

Lu Chou

NASA Postdoctoral Program Fellow

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🆔 0000-0003-0345-1635

🐦 astrobiophile

🌐 <https://astrobio.lu>

Research Interest

Agnostic biosignatures detection and characterization, astrobiology of icy/ocean worlds, mission design, instrument development (mass spectrometry), data science, machine learning, and project management.

Education

2019 | **PhD in Earth and Environmental Sciences**

University of Illinois at Chicago, IL, USA

Dissertation: “The Organic Matter of Lake Vida, Antarctica: Biogeochemistry of an Icy Planetary World Analog”
Advisor: Dr. Fabien Kenig

2013 | **BS in Microbiology.** Minor in Astronomy

University of Maryland, College Park, MD, USA

Research Experience

- 2019 - Ongoing | **NASA Postdoctoral Program Fellow.** *NASA Goddard & Georgetown University*
- Design, develop, and analyze astrobiology experiments on agnostic biosignatures including studying the chemical complexity of organic molecules using flight-capable mass spectrometry
 - Establish a research team with other scientists and engineers with a focus on novel biosignatures detection techniques, new theoretical framework in astrobiology, and the utilization of machine learning and science autonomy in space exploration
 - Independently install, optimize, and modify a commercial laser desorption-ion trap mass spectrometer to mimic flight instruments leading to a strong collaboration between NASA and Georgetown University
- 2013-2019 | **Graduate Researcher.** *University of Illinois at Chicago*
- Developed and implemented a graduate program with a focus on organic biosignatures detection in Mars and Icy Worlds analogs (Antarctica) using flight-capable instrumentation
 - Utilized, managed, and maintained a variety of flight-capable instruments including as gas chromatography-mass spectrometers (GC-MS), GCxGC, pyrolysis GC-MS, and SPME GC-MS
 - Coordinate research within and across institution on astrobiology related projects including analysis of subsurface brine planetary analogs and perchlorate-removal studies to enhance Mars mission science
- 2011-2013 | **Undergraduate Research Intern.** *University of Illinois at Chicago*
- Conducted research for 2 years in a microbiology lab focused on characterizing food-borne pathogens that disproportionately affect immunocompromised individuals
 - Performed laboratory analyses including microbial growth culture assays, microbial genetic manipulation such as DNA cloning, and bioinformatic analyses
 - Assisted in the discovery of a new genetic marker that is implicated in the growth of certain food-borne pathogens despite the presence of strong preservatives

Professional Activities

1. **NASA GSFC Planetary Science Winter School, Participant** Nov 2020 - Feb 2021
 - Instrument design exercise for planetary missions in the Solar System Exploration Division (focused on lasers for LiDAR instruments)
2. **NASA Review Panel, Group Chief, Panelist, External Panelist, and Executive Secretary** 2014 - present
 - Served on review panels for NASA Programs such as Exobiology, PICASSO, MATISSE, DALI, Habitable Worlds, FINESST, Small Business Innovative Research (SBIR) Program, and a Flagship-mission instrument panel
3. **NASA Dragonfly Meeting Observer Program, Participant** 2020
4. **Network for Life Detection (NfoLD) Early Career Council, Lead Team Member** Feb 2020 - present
5. **Santa Fe Institute, Visiting Scientist** Nov 2019, Dec 2021
6. **NASA JPL Planetary Science Summer Seminar (11 weeks), Project Manager** Aug 2017
 - Lead a team of 18 scientists and engineers for a mission design exercise for a Centaur Reconnaissance Mission
7. **The History and Philosophy of Astrobiology Summer School (1 week), Attendee** Jul 2015
8. **Josep Comas i Solà International Summer School in Astrobiology (1 week), Attendee** Jun 2014
9. **Smithsonian Institution (12 weeks), Intern** Jun-Aug 2010

Awards & Fellowships

- NASA Goddard Solar System Exploration Directorate - Diversity, Equity, & Inclusion - Group Award (x2) 2021
- NASA Postdoctoral Program Fellowship. USRA/ORAU. **\$136,166.** Mar 2020 - present
- NASA Early Career Collaboration Award. *declined Fall 2018
- NASA Earth and Space Science Fellowship (NESSF). **\$116,114.** Fall 2016 - Spring 2019
- Chancellor's Graduate Research Fellowship. University of IL at Chicago. **\$8,000.** Summer 2015-16
- On To the Future Travel Award. Geological Society of America. **\$500.** Fall 2015
- LAS PhD Travel Award. University of Illinois at Chicago. **\$250.** Fall 2015
- Bodmer Science International Travel Award. University of Illinois at Chicago. **\$750.** Summer 2015
- Outstanding Teaching Assistant Award. National Association of Geoscience Teachers. Spring 2015
- Graduate Research Fellowship. Illinois Space Grant Consortium (ISGC). **\$10,000.** Fall 2014
- Colonnade Society Undergraduate Scholarship. U of MD Alumni Association. **\$2,000.** Fall 2012
- College of Computer, Mathematical, and Natural Sciences Scholarship. U of MD. **\$2,000.** Spring 2012

Publications

*co-lead authors

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| 2022 | <ol style="list-style-type: none">1. *Grefenstette, N., *Chou, L., Colón-Santos, S., Fischer, T., Mierzejewski, V., Nural, C., Sinhadc, P., Vidaurri, M., Vincent, L. & Weng, M. Life As We Don't Know It. <i>Astrobiology (Primer 3.0)</i> (accepted) (2022).2. Theiling, B., Chou, L., Da Poian, V., Battler, M., Raimalwala, K., Arevalo, R., Neveu, M., Ni, Z., Graham, H., Elsila, J. & Thompson, B. Science Autonomy for Ocean Worlds Astrobiology: A Perspective. <i>Astrobiology</i> (accepted) (2022). |
| 2021 | <ol style="list-style-type: none">3. Chou, L., Mahaffy, P., Trainer, M., Eigenbrode, J., Arevalo, R., Brinckerhoff, W., Getty, S., Grefenstette, N., Da Poian, V., Fricke, G. M., Kempes, C. P., Marlow, J., Sherwood Lollar, B., Graham, H. & Johnson, S. S. Planetary Mass Spectrometry for Agnostic Life Detection in the Solar System. <i>Frontiers in Astronomy and Space Sciences</i> 8, 173 (2021).4. Chou, L., Murray, A. E. & Kenig, F. Organic sulfones in the brine of Lake Vida, East Antarctica. <i>Geochimica et Cosmochimica Acta</i> 292, 409–426 (2021).5. Smith, H. H., Hyde, A. S., Simkus, D. N., Libby, E., Maurer, S. E., Graham, H. V., Kempes, C. P., Sherwood Lollar, B., Chou, L., Ellington, A. D., Fricke, G. M., Girguis, P. R., Grefenstette, N. M., Pozarycki, C. I., House, C. H. & Johnson, S. S. The Grayness of the Origin of Life. <i>Life</i> 11 (2021). |

- 2020 | 6. Carrier, B., Beaty, D., Meyer, M., Blank, J., **Chou, L.**, DasSarma, S., Des Marais, D., Eigenbrode, J., Grefenstette, N., Lanza, N., Schuerger, A., Schwendner, P., Smith, H., Stoker, C., Tarnas, J., Webster, K., Bakermans, C., Baxter, B., Bell, M., Benner, S., Bolivar Torres, H., Boston, P., Bruner, R., Clark, B., DasSarma, P., Engelhart, A., Gallegos, Z., Garvin, Z., Gasda, P., Green, J., Harris, R., Hoffman, M., Kieft, T., Koepfel, A., Lee, P., Li, X., Lynch, K., Mackelprang, R., Mahaffy, P., Matthies, L., Nellesen, M., Newsom, H., Northup, D., O'Connor, B., Perl, S., Quinn, R., Rowe, L., Sauterey, B., Schneegurt, M., Schulze-Makuch, D., Scuderi, L., Spilde, M., Stamenković, V., Torres Celis, J., Viola, D., Wade, B., Walker, C., Wiens, R., Williams, A., Williams, J. & Xu, J. Mars Extant Life: What's Next? Conference Report. *Astrobiology* **20**, 785–814 (2020).
- 2019 | 7. Kenig, F., **Chou, L.** & Wardrop, D. J. Comment on Evaluation of the Tenax Trap in the Sample Analysis at Mars Instrument Suite on the Curiosity Rover as a Potential Hydrocarbon Source for Chlorinated Organics Detected in Gale Crater by Miller et al. (2015). *Journal of Geophysical Research: Planets* **124**, 644–647 (2019).
- 2018 | 8. **Chou, L.**, Kenig, F., Murray, A. E., Fritsen, C. H. & Doran, P. T. Effects of legacy metabolites from previous ecosystems on the environmental metabolomics of the brine of Lake Vida, East Antarctica. *Organic Geochemistry* (2018).
9. Howell, S. M., **Chou, L.**, Thompson, M., Bouchard, M. C., Cusson, S., Marcus, M. L., Smith, H. B., Bhattaru, S., Blalock, J. J., Brueshaber, S., Eggl, S., Jawin, E. R., Miller, K., Rizzo, M., Steakley, K., Thomas, N. H., Trent, K., Ugelow, M., Budney, C. J., Mitchell, K. L. & Lowes, L. Camilla: A centaur reconnaissance and impact mission concept. *Planetary and Space Science*, 1–10 (2018).
10. Stelmach, K. B., Neveu, M., Vick-Majors, T. J., Mickol, R. L., **Chou, L.**, Webster, K. D., Tilley, M., Zacchei, F., Escudero, C., Flores Martinez, C. L., Labrado, A. & Fernández, E. J. Secondary Electrons as an Energy Source for Life. *Astrobiology* **18**, 73–85 (2018).
- 2016 | 11. Kenig, F., **Chou, L.**, McKay, C. P., Jackson, W. A., Doran, P. T., Murray, A. E. & Fritsen, C. H. Perchlorate and volatiles of the brine of Lake Vida (Antarctica): Implication for the in situ analysis of Mars sediments. *Journal of Geophysical Research-Planets* **121**, 1190–1203 (2016).
- 2015 | 12. Burall, L. S., Simpson, A. C., **Chou, L.**, Laksanalamai, P. & Datta, A. R. A novel gene, *lstC*, of *Listeria monocytogenes* is implicated in high salt tolerance. *Food Microbiology* **48**, 72–82 (2015).

Non-refereed Publications

- Non-refereed | 13. ***Chou, L.**, *Grefenstette, N., Johnson, S. S., Graham, H., Mahaffy, P., Kempes, C., Elsila, J. E., Libby, E., Ellington, A., Anslyn, E., Hoehler, T., Girguis, P., Cronin, L., Brinkerhoff, W. & Lollar, B. S. Towards a more universal life detection strategy. *Bulletin of the AAS* **53** (1000).
14. Graham, H., Freeman, K. H., **Chou, L.** & Pasterski, M. J. Appeal for Improved Sample Selection, Preparation and Interpretation Standards for Organic Biosignature Experiments Performed by Flight Instruments. *Planetary Science and Astrobiology Decadal Survey 2023-2032 white paper e-id. 520*, 520 (1000).
15. Stoker, C., Blank, J. G., Boston, P., **Chou, L.**, DasSarma, S., Eigenbrode, J., Grefenstette, N., Northup, D., Schuerger, A., Schulze-Makuch, D., Stamenković, V. & Tarnas, J. We Should Search for Extant Life on Mars in this Decade. *Bulletin of the AAS* **53** (1000).
16. Theiling, B., Brinckerhoff, W., Castillo-Rogez, J., **Chou, L.**, Poian, V. D., Graham, H., Hosseini, S. S., Lyness, E., MacKinnon, J., Neveu, M., Raimalwala, K. & Thompson, B. Non-Robotic Science Autonomy Development. *Bulletin of the AAS* **53** (1000).

Conferences Organization

Astrobiology Graduate Conference 2022.

- *Core Organizing Committee.* Coordinate, organize, plan, and co-chair the early-career focused conference in Astrobiology. Develop the scientific program, coordinate the logistics, and work to secure funding for 100+ attendees including domestic and international participants.

Astrobiology Science conference 2022

- *Session Organizer and Session Chair.* "General Principles of Life: Towards understanding universal biology"
- *Session Organizer.* "Putting a scale on the spectrum of agnostic biosignatures" (panel)
- *Session Organizer.* "Chemometric, Chemoinformatic, and Machine Learning Strategies to Characterize Complex Organic and Inorganic Mixtures"

American Geophysical Union 2020

- *Session Organizer and Session Chair.* "Detecting life through space and time: from geochemistry to biology"

Conferences & Abstracts

**oral presentation

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| 2020 | <p>**Chou, L., Da Poian, V., Kempes, C., Graham, H., Kempes, C., Johnson, S.S., Mahaffy, P., Fricke, GM., (2020) Agnostic Polymer Detection in Astrobiological Samples Using Mass Spectrometry and Data-driven Analysis. <u>Goldschmidt 2020</u>. (Virtual)</p> <p>Da Poian, V., Chou, L., Grefenstette, N.M., Graham, H., Kempes, C., Mahaffy, P., Johnson, S.S. (2020) Agnostic Polymer Detection Using Mass Spectrometry for Astrobiological Samples. <u>American Society for Mass Spectrometry Conference Reboot 2020</u>. (Virtual)</p> <p>Chou, L., Grefenstette, N.M., Da Poian, V., Kempes, C., Graham, H., Roussel, A., Mahaffy, P., Johnson, S.S., (2020) Agnostic Polymer Detection Using Mass Spectrometry for Astrobiological Samples. <u>51th Lunar and Planetary Science Conference 2020</u>. The Woodlands, Texas. LPI Contribution No. 2706.</p> |
| 2019 | <p>Johnson, S.S., Graham, H., Anslyn, E., Conrad P., Cronin L., Ellington, A., Elsilá J., Girguis, P., House, C., Libby, E., Mahaffy, P., Sherwood Lollar, B., Steele, A., Chou, L., Grefenstette N., Da Poian, V., (2019) Agnostic Approaches to Extant Life Detection. Mars Extant Life: What's Next?. Carlsbad, NM. LPI Contr. No. 2108.</p> <p>**Chou, L., A. E. Murray, F. Kenig (2019). The nature of legacy biosignatures in cold-limited, slow-growing ecosystems. <u>Astrobiology Science Conference 2019</u>. Bellevue, WA. Paper 411-8.</p> |
| 2018 | <p>A. E. Murray, Chou, L., F. Kenig, C. H. Fritsen, P. T. Doran. (2018). Forecasting Habitability Through the Ice-Sealed Lens of Antarctica's Lake Vida. <u>American Geophysical Union 2018</u>, Washington, D. C.</p> <p>Chou, L. and F. Kenig (2018). Legacy metabolites and organic matter preservation in an Antarctic cryoencapsulated hypersaline brine. <u>Astrobiology Graduate Conference 2018</u>, Atlanta, GA.</p> <p>M.C. Bouchard, S.M. Howell, Chou, L., et al. (2018). Flyby and Impact of Chariklo: A New Frontiers Class Centaur Reconnaissance Mission Concept from the 2017 NASA-JPL Planetary Science Summer Seminar. <u>49th Lunar and Planetary Science Conference 2018</u>. The Woodlands, Texas. LPI Contribution No. 2083, id.2087.</p> |

- 2017 | ****Chou, L.**, F. Kenig, W. A. Jackson (2017). Strategies for facilitating organic matter detection in subsurface perchlorate-rich brines of Earth and Mars. American Geophysical Union 2017, New Orleans, LA.
- Chou, L.**, Howell S., et al. (2017) Centaur Reconnaissance Mission: a NASA JPL Planetary Science Summer Seminar mission design experience. American Geophysical Union 2017, New Orleans, LA.
- **Chou, L.**, F. Kenig, W. A. Jackson (2017). Perchlorate Removal From the Brine of Lake Vida for Volatile Organic Matter Analysis in a Mars Analog. Astrobiology Science Conference 2017. Mesa, AZ.
- 2016 | ****Chou, L.**, F. Kenig, A. E. Murray, C. H. Fritsen, P.T. Doran (2016). GC × GC-TOF MS of metabolites of Lake Vida brine (Antarctica). American Geophysical Union 2016. San Francisco, CA.
- 2015 | ****Chou, L.**, The 2015 International Geobiology Course, et al. (2015). Coupled Stratigraphy, Petrography, and $\Delta 47$ of Ancient Walker Lake, Nevada Reveals Unique Analog for Studying Proterozoic Stromatolite Formation and Climatic Forcings. Geological Society of America 2015. Baltimore, MD.
- L. A. Zinke, J. Buongiorno, **Chou, L.**, L. M. van Maldegem, et al. (2015). Couple geochemical and microbiological characterization of non-carbonate firmgrounds from a modern soda lake, Walker Lake, Nevada. Geological Society of America 2015. Baltimore, MD.
- Chou, L.**, F. Kenig, A. E. Murray, P.T. Doran, C. H. Fritsen (2015). The Metabolomics of the Brine of Lake Vida (McMurdo Dry Valleys, Antarctica). American Geophysical Union 2015. San Francisco, CA.
- Chou, L.**, F. Kenig, A. E. Murray, P.T. Doran, C. H. Fritsen (2015). The Lipidomics of the Brine of Lake Vida (McMurdo Dry Valleys, Antarctica). Astrobiology Science Conference 2015. Chicago, IL.

Technical Skills

Chemistry / Flight Instrumentation

Organic matter extraction, Mass Spectrometry (Q, ToF, IT), Laser Desorption Ionization (LDI)-MS, Gas chromatography (GC), pyrolysis-GC, Multidimensional GC×GC-ToF-MS, Solid-phase microextraction (SPME), Ion exchange chromatography (IX), GC-Flame Ionization Detector (GC-FID)

Molecular Biology

Growth Cultures Assays, CFU Study, DNA Extraction, PCR, Spectrophotometry, DNA cloning, Bacterial transformation

Programming & Other Software

Python, R, Qiime, NCBI, BLAST+, ChemStation, ChromaTOF, XCalibur, Adobe (Illustrator, InDesign, Photoshop), Geographic Information System (ArcGIS)

Invited Lectures

“Signatures of Life in Cold, Subsurface Brines: An Astrobiology Analog for Icy Planetary Worlds” May 2021
Woods Hole Oceanographic Institution, Department of Marine Chemistry & Geochemistry Seminar

“Biosignatures of Life-as-we-don’t-know-it” April 2021
University of Florida, Department of Geological Sciences, Astrobiology Course Seminar

“Agnostic Biosignatures Detection using Mass Spectrometry” March 2021
University of Maryland, College Park. Department of Geology Departmental Seminar

“Universal Life Detection Strategies and applicability to Mars missions” November 2020
NASEM Planetary Science & Astrobiology Decadal Survey Panel on Mars

“Biosignatures, familiar and unfamiliar” October 2020
Williams College, Geosciences Department, Astrobiology Course Seminar

“Agnostic Biosignatures Detection using Mass Spectrometry”

July 2020

NASA Goddard Space Flight Center. Solar System Exploration Division Science Seminar for the Director

“Environmental Geochemistry: Introduction to Organic Geochemistry.”

February 2017

University of Illinois at Chicago. Department of Earth and Environmental Sciences

“Astrobiology: in search of who’s out there by looking at who we are.”

February 2016

University of Illinois at Chicago. Biology Colloquium

Teaching Experience

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| Fall 2013 - Spring 2016 | Teaching Assistant. <i>University of Illinois at Chicago</i> <ul style="list-style-type: none">• Global Environmental Change• Earth, Energy, and Environment• Statistical Methods in Earth and Environmental Science |
| Summer 2013 | Teaching Assistant. <i>Princeton University (John Hopkins Center for Talented Youth)</i> <ul style="list-style-type: none">• Epidemiology |
| Fall 2012, Spring 2013 | Teaching Assistant. <i>University of Maryland, College Park</i> <ul style="list-style-type: none">• Principles of Microbiology (Post-baccalaureate degree-granting program) |

Field Experience

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| Summer 2016 | Biosignatures and the Search for Life on Mars Summer School. <i>2 weeks</i> <i>Nordic Network for Astrobiology</i> <ul style="list-style-type: none">• Studied several Mars analog sites in Iceland (Sample collection, analysis, geochemical characterization, ATP assay for biosignature detection) |
| Summer 2015 | The International Geobiology Course. <i>5 weeks</i> <i>University of Southern California, Caltech, Agouron Institute</i> <ul style="list-style-type: none">• California, Nevada, and Catalina Island (Sample preparation and field collection. Geochemical, petrographic, clumped isotope, and microbiological analyses, and paleoenvironmental reconstruction of Walker Lake, NV) |

Outreach Activities

Interview with students from the Netherlands.

November 2021

Interview to help students with research papers on Mars exploration, the ethics of space colonization, and astrobiology.

NASA Goddard CRESST II Undergraduate Interaction Day.

October 2021

Gave an lecture to a number of undergraduate students on NASA research as part of the CRESST Internship program.

NASA GSFC Early Career Scientist Spotlight.

May 2021

<https://science.gsfc.nasa.gov/600/ECSS/Luoth-Chou.html>

Astrobiology Lecture at the Stone Ridge School of the Sacred Heart. *Bethesda, MD*

April 2021

Gave an interactive lecture on bioorganic chemistry and how to search for life on Mars

Interview with NASA Goddard SSED Science Exhibit Team. . *NASA GSFC*

October, 2020

Subject matter expert for content development for the new planetary exhibit at the Goddard Visitor Center

- Visits to Chicago Montessori School.** *Chicago, IL* April 2016, 2017, 2019
Co-create lesson plans and in-class demonstrations of geology, and planetary science.
- Visit to Brentano Math and Science Academy (Chicago, IL)** Dec 2018
- SAGANet.org. Monthly newsletter organizer and Astrobiology “expert”** 2018 - 2019
- AbGradCon Outreach Event.** “An Evening of Wonder – Life and Art on Earth and Beyond”. *GA Tech* June 2018
Volunteered as an astrobiologist to speak with the general public at
- Social Media Organizer and Science Marshal.** *Chicago, IL* February to April, 2017
Part of the organizing group for the March for Science at Chicago event. On April 22nd, 2017, approximately 60,000+ people attended the march.
- UIC Today** April 2017
“Marching for Science” Interview for article on The March for Science. <https://today.uic.edu/marching-for-science>
- Interview on The Show About Science.** April 2017
A children’s podcast hosted by 6-years-old Nate Butkus. Episode title: Marching for Science and Extraterrestrials.
- (Honest) Conversations With (Real) Scientists.** June 2017
Invited to speak on panel about life in the universe and astrobiology. Cafe Mustache, Chicago. Hosted by Jimmy Dagger and Joey Pasterski.

Services

Diversity, Equity, & Inclusion

1. **NASA Goddard Association of Postdoctoral Scientists (NGAPS+).** *Member* 2021
Diversity, Equity, and Inclusion Subcommittee
2. **NASA Mission Equity Request for Information** 2021
3. **Bystandard Awareness Training Workshop** 2021
4. **NASA Goddard SSED Diversity and Inclusion Working Group** *Member* 2021
Activities resulted in concrete action plans to address workplace disparities, reports that audit inequitable policies and climate culture, and ongoing surveys and deliverables that aim to enhance the diversity and equity of NASA
5. **Unlearning Racism in Geosciences (URGE).** *Member* 2021
 - NASA Goddard Solar System Exploration Division
 - Georgetown University

Peer Reviewer. *Astrobiology, Icarus*

Students Mentored

- Anjali Britto (Aug 2021 - present). *Georgetown University.*
- Ulysse Prieto (Feb 2020 - Aug 2021). *NASA Goddard Space Flight Center.*
- Ruxandra Griza (Jan 2019 - August 2019). *University of Illinois at Chicago.*
- Kevin Englebert (April 2017 - March 2019). *University of Illinois at Chicago.*
- Elizabeth Zagorski (Jan 2016 - Dec 2016). *University of Illinois at Chicago.*