MAXIMILIAN JOSEF LUDWIG JOHANNES FÜRST, PHD

MRC Laboratory of Molecular Biology
PNAC Division
Francis-Crick Avenue, CB2 0QH
Cambridge, United Kingdom

e-mail: mfurst@mrc-lmb.cam.ac.uk
web: ORCID, Scholar, LinkedIn, Twitter
phone: +44 1223 267611
Born: 10/08/1988, Germany

ACADEMIC EMPLOYMENT, RESEARCH, EDUCATION

06/2022 – present **University of Groningen (RUG): Tenure-Track Assistant Professor / Group Leader.**
My lab is using computational protein design to engineer DNA-modifying enzymes. By combination with high-throughput screening, we create massive sequence-function data sets that serve as the basis for machine learning for protein design.

09/2019 – 05/2022 **MRC Laboratory of Molecular Biology: Postdoctoral Scientist with Dr. P. Holliger**
Ultra-high-throughput engineering of DNA polymerases to i) synthesise expanded genetic alphabets for synthetic biology applications of semi-synthetic organisms; ii) investigate disease-related nucleic acid modifications by defined reverse transcription (RT) error signatures. In my postdoc, I created large polymerase mutant libraries and screened millions of variants in bead emulsions followed by flow cytometry.
I also contributed to a project using ribosome display on sequencing chips for the generation of massive sequence-function maps.

03/2019 – 09/2019 **University of Groningen: Postdoctoral Scientist with Prof. M. W. Fraaije**
Initiated the first experiments of a new EU-funded group project ("Smartbox") that aims to engineer oxidative enzymes for industrial biocatalysis by computational design.

03/2015 – 03/2019 **RUG: PhD Student with Prof. M. W. Fraaije**
Explored the applicability of heme- and flavin-containing enzymes for application as biocatalysts within an EU-funded project comprising nine academic and eight industrial partners ("ROBOX"). Included the discovery, characterization, computational redesign, and engineering of proteins using biochemical, molecular biology, and computational approaches. Among others, I discovered and characterised new thermostable and promiscuous oxidative enzymes and engineered enzymes for increased solvent and thermostability based on energy calculations and MD simulations followed by experimental screening. I also performed several mutagenesis studies based on *in silico* structure analysis to elucidate mechanisms of substrate promiscuity, and used computational methods to rationalise altered specificities.
My resulting PhD thesis received a rare *cum laude* distinction.

05/2016 Visiting scholar at the **University of Pavia with Prof. A. Mattevi**
Gained experience in protein crystallography, incl. data collection at the synchrotron.

10/2011 – 11/2013 **University of Munich (LMU): Master of Science Biology**
Courses mostly in genetics, microbiology, and biochemistry.

04/2013 – 09/2013 **Master Thesis with Prof. J. Lassak and Prof. K. Jung, Microbiology Department**
Discovered and characterised a glycosyl transferase that post-translationally mounts rhamnose on elongation factor P, a universally essential protein required for translation. Performed *in vivo* reporter assays, created knock out strains, cloned various constructs, and performed some basic protein engineering. This work resulted in the first report of arginine glycosylation in bacteria.

09/2012 – 03/2013 Semester abroad via Erasmus Mobility Program at the **University of Málaga**
Intensive course in Spanish to level B1 through Erasmus. Expanded theoretical repertoire by a course selection focussed on cell biology and biotechnology.

06/2012 – 08/2012 **Research Internship with Prof. T. Lahaye, Genetics Department**
Created a genetic bioluminescence system (Split-GFP) to monitor delivery of transcription activator-like effectors (TALEs) of plant pathogenic bacteria. This project combined molecular approaches incl. cloning and *Agrobacterium* plant transfections.

12/2011 – 02/2012 **Research Internship with Prof. H. Jung, Microbiology Department**
Characterized essential virulence factor in *Helicobacter pylori* by characterising knock out strains. Applied methods included molecular complementation and phenotypic characterisation. This project was performed in a biosafety level 2 laboratory.

10/2008 – 11/2011 **University of Munich (LMU): Bachelor of Science Biology**
Course selection focussed on molecular biology subjects.

05/2011 – 07/2011 **Bachelor Thesis with Prof. D. Leister, Plant Science Department**
Mapped the location of signalling rescue mutations in *Arabidopsis* using a PCR-based assay. Characterised growth by writing an image analysis script.

TEACHING EXPERIENCE

03/2022 – present **RUG: Lecturer**
I hold various lectures in the "Biotechnology"(BSc) and "Advanced Genetic Engineering" (MSc) courses in the Biology program and am coordinator of the "Biochemistry and Biotechnology" (BSc) practical for Chemistry students. I am further involved in the RUG's teaching activities by acting as examiner for exams, essays, and colloquia.

06/2021 – 08/2021 **MRC LMB: daily supervisor for undergraduate summer student**
Together with this student, a colleague and I devised and tested various molecular biology techniques for the isolation of a single specific DNA fragment out of a large pool of identical DNA via their unique molecular identifier ("barcode").

05/2018 – 07/2018 **RUG: daily supervisor for bachelor thesis**
This student was involved in thermostability engineering and enthusiastic to learn computational approaches. I wrote a tutorial for basic bash scripting and structure analysis and the student later pursued a master and PhD in bioinformatics.

04/2016 – 01/2017 **RUG: daily supervisor for master thesis**
Also involved in thermostability engineering, this student had the challenging task to first perform structural analysis and then perform semi-high-throughput protein production, purification, and screening.

2015 – 2017 **RUG: mentor for visiting scientists**
04/2017 I guided a PhD student from Warsaw in screening monooxygenases for activity with challenging substrates using biochemical conversion assays and chemical analysis.

07/2016 I guided a postdoc from Delft (now a PI at the UMCG) in computational enzyme engineering, giving i.a. an introduction to scripting, docking, and MD simulations.

12/2015 I trained two PhD students from the ROBOX EU project with a background in chemistry in biochemical approaches for enzyme production and activity screening.

09/2015 – 01/2016 **RUG: co-supervisor for master thesis**
I supported supervision of a Dutch master student for a protein engineering project

09/2015 – 10/2015 **RUG: practical course supervisor** in protein engineering for master students

10/2012 – 11/2013 **LMU: practical course tutor** microbiology for year 2 undergrads

01/2011, 01/2012 **LMU: practical course tutor** in botany for year 1 undergrads

03/2012 **LMU: practical course tutor** in microbiology for year 1 undergrads

GRANTS, PRIZES, AND AWARDS

12/2021 **Compute Services Access** (Surf.nl) one year (500,000 SBUs) of GPU and CPU access on *Snellius* HPC

12/2021 **NWO-Talent programme Veni** (Science Domain) for "Designer Proteins on Display" (€280,000) for a fully funded PhD position in the Fürst lab

12/2020 **EMBO Postdoctoral Fellowship**, 2 years funding (€120,000) for the project "Engineered Reverse Transcriptases for High-Throughput Epitranscriptome Mapping"

06/2020 Nominee of RUG's Faculty of Science and Engineering for the **Wierenga Rengerink Prize** 2019

12/2019 **Van Swinderen Prize** (2nd place, 1000€), Groningen Royal Physics Society for the PhD thesis

08/2012 **Erasmus Mobility Scholarship**

INVITED TALKS AND POSTERS

12/2019 Lecture for Van Swinderen Prize at the Groningen Forum (to a non-specialist audience)

05/2019 MPI for Terrestrial Microbiology (Marburg, Germany) **group seminar talk**. Host: Prof. T. Erb

04/2019 MRC Laboratory of Molecular Biology (Cambridge, UK), **group seminar talk**. Host: Dr. A. Bertolotti

01/2019 University of Wageningen, **group seminar talk**. Host: Prof. M. Medema

03/2019 Netherlands' Catalysis and Chemistry Conference (Leiden, The Netherlands), **talk**

09/2018 EMBO Workshop Enzymes, Biocatalysis & Chemical Biology (Pavia Italy), **poster**

06/2018 Gordon Research Seminar & Conference on Biocatalysis (Biddeford, USA), **poster**

12/2017 CHAINS (Veldhoven, The Netherlands), **talk**

09/2017 Enzyme Engineering (Toulouse, France), **poster**

06/2017 Symposium on Flavins and Flavoproteins (Groningen, The Netherlands), **poster**

10/2016 Novel Enzymes (Groningen, The Netherlands), **poster pitch talk**

10/2016 Oxizymes (Wageningen, The Netherlands), **poster**

2016 – 2019 Regularly presented project progress at the biannual ROBOX project meetings

SCIENTIFIC TRAINING

2022 Yearly meeting Netherlands Society of Biomolecular Modeling (Brussels, Belgium), working group meeting COZYME cost action (Fuengirola, Spain).

2021 Attended **virtual conference** (without presenting): BioDesign Research Conference

2020 Various **virtual conferences** (without presenting): CINBI 2020, World CRISPR Day, RNA 2020, EFB Biocatalysis Open Day, BioDesign Research Conference

06/2020 Three-day course in **analysis of bulk RNA-seq data with R**, MRC LMB

11/2019 Four-day course in **Numeric Python and Deep Neural Network Basics**, MRC LMB

05/2016 Five-day training school **systems biocatalysis**, COST action, Siena, Italy

03/2016 One-day Workshop in **numerical python**, RUG

09/2015 Two-day course on **protein mass spectrometry**, RUG

04/2015 Five-day masterclass **Computational Approaches for Discovery & Engineering of Enzymes**, RUG

ACADEMIC SERVICES

2020-2021 Refereeing for *ChemBioChem*, *Angewandte Chemie*

03/2009 – 10/2013 Member of the LMU Faculty for Biology's student representative organisation
Representing students' in university councils, conflict mediation, event organisation

11/2011 – 08/2012 Student assistant, Prof. Michael Boshart, Genetics Department, LMU.
In this role, I supported the group's IT capacity by creating internally-used databases

EDUCATION BREAKS

12/2013 – 11/2014 Gap year; solo backpacking the Indian subcontinent on a budget
09/2007 – 05/2008 Obligatory alternative civilian service; served full time as operating room nurse in a hospital

LANGUAGES

German – native
English – fluent
Spanish – fluent
Dutch – conversational
French – basics
Programming: Python, Bash, R

PUBLICATIONS

The Journal Impact Factor is indicated (IF). An up-to-date citation count can be inferred from my Google Scholar count on my personal site (M.J.L.J. Fürst, h-index = 15, https://scholar.google.nl/citations?user=gVIpE-wAAAAJ&hl)

Key papers – peer-reviewed publications in international journals

(1) Fürst, MJLJ; Boonstra, M; Bandstra, S; Fraaije, MW; (**2019**) Stabilization of cyclohexanone monooxygenase by computational and experimental library design; *Biotechnol. Bioeng*. 116:2167-2177. (IF 4.1)

(2) Fürst, MJLJ; Romero, E; Gómez Castellanos, JR; Fraaije, MW; Mattevi, A. (**2018**) Side-Chain Pruning Has Limited Impact on Substrate Preference in a Promiscuous Enzyme. *ACS Catal*. 8:11648-11656. (IF 12.4)

(3) Fürst, MJLJ; Savino, S; Dudek, HM; Gomez Castellanos, JR; Gutierrez de Souza, C; Rovida, S; Fraaije, MW; Mattevi, A. (**2017**) Polycyclic Ketone Monooxygenase from the Thermophilic Fungus *Thermothelomyces thermophila*: A Structurally Distinct Biocatalyst for Bulky Substrates. *J. Am. Chem. Soc*. 139:627-630. (IF 14.6, highlighted paper in Thieme Synfacts 2017; 13(04): 0422)

(4) Fürst, MJLJ; Kerschbaumer, B; Rinnofner, C; Winkler, M; Fraaije, MW; (**2019**) Exploring the Biocatalytic Potential of a Self-Sufficient Cytochrome P450 from *Thermothelomyces thermophila. Adv. Synth. Catal.* 361:2487-2496. (IF 5.9)

Co-authored, peer-reviewed publications in international journals

(5) Aalbers, FS.; Fürst, MJLJ; Rovida, S; Trajkovic, M; Gómez Castellanos, JR; Bartsch, S; Vogel, A; Mattevi, A; Fraaije, MW. (**2020**) Approaching Boiling Point Stability of an Alcohol Dehydrogenase Through Computationally-Guided Enzyme Engineering. *Elife*. 9:e54639. (IF 7.1)

(6) Volkwein, WV; Krafczyk, R; Jagtap, PKA; Parr, M; Mankina, E; Macošek, J; Guo, Z; Fürst, MJLJ; Pfab, M; Frishman, D; Hennig, J; Jung, K; Lassak, J; (**2019**) Switching the Post-Translational Modification of Translation Elongation Factor EF P. *Front. Microbiol*. 10:1148. (IF 4.2)

(7) Li, G; Garcia-Borràs, M; Fürst, MJLJ; Ilie, A; Fraaije, MW; Houk, KN; Reetz, MT. (**2018**) Overriding Traditional Electronic Effects in Biocatalytic Baeyer-Villiger Reactions by Directed Evolution. *J. Am. Chem. Soc.* 140:10464-10472. (IF 14.6)

(8) Delgove, MA; Fürst, MJLJ; Fraaije, MW; Bernaerts, KV; de Wildeman, SM. (**2018**) Exploring the Substrate Scope of Baeyer–Villiger Monooxygenases with Branched Lactones as Entry Towards Polyesters. *ChemBioChem* 19:354-360. (IF 2.6)

(9) de Gonzalo, G; Fürst, MJLJ; Fraaije, MW. (**2017**) Polycyclic Ketone Monooxygenase (PockeMO): A Robust Biocatalyst for the Synthesis of Optically Active Sulfoxides. *Catalysts* 7:288. (IF 3.5)

(10) Li, G; Fürst, MJLJ; Mansouri, HR; Ressmann, AK; Ilie, A; Rudroff, F; Mihovilovic, MD; Fraaije, MW; Reetz, MT. (**2017**) Manipulating the Stereoselectivity of the Thermostable Baeyer-Villiger Monooxygenase TmCHMO by Directed Evolution. *Org. Biomol. Chem*. 15:9824-9829. (IF 3.6)

(11) Valencia, D; Guillén, M; Fürst, MJLJ; López-Santín, J; Álvaro, G. (**2017**) An Immobilized and Highly Stabilized Self-Sufficient Monooxygenase as Biocatalyst for Oxidative Biotransformations. *J. Chem. Technol. Biotechnol*. 93:985-993. (IF 2.8)

(12) Lassak, J; Keilhauer, EC; Fürst, M; Wuichet, K; Gödeke, J; Starosta, AL; Chen, J-M; Søgaard-Andersen, L; Rohr, J; Wilson, DN; Häussler, S; Mann, M; Jung, K. (**2015**) Arginine-Rhamnosylation as New Strategy to Activate Translation Elongation Factor P. *Nat. Chem. Biol*. 11:266. (IF 12.6)

(Co-)authored review articles and book chapters

(13) Korbeld, KT; Fürst, MJLJ. (**2023**) Curse and Blessing of Non-proteinogenic Parts in Computational Enzyme Engineering; *ChemBioChem* (IF 3.5)

(14) Gerecht, K; Freud, N; Liu W; Liu Y; Fürst, MJLJ; Holliger, P. (**2023**) The Expanded Central Dogma: Genome Resynthesis, Orthogonal Biosystems, Synthetic Genetics; *Annu. Rev. Biophys.* (IF 19.76)

(15) Freud, N; Fürst, MJLJ; Holliger, P. (**2021**) New chemistries and enzymes for synthetic genetics; *Curr. Opin. Biotechnol.* (IF 9.74)

(16) Fürst, MJLJ; Gran-Scheuch, E; Aalbers, FS; Fraaije, MW. (**2019**) Baeyer-Villiger Monooxygenases: Tunable Oxidative Biocatalysts; *ACS Catal*. 9:11207-11241. (IF 12.4)

(17) Fürst, MJLJ; Fiorentini, F; Fraaije, MW. (**2019**) Beyond Active Site Residues: Overall Structural Dynamics Control Catalysis in Flavin-Containing and Heme-Containing Monooxygenases. *Curr. Opin. Struct. Biol*. 59:29. (IF 6.9)

(18) Fürst, MJLJ; Martin, C; Lončar, N; Fraaije, MW. (**2018**) Experimental Protocols for Generating Focused Mutant Libraries and Screening for Thermostable Proteins. In: *Methods in Enzymology*; Academic Press; 608:151-187. (IF 1.9)

(19) Wijma, HJ; Fürst, MJLJ; Janssen, DB. (**2018**) A Computational Library Design Protocol for Rapid Improvement of Protein Stability: Fresco. In: *Methods in Molecular Biology*; Springer; 1685:69-85. (IF 10.7)