The influence of multiple stressors on aquatic ecosystems is a key issue in water research at the Faculty of Biology.

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Faculty of Biology

The main research areas of the Faculty of Biology are divided into three fields: water and environmental research, medical biotechnology, and empirical research in education. They are closely linked to three research centres of the University, the Centre for Water and Environmental Research (ZWU), the Centre for Medical Biotechnology (ZMB), and the Interdisciplinary Centre for Educational Research (IZfB).

Research

With only 23 research groups, the Faculty of Biology is a relatively small faculty, but its three main research areas give it a very solid profile. The Faculty's groups are closely connected to various UDE research centres, and they collaborate intensively with the Faculty of Chemistry, the Faculty of Medicine, the Faculty of Engineering Sciences and various non-university research institutes. This allows its researchers to address a wide range of interdisciplinary and transdisciplinary topics. In its research as well as its teaching, the Faculty seeks to represent biology at all system levels: from biomolecules and cells to tissue, organisms and entire ecosystems.

Water and Environmental Research

The groups in the field of water and environmental research are closely linked to the Centre for Water and Environmental Research (ZWU). The majority of their work is on fundamental ecological and evolutionary topics, such as higher single-celled organisms (protists), and issues of applied ecotoxicology, environmental observation and long-term ecological research. They maintain a particularly close partnership in the study of the effects and detection of multiple stressors. In this field, they use a wide range of research methods ranging from traditional field studies to modern genomic analysis processes. The Genomics Core Facility (GCF) and the Central Collection of Algal Cultures (CCAC) provide infrastructural support to the groups working on water and environmental research.

The latter was transferred to the UDE's Faculty of Biology from the University of Cologne in 2020. It contains more than 7,000 strains of algae, making it one of the world's largest and most important algal collections. The University of Duisburg-Essen has established a modern infrastructure for cultivating algae, which includes cultivation rooms with light and temperature controls. Researchers all over the world have access to the large variety of algae taxa from freshwater and marine habitats held by the CCAC. Professor Michael Melkonian's senior professorship, which is closely associated with the CCAC, works on major genomic projects on the evolution of land plants. The new Phycology research group under Professor Bánk Beszteri was recently established in connection with the algae collection It focuses on diatoms, which are highly significant for global primary production and biomonitoring. The group has revealed how local genomic, ecophysiological and morphological differences can spread across diatom populations in different latitudes of the Southern Ocean despite existing migration opportunities.

Professor Jens Boenigk's Biodiversity research group examines the generalisability of ecological and evolutionary theories and hypotheses across various groups of organisms, also focusing on interdependencies between biodiversity and ecosystem functions. The researchers recently found evidence of geographical and ecological differentiation for microorganisms. Their main distribution ranges and regions with a high proportion of endemic species do no correspond to the pattern exhibited by plants and animals, however. Professor Micah Dunthorn's Eukaryotic Microbiology group also studies the applicability of theories and observations with a focus on protists in aquatic and terrestrial ecosystems, such as parasitic single-cell organisms. It uses modern molecular omics processes, bioinformatics and microscopy to understand microbial diversity from an ecological and evolutionary perspective.

Professor Florian Leese's Aquatic Ecosystems research group dedicates its work to the influence of multiple stress factors on aquatic animal populations and communities. It focuses on the impact of pesticides, salinisation, fine-sediment delivery and the fragmentation of rivers by transverse structures. The researchers use modern genetic methods to analyse the stressor effects. Within the scope of the EU COST Action DNAqua-Net (headed by Dr Leese) and other national and international projects (GeDNA and SCANDNAnet), researchers of the Faculty of Biology develop concepts for the standardised use of such processes in the context of EU-wide water monitoring initiatives.

Professor Daniel Hering's Aquatic Ecology research group also studies the effects of multiple stressors on freshwater ecosystems. His team creates data sets on the intensity of hydrological, morphological and material stressors affecting bodies of water across Europe and compares them to the ecological state of said surface waters. They have also accumulated original data from experiments and field work on multiple stressors

Researchers of the Faculty take water samples to determine the composition of an ecosystem in a non-invasive way using "environmental DNA".

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from all of Europe and evaluated them to determine general patterns. Case studies on the effects of individual stressors, such as intensive leisure activity, dessication of bodies of water and intensive agricultural use, supplement the overview. Professor Bernd Sures's research group also studies aquatic ecology. Using a 'one-health approach', it focuses on the intactness and functioning of aquatic ecosystems and their inhabitants. The group examines the effect of biotic and abiotic (toxic) stressors in bodies of water in one of its projects. In particular, this involves assessing how the implementation of a fourth cleaning phase in water treatment plants, aimed at reducing micropollutant concentrations, could impact the biocenoses of connected flowing bodies of water. Research into diffuse pollution in flowing waters and its effect on local organisms is carried out in the Emscher basin and the North West province of South Africa. In the bodies of water of the Ruhr area and Sicily (in partnership with the Aquatic Ecosystems group), the Baltic Sea and the Levant, the group studies the distribution and effects of various groups of parasites.

Professor Peter Haase of the Senckenberg Research Institute oversees the River and Floodplain Ecology group, which carries out long-term ecological research. It is part of the global network International Long-Term Ecological Research (ILTER). Within this context, Professor Haase has headed a study on the loss of aquatic insects from a German nature reserve over the course of 42 years. Using the world's highest-resolution dataset, he was able to show that even significant losses in the number of organisms do not necessarily lead to a loss of biodiversity.

Professor Hardy Pfanz's Applied Botanics and Volcanic Biology research group examines the effects of the extreme volcanic release of carbon dioxide (mofetta) on local organisms. At the Laacher See in the Eifel mountains, of several European and German locations surveyed, the researchers were able to characterise a mofetta discharging large volumes of gas using conclusive soil parameters, such as water content, buffering capacity and soil gas concentrations.

Professor Ulrich Schreiber's (Geology) work also focuses on carbon dioxide. He researchers processes taking place at a depth of around 1,000 metres in fissures in the Earth's crust. On the early Earth, it contained all raw materials required for life to develop. Laboratory experiments emulating those conditions found that vesicles formed. Combining these results with amino acids, which emerge in hydrothermal conditions, they were able to prove the chemical evolution of peptides for the first time.

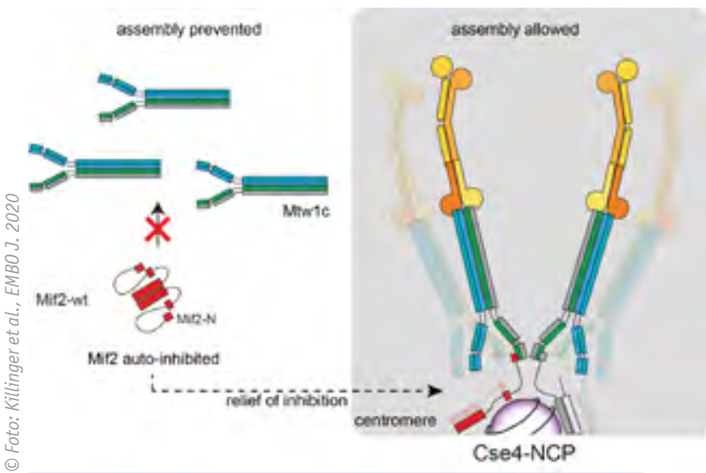
Medical Biotechnology

The research area of Medical Biotechnology is closely linked to the Centre for Medical Biotechnology (ZMB), which also incorporates research groups from the Faculty of Medicine and the Faculty of Chemistry. It is an interdisciplinary field that focuses on the mechanistic understanding of (patho)biological processes. Its insights can be transferred to medical practice. In this context, the research groups involved work on a range of topics in basic research and on the development of diagnostic approaches and new active ingredients. The Imaging Centre Campus Essen (ICCE), Imaging Centre Essen (IMCES) and the Analytics Core Facility (ACE) provide infrastructural support to this research area.

The ability of cells to divide and flawlessly to pass on their full genetic blueprint to the next generation is a fundamental requirement for life. Two research groups, Molecular Genetics I and II, study this consistency of genetic information across many generations. Professor Stefan Westermann's group focuses on mitosis. Using methods from molecular biology and biochemistry, the group has shown how cells ensure that a kinetochore can only assemble at a single point of a chromosome (FIGURE 1). Kinetochores are the structures at which chromosomes attach to the mitotic spindle; they are one of the most complicated molecular machines that exist in cells. Errors in this process may have serious consequences, such as the emergence of cancer cells. Professor Dominik Boos's research group studies how replication initiation, the process that forms the molecular machines which carry out DNA replication, is regulated. Using genetic manipulation and methods from bioinformatics, the group has been able to gain insights into the structure and functioning of the central regulatory platform, a complex composed of the proteins treslin and MTBP.

Professor Peter Bayer's Structural and Medical Biochemistry group also researches the structure and function of proteins. It focuses on peptidyl-prolyl isomerases. These enzymes are important for the functioning of other other proteins within the cell, enabling them to switch their activities on or off. In collaboration with chemistry groups, the researchers studied the interaction of molecular tweezers and guanidiniocarbonyl pyrrole ligands with proteins in CRC 1093 'Supramolecular Chemistry on Proteins'. Using spectroscopic methods such as nuclear magnetic resonance (NMR), they were able to detect binding sites on proteins such as survivin. Survivin is a protein that inhibits programmed cell death (apoptosis inhibitor). It is found in cancer cells. Professor Shirley Knauer (Molecular Biology II) also researches this enzyme and taspase 1. Her work focuses on the regulation of nucleo-cytoplasmic transport and its significance for the cell cycle. New insights into this process can help science understand the malignant transformation that occurs when cancer develops, for instance, Together with groups from the Faculty of Chemistry, Professor Knauer has identified

Dean: Professor Dr Philipp Schmiemann



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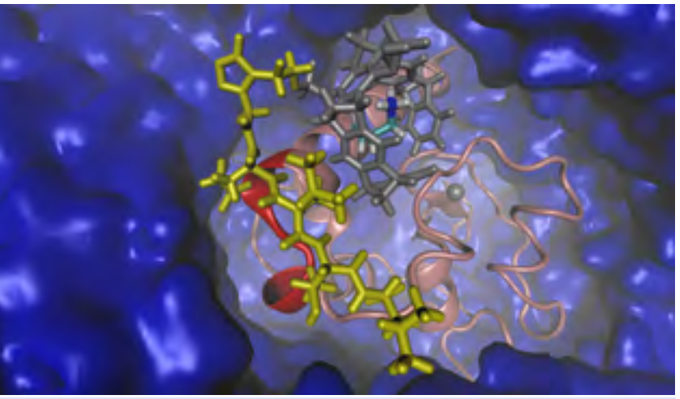
Model for Mif2 regulation during budding yeast kinetochore assembly.



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The protein survivin (red, pink) with artificial ligands (grey, yellow) in water (blue). Several research groups focus on survivin, including those of Professor Hoffmann, Professor Bayer, Professor Sánchez-García and Professor Knauer in collaboration with Professor Schrader from the Faculty of Chemistry (CRC 1093).

a specific ligand that inhibits the formation of survivin on histone H3 inside cells and prevents the proliferation of cancer cells. These results may potentially inform new therapeutic approaches.

While the absence of programmed cell death (apoptosis) is a problem in cancer cells, its occurrence can be similarly problematic in other contexts. Processes of ageing and other factors can damage the fragile components of cells, causing cell death and neurodegenerative disorders. Professor Hemmo Meyer's (Molecular Biology II) research group has successfully proven that the enzyme VCP/p97 plays an important role in the clearance of damaged lysosomes. Lysosomes are cell organelles containing digestive enzymes. They must be replaced by new, functional organelles regularly. In collaboration with international partners, the group has identified another important player in this process: the enzyme UBE2QL1 marks damaged lysosomes with the protein ubiquitin to ensure that VCP/p97 recognises them and initiates their clearance. Because mutations in VCP/p97 cause neural and muscular degeneration in humans, this is a significant step towards decyphering the molecular and cellular causes of degenerative disorders.

Professor Michael Ehrmann's (Microbiology) research group also focuses on the causes of degenerative disorders. The protease HTRA1, for example, plays an important part in the pathogenesis of age-related macular degeneration (AMD). Deliberate inhibition of this protease, then, could constitute a new approach in AMD therapy. In its pursuit of a selective and potent inhibitor, the research group works with partners from the Faculty and the private sector on analysing various classes of substances that may potentially be suitable. It has found that inhibitors can activate their target in certain conditions, which would not only cause therapy to fail but even lead to harmful results – a very important insight for the development of drugs.

Professor Perihan Nalbant's (Molecular Cell Biology) group studies the role of cell movement mechanisms in the development of tumour-relevant phenotypes. Using total internal reflection fluorescence microscopy (TIRFM), activity sensors and live-cell analyses, the researchers study signal networks that can regulate the temporal and spatial organisation of the actin cytoskeleton by creating dynamic, sub-cellular activation patterns of Rho proteins. The actin cytoskeleton is responsible for cell movement among other things.

Professor Andrea Vortkamp's Developmental Biology research group is interested in the molecular mechanisms causing degenerative musculoskeletal disorders such as osteoarthritis. The researchers focus on long-chain sugar molecules (heparan sulfates), which play a role in forming and sustaining the cartilage matrix. Experiments on mice have shown that certain changes to their structure slow the advance of osteoarthritis. In collaboration with researchers from France, the group examines how the structure of the sugar molecules controls the composition of the cartilage matrix and the activity of enzymes that cause cartilage degeneration.

Professor Doris Hellerschmied's Mechanistic Cell Biology research group is interested in cells under stress. It investigates the molecular mechanisms that control the stress response and protein quality control in human cells. At their centre lies an important cellular compartment, the Golgi apparatus: its functioning is crucial for the right modification and distribution of cellular proteins. Any dysfunction of the Golgi apparatus can lead to neurodegenerative disorders, which cause the cells of the nervous system gradually to die. The researchers examine this quality control mechanism in proteins by manipulating the folding state, i.e., the structure, of model proteins with chemical tools. Professor Barbara Saccà (Bionanotechnology) also focuses on the folding of biomolecules, or rather, THE biomolecule: DNA. Using DNA nanotechnology, the group can produce simplified models of complex biological objects with specific properties. They can be artificial viruses for gene or protein transfer or, as in this case, DNA. The researchers have shown that the further folding of biomolecules is decided at an early stage at germinal centres, i.e., regions along which a structure grows. The forces in play here, then, determine the future structural fate of complex structures.

Professor Markus Kaiser's Chemical Biology group designs and validates chemical probes for basic research in biology and as starting points for the development of pharmaceuticals. They are then used to solve a variety of biological issues. In particular, the researchers use target-oriented design concepts. They also work on decyphering the molecular mechanisms of action of bioactive substances.

Besides biochemical and cellular tools for experiments with molecules and cells, computer technologies and bioinformatics tools play an important role in modern biology. In collaboration with other researchers, Professor Daniel Hoffmann's (Bioinformatics and Computational Biophysics) group develops models for complex biomedical systems in order to analyse their data quantitatively. This includes models for the efficacy of cancer drugs and the protective effect of certain sugar chains against osteoarthritis. Not only does the group's work simplify access to complex models, it enables other researchers to develop their own models using specific tools. Professor Elsa Sánchez-García's Computational Biochemistry group focuses on the development and application of computer tools for examining biomolecules. These tools can, for instance, be used to understand the mechanism by which molecular tweezers disrupt the viral envelope. The corresponding molecules can then be established as broad-spectrum

Selected Publications

Bachvarova, V., T. Dierker, J. Esko, D. Hoffmann, L. Kjellen, A. Vortkamp (2020): *Chondrocytes respond to an altered heparan sulfate composition with distinct changes of heparan sulfate structure and increased levels of chondroitin sulfate. Matrix Biology 93, 43–59. doi: 10.1016/j.matbio.2020.03.006.*

Birk, S., D. Chapman […], B. Sures […], D. Hering (2020): *Impacts of multiple stressors on freshwater biota across spatial scales and ecosystems. Nature Ecology and Evolution 4, 1060–1068. doi: 10.1038/s41559-020-1216-4.*

Killinger, K., M. Böhm, P. Steinbach, G. Hagemann, M. Blüggel, K. Jänen, S. Hohoff, P. Bayer, F. Herzog, S. Westermann (2020): *Autoinhibition of Mif2/CENP-C ensures centromere-dependent kinetochore assembly in budding yeast. The EMBO Journal 39, e102938. doi: 10.15252/embj.2019102938.*

Koerver, L., C. Papadopoulos, B. Liu, B. Kravic, G. Rota, L. Brecht, T. Veenendaal, M. Polajnar, A. Bluemke, M. Ehrmann, J. Klumperman, M. Jäättelä, C. Behrends, H. Meyer (2019): *The ubiquitin-conjugating enzyme UBE2QL1 coordinates lysophagy in response to endolysosomal damage. EMBO Reports 20, e48014. doi: 10.15252/embr.201948014.*

Kosinski, R., A. Mukhortava, W. Pfedifer, A. Candelli, P. Rauch, B. Saccà (2019): *Sites of high local frustration in DNA origami. Nature Communication 10, 1061. doi: 10.1038/s41467-019-09002-6.*

Mambrey, S., J. Timm, J.J. Landskron, P. Schmiemann (2020): *The Impact of System Specifics on Systems Thinking. Journal of Research in Science Teaching 57, 1632–1651. doi: 10.1002/tea.21649.*

Pilotto, F., I. Kühn, R. Adrian […], P. Haase (2020): *Meta-analysis of multidecadal biodiversity trends in Europe. Nature Communications 11, 3486. doi: 10.1038/s41467-020-17171-y*

Postel, U., B. Glemser, K. Salazar Alekseyeva, S.L. Eggers, M. Groth, G. Glöckner, U. John, T. Mock, K. Klemm, K. Valentin, B. Beszteri (2020): *Adaptive divergence across Southern Ocean gradients in the pelagic diatom Fragilariopsis kerguelensis. Molecular Ecology 29, 4913–4924. doi: 10.1111/mec.15554.*

Vallet, C., D. Aschmann, C. Beuck, M. Killa, A. Meiners, M. Mertel, M. Ehlers, P. Bayer, C. Schmuck, M. Giese, S.K. Knauer (2020): *Functional disruption of the cancer-relevant interaction between Survivin and Histone H3 with a guanidiniocarbonyl pyrrole ligand. Angewandte Chemie International Edition 59, 5567–5571. doi: 10.1002/anie.201915400.*

Wang, S.B., […] M. Melkonian, H. Liu, H., X. Liu, (2020): *Genomes of early-diverging streptophyte algae shed light on plant terrestrialization. Nature Plants 6, 95–106. doi: 10.1038/s41477-019-0560-3.*

Professors

Medical Biotechnology
Professor Dr Peter Bayer
Professor Dr Dominik Boos
Professor Dr Michael Ehrmann
Professor Dr Doris Hellerschmied-Jelinek
Professor Dr Daniel Hoffmann
Professor Dr Christian Johannes
Professor Dr Markus Kaiser
Professor Dr Shirley Knauer
Professor Dr Hemmo Meyer
Professor Dr Andrea Musacchio
Professor Dr Barbara Saccà
Professor Dr Elsa Sánchez-García
Professor Dr Alexander Schug
Professor Dr Andrea Vortkamp
Professor Dr Stefan Westermann

Water and environmental research
Professor Dr Sabine Begall
Professor Dr Bank Beszteri
Professor Dr Jens Boenigk
Professor Dr Micah Dunthorn
Professor Dr Peter Haase
Professor Dr Daniel Hering
Professor Dr Florian Leese
Professor Dr Michael Melkonian
Professor Dr Hardy Pfanz
Professor Dr Ulrich Schreiber
Professor Dr Bernd Sures

Empirical research in education
Professor Dr Angela Sandmann
Professor Dr Philipp Schmiemann

antiviral drugs. The group also employs tools for predicting protein-protein interactions (PPI-Detect) and examining proteins using machine-learning methods (ProtDCal suite), which are highly popular with other researchers.

Subject-specific empirical research in education

Two research groups focusing on biology education make up the research area of subject-specific empirical research in education. They work on questions related to learning and teaching biology in schools and in education contexts outside of school. In partnership with other research groups from the field of subject-specific and general education research, they also focus on interdisciplinary issues. Both groups are integrated into the Interdisciplinary Centre for Educational Research (IZfB), which pools all research activities in this area.

The Lehr-Lern-Labor (Learning and Teaching Laboratory) gives school classes a professional environment for independent experimenting.

Professor Angela Sandmann's research group works on topics of digital and extracurricular learning, focusing primarily on the services of the Faculty's Bio-Innovativ Lehr-Lern-Labor (Innovative Biology Learning and Teaching Laboratory) and questions of teacher education and professional development. Its research interests are centred around the individual acquisition of proficiency in subject-specific and conceptual knowledge and the development of new insights in the natural sciences.

Professor Philipp Schmiemann's research group concentrates on the difficulties learners face in comprehending various fields of biology. It studies how learners understand biological systems, such as the feeding relationships in an ecosystem or the regulation of blood sugar levels. In partnership with the other research groups at the Faculty of Biology, Professor Schmiemann's group aims to support the learning experience of biology students and gain a better understanding of what causes students to quit their studies.

Awards

Doris Hellerschmied of the Faculty of Biology has won the Sofja Kovalevskaja Award, one of the most highly endowed research prizes in Germany. The Alexander von Humboldt Foundation is funding the Faculty's new research group on mechanistic cell biology with 1.65 million euros. This new group focuses on an important cellular sub-unit called the Golgi apparatus and how it handles stress and ensures the functioning of its proteins under normal and pathological conditions.

Transfer and sustainability

Due to the nature of the subject, sustainability plays an important role at the Faculty of Biology. Its research reflects this by addressing questions of sustainability directly. The research area of water and environmental research contributes to a better understanding of aquatic ecosystems, for example. Its insights can inform new measures for protecting our natural environment. This transfer of research results into practice also takes place in the areas of medical biotechnology and subject-specific empirical research in education. Insights from biomedical research, for instance, can constitute a basis for new ways of treating cancer and other conditions in future. In the area of subject-specific education research, the work of the Lehr-Lern-Labor and the available professional-development courses for biology teachers transfer expertise in the fields of biology and biology education into school-based teaching practice.

The Faculty's commitment to sustainability also includes the establishment of a research data management system, which facilitates the re-use of research data and the joint use of large scientific equipment in core facilities. This includes the CCAC algae collection. Not only does it contribute to the protection of the unique life forms, it grants all researchers worldwide access to its resources.

Outlook

The Faculty of Biology will continue to deepen and hone its key research areas in the coming years. CRC 1439, 'Multilevel Response to Stressor Increase and Release in Stream Ecosystems (RESIST)', will constitute a major focus in the area of water and environmental research. Various research groups based at the University of Duisburg-Essen and its partner institutions will spend an initial period of four years studying the impact of individual and combined stressors in flowing bodies of water on biodiversity and its functions. The project is funded with 12.3 million euros by the German Research Foundation (DFG) and headed by its two CRC spokesmen, Professor Bernd Sures and Professor Daniel Hering. It will focus on the three most harmful stressors: rising temperatures, salinisation and hydromorphological degradation. Its insights may inform models for describing and predicting the degradation and recovery of flowing bodies of water.

In the area of medical biotechnology, a CRC initiative involving an interdisciplinary approach of biology, molecular oncology and chemistry aims to make conceptual progress in the understanding of cell state transitions. The diverse, switch-like trigger mechanisms of the critical transitions between these states play an important role in processes such as carcinogenesis and treatment resistance. The initiative has already strengthened the profile of biomedical research and intensified the partnership between the involved disciplines considerably.

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