ Service which will be returned when moving out. Living costs are at about €600 per month on top of the above costs.

Please note that you have to furnish proof of your financial standing by sending us proof of your financial means of €6,000.

For further information please do not hesitate to contact us.

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Attachment: MSc Biotechnology Prerequisites to Admission

There may be a little uncertainty as to what basic knowledge and skills are required to follow both focuses of the master course. In general, the prerequisites for the Biomedical Science and Technology (BST focus) are covered by a standard bachelor programme in a biological science whilst the Bioprocess Development (BPD) focus requires more deeper knowledge and skills in process engineering.

Part 1 summarizes different subject areas and indicates the topics in which we expect a potential applicant to have solid knowledge and skills in to follow both focuses. Part II summarizes specific knowledge and skills which make it easier for the student to follow the BDP focus.

Part 1: Basic Knowledge and Skills

Mathematics

Sets: number systems, real and complex numbers, vectors and vector spaces, the principle of induction
Sequences: properties of real sequences, sequence limits, properties of sequence limits
Functions: mappings, functions of one real variable, elementary functions, function limits, continuity of functions
Differentiation: slope and differentiability, standard derivatives, higher derivatives, L'Hospital’s rules, local extrema and points of inflection
Series: basic terms, convergence, power series, Taylor’s series, approximation
Integration: definite, indefinite and improper integrals, the fundamental theorem of calculus, methods of integration
Ordinary differential equations: separable differential equations, first and second order linear differential equations
Functions of Several Variables: limits and continuity of functions of several variables, partial derivatives, higher order derivatives, Taylor’s Theorem, local extrema, multiple integrals

Statistics

Descriptive statistics: basic model of system and data analysis, tabulations and frequency distributions, measures of location, measures of spread,
Probability theory: axioms of probability, working with probabilities, elements of combinatorial analysis, conditional probability
Probability distributions: random variables and distribution functions, discrete probability distributions, continuous probability distributions, central theorem of statistics, law of large numbers, central limit theorem, measures of probability distributions
Special probability distributions: normal, exponential, uniform, poisson, binomial, geometric, pascal, hypergeometric, multinomial

Physics

Kinematics: describing the motion in one, two and three dimensions, vectors, angular kinematics
Dynamics: force, mass, Newton’s laws, momentum, examples of forces, gravitation, friction
Work and energy: work, power, kinetic energy, conservative forces, potential energy, dissipative forces, the law of conservation of energy
Dynamics of rigid bodies: translational and rotational motion of rigid bodies, centre of mass, angular momentum, torque, moment of inertia
Oscillations: Harmonic oscillator, dampened, coupled, and forced oscillations, resonance, superposition, spectral analysis of oscillations
Waves: wave motion, wave types, standing waves, Doppler effect, Huygen’s principle, reflection and refraction, interference, diffraction
Optics: basic terms, geometrical optics, imaging by mirrors, lenses and compound lenses, aberrations, resolving power
Electricity: electrical forces and fields, work, electric potential, voltage, matter in electric fields, electric currents, metal conductors, semiconductors, insulators, Ohm's law, Kirchhoff’s laws, electric measurement techniques
Magnetism: charges in motion and magnetic forces, magnetic fields, inductance, electric generators, AC networks, impedance, matter in magnetic fields, ferromagnetism
Atom and quantum physics: matter and radiation, quantum nature of matter and radiation, wave nature of matter and radiation, photoelectric effect, Compton effect, properties of elementary particles (electron, proton, neutron, quark, photon), uncertainty principle, energy and angular momentum in quantum physics, emission and absorption of photons, atomic spectra and atomic shell model, periodic system

General Chemistry
Stoichiometric calculations and principles; chemical terminology; nomenclature of inorganic compounds; outline of the history of chemistry
Atomic structure; electronic configuration and the periodic table; periodicity of properties of the elements; chemical bonds; basic principles of molecular structure; introductory co-ordination chemistry; principles of radioactivity and nuclear reactions
Chemical equilibria and chemical reactions in aqueous solutions: redox reactions; acid-base chemistry; precipitation reactions
Introductory physical chemistry: properties of gases, liquids and solids; enthalpy and entropy; basics in electrochemistry
Application of the de Broglie, Pauli and Heisenberg theories in the study of atomic structure
Covalent bonding in terms of orbital overlap
Lattice energy; Born-Haber cycle; calculation of lattice energies of ionic compounds
Chemistry of selected main group elements in the environment (and biological systems), including analytical aspects
Introductory inorganic and co-ordination chemistry of transition elements in biological systems

Organic Chemistry
Bonding, structure, and nomenclature of organic molecules
Alkanes: physical properties; rotational conformation; halogenation of alkanes; nucleophilic displacement
Stereochemistry: stereoisomers; optical isomers; R-, S-
reactions of alkyl derivatives, properties of cycloalkanes
nomenclature; stereoselective reactions
Alkenes: properties of alkenes, elimination reactions for synthesis of alkanes, electrophilic addition to alkenes
Arenes: electrophilic aromatic substitution, effect of substituents on reactivity, orientation of electrophilic aromatic substitution
Molecules with a carbonyl group: properties and nomenclature of aldehydes and ketones, nucleophilic addition to the carbonyl group, properties, nomenclature and reactions of carboxylic acids and derivatives
Amino Acids: types and properties of biologically important amino acids, synthesis of amino acids
Peptides: peptide bond, properties of peptides, determination of the primary structure, peptide synthesis
Carbohydrates: classification of carbohydrates, structure and properties of D-glucose, D-fructose, and D-ribose, projection formulas for carbohydrates, conformations of carbohydrates, mutarotation
Derivatives of glucose: disaccharides - sucrose, maltose, cellobiose, lactose; polysaccharides - starch, cellulose
Lipids: types, structures and properties of different lipids - fatty acids, triacylglycerides, phospholipids, sphingolipids, terpenes, steroids, and prostaglandins
Detergents: types, structures, properties, and different syntheses
Synthesis, isolation, and purification of seven substances

Physical Chemistry
Physical properties of gases; Kinetic molecular theory of gases; Energy and the first law of thermodynamics
Entropy and the second and third laws of thermodynamics; Free energy and chemical equilibria
Chemical potential and its application
Electrolytic conductance, conductimetry, electrolytic dissociation, migration of ions, liquid potential, pH value, glass electrodes, sensitive electrodes, applications of potential measurement; voltaic cells (theory, classification, applications)
Physical transformations of pure materials, mixtures, phase rule, thermodynamics of mixing
Raoult’s law, colligative properties, mixtures of volatile liquids, Henry’s law
Mixtures with solid phases, three-component systems
Surface tension, adsorption at surfaces, adsorption isotherms, viscosity, diffusion
Kinetics of reactions under static conditions; irreversible reactions; first and second order reactions; temperature-dependence of the rat-constant; consecutive and parallel reactions; multiple phase reactions; catalytic reactions and enzymatic reactions
Selectivity of chemical reactions; Vapour pressure and enthalpy of vapourisation of liquids, liquid / gas equilibrium
Molecular Cell Biology

Evolutionary origin and molecular composition of cells, chemical foundations
Nucleic acids and proteins
Cell organisation and subcellular structures
DNA replication and recombination; basics of recombinant technology
The genetic code; gene expression; molecular anatomy of genes
Transcription and RNA processing; post-transitional modifications
Regulation of gene activity
Structure and function of biomembranes
Basics of cellular energetics, signal transduction; cell cycle and growth regulation

Monitoring and Control

Basic concepts and terminology of measuring techniques; steady state and dynamic characteristics of measuring devices; errors of measurement; statistical analysis of data
Sensors for temperature, force, torque, strain, displacement, path, pressure, mass flow and optoelectronics;
direct-current and alternating current bridges
Signal amplifiers; requirements and tasks; selected circuits with operational amplifiers; carrier amplification technique
Closed-loop control systems: transfer elements; frequency and time domain response; P-, I-, D-, PID-controllers; delay elements
Quality of closed-loop control: command and interference action, steady state error, closed-loop stability
Methods for optimising a closed loop system (CHR, Ziegler-Nichols); two-step and three-step control
Introduction to digital measuring technique

Biochemistry

Proteins, enzymes, immunoglobulins, proteins in blood, plasma and serum
Vitamins and coenzymes
Inhibition and enzyme kinetics; nucleic acids
Oxidation and biosynthesis of fatty and amino acids
Anabolic and catabolic metabolism of carbohydrates, lipids, and amino acids
Active and passive membrane transports
Citric acid, TCA, redox, electron transport and glyoxylate cycles
Electron transport and oxidative phosphorylation
Biochemical aspects of hormone action

Computing/Data Processing

Computer architecture including an overview of CPU, busses, memory, and I/O device concepts
Data representation of signals, images, text, sound, etc. in computer systems and binary concepts
Use of operating systems and IT packages, DOS and/or Windows, file management, basic IT introduction including word processing, graphics, and spreadsheets
Elementary Computer Programming with appropriate language (visual basic, basic, or C are examples)

Genetic Engineering and Lab

Principles of DNA manipulation
Gene cloning and analysis
Vectors; expression systems
DNA hybridisation and sequencing
PCR; DNA
Transgenic animals and plants
Gene transfer and therapy
In vitro mutagenesis; molecular diagnosis
Safety in genetic engineering labs, legal aspects, genetic engineering and ethics
Practical work: plasmid isolation, restriction enzyme mapping, gene cloning and selection
Southern blot analysis
Part 2: Specific Knowledge and Skills in BPD

Microbiology

Microorganisms, occurrence, and signification; Microbial evolution, systematics, and taxonomy
Bacteria and the structure of the bacterial cell; Introduction to fungi as important eukaryotic microorganisms
Microbial growth, Laboratory safety; Metabolic diversity in energy production
Microbial ecology: Cycles of carbon, nitrogen, and sulphur
Microscopy and specimen preparation; Differentiation of bacterial groups and structures by staining
Cultivation and enumeration techniques; Antibiotic sensitivity testing
Microbial examination of potable water and river water
Differentiation by biochemical reactions: The IMViC test
Bacteriophage titration; recombination; Genetics and molecular biology
Mutation, mutagenese and selection of mutants
Parasexual processes; regulation of gene expression

Industrial Microbiology

Enrichment, isolation, screening and improvement of industrial micro-organisms
Substrates and culture media for fermentation processes
Regulation of growth and product formation in fermentation processes
Anaerobic production processes: ethanol, glycerol, butanol/acetone
Aerobic production processes: citric acid, amino acids, antibiotics
Sewage and waste-water treatment by aerobic and anaerobic processes
Degradation of complex substances (aromatic, halogenated, hydrocarbons) and bioremediation

Bioreactors

Development of bioreactors as an evolution of reactors: bubble columns, airlift reactors, jet reactors, fluidised bed reactors, fixed bed reactors, membrane reactors, tube reactors and stirred tank reactors with variations in stirrers
Techniques using sterile filters, heat exchangers, pumps, valves, tubes, measurement and control systems
Details of sterile constructions
Optimisation by minimising the dead volume
Selection - with reference to a given matrix - of the most suitable bioreactor for a given biotechnological process

Fluid Dynamics and Mechanical Process Engineering

Particle characterisation; Particle size distributions; Characterisation of different separation processes
Forces acting on a particle in a fluid flow; Sedimentation
Counter-current separations, crosscurrent separations, separation equipment
Characterisation of granular beds, flow through packed beds, filtration; Fluidised beds
Characterisation and mathematical modelling; Mixing and mixing equipment
Introduction to water and other fluids in their relevance to society
Basic properties of fluids: density, specific weight, specific gravity
Elementary Fluid Statics: pressure variations in a static fluid
Evaluation of forces with static pressure gauges; Rotation of a fluid about a vertical axis
Continuity, energy, and momentum equations
Derivations and applications of various equations to flow measurement in pipes and open channels (venturi meter, orifice meter and sharp-crested weir) and in the calculation of dynamic fluid forces on pipe fittings
Flow in pipes: viscosity, pipe fittings and bends, flow in simple pipe systems; equivalent pipe diameters and flow through equipment
Newtonian and Non-Newtonian Fluids; Reynolds Number and the classification of flow regimes
Head-losses due to friction; head-gain via a pump; space energy and hydraulic grade lines
Uniform flow in open channels; roughness coefficients and the determination of flow in channels of simple cross sections
Conduction, convection, and radiation
Conduction through simple shapes and composite materials
Downstream Processing

Definition of downstream processing
General pathways of biotechnological downstream processing
Factors influencing downstream processing
Characterisation, mathematical modelling and scale-up of downstream processing steps, e.g.:
Cell disintegration; cross flow filtration
Cake filtration with compressible cakes
Centrifugal separation steps; chromatograph
Cell and product partitioning in two aqueous phases
Basic P&I Diagrams of the above-mentioned steps

Heat and Mass Transfer

Kinetic equation of heat and mass transfer
Calculation of the heat transfer coefficients with heat conduction, convection, thermal radiation, condensation and boiling
Heat exchanger calculation
Calculation of the mass transfer coefficient for diffusion and convection