# PhD and Postdoctoral Researcher Positions

## ERC Advanced Grant Project ProtoEco

*Protoecologies between Artificial Cells and Mammalian Cells*

**Walther Lab @ Johannes Gutenberg University Mainz, Germany**

Max Planck Research Fellow Group @ Max Planck Institute for Polymer Research

www.walther-group.com

European Research Council

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## Keywords

*Artificial cells, synthetic cells, biomaterials, synthetic biology, DNA nanoscience, polymer gels, systems chemistry, enzymatic reaction networks, cell biology, biointerfaces, mammalian cells, tissue-like systems, cell spheroids, biointeractive materials.*

## Project Background

The Walther Lab at JGU Mainz pioneers life-like materials and systems at the interface of systems chemistry, chemical reaction networks, DNA nanoscience, artificial cells, polymer materials, and cell-facing biomaterials. We are interested in empowering molecular systems, materials, and artificial cells with embodied intelligence — chemical and physical — so that they can compute, adapt, self-regulate, or make simple decisions.

With the new **ERC Advanced Grant project ProtoEco – Protoecologies between Artificial Cells and Mammalian Cells**, we aim to pioneer a new generation of interactive communities between life-like artificial and living matter. The central question is whether life-like artificial/synthetic cells can coexist, communicate, and cooperate with mammalian cells in structured 2D and 3D environments.

Instead of treating artificial/synthetic cells as isolated mimics of life, ProtoEco will develop biohybrid micro-communities that exchange metabolites, energy, and signals. We aim to understand how such synthetic–living communities can give rise to emergent, adaptive, collective, and potentially homeostatic properties, and how these concepts may open new directions in intelligent biomaterials, tissue engineering, and adaptive therapeutic systems.

## Research Directions

We are looking for excellent PhD researchers and postdoctoral researchers who want to contribute to one or more of the following research directions.

### 1. Polymer-based artificial cells, biointeractive materials, and metabolic coupling

We will develop soft polymer capsules and microgel artificial-cell platforms with tunable mechanics, permeability, responsiveness, and biointerface properties. By integrating enzymatic reaction networks, metabolic modules, and homeostatic feedback systems, we will establish synthetic cross-feeding and metabolic interactions with mammalian cells.

**Possible project elements include:**

- Microfluidic synthesis of polymer capsules and microgels
- Encapsulation of enzymatic reaction networks, metabolic modules, or pH-feedback systems
- Tuning the mechanics, permeability, and responsiveness of artificial cells
- Quantification of metabolic exchange and synthetic cross-feeding
- Construction of metabolic interaction maps with mammalian cells

### 2. DNA-based artificial cells and molecular computing

We will engineer DNA-based artificial cells and condensates that can sense, process, and respond to molecular signals. These systems provide a powerful platform for DNA computing and programmable signal processing.

**Possible project elements include:**

- Preparation and functionalization of DNA-based artificial cells
- Design of DNA computing circuits
- Integration of molecular logic gates into artificial cell compartments
- Protein, cytokine, or metabolite sensing
- Development of signal-processing artificial cells that communicate with living cells

### 3. Artificial-cell/mammalian-cell interfaces and biomaterials concepts

ProtoEco will combine artificial and mammalian cells in structured 2D landscapes, co-spheroids, and tissue-like assemblies to determine how spatial organization, cell–material interactions, mechanics, and molecular communication shape emergent behavior.

**Possible project elements include:**

- Mammalian cell culture and artificial cell / cell co-culture
- Assembly of artificial cell / mammalian cell co-spheroids
- Lithographic or colloidal approaches to 2D and 3D organization
- Quantitative fluorescence and confocal microscopy
- Image analysis of spatial organization, viability, signaling, and dynamics
- Development of structure–function–behavior maps for biohybrid communities

### 4. Therapies and applications: Adaptive and homeostatic signaling concepts

We will develop artificial cells that sense disease-relevant signals and generate regulated outputs, with a long-term focus on adaptive responses in tumor-microenvironment models and immunotherapy.

**Possible project elements include:**

- Artificial cells that process cytokine signals or re-establish tissue homeostasis
- Synthetic signaling hubs for tumor-microenvironment models
- Reporter cell assays and quantitative microscopy and cell biology

Projects may emphasize chemistry, materials, DNA, cell interfaces, or biology. We welcome interdisciplinary researchers motivated by ambitious, high-risk, high-gain science.

## Candidate Profile

We are looking for highly motivated researchers with strong training in one or more of the following areas:

- Chemistry (e.g. polymer chemistry, systems chemistry, chemical biology, biochemistry)
- Synthetic biology
- Biomaterials, Biotechnology, Biophysics
- Bioengineering, cell biology, molecular biology

Ideal candidates have performed at the top of their study programs and combine scientific curiosity, quantitative thinking, and interdisciplinary teamwork. Relevant experience may include artificial cells, DNA nanotechnology, reaction networks, microfluidics, cell culture, biomaterials, or image analysis.

We expect excellent English skills, an independent and self-responsible work ethic, and genuine curiosity for complex interdisciplinary research. Postdoctoral applicants should have a strong publication record and the independence, creativity, and rigor to lead an ambitious research direction. Cover letters should explain your fit with ProtoEco and contribution to its high-risk, high-gain goals.

## We Offer

- A collaborative, international, and interdisciplinary team working on an ambitious ERC-funded topic offering excellent skills development and publication opportunities
- Excellent state-of-the-art laboratory infrastructure with access to advanced analytical, imaging, materials, and cell-culture facilities
- Close supervision and strong support for scientific development
- Opportunities to develop your own ideas within the broader ProtoEco framework
- A stimulating research environment with national and international collaboration opportunities
- Support for conferences, workshops, networking, and career development
- Possible association with the Max Planck Graduate Center for excellent PhD candidates

## Application

Please send your application as a single PDF file including:

- Letter of motivation, including a short summary of your past research experience and research interests
- Curriculum vitae
- Transcript of records for Bachelor’s and Master’s studies
- For PhD applicants: a meaningful summary of your Master’s thesis
- For postdocs: a brief overview of key achievements and future interests, explaining your fit with ProtoEco

- List of publications, if applicable
- Contact details for two referees

**Please send applications to: walther-application@uni-mainz.de**

Applications are reviewed on a rolling basis until the positions are filled; the first team members will be recruited by the end of November.

Positions are paid according to the German public salary scale with full social benefits.

**We look forward to receiving your application and to building the next generation of artificial–living protoecologies together.**

## Selected Further Reading from the Walther Lab

**3 Conceptual Reviews:**

- Walther, "**Viewpoint: From Responsive to Adaptive and Interactive Materials and Materials Systems: A Roadmap**," *Advanced Materials* **32**, 1905111 (2020).
- Samanta, L. Baranda Pellejero, M. Masukawa, A. Walther, "**DNA-Empowered Synthetic Cells as Minimalistic Life Forms**," *Nature Reviews Chemistry* **8**, 454 (2024).
- R. Merindol, A. Walther, "**Materials Learning from Life: Concepts for Active, Adaptive and Autonomous Molecular Systems**," *Chemical Society Reviews* **46**, 5588 (2017).

**Artificial/Synthetic Cell Technologies:**

- J. Krehan, C.-R. Li, M. Masukawa, E. Amstad, A. Walther, "**Homeostatic Artificial Cells Enable Self-Protection in Prototissue Spheroids**," *Chem* **11**, 102409 (2025).
- W. Chen, S. Song, A. Samanta, S. Sethi, C. Drees, M. Kappl, H.-J. Butt, A. Walther, "**Growing Functional Artificial Cytoskeletons in the Viscoelastic Confinement of DNA Synthetic Cells**," *Nature Chemical Engineering* **2**, 627 (2025).
- W. Chen, B. Dúzs, P. G. Argudo, S. V. Bauer, W. Liu, A. Samanta, S. H. Parekh, M. Bonn, A. Walther, "**Ballistic Diffusion Fronts in Biomolecular Condensates**," *Nature Nanotechnology* **20**, 1062 (2025).
- M. Xie, W. Chen, M. de Roy, A. Walther, "**Constructing Synthetic Nuclear Architectures via Transcriptional Condensates in a DNA Protonucleus**," *Nature Communications* **16**, 8254 (2025).
- L. Baranda Pellejero, M. Vonk-de Roy, D. Baykal, L. Lehmann, A. Walther, "**DNA Flipping as Facile Mechanism for Transmembrane Signaling in Synthetic Cells**," *Journal of the American Chemical Society* **147**, 33643–33654 (2025).
- W. Chen, J. Fritzen, A. Walther, "**Phase Separation of Nucleic Acids: Mechanisms, Properties, and Applications**," *Angewandte Chemie International Edition* **65**, e202523943 (2026).
- Samanta, M. Hörner, W. Liu, W. Weber, A. Walther, "**Signal-Processing and Adaptive Prototissue Formation in Metabolic DNA Protocells**," *Nature Communications* **13**, 3968 (2022).
- Samanta, V. Sabatino, T. R. Ward, A. Walther, "**Functional and Morphological Adaptation in DNA Protocells via Signal Processing Prompted by Artificial Metalloenzymes**," *Nature Nanotechnology* **15**, 914 (2020).
- R. Merindol, S. Loescher, A. Samanta, A. Walther, "**Pathway-Controlled Formation of Mesostructured All-DNA Microgels and Their Superstructures**," *Nature Nanotechnology* **13**, 730 (2018).

**Molecular Circuits and Computing**

- P. J. M. Swinkels, B. Dúzs, O. Skarsetz, K. Nishiyama, A. Walther, "**Soft Hardware, Flowing Software: Reconfigurable Microfluidics for Adaptable Chemical Computation**," *Advanced Materials*, e73669 (2026).
- W. Chen, R. Demirci, M. Xie, A. Walther, "**DNA Condensates Enable Crosstalk-Free Operation of Identical DNA Computing Cascades**," *Angewandte Chemie International Edition* **65**, e5954994 (2026).
- L. Heinen, A. Walther, "**Programmable Dynamic Steady States in ATP-Driven Nonequilibrium DNA Systems**," *Science Advances* **5**, eaaw0590 (2019).
- J. Deng, A. Walther, "**Programmable ATP-Fueled DNA Coacervates by Transient Liquid–Liquid Phase Separation**," *Chem* **6**, 3329–3343 (2020).
- C. Sharma, I. Maity, A. Walther, "**pH-Feedback Systems to Program Autonomous Self-Assembly and Material Lifecycles**," *Chemical Communications* **59**, 1125–1144 (2023). (Invited Feature Article)
- B. Dúzs, O. Skarsetz, G. Fusi, C. Lupfer, A. Walther, "**Mechano-Adaptive Meta-Gels through Synergistic Chemical and Physical Information-Processing**," *Nature Communications* **15**, 8957 (2024).

**Biomaterials and Cell-Interface:**

- S. Sethi, C. Sharma, A. Walther, "**ATP-Powered Signaling Between Artificial and Living Cells**," *Angewandte Chemie International Edition* **64**, e202517843 (2025).
- T. Xu, S. Sethi, C. Drees, A. Walther, "**Synthetic Aptamer Mechanoreceptors Enable Cell-Specific Force Sensing and Temporal Control via DNA Circuits**," *Nature Communications* **17**, 2492 (2026).
- S. Sethi, T. Xu, A. Sarkar, C. Drees, C. Jacob, A. Walther, "**Nuclease-Resistant L-DNA Tension Probes Enable Long-Term Force Mapping of Single Cells and Cell Consortia**," *Angewandte Chemie International Edition* **63**, e202413983 (2024).