

# Cole Mathis

ASSISTANT PROFESSOR

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Computational & Statistical Physicist. Origins of Life, Complex Systems, Life Detection, Molecular Assembly.

## Current Position

### Center for Biocomputation, Security, and Society

ASSISTANT PROFESSOR

Biodesign Institute

Arizona State University

### School of Complex Adaptive Systems

ASSISTANT PROFESSOR

College of Global Futures

Arizona State University

### 39 Alpha Research

FOUNDER & TREASURER

Team 0

### Earth-Life Science Institute

VISITING ASSISTANT PROFESSOR

World Research Hub

Tokyo Tech

## Experience

### Assistant Professor

ARIZONA STATE UNIVERSITY

Joint Appointment

1/1/2024 - Present

### Research Lab Coordinator

ARIZONA STATE UNIVERSITY

Emergence lab

7/1/2023 - 12/31/2023

### Astrobiology Postdoctoral Fellow

NASA

Santa Fe Institute

7/30/2021 - 7/1/2023

### Founder & Treasurer

39 ALPHA RESEARCH

Team0

6/1/2020 - Present

### Postdoctoral Researcher & Team Leader

UNIVERSITY OF GLASGOW

Cronin Lab

8/1/2018 - 6/30/2021

### Graduate Research Assistant

ARIZONA STATE UNIVERSITY

Beyond Center

1/1/2014 - 8/1/2018

## Education

### Arizona State University

PHD PHYSICS

Tempe, Arizona

2013-2018

### San Francisco State University

BSC PHYSICS

San Francisco, California

2010-2013

## Publications

#: Author of Correspondence. \*: Joint First authors. -: Not Peer Reviewed.

1.# Foote, S., Sinhadc, P., **Mathis, C.**, & Walker, S. I. (2023). False positives and the challenge of testing the alien hypothesis. *Astrobiology*, 23(11), 1189–1201.

2.- Jirasek, M., Sharma, A., Bame, J. R., Bell, N., Marshall, S. M., **Mathis, C.**, Macleod, A., Cooper, G. J., Swart, M., Mollfulleda, R., et al. (2023). Multimodal techniques for detecting alien life using assembly theory and spectroscopy. *arXiv Preprint arXiv:2302.13753*.

3.- OoLEN, Asche, S., Bautista, C., Boulesteix, D., Champagne-Ruel, A., **Mathis, C.**, Markovitch, O., Peng, Z., Adams, A., Dass, A. V., et al. (2023). What it takes to solve the origin (s) of life: An integrated review of techniques. *arXiv*

- 4.\* Smith, H. B., & **Mathis, C.** (2023). Life detection in a universe of false positives: Can the fatal flaws of exoplanet biosignatures be overcome absent a theory of life? *BioEssays*, 45(12), 2300050.
5. Lockey, D., **Mathis, C.**, Miras, H. N., & Cronin, L. (2022). Investigating the autocatalytically driven formation of kegg-in-based polyoxometalate clusters. *Matter*, 5(1), 302–313.
- 6.- Meadows, V., Graham, H., Abrahamsson, V., Adam, Z., Amador-French, E., Arney, G., Barge, L., Barlow, E., Berea, A., Bose, M., et al. (2022). Community report from the biosignatures standards of evidence workshop. *arXiv Preprint arXiv:2210.14293*.
7. Asche, S., Cooper, G. J., Keenan, G., **Mathis, C.**, & Cronin, L. (2021). A robotic prebiotic chemist probes long term reactions of complexifying mixtures. *Nature Communications*, 12(1), 3547.
8. Doran, D., Clarke, E., Keenan, G., Carrick, E., **Mathis, C.**, & Cronin, L. (2021). Exploring the sequence space of unknown oligomers and polymers. *Cell Reports Physical Science*, 2(12).
9. Liu, Y., **Mathis, C.**, Bajczyk, M. D., Marshall, S. M., Wilbraham, L., & Cronin, L. (2021). Exploring and mapping chemical space with molecular assembly trees. *Science Advances*, 7(39), eabj2465.
- 10.\* **Mathis, C.**, Marshall, S., Carrick, E., Keenan, G., Cooper, G., Graham, H., Bame, J., Craven, M., Bell, N., Gromski, P. S., et al. (2021). Identifying molecules as biosignatures with assembly theory and mass spectrometry. *Nature Communications*, 12(1), 3033.
11. **Mathis, C.** (2020). Meaning of the living state. *Social and Conceptual Issues in Astrobiology*, 91.
12. Miras, H. N., **Mathis, C.**, Xuan, W., Long, D.-L., Pow, R., & Cronin, L. (2020). Spontaneous formation of autocatalytic sets with self-replicating inorganic metal oxide clusters. *Proceedings of the National Academy of Sciences*, 117(20), 10699–10705.
13. Antonioni, A., Martinez-Vaquero, L. A., **Mathis, C.**, Peel, L., & Stella, M. (2019). Individual perception dynamics in drunk games. *Physical Review E*, 99(5), 052311.
14. Kim, H., Smith, H. B., **Mathis, C.**, Raymond, J., & Walker, S. I. (2019). Universal scaling across biochemical networks on earth. *Science Advances*, 5(1), eaau0149.
- 15.- **Mathis, C.**, Miras, H., & Cronin, L. (2019). Autocatalysis in a hierarchically organized inorganic chemical network. *Artificial Life Conference Proceedings*, 652–653.
16. Surman, A. J., Rodriguez-Garcia, M., Abul-Haija, Y. M., Cooper, G. J., Gromski, P. S., Turk-MacLeod, R., Mullin, M., **Mathis, C.**, Walker, S. I., & Cronin, L. (2019). Environmental control programs the emergence of distinct functional ensembles from unconstrained chemical reactions. *Proceedings of the National Academy of Sciences*, 116(12), 5387–5392.
- 17.- Walker, S. I., & **Mathis, C.** (2018). Network theory in prebiotic evolution. *Prebiotic Chemistry and Chemical Evolution of Nucleic Acids*, 263–291.
18. **Mathis, C.**, Bhattacharya, T., & Walker, S. I. (2017). The emergence of life as a first-order phase transition. *Astrobiology*, 17(3), 266–276.
19. **Mathis, C.**, Ramprasad, S. N., Walker, S. I., & Lehman, N. (2017). Prebiotic RNA network formation: A taxonomy of molecular cooperation. *Life*, 7(4), 38.

## Grants and Awards

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### NASA Postdoctoral Program

AGNOSTIC LIFE DETECTION FROM MEASUREMENTS TO THEORY

July 2021 - July 2023

- PI, Funding Amount \$155,750

### World Research Hub

Tokyo, Japan

OVERSEAS RESEARCHER INVITATION

December 2023 - March 2025

- Co-I, Travel Grant

## Invited Talks

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### Life Detection in a Universe of False Positives

- COLLOQUIUM

University of Montreal

2023-11-01

### Identifying Molecules a Universal Biosignatures with Assembly Theory and Mass Spectrometry.

INTERDISCIPLINARY ORIGIN OF LIFE MEETING FOR EARLY CAREER SCIENTISTS - ORAL PRESENTATION

University of Montreal

2022-08-01

### Molecular Assembly and Mass Spectrometry.

GEOMICROBIOLOGY GLG461 SPRING 2022 - GUEST LECTURE

Arizona State University

2022-04-01

### Complex Molecules as Universal Biosignatures.

- COLLOQUIUM

Earth-Life Science Institute

2020-12-01

### Quantitative Astrobiology.

- COLLOQUIUM

University Louvain la Neuve

2018-02-01

### Noisy Channels, Error Correction, and the Origin of Life

UNIVERSAL BIOLOGY WORKSHOP - ORAL PRESENTATION

Earth-Life Science Institute

2017-08-01

### The Meaning of the Living State

SOCIAL AND CONCEPTUAL ISSUES IN ASTROBIOLOGY - ORAL PRESENTATION

Clemson University

2016-09-01

### The Emergence of Life as a First Order Phase Transition

- RESEARCH PRESENTATION

Santa Fe Institute

2016-01-01

## Conferences, Workshops, and Seminars

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### 12th Annual ELSI Symposium - Oral Presentation

LIFE DETECTION IN A UNIVERSE OF FALSE POSITIVES

Earth-Life Science Institute

2024-01-01

### Astrobiology Science Conference - Oral Presentation

IDENTIFYING MOLECULES A UNIVERSAL BIOSIGNATURES WITH ASSEMBLY THEORY AND MASS SPECTROMETRY.

Atlanta Georgia

2022-05-01

### Astrobiology Science Conference - Oral Presentation

THE ORIGIN OF LIFE EARLY-CAREER NETWORK: BUILDING THE COMMUNITY NEEDED TO SOLVE THE PROBLEM.

Atlanta Georgia

2022-05-01

### New Frontiers on the Origins of Life

PARTICIPANT

Santa Fe Institute

2022-03-01

### Uncovering the laws of life.

PARTICIPANT

Grindavik, Iceland

2021-10-01

### Conference on Artificial Life - Oral Presentation

AUTOCATALYSIS IN AN HIERARCHICALLY ORGANIZED INORGANIC CHEMICAL NETWORK

Newcastle, UK

2019-07-01

### 7th Annual ELSI Symposium - Poster Presentation

BOUNDING MOLECULAR COMPLEX USING PATHWAY ASSEMBLY

Earth-Life Science Institute

2019-01-01

### Winter Workshop on Complex Systems

PARTICIPANT

University of Utrecht

2018-02-01

### Astrobiology Science Conference - Oral Presentation

THE EMERGENCE OF DYNAMIC ORDER IN AN AUTOCATALYTIC SET

Mesa, Arizona

2017-04-01

### Astrobiology Graduate Conference - Oral Presentation

THE EMERGENCE OF DYNAMIC ORDER IN AN AUTOCATALYTIC SET

University of Colorado, Boulder

2016-07-01

### Reconceptualizing the Origin of Life. - Poster Presentation

THE EMERGENCE OF LIFE AS A FIRST ORDER PHASE TRANSITION

Carnegie Institution for Science

2016-01-01

### Conference on Complex Systems - Oral Presentation

THE EMERGENCE OF LIFE AS A FIRST ORDER PHASE TRANSITION

Tempe, Arizona

2015-08-01

### Astrobiology Graduate Conference - Oral Presentation

THE EMERGENCE OF LIFE AS A FIRST ORDER PHASE TRANSITION

University of Wisconsin, Madison

2015-07-01

### Astrobiology Science Conference - Oral Presentation

THE EMERGENCE OF LIFE AS A FIRST ORDER PHASE TRANSITION

Chicago, Illinois

2015-06-01

## Service & Outreach

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### FOUNDING MEMBER, OOLEN (ORIGINS OF LIFE EARLY CAREER NETWORK)

The Origin of Life Early career Network (OoLEN) supports and accelerates research on the Origin of Life by bringing together early-career scientists from very different disciplines and backgrounds. I founded this network together with Dr Joana Xavier, Dr Martina Preiner and Silke Asche. More information can be found at [oolen.org](http://oolen.org).

### CONFERENCE ORGANIZER

- Interdisciplinary Origin of Life Meeting for Early Career Researchers, University of Montreal, August 2022.
- New Frontiers in the Origins of Life, Santa Fe Institute, March 2022.
- Satellite Session, Conference on Complex Systems, Arizona State University, October 2015.

### REFEREEING

- Astrobiology
- Life (MDPI)
- Nature Astronomy
- Scientific Reports
- Journal of the Royal Society: Interface Focus
- PloS Computational Biology,
- Journal of Molecular Evolution,
- Journal of the Royal Society: Phil Trans A

## Summer & Winter Schools

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### Santa Fe Institute

COMPLEX SYSTEMS SCIENCE SUMMER SCHOOL

*Santa Fe, New Mexico*

2014

### Universidad Internacional Menéndez Pelayo

JOSEP COMAS I SOLA INTERNATIONAL SUMMER SCHOOL IN ASTROBIOLOGY

*Santander, Spain*

2015

## Field Experience

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### Yellowstone National Park

GEOPIG, ARIZONA STATE UNIVERSITY

*Montana, USA*

2016

- I worked closely with geologists, chemists, and microbiologists to collect samples and measurements from several hot spring environments in Yellowstone National park. I worked under the supervision of Prof Everett Shock