M U N I

COMMENTARY TO HABILITATION THESIS

Archaea have colonized Earth for almost 3.5 billion years. Together with bacteria they are regarded to be one the most ancient life forms that exist on our planet. Archaea were initially described as an independent phylogenetic group of organisms in 1977. They are prokaryotic organisms with fascinating physiological, cell biological, evolutionary and biotechnological characteristics. Archaea also possess an ecological importance as they contribute to the global carbon and nitrogen cycles.

Concerning biotechnology, Archaea are still heavily overshadowed by Bacteria and Eukaryotes in terms of scientific studies, public awareness, research and development as well as in industrial application. Yet, the genomic, biochemical, physiological and cell biological properties of archaea show a vast potential for a wide range of applications that would allow using or developing them as natural or into engineered microbial cell factories though synthetic biology or bioprocess development.

Some of the many advantages of utilizing archaea as microbial cell factories include the ability to cultivate many of these sometimes extremophilic strains under non-sterile conditions. Another advantage is that some bioprocesses use inexpensive or sometimes toxic feedstock, which reduces the cultivation costs. Moreover, there are often simply no bacterial or eukaryotic cell factories available that could produce the desired products. Eventually, with regard to synthetic biotechnology of archaea, genetic systems have already been established to be able to perform genetic, metabolic and pathway engineering manipulations to develop recombinant archaeal cell factories.

My work focuses on anaerobic and extremophilic microorganisms with an emphasis on archaea physiology and biotechnology. The main archaeal groups that are used in my research are methanogenic archaea, extreme halophilic archaea, ammonium oxidizing archaea, thermoacidophilic archaea and anaerobic archaea. A specific focus of my research lies on Archaea Biotechnology, artificial archaeal co-cultures and carbon dioxide converting enzymes and bioprocesses. Moreover, the role and the potential of archaea in the future of sustainable bioprocessing, circular bioengineering and biorefining are important research avenues.

My cumulative habilitation thesis presents the background of research on archaea biology with an emphasis on extremophilic and anaerobic microorganisms and various aspects of Archaea Biotechnology. My cumulative habilitation thesis then shows results and discusses their contribution to the physiology, cell biology and biotechnology of archaea. For this cumulative habilitation thesis, I have chosen 12 published, peer-reviewed research articles to which I contributed as co-author, last author or as corresponding author. All these research

papers broadly belong to the research field of archaea physiology and biotechnology. My research, that led to these papers, strongly benefitted from national and international scientific collaborations. My contribution to these 12 peer-reviewed research articles in summarized in the following tables and in the author contribution statements of the individual papers. Specifically, my contribution regarding experimental work, supervision of bachelor, master, PhD students or post docs, as a PI, group leader and manager, my contribution to manuscript genesis, writing and editing as well as my contribution for providing research direction guidance, development and implementation, is indicated.

1) Palabikyan, H., Ruddyard, A., Pomper, L., Novak, D., Reischl, B., Rittmann, S.K.-M.R., 2022. Scale-up of biomass production by *Methanococcus maripaludis*. Frontiers in Microbiology 13. https://doi.org/10.3389/fmicb.2022.1031131; SJR(2023): 1.065, Q2: Microbiology (2023)

Experimental work (%)	Supervision (%)	Manuscript (%)	Research direction (%)
-	100	35	100

2) Taubner, R.-S., Baumann, L.M.F., Steiner, M., Pfeifer, K., Reischl, B., Korynt, K., Bauersachs, T., Mähnert, B., Clifford, E.L., Peckmann, J., Schuster, B., Birgel, D., Rittmann, S.K.-M.R., 2023. Lipidomics and Comparative Metabolite Excretion Analysis of Methanogenic Archaea Reveal Organism-Specific Adaptations to Varying Temperatures and Substrate Concentrations. mSystems 8, e01159-22. https://doi.org/10.1128/msystems.01159-22; SJR(2023): 1.642, Q1: Microbiology (2023)

Experimental work (%)	Supervision (%)	Manuscript (%)	Research direction (%)
5	80	35	95

3) Pfeifer, K., Ehmoser, E.-K., Rittmann, S.K.-M.R., Schleper, C., Pum, D., Sleytr, U.B., Schuster, B., 2022. Isolation and Characterization of Cell Envelope Fragments Comprising Archaeal S-Layer Proteins. Nanomaterials 12, 2502. https://doi.org/10.3390/nano12142502; SJR(2023): 0.798, Q1: General Chemical Engineering (2023)

Experimental work (%)	Supervision (%)	Manuscript (%)	Research direction (%)
-	10	10	50

4) Baumann, L.M.F., Taubner, R.-S., Oláh, K., Rohrweber, A.-C., Schuster, B., Birgel, D., Rittmann, S.K.-M.R., 2022. Quantitative Analysis of Core Lipid Production in *Methanothermobacter marburgensis* at Different Scales. Bioengineering 9, 169. https://doi.org/10.3390/bioengineering9040169; SJR(2023): 0.627, Q3: Bioengineering (2023)

Experimental work (%)	Supervision (%)	Manuscript (%)	Research direction (%)
-	80	35	95

5) Steger, F., Reich, J., Fuchs, W., Rittmann, S.K.-M.R., Gübitz, G.M., Ribitsch, D., Bochmann, G., 2022. Comparison of Carbonic Anhydrases for CO_2 Sequestration. International Journal of Molecular Sciences 23, 957. https://doi.org/10.3390/ijms23020957; SJR(2023): 1.179, Q2: Molecular Biology (2023)

Experimental work (%)	Supervision (%)	Manuscript (%)	Research direction (%)
-	5	5	50

6) Zipperle, A., Reischl, B., Schmider, T., Stadlbauer, M., Kushkevych, I., Pruckner, C., Vítězová, M., Rittmann, S.K.-M.R., 2021. Biomethanation of Carbon Monoxide by Hyperthermophilic Artificial Archaeal Co-Cultures. Fermentation 7, 276. https://doi.org/10.3390/fermentation7040276; SJR(2023): 0.549, Q2:Biochemistry, Genetics and Molecular Biology (miscellaneous) (2023)

Experimental work (%)	Supervision (%)	Manuscript (%)	Research direction (%)
-	100	35	100

7) Fuchs, W., Steger, F., Reich, J., Ribitsch, D., Rittmann, S.K.-M.R., Bochmann, G., 2021. A Simple and Straightforward Method for Activity Measurement of Carbonic Anhydrases. Catalysts 11, 819. https://doi.org/10.3390/catal11070819; SJR(2023): 0.693, Q1: General Environmental Science (2023)

Experimental work (%)	Supervision (%)	Manuscript (%)	Research direction (%)
-	5	5	50

8) Pende, N., Sogues, A., Megrian, D., Sartori-Rupp, A., England, P., Palabikyan, H., Rittmann, S.K.-M.R., Graña, M., Wehenkel, A.M., Alzari, P.M., Gribaldo, S., 2021. SepF is the FtsZ anchor in archaea, with features of an ancestral cell division system. Nature Communications 12, 3214. https://doi.org/10.1038/s41467-021-23099-8; SJR(2023): 4.887, Q1: General Biochemistry, Genetics and Molecular Biology (2023)

Experimental work (%)	Supervision (%)	Manuscript (%)	Research direction (%)
15	15	10	10

9) Mauerhofer, L.-M., Zwirtmayr, S., Pappenreiter, P., Bernacchi, S., Seifert, A.H., Reischl, B., Schmider, T., Taubner, R.-S., Paulik, C., Rittmann, S.K.-M.R., 2021. Hyperthermophilic methanogenic archaea act as high-pressure CH_4 cell factories. Communications Biology 4, 289. https://doi.org/10.1038/s42003-021-01828-5; SJR(2023): 2.090, Q1: General Biochemistry, Genetics and Molecular Biology (2023)

Experimental work (%)	Supervision (%)	Manuscript (%)	Research direction (%)
5	80	60	100

10) Ergal, İ., Reischl, B., Hasibar, B., Manoharan, L., Zipperle, A., Bochmann, G., Fuchs, W., Rittmann, S.K.-M.R., 2020. Formate Utilization by the Crenarchaeon *Desulfurococcus amylolyticus*. Microorganisms 8, 454. https://doi.org/10.3390/microorganisms8030454; SJR(2023): 0.944, Q2: Microbiology (2023)

Experimental work (%)	Supervision (%)	Manuscript (%)	Research direction (%)
5	90	35	100

11) Mooshammer, M., Alves, R.J.E., Bayer, B., Melcher, M., Stieglmeier, M., Jochum, L., Rittmann, S.K.-M.R., Watzka, M., Schleper, C., Herndl, G.J., Wanek, W., 2020. Nitrogen Isotope Fractionation During Archaeal Ammonia Oxidation: Coupled Estimates From Measurements of Residual Ammonium and Accumulated Nitrite. Frontiers in Microbiology 11, 1710. https://doi.org/10.3389/fmicb.2020.01710; SJR(2023): 1.065, Q2: Microbiology (2023)

Experimental work (%)	Supervision (%)	Manuscript (%)	Research direction (%)
10	5	5	5

12) Milojevic, T., Kölbl, D., Ferrière, L., Albu, M., Kish, A., Flemming, R.L., Koeberl, C., Blazevic, A., Zebec, Z., Rittmann, S.K.-M.R., Schleper, C., Pignitter, M., Somoza, V., Schimak, M.P., Rupert, A.N., 2019. Exploring the microbial biotransformation of extraterrestrial material on nanometer scale. Scientific Reports 9, 1–11. https://doi.org/10.1038/s41598-019-54482-7; SJR(2023): 0.900, Q1: undefined (2023)

Experimental work (%)	Supervision (%)	Manuscript (%)	Research direction (%)
20	5	10	5