

Presentation Overview

- Research topic
 - **Membraneless Protocells at the Origins of Life**
- Research question
 - How did membraneless protocells contribute to the origins of life?
- Table of contents
 - Introduction to Tony and overview of our lab at ELSI
 - History of polyester protocells – Pt 1
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Research & Presentation

Introduction to Tony and our lab at ELSI



Blue Marble Space
 Institute of Science
 Celebrating 10 years of exploration

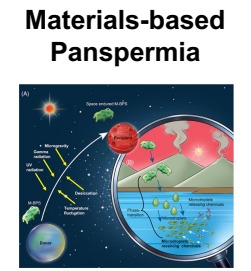
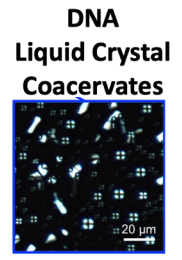
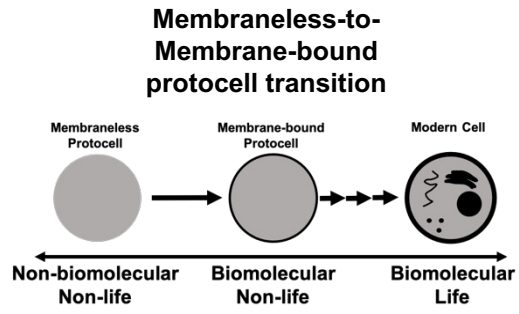
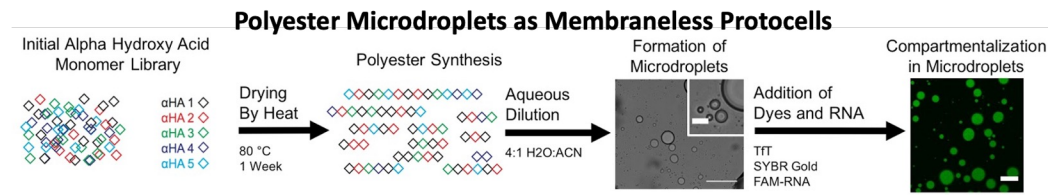
What were the first cells on Earth made of?
How did the first cells on Earth assemble?
What primitive chemistries were relevant?

What was the role of membraneless droplets as protocells on early Earth?
How can protocells derive function?

About Tony:

- BS Chemistry & Business, Econ., Mgmt. at Caltech '10
 Studying proteins and Lipids
- MS and PhD Chemistry at Harvard '16
 Studying DNA and RNA
- Researcher at ELSI since 2017
 Since 2019, Specially Appointed Assistant Professor, **Unit C** Lab Manager
 Since 2022, Specially Appointed Associate Professor, Associate PI

Research interests of our lab



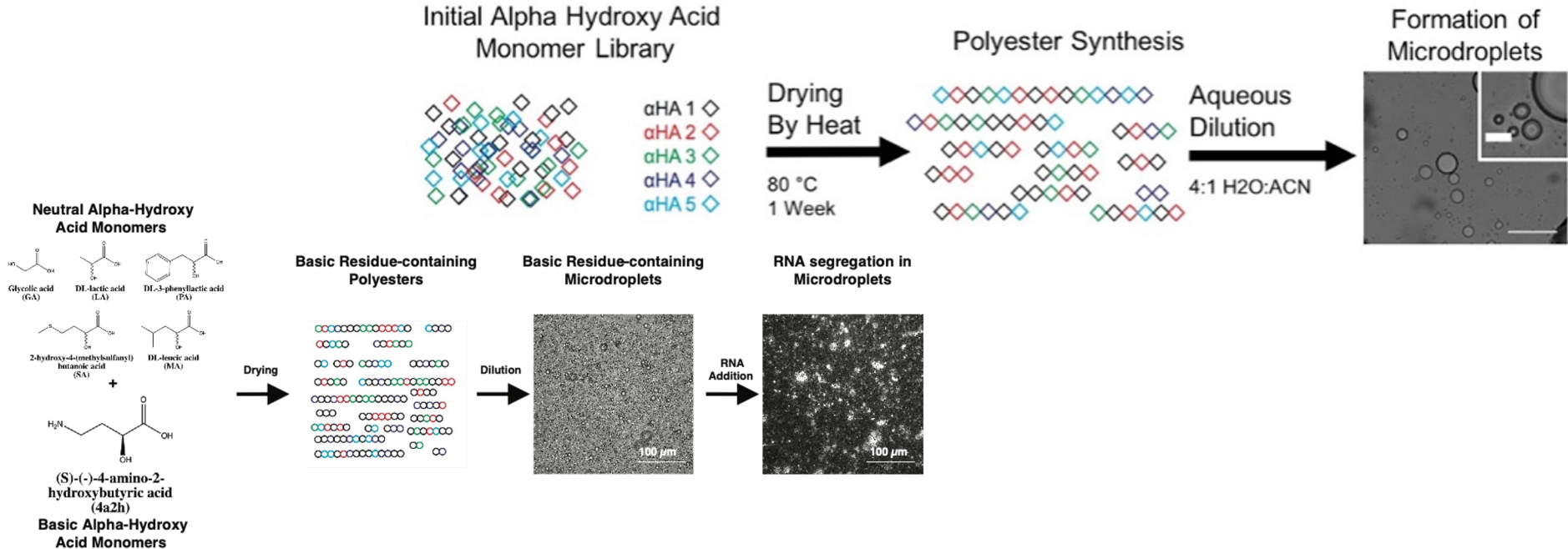
Caltech

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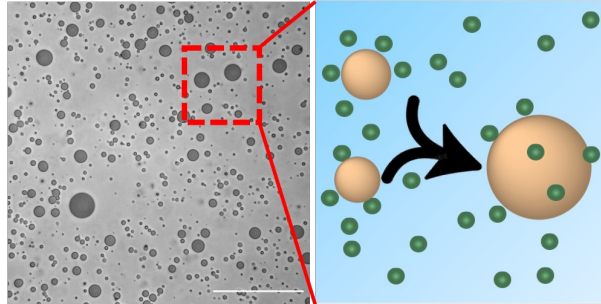
History of Polyester Protocells – Pt. 1

- 2018: Combinatorial polyester synthesis from alpha hydroxy acids
 - Chandru, et al. *Commun. Chem.* 1, 30 (2018).
- 2019: Assembly of polyester microdroplets
 - Jia, et al. *PNAS.* 116, 15830-15835 (2019).
- 2020: Polyester synthesis through ring opening polymerization
 - Chandru, et al. *Sci. Rep.* 10, 17560 (2020).
- 2021: Segregation of RNA in polyester microdroplets
 - Jia, et al. *Biomacromolecules.* 22, 1484-1493 (2021)



History of Polyester Protocells – Pt. 2

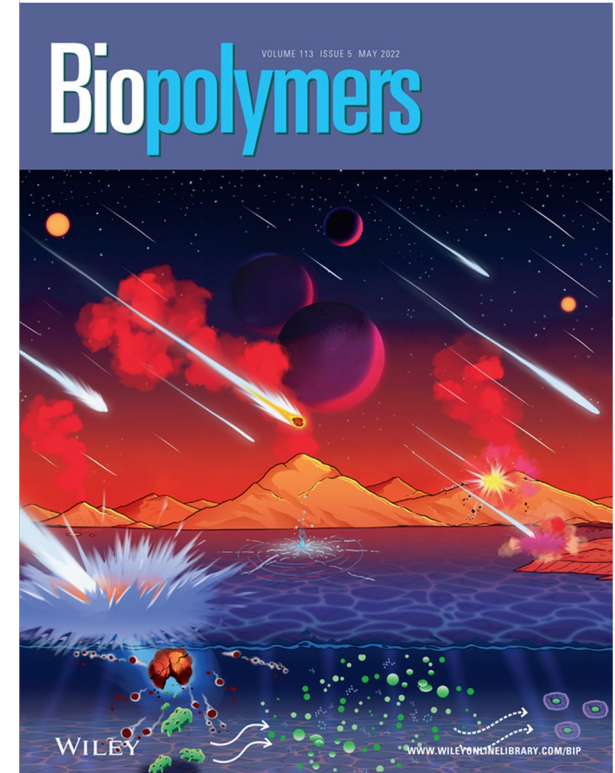
- **2022: Proposal of gel-based panspermia seeds**
 - Sithamparam, et al. *Biopolymers*. 113, e23486 (2022).
- **2022: Temperature and chirality-dependent polyester synthesis**
 - Afrin, et al. *Macromol. Chem. Phys.* 223, 2200235 (2022).
- **2023: Preferential salt uptake in polyester microdroplets**
 - Chen, et al. *Small Methods*. 7, 2300119 (2023).



 Salt Ion



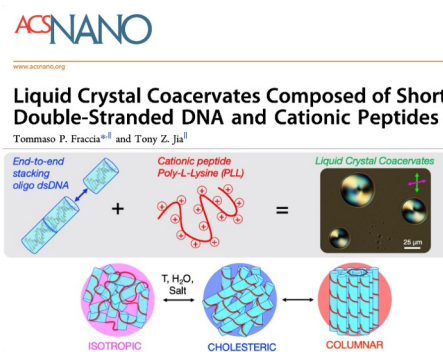
Polyester Microdroplet



References

Selected lab publications since 2019

- **TZ Jia***, †, K Chandru*, †, et al. Membraneless Polyester Microdroplets as Primordial Compartments at the Origins of Life. *PNAS*, 116(32), 15830-15835 (2019).
- K Chandru, **TZ Jia**, et al. Prebiotic Oligomerization and Self-Assembly of Structurally Diverse Xenobiological Monomers. *Scientific Reports*, 10, 17560 (2020).
- TP Fraccia†, **TZ Jia**†. Liquid Crystal Coacervates Composed of Short Double Stranded DNA and Cationic Peptides. *ACS Nano*, 14(11), 15071-15082 (2020).
- **TZ Jia***, et al. NV Bapat, Incorporation of Basic Alpha-Hydroxy Acid Residues into Primitive Polyester Microdroplets for RNA Segregation. *Biomacromolecules*, 22(4), 1484-1493 (2021).
- M Sithamparam, N Satthiyasilan, C Chen, **TZ Jia***, K Chandru*. A Material-based Panspermia Hypothesis: The Potential of Polymer Gels and Membraneless Droplets. *Biopolymers*, 113, e23486 (2022).
- R Afrin, et al. [incl **TZ Jia***]. The Effects of Dehydration Temperature and Monomer Chirality on Primitive Polyester Synthesis and Microdroplet Assembly. *Macromolecular Chemistry and Physics*, 223(23), 2200235 (2022).
- C Chen*, et al. [incl **TZ Jia***]. Spectroscopic and Biophysical Methods to Determine Differential Salt-Uptake by Primitive Membraneless Polyester Microdroplets. *Small Methods*, 2300119 (2023).

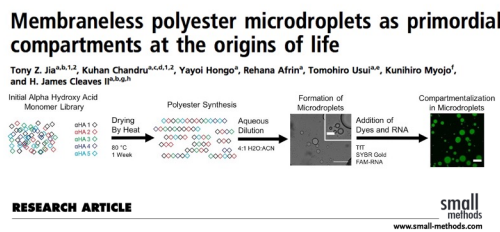


ACS NANO
www.acsnano.org

Liquid Crystal Coacervates Composed of Short Double-Stranded DNA and Cationic Peptides
Tommaso P. Fraccia¹ and Tony Z. Jia¹

End-to-end stacking oligo dsDNA + Cationic peptide Poly-L-Lysine (PLL) = Liquid Crystal Coacervates

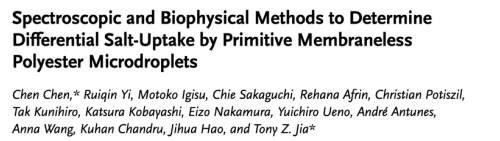
ISOTROPIC → CHOLESTERIC → COLUMNAR



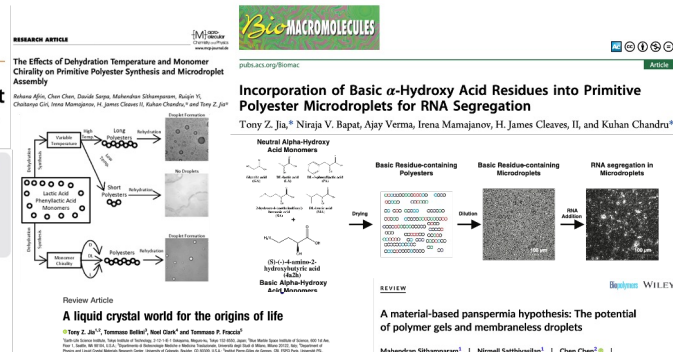
Membraneless polyester microdroplets as primordial compartments at the origins of life
Tony Z. Jia^{1,2}, Kuan Chandru^{1,4,5,12}, Yayoi Hongo⁶, Rehana Afrin⁷, Tomohiro Usui⁸, Kunihiko Myojo¹, and H. James Cleaves Jr^{3,9,10,11}

Initial Alpha Hydroxy Acid Monomer Library → Polyester Synthesis → Formation of Microdroplets → Compartmentalization in Microdroplets

RESEARCH ARTICLE
www.smallmethods.com



Spectroscopic and Biophysical Methods to Determine Differential Salt-Uptake by Primitive Membraneless Polyester Microdroplets
Chen Chen*, Ruigui Yi, Motoko Igisu, Chie Sakaguchi, Rehana Afrin, Christian Potzisl, Tak Kunihiro, Katsura Kobayashi, Eizo Nakamura, Yuichiro Ueno, André Antunes, Anna Wang, Kuan Chandru, Jihua Hao, and Tony Z. Jia*



BioMACROMOLECULES
pubs.acs.org/Biomac

Incorporation of Basic α -Hydroxy Acid Residues into Primitive Polyester Microdroplets for RNA Segregation
Tony Z. Jia*, Niraja V. Bapat, Ajay Verma, Irena Manojanov, H. James Cleaves, II, and Kuan Chandru*


Neutral Alpha-Hydroxy Acid Monomers → Drying → Basic Residue-containing Polyester → RNA Segregation in Microdroplets

REVIEW
A liquid crystal world for the origins of life
"Tony Z. Jia", "Tommaso Fraccia", "Rehana Afrin", and "Tommaso P. Fraccia"



EMERGING TOPICS IN LIFE SCIENCES
VOLUME 6 • ISSUE 4 • DECEMBER 2022
portlandpress.com/emergingtopics

Soft Matter Biophysics



Biopolymers
VOLUME 113, ISSUE 1, MAY 2022

A material-based panspermia hypothesis: The potential of polymer gels and membraneless droplets
Mahendran Sithamparan¹ | Nirmel Satthiyasilan¹ | Chen Chen² | Tony Z. Jia³ | Kuan Chandru⁴

Acknowledgements

- Funding

- JSPS Kakenhi **18K14354, 21K14746**
- Japan Astrobiology Center **AB311021, AB021008**
- Tokyo Institute of Technology **Yoshinori Ohsumi Fund for Fundamental Research**
- **Mizuho Foundation for the Promotion of Science**
- Assistant Staffing Program, Gender Equality Section, Diversity Promotion Office, Tokyo Institute of Technology
- Malaysian Ministry of Education's Fundamental Research Grant Scheme (**FRGS/1/2021/STG04/UKM/02/1**)
- French Embassy in Japan France-Japan “Programme Exploration France” Grant
- Tokyo Institute of Technology Seed Grant “Tane” for Challenging Research (種**1798**)

- Current and Former Lab members

- Rehana Afrin
- Chen Chen (RIKEN)
- Mahendran Sithamparam (UKM)
- Ming-Jing He (NCU)

Collaborators' Institutes

- **Asia/Oceania**

- JAMSTEC (Japan)
- RIKEN (Japan)
- Okayama University-IPM (Japan)
- Nara Medical University (Japan)
- University of Tokyo (Japan)
- JAXA (Japan)
- USTC (China)
- China University of Geosciences
- MUST/SKL Planets (Macau, China)
- National University of Malaysia
- University of New South Wales (Australia)
- National Central University (Taiwan)
- National Cheng Kung University (Taiwan)
- Amity University (India)
- IISER-Pune (India)
- FLAME University (India)

- **Europe**

- ESPCI (France)
- IPGG-Paris (France)
- University of Milan (Italy)
- University of Southampton (UK)
- German Aerospace Center (DLR)
- University of Chemistry and Technology (Czechia)
- Hebrew University of Jerusalem (Israel)

- **North America**

- City University of New York (USA)
- Penn State University (USA)
- Carnegie Institute of Washington (USA)
- BMSIS (USA)
- New York Institute of Technology (USA)
- Columbia University (USA)
- University of Colorado (USA)

If you're interested in working with us, let us know!

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