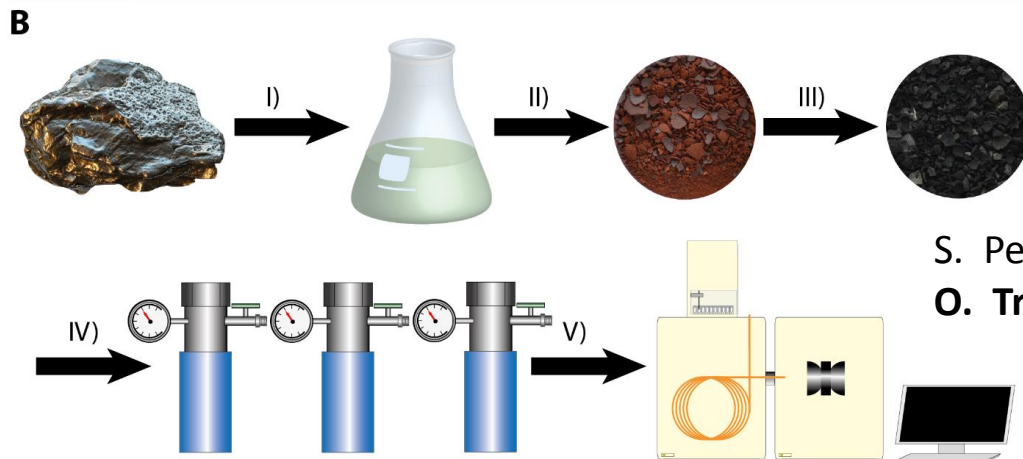
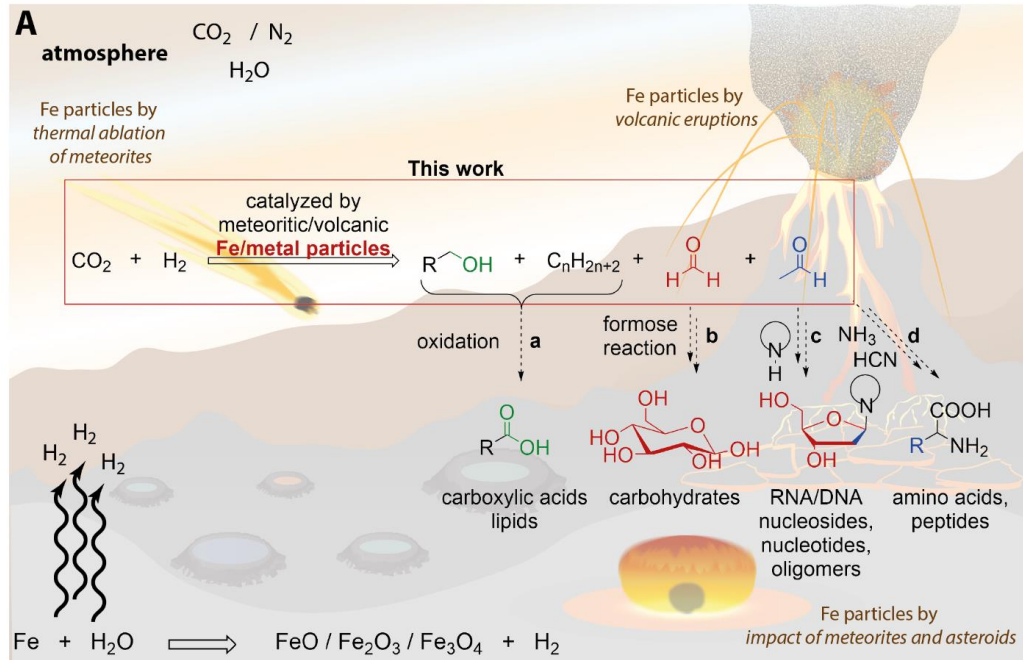


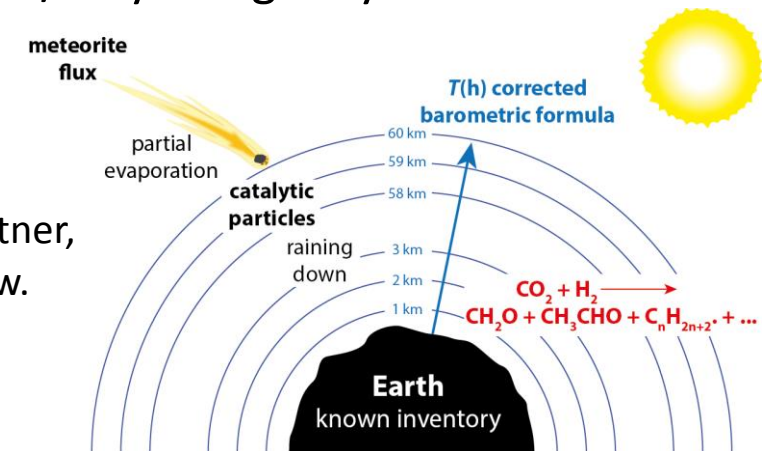
Change of Earth's Atmosphere and Emergence of Prebiotic Key Molecules by Catalytic Processes

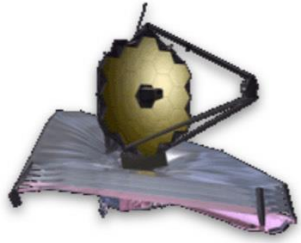


S. Peters, D. A. Semenov, R. Hochleitner,
O. Trapp, *Sci. Rep.* **2022**, under review.

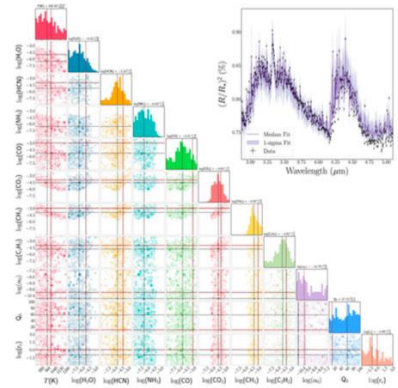
Objectives:

- Large scale reaction network analysis of the CO_2 conversion to organic molecules
- When was the activation of N_2 possible?
- Effect of catalysis on the change of the atmosphere?
- Chemistry in liquified outgassing SO_2
- Combining astrophysics&chemistry
- Formation of the first organocatalytic system, able to perform photochemistry
- Planet's rotation/ day & night cycles



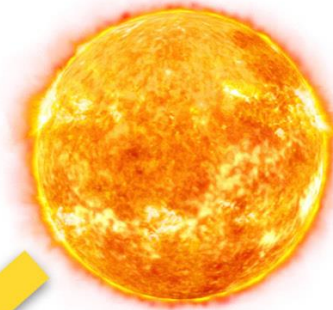
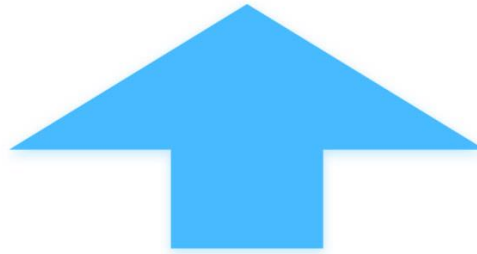


thermal emission
+ reflected light

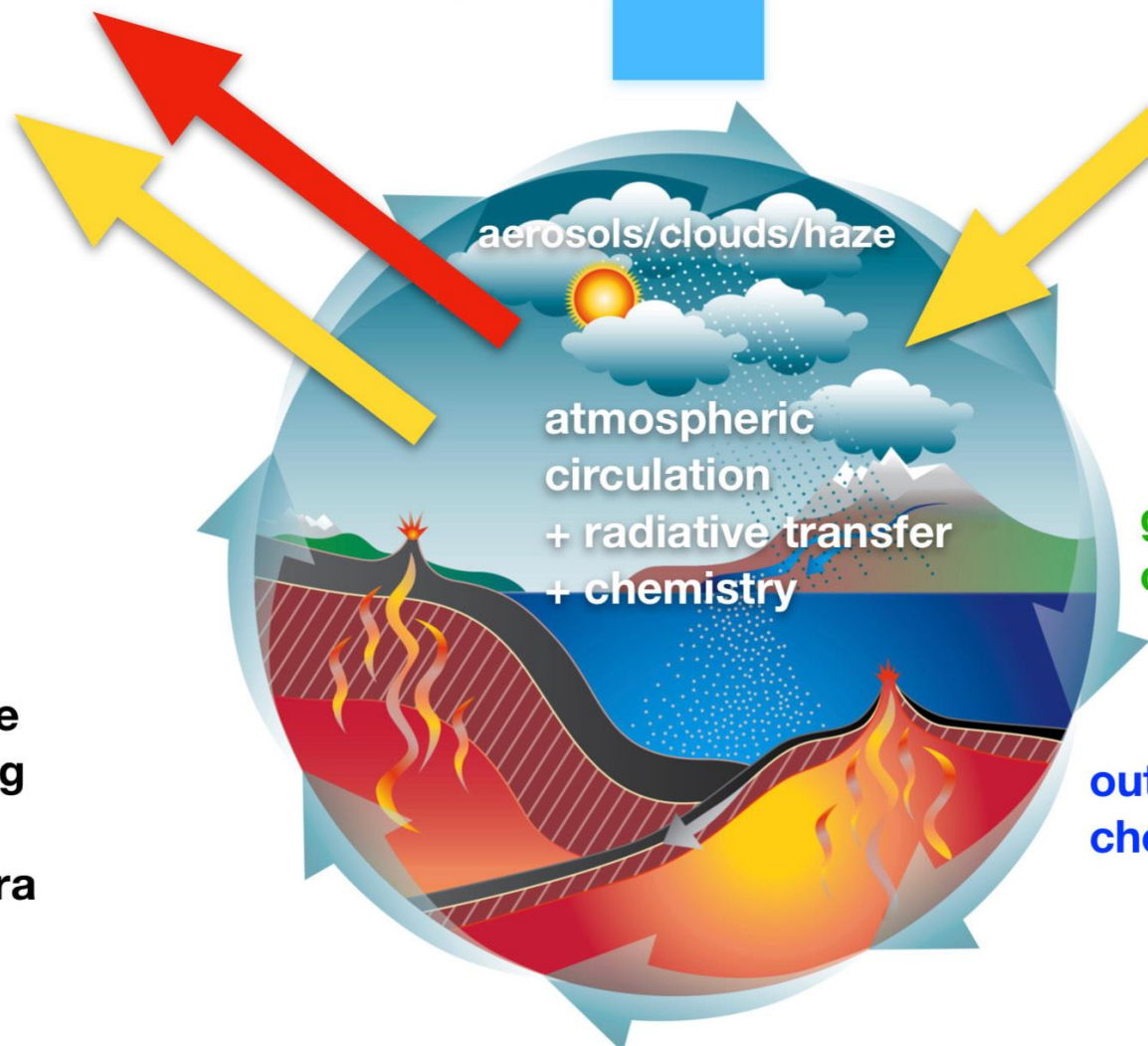


Bayesian inference
& machine learning
techniques for
interpreting spectra

atmospheric escape



stellar irradiation
(photochemistry)



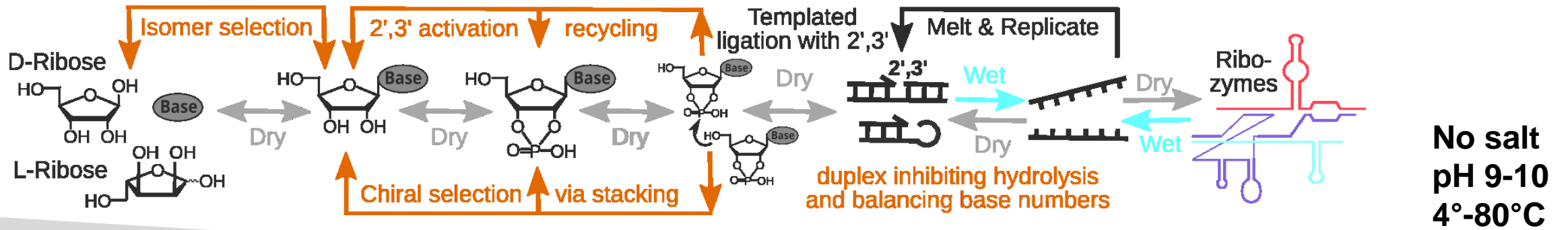
aerosols/clouds/haze

atmospheric
circulation
+ radiative transfer
+ chemistry

geochemical
cycling of volatiles

outgassing
chemistry

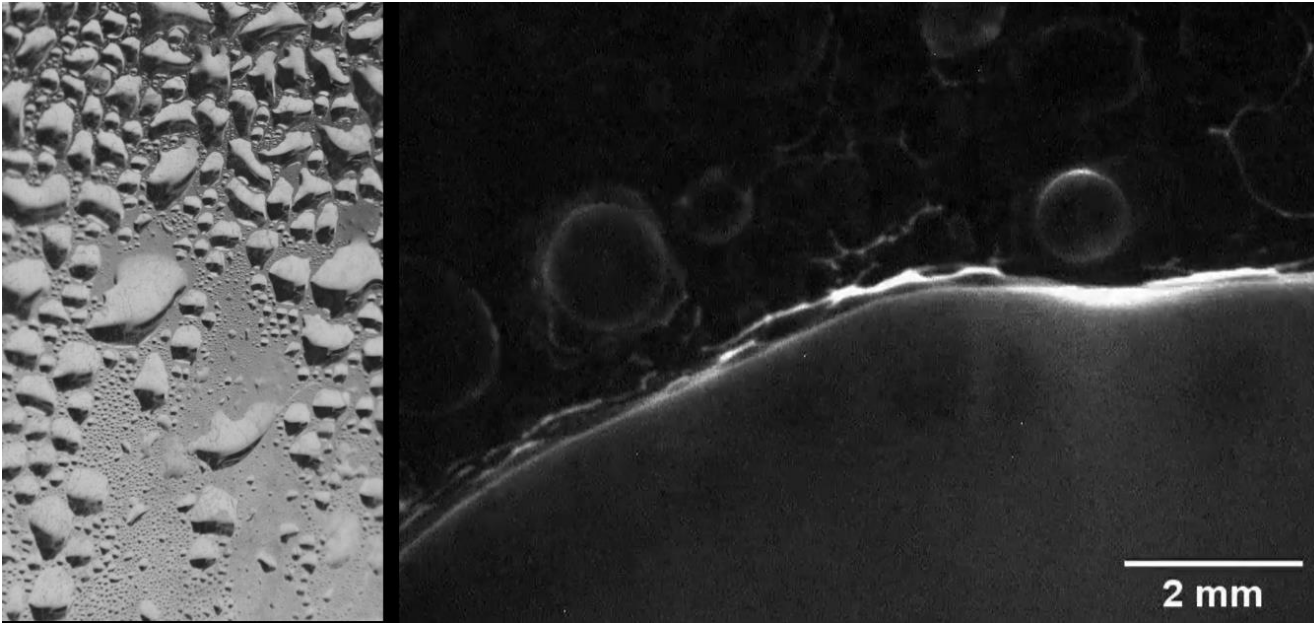
A prebiotic cascade to Darwinian evolution by self-selection



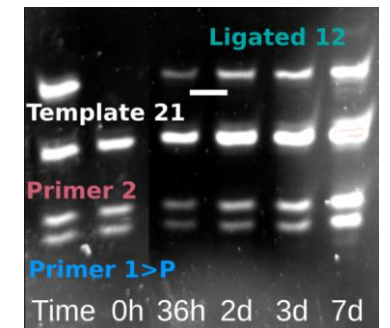
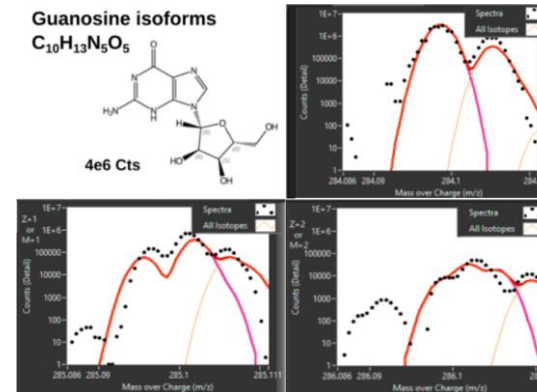
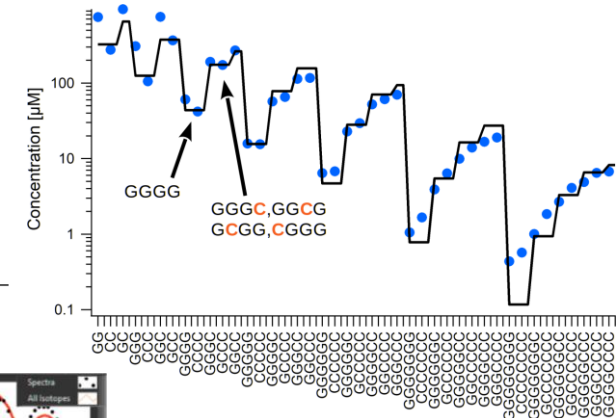
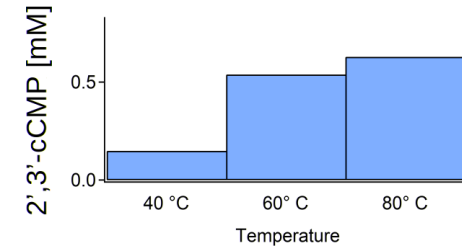
**Nucleoside Isomers; 2'5' vs 3'5'; Chiral mix;
Random sequence; Base imbalance**

**Self-selected
Ribozyme**

Experiment in a microscale Geosetting



Nature Physics doi.org/10.1038/s41567-022-01516-z (2022)



Worked well:

- The infrastructure and support **professionalized the field** in Munich, adding to the CRC and the Molecular Origins Meetings also connections to Astrophysics and support for new experiments.
- The support by RU-E lead to **attraction of young scientists**, although not hired by LMU or TU, but by neighboring Universities: Christoph Weber (Augsburg), Corinna Kufner (Emmy Noether proponent), Kerstin Göpfrich (perhaps to nearby University).
- Establishment of a **co-teaching course** “Emergence of Life in the universe” between Physics, Chemistry, Geoscience and Astrophysics.
- The projects in the connector “emergence” (CN-8) led to several publications and projects of good relevance to the RU. The recent workshop on “**self-organization across scales**” showed that there are interesting conceptual similarities which are interesting to explore but at present a concrete connection between self-organisation phenomena at different scales can not be made.

Aspects to improve:

- Proactive hiring of neighboring / contributing positions for **Biophysics of Engineering Life** at LMU was frustrating, Origins Cluster did not provide the expected push for the topic in general.
- Outreach within the Cluster to offer better in cluster **teaching** to foster more connections.
- Improve the number of female PIs

New directions:

- High resolution mass spectrometry of Meteorites to participate in return missions with the Cluster. Possible new PI **Philippe Schmidt-Kopplin** (high resolution mass spectrometry, PhD advisor of Alexander Ruf, TU)

- “Microscale Geoscience”: providing minerals, glasses and methods to connect molecular evolution with geological settings. Possible new PIs for this: **Bettina Scheu** (Geoscience, LMU) and **Bill Orsi** (Geobiology, LMU). Will provide important input and connections for Geochemistry (see below)
- “Extraterrestrial Geochemistry”: linking Atmospheric detections and theory (Kevin Heng) with experimental Geoscience at LMU. Possible new PI for this: **Yan Lavallee**, Position follower of Don Dingwell. **Proposal to add a W2** here to link Lavallee with Heng. See scientific rationale from Kevin on the slides.
- As the proactive W3 hiring in Engineering Life was not successful, we should aim for a **W2 link between Biophysics and Astrophysics**. Hirings for Assistants between Kevin Heng and Dieter Braun + Oliver Trapp were not competitive enough (Paul Rimmer and Zoe Todd did not come, and are now Lecturers or Assistant Professors in the UK / US).
- Proposed replacement for RNA expert Hannes Mutschler: **Cathleen Zeymer** (Synthetic Protein Evolution, TU) who is expert on molecular evolution (www.bio.nat.tum.de/en/proteinchemie/research/).
- Proposed replacement for theoretical biophysicist Chase Broedersz: **Karen Alim** works on both experiments and theory of the complex fluidics of porous systems, such as hydrothermal pore spaces, geological settings or slime molds (www.bpm.ph.tum.de/research/)
- **Steffen Rulands** was recently hired as W2 Professor in Theoretical Physics at the LMU, defining his research area as follows: “We use methods from non-equilibrium statistical physics and machine learning to understand the processes underlying the behavior of active biosystems and the inner workings of artificial intelligence. We also study ensuing questions on fundamental physical principles underlying non-equilibrium matter.” https://www.theorie.physik.uni-muenchen.de/lsfrey/rulands_group/research/index.html