PERSONAL DETAILS

Name: **Braun, Dieter**
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• EDUCATION

02/05/2000	PhD in Physics, Technische Universität München, Munich, Germany (Prof. Peter Fromherz)
1997	Diplom in Physics, Technische Universität München, Munich, Germany

• CURRENT POSITION

2007 – today	Professor (independent, permanent), Systems Biophysics, Ludwig-Maximilians-Universität München, Munich, Germany

• PREVIOUS POSITION(S)

2003 – 2007	**Emmy Noether** Junior Research Group Leader, Ludwig-Maximilians-Universität München, Munich, Germany
2000 – 2003	Postdoctoral Fellow with Prof. Albert Libchaber, Rockefeller University, New York, NY, USA

RESEARCH ACHIEVEMENTS AND PEER RECOGNITION

Research achievements

Research focus. Our group combines physics and chemistry to solve the puzzles of the origins of life. My vision is to **understand by lab experiments how life could have emerged**. Despite the niche in which we are working, publications in high-profile journals of diverse disciplines (PNAS, Nature Physics, Nature Chemistry, Angewandte, JACS, PRL), demonstrating our leadership combining various disciplines such as **geoscience, chemistry, biology and physics**.
Being part of the **Simons Collaboration** on the Origins of Life, we bridged from non-equilibrium physics and performed the most challenging experiments in the origins-of-life field. Before the ERC Starting and ERC advanced grant, I was awarded the **Klung Wilhelmy Price**, the highest endowed price for young physicists in Germany. One of our track records is our ability to combine **experimental explorations with a full theoretical modeling** of the experiments. For this, we have gained a decade-long experience in using Comsol Multiphysics finite element calculations to fit our experimental data.

Our open lab structure and scientific mindset is very flexible and we **grab new opportunities fast**. For example we were able to debug the debated cGMP Polymerization in the dry state of di Mauro (doi:10.1002/cbic.201300773), triggered hydrothermal microfluidic and volcanic experiments in collaboration with geoscientists (doi:10.1111/gbi.12572, doi:10.1126/sciadv.adi1884, doi:10.1016/j.chemgeo.2023.121343). Aggregation and sedimentation is possible for short RNA, enabling a mode for replication, as shown with theorists (**PNAS** doi:10.1073/pnas.2218876120).

Unexpected combination of optics, physics and biochemistry is one of our hallmarks. For example, a Fourier-space imaging lock-in allowed us to image fast kinetics in living cells (**PNAS** doi:10.1073/pnas.0901313106), scanning IR lasers enable light-driven optofluidics in water and pH uncaging enable an all-optical Zeta potential measurement. Our studies of Thermophoresis led to **Nanotemper, a biotech company** coming from Origin of Life research with >210 employees. We expect **fast evolutionary biotechniques** to emerge from this synergy ERC Grant, significantly improving SELEX in terms of speed and leading the way to yet another Startup Company.

Last but not least, I try to bring together PIs in the **Origin of Life field network**. Most notably, With the CRC initiative in Munich (now relaunched) and the Origins Excellence initiative, I established Munich as an **Origin of Life hub of Germany** and Europe. I try to balance the sometimes fighty environment by fostering direct communication through discussion formats at the yearly Molecular Origins Munich (MOM) meetings which I have now organized since 2016.

Since the beginning of my academic career I have published **147 articles** in international peer-reviewed journals including 10x *PNAS*, 5x *Nature Chemistry*, 1x *Nature Physics*, 3x *JACS*, 2x *Nature Communications*, 13x *Angewandte*, 18x *Physical Review Letters,* 11x *Biophysical Journal,* 1x *eLife*; **12331 citations** (Google Scholar, 11.11.2023), **h-index 50**.

• MOST RELEVANT PUBLICATIONS FROM THE LAST 10 YEARS (descending chronology)

(1) Salditt, A., Karr, L., Salibi, E., Le Vay, K., Braun, D.*, & Mutschler, H.* (2023). Ribozyme-mediated RNA synthesis and replication in a model Hadean microenvironment. *Nat. Commun.*, *14*(1), 1495.

> In this work, we demonstrate that heated air-water interfaces exposed to a CO_2-rich atmosphere can enable ribozyme-catalyzed RNA replication as well as template-directed synthesis and release of functional ribozymes in a single environment. Our results establish air bubbles as compelling environments for prebiotic replication and synthesis of functional RNAs. The project is a testimony to our collaborative work on the design of complex ribozyme systems (Mutschler) and microfluidic non-equilibrium systems (Braun).

(2) Ianeselli, A., Atienza, M., Kudella, P. W., Gerland, U., Mast, C. B., & Braun, D. (2022). Water cycles in a Hadean CO2 atmosphere drive the evolution of long DNA. *Nature Physics*, *18*(5), 579-585. (23 citations)

> We could show that air-water interfaces are a unique setting to drive RNA or DNA evolution. Here we probed the robust protein-driven PCR reaction as a proxy and showed that very long sequences with complex sequence patterns emerge. Fluorescence imaging was used to show that both pH and salt cycling separate the strands. As the replication occurs only at the interface, very long replication is possible by the feeding from the bulk fluid.

(3) Ianeselli, A., Tetiker, D., Stein, J., Kühnlein, A., Mast, C. B., Braun, D., & Dora Tang, T. Y. (2022). Non-equilibrium conditions inside rock pores drive fission, maintenance and selection of coacervate protocells. *Nature chemistry*, *14*(1), 32-39. (44 citations)

> In this work we show that air-water interfaces are a unique place to accumulate coacervates and thus keep them away from a fully phase separated end state. Only at the interface did the coacervate droplets form and exhibit rich droplet separation dynamics, suggesting that they may provide a long term protocell environment for early reactions.

(4) Kudella, P. W., Tkachenko, A. V., Salditt, A., Maslov, S., & Braun, D. (2021). Structured sequences emerge from a random pool when replicated by templated ligation. *Proceedings of the National Academy of Sciences*, *118*(8), e2018830118. (26 citations)

> Through deep sequencing, we observed the formation of replication networks with unexpected complex selection patterns and intricate self-control kinetics. Random initial strands quickly divided into complementary subnetworks, enhancing replication and elongation, leading to the rapid generation of long strands. These findings highlight templated ligation as a unique mechanism for creating autocatalytic networks.

(5) Hudson, R., de Graaf, R., Strandoo Rodin, M., Ohno, A., Lane, N., McGlynn, S. E., …, Braun, D. & Sojo, V. (2020). CO_2 reduction driven by a pH gradient. *Proceedings of the National Academy of Sciences*, *117*(37), 22873-22879. (79 citations)

> In this collaboration with Victor Sojo, we tested if simple organics could be made from CO_2 by reduction from H_2 in the hydrothermal pH gradients provided by microfluidics. This process was demonstrated under moderate conditions, driven by microfluidic pH gradients across inorganic Fe(Ni)S precipitates. Interestingly, the kinetics was fast, but the overall yield was moderate, indicating that hydrothermal settings seem not optimal for such reactions.

(6) Morasch, M., Liu, J., Dirscherl, C. F., Ianeselli, A., Kühnlein, A., Le Vay, K., ... & Braun, D. (2019). Heated gas bubbles enrich, crystallize, dry, phosphorylate and encapsulate prebiotic molecules. *Nature Chemistry*, *11*(9), 779-788. (75 citations)

> This seminal publication introduces the utilization of air-water interfaces for diverse prebiotic chemistries. Cooperative molecular accumulation, driven by the continuous evaporation and recondensation water cycle, was confirmed within minutes through simulation. Exploring a broad range of prebiotic reactions prompted experiment optimization, yielding numerous fruitful experiments and inspiring this grant proposal.

(7) Kreysing, M., Keil, L., Lanzmich, S., & Braun, D. (2015). Heat flux across an open pore enables the continuous replication and selection of oligonucleotides towards increasing length. *Nature chemistry*, *7*(3), 203-208. (177 citations)

For the first time, we demonstrated that the 'tyranny of the shortest' - the dominance of shorter replicating sequences, can be overcome through a thermophoretic accumulation mechanism. DNA replication is facilitated by a polymerase, while accumulation and strand separation are governed by a static temperature difference. Notably, 75-mers replicate more rapidly than 35-mers under these conditions. The continuous fluid flow establishes an environment conducive to perpetually sustained replication.

(8) Reichl, M., Herzog, M., Götz, A., & Braun, D. (2014). Why charged molecules move across a temperature gradient: The role of electric fields. *Physical review letters*, *112*(19), 198101. (151 cit.)

We revealed the key factors driving the movement of DNA or RNA along a temperature gradient, providing the first fully quantitative prediction of charge-triggered thermophoresis. Our results demonstrated that thermophoresis is governed by local equilibrium statistical mechanics – a breakthrough in the fundamental understanding of this phenomenon.

(9) Mast, C. B., Schink, S., Gerland, U., & Braun, D. (2013). Escalation of polymerization in a thermal gradient. *Proceedings of the National Academy of Sciences*, *110*(20), 8030-8035. (188 cit.)

We show both in experiment and theory that thermophoresis across cracks of rock accumulated RNA or DNA strands exponentially to the point that polymerization yields increase non-linearly, leading to very long strands. It was tested with sticky-ended DNA and showed that physical non-equilibrium conditions significantly change prebiotic chemistry.

(10) Seidel, S. A., Dijkman, P. M., Lea, W. A., van den Bogaart, G., Jerabek-Willemsen, M., Lazic, A., …, Braun, D. & Duhr, S. (2013). Microscale thermophoresis quantifies biomolecular interactions under previously challenging conditions. *Methods*, *59*(3), 301-315. (662 citations)

This publication describes how thermophoresis inside capillaries can be used to quantify biomolecular binding in solution. It is one of the seminal publications of the Biotech NanoTemper, founded by the first two PhD students of my group from Origin of Life research, demonstrating that we can transfer basic research into successful commercial products.

• FELLOWSHIPS AND AWARDS

2023	Fellow in the Max Planck School **Matter to Life**
2023	Spokesperson of reapplication Research Center CRC 392 Molecular evolution in prebiotic environments
2019	**Technology Transfer** Price of the **German Physical Society**
2018	**ERC Advanced Grant 'EvoTrap'**
2018	Volkswagen Foundation Life! Grant
2018-today	**Spokesperson** and initiator of Research Center CRC 235 Emergence of Life
2018-today	**Spokesperson** of the Center for NanoScience (CeNS)
2018-today	**Coordinator** and initiator of the Molecular Origins in the Origins Cluster
2015	**Founder of Origins of Life Initiative Munich** (OLIM)
2015	**Deutscher Gründerpreis** for NanoTemper
2014-today	**Simons Foundation Collaborator** on the Origins of Life
2013-today	Member of the Board of Center for Nanoscience (CeNS)
2013	**Deutscher Innovationspreis** for NanoTemper
2013	**STEP Award** for NanoTemper
2011	**Klung-Wilhelmy Weberbank Price** (highest paying young scientist price Germany)
2010	**ERC Starting Grant**
2008	Biotech Start-up **NanoTemper** from 2 PhD students (now >210 employees)
2003-2007	**Emmy Noether Young investigator Grant** of the German Science foundation
2001	Schloessmann Award in Optical Methods in Modern Biology
2000-2003	**Emmy Noether Postdoctoral** Fellowship (DFG)

• ORGANIZATION OF SCIENTIFIC MEETINGS

2016-today **Organiser** of Molecular Origins Munich **2016, 2018, 2020, 2021,2022 and 2023** with >24 invited international PIs and >250 on site participants.

2020 Co-organizer of the Emergence of Life Focus session at the annual meeting of the Dresden DPG German Physical Society (DPG) meeting, Dresden

• SUPERVISION OF GRADUATE STUDENTS AND POSTDOCTORAL FELLOWS (if applicable)

2007-today Supervision of **36 Master students**, **30 PhD students**, **10 Postdocs** at the Physics Faculty of LMU, Germany

• TEACHING ACTIVITIES

2007-today Teaching fundamental courses in physics at LMU, including **Thermodynamics, Optics** and **Electrodynamics** to all second year physics students.

2010- Defining a course on **Systems Biophysics**, bridging disciplines from Biochemistry, Game Theory, Economics, Biophysics and Evolutionary Ecology

2015-today Organizing and defining a Course on **Origins of Life in the Universe** in collaboration with colleagues from Chemistry, Geoscience and Astrophysics.

• INSTITUTIONAL RESPONSIBILITY

2023-today Faculty member of the International Max Planck Research School **Matter to Life**

2012-2016 **Prodekan of the Physics Faculty** LMU

• REVIEWING ACTIVITIES (if applicable)

2019-today **Scientific board** Origins of Life initiative Paris

2019-today **Scientific board** Origin of Life initiative Netherlands

2007-today Reviewer of many international journals, including Nature, Nat. Chem., Nat. Physics, Angew.Chem., PNAS, Nucleic Acid Research, Nat. Comms., Scientific reports, Physical Review letters.

• MEMBERSHIPS OF SCIENTIFIC SOCIETIES

2007 - today Member of the German Physical Society

2023-today Member of the German Chemical Society

2012 - today Member of International Society for the Study of the Origins of Life**.**

2018 - 2023 **Executive Council Member**, International Society for the Study of the Origins of Life (ISSOL)**.**

2015 **Founder of Emergence of Life network Munich**, LMU, Germany

• MAJOR COLLABORATIONS

Matt Powner (UCL London), John Sutherland (MRC-LMB, Cambridge), Judit E. Sponer (Biophysics Institute Brno), Thomas Franosch (University Innsbruck), Ram Krishnamurthy (Scripps), Gerald Joyce (Salk), Andres Jäschke (Heidelberg), Uli Gerland (TU Munich), Erwin Frey (LMU), Irene Chen (UCLA), Don Dingwell (LMU), Dora Tang (MPI Dresden), Hannes Mutschler (TU Dortmund), Christof Weber (Augsburg), Dimitar Sasselov (Harvard).

ADDITIONAL INFORMATION

Career breaks. Between 04/2005 and 09/2006, I took a **parental halftime leave** to care for our two children and to promote the career of my wife who is now Professor at University Regensburg (Veronica Egger). I have in depth insights into the multifaceted problems of women in science. We recently celebrated the first newborn from a PhD student. We learned how to create a fitting environment also for these challenging conditions.