CAROL E. CLELAND

(2026)

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EDUCATION:

Post-Doc in philosophy and computer science, Center for the Study of Language and Information, Stanford University
Ph.D. in philosophy, Brown University
B.A. in mathematics, University of California Santa Barbara

PROFESSIONAL EXPERIENCE:

Full Professor (2006-present), University of Colorado Boulder, Philosophy Department, Boulder, CO 80309.
Member (2026-), *UAP Science Advisory Counsel to the U.S. Government*, Washington DC.
Spoke Leader (2022-present), *Leverhulme Center for Life in the Universe*, Cambridge, UK.
Affiliate, (2020- present), SETI Institute, Mountain View, CA.
Director (1/17-1/23), Center for the Study of Origins, University of Colorado Boulder.
Visiting Fellow (spring semester, 2016), Center for the Philosophy of Science, University of Pittsburgh, PA
Associate Professor (1993-2006), University of Colorado Boulder, Philosophy Department, Boulder, CO 80309.
Visiting Researcher (2002-2003), Centro de Astrobiologia, Madrid, Spain
Exchange Professor (1998-99), Australian National University, Philosophy Department, Canberra, ACT, Australia
Assistant Professor (1986-1993), University of Colorado Boulder, Philosophy Department, Boulder, CO 80309.
Postdoctoral Fellow in Philosophy and Computer Science (1985-86), Center for The Study of Language and Information (CSLI), Stanford University, Stanford, CA 94305
Software Engineer (1984-85), Motion Analysis Corporation, Santa Rosa, CA, 95401.
Assistant Professor (1981-84), Wheaton College, Department of Philosophy, Norton, MA 02766.
Visiting Lecturer (1979-81), Wheaton College, Department of Philosophy, Norton, MA 02766.

AREAS OF TRAINING:

Areas of Specialization/current areas of research
Philosophy of Science (general), Philosophy of Biology (molecular, microbiology, origin of life, and astrobiology), Philosophy of the Geological Sciences (including field geology, historical geology, mineralogy, and planetary science).

Areas of Competence/training

Metaphysics, Philosophical Logic, Epistemology, History of Modern Philosophy (Descartes, Leibniz, and Hume), History of Analytic Philosophy.

SCHOLARLY WORK:

Volumes:

5. *Universal Biology*, Cambridge University Press (under contract).
   [invited monograph, Ramsey, G. and M. Ruse, eds., *Elements in the Philosophy of Biology*] (in progress).

4. *Anomalies in Science,* **Cleland, C.E.** and M.R. Dietrich (eds.) *Springer Nature*, open access (in press).

3. *The Quest for a Universal Theory of life: Searching for life as we don't know it,* Cambridge: Cambridge University Press (2019).
   Selections reprinted as Ch. 3 ("Why Life Can't be Defined?"). In Wasko & Swartz (eds.) *Life: A Transdisciplinary Inquiry*, University of Chicago Press (2023)

   Reviews of this book

   4. Parke, E. (2022), "Review of Cleland, Carol E., *The quest for a universal theory of life: searching for life as we don't know it*", *Philosophy of Science* **89** (4), pp. 872-875.

   3. APA Session "Author Meets Critics: Carol Cleland, *The Quest for a Universal Theory of Life*", Jan 11, 2021.

   2. Pilcher, C. (2020), "Review of *The Quest for a Universal Theory of Life: Searching for Life as we Don't Know it* by Carol E. Cleland", *Astrobiology* **20** (7): 922-23.

   1. Schultze-Makuch, D. (2020), "*The Quest for a Universal Theory of life*", *Basic and Applied Ecology*: https://doi.org/10.1016/j.baae.2020.02.009

2. *The Nature of Life: Classic and Contemporary Perspectives from Philosophy and Science* (Bedau, M.A. & **C.E. Cleland** eds.), Cambridge: Cambridge University Press (2010). [**English edition reprinted** in paperback 2019; **Spanish Language edition** published in 2016]

1. *Effective Procedures,* (guest editor) special volume of *Minds and Machines* 12 (2002).

Articles (forthcoming or in progress)

60. "Anomalies in the Geosciences", in A. Watkins & M. Ohnesorge (eds), *Philosophy of the Geosciences*, Ch. 5, Elsevier (invited and in progress).

59. "On the Calculation of Functional Information" (Wong, Babcock, Cleland, Demarest, McShea, Bartlett, Cleaves II, Prabhu and Hazen) (in progress)

58. "A Discussion on the Chemical Origins of Life as we don't know it (Rahm, M., …, Cleland, C.E., …, and R.C. Remsing) (submitted)

Articles (published or in press)

57. "Anomalies and their role in Scientific Discovery", in Cleland, C.E. and M.R. Dietrich (eds.), *Anomalies in Science*, Springer-Nature, Ch. 1 (**in press**).

55. "Life Happened: How we can and cannot describe its origin," in R. Scheps (ed.) *Living & inert matter: a planetary perspective.* Springer-Nature (**in press**).

54. "Searching for Potentially Biological Anomalies: An alternative to contemporary biosignature approaches" (C.E. Cleland and M.L. Wong), in S. Dick (ed.) *Astronomy and Philosophy*, Cambridge University Press (2026), Ch. 12.

53. "Selective Funneling and State-Space Expansion: A Conceptual Framework for Novelty Generation and Origin Events" (Wong, M. L., Demarest, H., **Cleland**, C. E., …, R.M. Hazen), *Interface Focus*, 15, 6 (2025): https://royalsocietypublishing.org/rsfs/article/15/6/20250009/366157/Selective-funnelling-and-state-space-expansion-a

52. "On the roles of function and selection in evolving systems" (M.L. Wong, **C.E. Cleland**, D.J. Arend Jr, S. Bartlett, H. J. Cleaves II, H. Demarest, A, Prabhu, J. I. Lunine & R. M. Hazen), *PNAS* 120, 43 (2023). e2310223120:www.pnas.org/doi/10.1073/pnas.2310223120

51. "Reply to Root-Bernstein: Increasing complexity allows for the pervasiveness of low-complexity entities and is not anthropocentric**"** (M.L. Wong, S. Bartlett**, C.E. Cleland**, …, R. M. Hazen), *PNAS 121, 34 (2024)* e2406598121: *https://www.pnas.org/doi/10.1073/pnas.2406598121*

50. "Time in Historical Natural Science" (**Cleland, C.E.** & J. Wilson). In Lestienne, R. & P. Harris (eds.), *Time and Science*, Vol. I, World Scientific Publishing, (2023), Ch. 10.

49. "The Scientific Investigation of Unidentified Aerial Phenomena (UAP) Using Multimodal Ground-Based Observatories" (W. A. Watters, …, **C. Cleland**, …, M. Zorzano), *Journal of Astronomical Instrumentation* 12, 1 (2023), 43 pages (Open Access): https://www.worldscientific.com/doi/10.1142/S2251171723400068

48. "Ammonia and Phosphine in the Clouds of Venus as Potentially Biological Anomalies" (**Cleland, C. E.** and P. B. Rimmer), *Aerospace* 9, 753 (2022), pp. 1-10: https://www.mdpi.com/2226-4310/9/12/752

47. "Why astrobiologists should NOT get rid of the term 'life', Primordialscoop (May 24, 2022): https://primordialscoop.org/2022/05/24/why-astrobiologists-should-not-get-rid-of-the-term-life/

46. "Why the term 'life' is important to research in astrobiology" (response to J. Spacek), *Primordialscoop* (June 1, 2022): https://primordialscoop.org/2022/06/01/why-the-term-life-is-important-to-research-in-astrobiology/

45. "Cleland & Grinspoon Response to Benner: Do synthetic microbes provide another example of life?" (Cleland, C. & D. Grinspoon), *Primordialscoop* (May 19, 2022): https://primordialscoop.org/2022/05/19/cleland-grinspoon-response-to-benner-do-synthetic-microbes-provide-another-example-of-life/

44. "Historical Natural Kinds and Mineralogy: Systematizing contingency in the context of necessity" (**Cleland, C.E.**, Hazen, R. M. & S. M. Morrison), Perspective Article, *Proceedings of the National Academy of Sciences* (*PNAS*) 118 (2021), pp. 1-9.

43. "Is it possible to scientifically reconstruct the history of life on Earth? The biological sciences and deep time. In Kampourakis, K. and T. Uller (eds.), *Philosophy of Science for Biologists*, Cambridge: Cambridge University Press (2020), pp. 193-215.

42. "Hidden Concepts in the History and Philosophy of Origins-of-Life Studies" (Mariscal, C., …, **Cleland, C. E.** , … & H. J. Cleaves) *Origins of Life and Evolution of the Biospheres* (2019) https://doi.org/10.1007/s11084-019-09580-x

41. "Moving beyond Definitions of Life in the Search for Extraterrestrial Life" *Astrobiology* 9 (2019), pp. 722-729.

40. "Should We Call E.T.? An Ethical-Political Analysis of METI" (Wilson, E. M. and **C. E. Cleland**) *Theology and Philosophy* 17 (2019), pp. 382-394.

39. "Traces of the Past: Drumlins", *Extinct: The Philosophy of Paleontology Blog (2016)*: http://www.extinctblog.org/extinct/2016/3/14/18vx759zkrz8jdm86uq3h5pmyiaued

38. "The Moral Subject of Astrobiology: Guideposts for exploring our ethical and political responsibilities towards extraterrestrial life" (Wilson, E. M. & **C. E. Cleland)** in Dick, S. J. (ed.), *The Impact of Discovering Life Beyond Earth*. Cambridge: Cambridge University Press (2015), pp. 207-221.

37. "Common cause explanation and the search for a smoking gun," in Baker, V. (ed.) *125th Anniversary Volume of the Geological Society of America: Rethinking the Fabric of Geology*, Special Paper 502 (2013), pp. 1-9.

36. "Lessons from Earth: Towards an Ethics of Astrobiology," (**Cleland, C. E.** & M. E. Wilson), in Impey, Spitz, and Stoeger (eds.), *Encountering Life in the Universe: Ethical Foundations and Social Implications of Astrobiology*. Tucson: University of Arizona Press (2013), pp. 17-55

35. "Conceptual Challenges for Contemporary Theories of the Origin of Life," *Current Organic Chemistry* 17 (2013), pp. 1704-1709.

34. "Science and the Messy, Uncontrollable World of Nature" (**Cleland, C.** E. & S. Brindell), in Pigliucci, M and Boudry, M. (eds.), *Philosophy of Pseudoscience: Reconsidering the Demarcation Problem*. Chicago: University of Chicago Press (2013), pp. 183-202.

33. "What is life?" (**Cleland, C. E.** & M. Zerella), in Kampourakis, K. (ed.), *The Philosophy of Biology: A Companion for Educators*, Springer (2013), pp. 31-48.

32. "Is a General Theory of Life Possible? Seeking the nature of life in the context of a single example," *Biological Theory* 7 (2013), pp. 368-379.

31. "Pluralism or Unity in Biology: Do microbes hold the secret to life?" *Biology & Philosophy* 28 (2013), pp. 189-204.

30. "Life without Definitions," *Synthese* 185 (2012), pp. 125-144.

29. "Prediction and Explanation in Historical Natural Science," *British Journal of Philosophy of Science* 62 (2011), pp. 551-582.

28. "Justification in Historical Natural Science," *EUI Working Papers*, Max Weber Programme, (2010), pp 17-29.

27. "Signatures of a shadow biosphere" (Davies, P., Benner, S., **Cleland, C.**, Lineweaver, C. & C. McKay), *Astrobiology 9* (2009), pp. 241-249.

26. "Philosophical issues in natural history and its historiography" in Tucker, A. (ed), *Blackwell Companions to Philosophy: A Companion to the Philosophy of History and Historiography*. Oxford: Blackwell Pub. (2009), pp. 44-62.

25. "Epistemological issues in the study of microbial life: alternative biospheres?," *Stud. Hist. Phil. Bio. & Biomed. Sci.* 38 (2007), pp. 847-861.

24. "Does 'life' have a definition?" (**Cleland. C**. & C. Chyba), in Sullivan and Baross (eds.), *Planets and Life: The Emerging Science of Astrobiology,* Ch. 5. Cambridge: Cambridge University Press. (2007), pp. 119-131. [***Reprinted*** in C. E. Cleland & M. A. Bedau (eds.) *The Nature of Life: Classical and Contemporary Perspectives from Philosophy and Science*. Cambridge (2010), pp. 326-339.]

23. "A Shadow Biosphere," *Astrobiology Magazine*, December 1, 2006, pp. 1-4.

22. "The Church-Turing Thesis: A last vestige of a failed mathematical program," in Olszewksi, A., Wolenski, J. and R. Janusz (eds.), *Church's Thesis after Seventy Years*. Berlin: Ontos Verlag (2006) pp. 119-146.

21. "Understanding the Nature of Life: A Matter of Definition or Theory?," in Seckbach, J. (ed.), *Life as We Know It*. (Vol. 10 of the *Cellular Origins, Life in Extreme Habitats and Astrobiology Series*). Berlin: Springer (2006), pp. 589-600.

20. "The Possibility of Alternative Microbial Life on Earth," (**Cleland, C.** E. & S. D. Copley), *International Journal of Astrobiology* 4 (2005), pp. 165-173. [***Reprinted*** in C. E. Cleland & M. A. Bedau (eds.) *The Nature of Life: Classical and Contemporary Perspectives from Philosophy and Science*. Cambridge (2010), pp. 198-209.]

19. "The Concept of Computability," *Theoretical Computer Science* 317/1-3 (2004), pp. 209-225.

18. "Why it is a mistake to define 'life'," in Bedau, Husbands, et al. (eds), *Artificial Life IX Workshop Proceedings* (2004), pp. 93-95.

17. "Defining 'Life'" (with Christopher Chyba), *Origins of Life and Evolution of the Biosphere* 32(4) (2002), pp. 387-93.

16. "Methodological and Epistemic Differences Between Historical Science and Experimental Science," *Philosophy of Science* 69 (2002), pp. 474-496.

15. "Effective Procedures," *Minds and Machines* 12 (2002), pp. 159-179.

14. "Historical science, experimental science, and the scientific method," *Geology* 29 (2001), pp. 987-990.

13. "Reply to Kevin Kilty's 'Comment on: Historical science, experimental science, and the scientific method'," *Geology* 30 (2002), pp. 951-952.

12. "Reply to R. J. Bailey's 'Comment on: Historical science, experimental science, and the scientific method'," *Geology* 30 (2002), pp. 953-954.

11. "Recipes, Algorithms, and Programs," *Minds and Machines* 11 (2001), pp. 219-237.

10. "Standards of Evidence: How High for Ancient Life on Mars?", *The Planetary Report Vol*. XVII No.1 (1997), pp. 20-21.

9. "Effective Procedures and Computable Functions," *Minds and Machines* 5 (1995), pp. 9-23.

8. "Is the Church-Turing Thesis True?" *Minds and Machines* 3 (1993), pp. 283-312.

7. "The Church/Turing Thesis: Procedures, Processes and Causation," *ICS Technical Report,* No. 92-04 (1992), pp. 1-38.

6. "On the Individuation of Events," *Synthese*, Vol 86 (1991), pp. 229-254. [***Reprinted*** in R. Casati & A. Varzi (eds.) *Events.* Dartmouth (1996), pp. 373 400].

5. "The Difference Between Real Change and *Mere* Cambridge Change," *Philosophical Studies*, Vol 60 (1990), pp. 257-280.

4. "Is Smolensky's Treatment of Connectionism on the Level?" *Behavioral and Brain Sciences* 11:1 (1988), pp. 27-28.

3. "Change, Process and Events," *CSLI Report*, No. CSLI-87-95 (1987), pp. 1-36.

2. "Causality, Chance and Weak Non-Supervenience," *American Philosophical Quarterly*, Vol. 22 (1985), pp. 287-298.

1. "Space: An Abstract System of Non-Supervenient Relations," *Philosophical Studies*, Vol. 46 (1984), pp. 19-40

Book Reviews:

4. "Review of Keith M. Parsons, *Drawing Out Leviathan: Dinosaurs and the Science Wars*" *Philosophy of Science* 71 (2004), pp. 605-607.

3. "Alice Ambros (ed), Moore, G. E., 'Lectures on Metaphysics 1934-35,'" *The Review of Metaphysics,* March (1995), pp. 671-673.

2. "John Carroll, *Laws of Nature*," *The Review of Metaphysics,* December (1995), pp. 406-408.

1. "Jonathan Bennett, *Events and their Names*, *Noûs* Vol. XXVIII, No. 1 (1994), pp. 103-109.

SELECTED PRESENTATIONS:

"Moving Beyond Definitions in the Search for Extraterrestrial Life; searching for potentially biological anomalies vs. life per se", AbSciCon, Madison, Wisconsin, May 22, 2026.

"The role of theoretical kinds in scientific laws and theories", Mini-WISE Workshop (invited), Carnegie Institution for Science, Washington DC, Nov. 3, 2025.

"How anomalies drive scientific discovery: application to the origin of life" (invited), Telluride Science Workshop: Chemical Origins of Life as We Don't Know It, Telluride, CO, Oct 6, 2025.

"How Anomalies Drive Scientific Discovery" (invited **Keynote**), Conference: Exploring Otherness on Earth and Beyond: Bridging the gap between natural sciences, social sciences and humanities, Freie Universität Berlin campus Lankwitz, April 11, 2025.

Invited participant, Panel: *Adventures in Space*, *HowTheLightGetsIn Festival of Ideas*, London, England, Sept 22, 2024

"The Role of Time in Scientific Reasoning about the Past" (invited), Dipartimento FISPPA - Università degli Studi di Padova, Sept 18, 2024.

"Searching for Life-as-we-don't-know-it" (invited), Origins Federation (annual meeting), University of Cambridge (UK), Sept 13, 2024.

"Philosophical Thoughts on Reconstructing the History of Life on Earth" (invited), XLV Annual Meeting of the Willi Hennig Society, University of Mexico, Mexico City, August 1, 2024

"How Anomalies Drive Scientific Discovery" (invited), Kepler Center, University of Oslo, Norway, May 30, 2024.

"Three Approaches for Searching for Extraterrestrial Microbes" (invited), Workshop: From Gas to Life, CU Boulder, May 20, 2024.

"How Anomalies Drive Scientific Discovery" (invited), Chemistry Department & Center of Theological Inquiry, Princeton University, Princeton, NJ, April 22, 2024

"How anomalies drive scientific discovery" (invited), Foundation for Applied Molecular Evolution, Gainesville, FL, Feb 2, 2024.

"Searching for extraterrestrial life without a definition of life" (invited), Department of History and Department of Biological Sciences, University of Florida, Gainesville, Fl. Feb 1, 2024.

"How anomalies drive scientific discovery" (invited), "Workshop: Rethinking anomalies in Science", Center for Philosophy of Science, University of Pittsburgh, Pittsburgh, PA, Oct 26. 2023

"How anomalies drive scientific discovery" (invited **Keynote**), "Workshop: New Perspectives on Anomalies in the Sciences", Instituto de Filosofia e Ciências Sociais-IFCS/UFRJ, Federal University of Rio de Janeiro, Rio de Janeiro, BRA., Oct. 5, 2023.

"Searching for Extraterrestrial Life without a Definition of Life" (invited **Keynote**), Origins 2023 (joint meeting of the International Society for the Origins of Life and the International Astronomical Union), Quito, Ecuador, August 15, 2023.

"Moving Beyond Definitions in the Search for Extraterrestrial Life", ISHPSSB (International Society for the History, Philosophy and Social Science of Biology"), Toronto, Canada, July 11, 2023.

"Rethnking mineralogy from a more historical perspective" (invited), *Philosophy of the Geosciences Boston Colloquium*, Boston, MA, May 5, 2023.

"How anomalies drive scientific discovery" (invited), *Carnegie Institute for Science*, Washington DC, May 1, 2023.

"The Quest for a Universal Theory of Life" (invited **Keynote**), Conference: What is Life? University of California (Santa Cruz), Santa Cruz, CA, USA Feb. 18, 2023.

"Moving beyond definitions in the search for extraterrestrial life" (invited talk on my book), The Riyadh Philosophy Conference, Riyadh, Saudi Arabia, Dec 3, 2022.

"Adventures with Scientists" (invited), special session on collaborating with scientists at the biennial meeting of the *Philosophy of Science Association*, Nov. 11, 2022.

"The Quest for a Universal Theory of Life: Building blocks of scientific theories," (invited "Provocateur Talk"), Santa Fe Institute, New Mexico, USA, August 23, 2022.

"How Recognition of Anomalies Drives Scientific Discovery" (invited), Galileo Project Conference, Harvard Univ, Cambridge, USA, August 3, 2022.

"Natural Kind Taxonomies: their nature, varieties, and roles in scientific reasoning" (invited), special session on mineral systematics, International Mineralogical Association, Lyon, Fr., July 20, 2022.

"How Recognition of Anomalies Drives Scientific Discovery" (invited **Keynote**), International History, Philosophy, and Science Teaching (IHPST) Conference, Calgary, CA, July 6, 2022.

"Three Approaches for Searching for Extraterrestrial Microbes "(invited), Leverhulme Center for the Study of Life in the Universe (Launch Celebration), Cambridge University, UK, June 26, 2022.

"The Quest to find Extraterrestrial Life" (invited public talk), Late Night Conference Series, Institute for Molecules & Materials, Radboud University Nijmegen, The Netherlands, June 2, 2022.

"Moving beyond definitions in the search for extraterrestrial life" (invited), NASA Goddard, May 11, 2022.

"The Quest to find Extraterrestrial Life" (invited Keynote), Univ. of Northern Colorado, April 11, 2022.

"How Recognition of Anomalies Drives Scientific Discovery" (invited), Kings College, PA, March 21, 2022.

"Answering the question: What is life?" (invited), Crossroads of Ideas Public Lecture Series, Department of Philosophy, University of Wisconsin, Oct 12, 2021.

"Searching for Extraterrestrial Life without a Definition of Life" (invited), Cambridge Life in the Universe Initiative (Seminar), Cambridge University, UK, April 15, 2021.

"How to Search for Extraterrestrial Life without a Definition of Life" (invited), CHESS Seminar, Department of Philosophy, Durham University, UK, March 23, 2021.

Author-Meets-Critic Session: "Cleland's *The Quest for a Universal Theory of Life*", American Philosophical Association (APA), Eastern Division Meeting, Jan 2021.

Panelist, "What is Life", Dartmouth's *Institute of Cross-disciplinary Engagement*.Oct.13, 2020

Panelist, Asimov Memorial Debate 2020, American Museum of Natural History, New York City, Sept 9, 2020.

"Searching for unfamiliar forms of life without a definition of life" (invited), Geophysical Lab Seminar, Carnegie Institution for Science, Washington DC, June 3, 2019.

"Common Cause Explanation and the Search for a Smoking Gun" (invited), Department of Philosophy, University of Auckland, N.Z., April 20, 2019.

"Searching for Potentially Biological Anomalies using Tentative Criteria for Life" (Keynote Speaker) Workshop: Perspectives on the origin, nature and limits of life, University of Auckland, New Zealand, April 19, 2019.

"Searching for *potentially* biological anomalies using tentative criteria" (invited), Life Detection Challenge Workshop (for NASA scientists and engineers), NASA-Ames, Moffett Field, CA, April 25, 2018.

"Scientific Realism & Common Cause Explanation" (invited), Workshop on Contemporary Scientific Realism and the Earth Sciences", University of Durham, England, January 16, 2018.

"Life without Definitions" (invited), Science Colloquium Series, NASA-Goddard, Maryland, October 4, 2017.

"Prediction and Explanation in Historical Science" (invited), Department of Philosophy, University of Bern, Switzerland, June 7, 2017.

"Searching for Extraterrestrial Life without a definition of life" (invited), Center for Space and Habitability, University of Bern, Switzerland, June 6, 2017.

"The Quest to Find Extraterrestrial Life" (invited), *Brain Bar Budapest 2017*, Budapest, Hungary, June 2, 2017.

"Microbial Life on Earth: Tree or Forest," Shadow Biosphere and the Nature of Life (Invited Symposium), American Philosophical Association (APA), Pacific Division Meeting, April 14, 2017.

"Developmental Plasticity and Common Cause Explanation", Philosophy of Science Association (PSA), Atlanta, Georgia, Nov. 4, 2016.

"Models of the origin(s) of Life: Scientific puzzles or philosophical confusions" (invited), History and Philosophy of Origins Research Workshop, August 24, 2016, ELSI Tokyo, Japan.

"Microbial Life on Earth: Tree or Forest" (invited), Workshop on Understanding Life, May 27, 2016, University of Bern, Switzerland.

"Common Cause Explanation and the Search for a Smoking Gun, Department of Geology and Environmental Science, University of Pittsburgh, Feb. 18, 2016.

"Is Earth Host to a Shadow Biosphere?" (invited), University of Mississippi Medical School, Jackson, Miss., Feb. 3, 2016.

"Searching for Extraterrestrial Microbial Life: Will we recognize it if we encounter it?" (invited), Dunbar Lecture, Millsapp College, Jackson, Miss, Feb 2, 2016.

"Microbial Life on Earth: Tree or Forest" (invited), Center for Philosophy of Science, University of Pittsburgh, PA, Jan 26, 2016.

"Searching for a Shadow Biosphere" (invited), Workshop: Exploring the Diversity of Life, Joint Genome Institute & Boundaries of Life Initiative (Lawrence-Berkeley Laboratory), Pacifica, CA, Dec.17, 2015.

"Life without Definitions" (invited keynote), Second Conference on History and Philosophy of Astrobiology, Höör, Sweden, May 8-10, 2015.

"Prediction and Explanation in Historical Natural Science" (invited), Department of Philosophy, University of Pennsylvania, Jan. 30, 2015.

"Scientific Theories: Structure & Function" (invited), Graduate Reading Seminar, Department of History and Philosophy of Science, Indiana University (Bloomington), Oct. 29, 2014.

"Lessons from Earth: The moral status of nonhuman organisms" (invited), Astrobiology and Society Symposium, Library of Congress, Washington DC, Sept. 19, 2014.

"Could there be alternative forms of microbial life on Earth?" (invited), Molecular Biology Roundtable, University of Colorado Medical School, Denver, Colorado, June 17, 2014.

"Scientism and the Peculiar Case of Possible Worlds Semantics" (invited), Workshop on Scientism, City University of New York, May 16, 2014.

"Prediction and Explanation in Historical Science" (invited), IHPST Seminar, University of Paris Sorbonne, April 29, 2014.

"Common Cause Explanation and the Search for a Smoking Gun" (invited), Department of History and Philosophy of Science, Indiana University (Bloomington), February 14, 2014.

"Common Cause Explanation and the Search for a Smoking Gun" (invited), Department of Philosophy, University of Illinois (Urbana-Champaign), Jan 31, 2014.

"Common cause explanation and the search for a smoking gun," International Doctoral Summer School in Forensic Science and Criminology, Arolla Switzerland, August 27, 2012.

"Differences in the methodology and justification of the field sciences and classical experimental science" (keynote talk), Teaching the Methods of Geoscience (workshop), sponsored by InTeGrate (Interdisciplinary Teaching of Geoscience for a Sustainable Future), Montana State University (Bozeman), July 2012.

"Common Cause Explanation and the Search for a 'Smoking Gun'" (invited), Van Tuyl Lecture, *School of Mines*, Golden, CO, April 19, 2012.

"Conceptual Challenges for Contemporary Theories of the Origins of Life" (invited), *American Chemical Society*: Special Session on Prebiotic Chemistry, San Diego, CA, March 26, 2012.

"Is a General Theory of Life Possible? Understanding the nature and origin of life in the context of a single example" (invited), Konrad Lorenz Institute (KLI) Workshop, Vienna, Austria, July 2, 2011.

"Philosophical Perspectives on the Mono Lake Arsenic Paper" (invited "testimony"), Meeting of the *National Research Council's Committee on the Origins and Evolution of Life (COEL)*, Washington D.C., March 2, 2011.

"Conceptual Challenges for Contemporary Theories of the Origin of Life" (invited), Symposium on the Origin of Life, *CEES Colloquia on Ecology and Evolution*, University of Groningen, Netherlands, Dec. 2, 2010.

"The Methodology of Historical Science" (invited), Special Session: High Country of the Geological Mind, *Geological Society of America*, November 2, 2010.

"Prediction and Explanation in Historical Science" (Plenary Talk). Integrating Complexity: Environment and History, *Rotman Institute for Science and Values*, University of Western Ontario, Ontario, Oct 10, 2010.

"Historical Science" (invited), Workshop: Types of Explanation in the Special Sciences: The Case of Biology and History, Universität zu Köln, Germany, Sept. 30, 2010.

"Towards an Ethics of Astrobiology" (invited), NASA Planetary Protection Workshop, Princeton University, June 8, 2010.

"Common Cause Explanation and the Asymmetry of Overdetermination" (invited), Karl Popper and Beyond, *Max Weber Programme*, European University, Florence, Italy, Feb, 2009.

"What is life?" (invited), Astrobiology: Expanding our Views of Society and Self, Biosphere II, University of Arizona, May 9, 2008.

"The Evolution of Microbial Life on Earth: Tree or Forest" (invited), Darwin Day Symposium: Origin & Early Evolution of Life, *National Evolutionary Synthesis Center*, Feb. 8, 2008.

"Could there be undetected alternative forms of microbial life on Earth?," *International Society for the History, Philosophy, and Social Studies of Biology*, Exeter, England, July 12, 2007.

"Has alien life been detected already? (invited), Tree or Forrest? Searching for Alternative Forms of Life on Earth (workshop), Arizona State University, Tempe, Dec. 9, 2006.

"Epistemological issues in the study of microbial life: Alternative Terran Biospheres (invited), Philosophical and Social Dimensions of Microbiology (workshop), University of Exeter, England, July 14, 2006.

"Answering the question 'what is life?'" (invited), *Templeton Lecture*, University of Arizona, Tucson, Arizona, May 11, 2006.

"Answering the Question 'What is life?'" (invited), *AAAS*, Feb 18, 2006.

"Epistemic and methodological differences between historical science and classic experimental science" (invited), Center for the History and Philosophy of Science, University of Minnesota, October 21, 2005.

"What is life?" *International Society for the History, Philosophy, and Social Studies of Biology*, Guelph, Canada, July 16, 2005.

"Answering the Question 'What is life?'," (invited), Center for Astrobiology and the Origin of Life, Harvard University, May 23, 2005.

"Searching for a General Theory of Living Systems" (invited presenter), *Dibner Seminar in the History and Philosophy of Biology*, MBL, Woods Hole, MA, May 20, 2005.

"Defining 'Life'" (invited), *American Philosophical Association* (Pacific Division), March 25, 2005.

"Why it is a mistake to define 'life'" (invited), *ALIFE9,* Boston, MA, Sept. 12, 2004.

"The Advent of Historical Science" (invited), Woodfest (The New Astronomy: Opening the Electromagnetic Window and Expanding our View of Planet Earth), University of Washington, Seattle, Washington, June 16, 2004.

"Rethinking the justification of phylogenetic methods" (invited), *A. Watson Armour III Spring Symposium*: Systematics at a Crossroads Again: Biological and Philosophical Arguments in Contemporary Phylogenetics, Chicago, May 10, 2003.

"The Concept of Computability" (invited). *American Mathematical Society* (Special Session: "Beyond classical Boundaries of computability"), May 4, 2003.

"Defining 'life'' (invited). Inaugural Ceremonies, *Centro de Astrobiologia*, Madrid, Spain, January 16, 2003.

"Historical Science, Experimental Science, and the Scientific Method" (invited), Department of Earth Resources, Colorado State University, October 7, 2002.

"Defining 'life'" (invited), *ISSOL'02* (13th International Conference on the Origin of Life). Oaxaca, Mexico, July 4, 2002.

"What is Life?" (invited). *AAAS* (workshop on the nature of life), Washington D.C, March 5, 2001.

"Effective Procedures and Causal Processes" (invited), *Hypercomputation Workshop*, London, England, May 24, 2000.

"Life in ALH84001: Confirming the Best Explanation", *NASA Institute of Astrobiology* (Video-Seminar), Jan. 20, 2000.

"Recipes, Algorithms, and Programs" (invited), *American Philosophical Association* (Eastern Division), Dec. 28, 1999.

"Recipes, Algorithms, and Programs" *Australasian Association of Philosophy*, Melbourne (Logic Stream), Australia, July 10, 1999.

"Standards of Evidence" (invited). Mars Meteorite Symposium, University of Colorado (Boulder), August 29, 1996.

"On the Nature of Computation" (invited). Symposium on Computation, *Society for Philosophy and Psychology*, San Francisco State University, June 1996.

"Response to Horsten's "Can Turing Machines Bake Cakes?" (invited). *American Philosophical Association* (Midwest Division), April 29, 1995.

"The Covenience of Spatial Relations" (invited). Symposium on Symmetrical Universes, *American Philosophical Association* (Pacific Division), March 30, 1995.

"The Church/Turing Thesis: Procedures, Processes and Causation" (invited). University of California (Davis), Nov. 22, 1991.

"Events and Modes of Change," Center for the Study of Language and Information, Stanford University, April, 1986.

"Space as an Abstract System of Non-Supervenient Relations" (invited) Symposium on Space and Time, University of California at Davis, June 6, 1985.

SELECTED MIXED MEDIA INTERVIEWS

Interviewed by Leonard David for article "Disclosure day: If ET made contact, how would we handle the news?", *Space Insider*, May 5, 2026.

Interviewed on *Event Horizon Show* (podcast), hosted by John Michael Godier, Feb. 5, 2026.

Interviewed by Tharin Pillay for article "Digital Minds", *Time Magazine*, Jan 16, 2026

Interviewed by Jessica Hyndman, Supervising Producer, for potential Netflix series on UFOs, Aug 2023.

Interviewed by Jaime Green for article "What is Life?", *Atlantic Monthly,* Dec. 2023.

Interviewed by Shi En Kim for article "Life Evolves. Can Attempts to Create 'Artificial Life' Evolve", *Scientific American*. April 6, 2023

Filmed interview in New York City for topics/segments of PBS documentary series *Closer to the Truth: (Issues in) Philosophy of Biology*, March 8, 2023.

Interviewed by Leonard David for article "Contact with. ET: How would humanity react?", *Space Insider,* Sept 27, 2022.

Interviewed about the UFO Congressional Hearing (live on LinkedIn's flagship news show) *LinkedIn News LIVE,* June 6, 2022.

Interviewed by Samuele Lilliu, for feature documentary on the Origins of Life, Cambridge UK, May 5, 2022.

Interviewed by Charlie Taben for APA blog on Extraterrestrial Technology, Feb. 10, 2022.

Interviewed by Shi En Kim for article ("Desert Varnish's Secrets") in *Scientific American*, Sept 21, 2022; article published Nov. 3, 2022 and Vol 100 (39)

Interviewed by reporter Elly Posthumus about UFOs, for the Dutch magazine *Quest*, June 2021.

Interviewed by Jordana Cepelewicz (on the possibility of a shadow biosphere using a different genetic code) for *Quanta Magazine*, May 2021.

Interviewed by editors: "20 Big Questions about the Future of Humanity: We asked leading scientists to predict the future. Here is what they said", *Scientific American*, Sept 1. 2016.

(Note: With the exception of the very prestigious interview in Scientific American in 2016, I only recently started tracking interviews that ended up in public venues. Earlier mentions and reviews of my work have appeared in *National Geographic*, *New Scientist*, etc.)

HONORS, AWARDS & GRANTS:

Co-investigator, Subaward #63158 (No. 21163-1328), John Templeton Foundation: A Missing Law: Exploration of a temporally asymmetric universal natural law of information and evolving systems, 7/1/24--4/30/27, $110,068 (55,062.00/yr for 2 yrs). Awarded 8/24

College Scholar Award, Fall 2023.

Co-investigator on NSF grant (#2123995) "Collaborative Research: synthetic and Systems Biology Approaches to semi-synthetic Cells with Expanded DNA alphabets, Steven Benner (PI), Foundation for Applied Molecular Evolution (Fflame), Florida, Aug. 2021-2024.

Co-Investigator on Templeton Grant #61783 (No. 02-10990-02) "Frequency distributions in complex organic molecular mixtures: A search for biological anomalies and their meaning", Robert Hazen (PI), Carnegie Institute for Science, Jan. 2021-2024.

Co-Investigator on Templeton Grant (#60645) "Chance, Necessity, and the Origins of Life", Robert Hazen (PI), Carnegie Institute for Science, June 2017-2020.

Visiting Fellowship, Center for Philosophy of Science, University of Pittsburgh, spring 2016

BFA (Boulder Faculty Assembly) Award for Excellence in Research, 2013.

Co-Investigator NASA Astrobiology Institute (NAI) Teams, 1st & 2nd round funding (Grant to Cleland, PI, and the University of Colorado's Center for Astrobiology, CO-I), 1999-2008.

GCAH (Graduate Committee on the Arts and Humanities) Grant, University of Colorado (Boulder), 1991 (spring), 1998 (spring).

Nominated for SOAR Outstanding Teacher Award, 1992 (spring).

Research grant from Institute of Cognitive Science, University of Colorado (Boulder), 1987 (winter) & 1989 (fall).

CSLI (Center for the Study of Language and Information) Postdoctoral Fellowship in Philosophy and Computer Science, Stanford University, 1985-86.

Mellon Grant, Wheaton College, 1982 (summer) & 1980 (summer).

FIPSE Grant, Wheaton College, 1982 (spring).

NEH Postdoctoral Fellowship, Institute on Psychology and Philosophy of Mind,

University of Washington, 1981 (summer).
Fellowships, Philosophy Department, Brown University, 1975-78.

TEACHING EXPERIENCE

Undergraduate

Courses: General Philosophy of Science (introductory & advanced); Metaphysics (introductory & advanced); Epistemology (introductory & advanced); Logic (introductory & advanced); History of Modern Philosophy; Twentieth Century Philosophy; Critical Thinking; Philosophy of Mind; Introduction to Philosophy; Senior Seminar on Leibniz; Senior Seminar (What is life?).

Thesis Supervision: 13 undergraduate theses.

Graduate

Courses: Causation, Causation and Events; Connectionism and the Mind/Body Problem; Philosophy of Quantum Mechanics; Is a naturalistic theory of intentionality possible?; The Nature of Scientific Explanation; Nature of Life; Philosophical Problems in Astrobiology; Historical Science; Emergence and Mechanism; Natural kinds and Scientific Theories, the Role of Anomalies in Scientific Practice.

Thesis Supervision

Principle Advisor: 4 Ph.D. students, 9 M.A. Students.

Member of Committees: 11 Ph.D. students (philosophy), 6 M.A. students (philosophy), 7 Ph.D. students in mathematics, 1 Ph.D. student in Astronomy, 1 Ph.D. student in Chemistry & Biochemistry, 2 Ph.D. student in geological sciences, 1 Ph.D. student in English, 1 Ph.D. student (computer science).

COMMUNITY, PROFESSIONAL AND UNIVERSITY SERVICE:

Philosophy Department

Committee on the History and Philosophy of Science	Member	4/88-6/92, 6/03-
	Chair	8/03-1/16, 8/23-8/24
Program Review ("Self Study")		6/95-96, 6/03-04, 6/08-09
Faculty Reappointment Committees		(circulates)
Post Tenure Review Committees		2016, 2018, 2022
Graduate Admissions Committee	Member	6/94-95, 7/14-15, 7/16-17, 7/23-
	Chair	8/04-6/05, 1/11-6/11
Departmental Honors Advisor		6/94-96
Ad Hoc Committee on Improving Teaching		8/92-6/93
Undergraduate Advisor		1991-96
Curriculum Committee	Chair	8/91-8/92
	Member	(circulates)
Salary Committee		(circulates)
Personnel Committee		(circulates)
Faculty Advisor to the Undergraduate Philosophy Club		9/87-6/91
Graduate Teaching Mentor		9/87-6/88
Fellowships and Appointments Committee		9/87-6/88
Ad Hoc Committee for Prelim Reform		1/87-6/87

Graduate Prelim Exam Committe on Metaphysics and Epistemology	Chair, Member,	9/86-6/87, 9/89-93 9/86-93
Colloquium Committee		9/86-6/88
Graduate Studies Committee		9/86-6/87, 9-6/2013
Center for Astrobiology		8/98-present
Institute of Cognitive Science (ICS)		
Member		1/87-2005
Curriculum Committee		10/89-91
Executive Committee		(circulated)
Personnel Committee (joint positions with Computer Science)		1/87-6/88
Joint ICS/Philosophy Colloquium Series Committee	Chair,	1/90-6/97
College of Arts and Sciences		
Internal Reviewer for EBio (Department of Ecology and Evolutionary Biology) Program review		8/11-6/12
A & S Council		8/96-6/98
A & S Committee on Committees		1/97-6/98
A & S Budget Committee		1/97-6/98
University of Colorado		
Director, Center for the Study of Origins		1/17-1/22
Grand Challenge Steering Committee		9/14-6/15
Executive Advisory Council of the Graduate School		8/04-07
President's Fund for the Humanities		6/93-6/97
BFA		8/99-2003
Student Affairs Committee		8/99-2003
Committee on Women		7/92-6/94
Core Advisor for College of Arts & Sciences		5/92-8/92

Profession

Member, Galileo Project (Harvard University)	2/22-
Member/Hub director, Leverhulme Centre for Life (Cambridge University, UK)	8/21-
Member-at-Large, Section L (History & philosophy of Science), American Association for the Advancement of Science (AAAS):	2/2020-2/24
Program Committee, Philosophy of Science Association	6/2017-2018
External Reviewer, Department of Philosophy and Classics, University of Texas San Antonio:	2017
Editorial Board:	
Frontiers in Astronomy and Space Science (Astrobiology Section)	4/23-
International Journal of Astrobiology	03/16-9/21
Philosophy & Theory in Biology	10/08-
Philosophy of Science Association, Program Committee, member, November 2016 meeting:	8/15-11/16
Reviewer for NSF Proposals in Philosophy of Science	4/21, 11/06, 10/08, 4/16
NEH Summer Stipend Panelist	10/92-12/92
Philosophy Expert Reviewer, John Templeton Foundation	3/2015-12/2015
Reviewed philosophers for promotion to tenure	1/2016, 9/13/2020

Reviewed philosophers for promotion to full 10/2014, 11/2014

Reviewer for the following journals: (varies from yr to yr)

Analysis, Australian Journal of Philosophy, Biology and Philosophy, *Biological Theory*, *History and Philosophy of Science, Origins of Life and Evolution of the Biosphere, Philosophical Studies, Astrobiology, International Journal of Astrobiology, Journal of Philosophical Research, The Computer Journal, Dialogue*, *Minds and Machines*, *Synthese*, *Philosophy and Phenomenological Research, Philosophy and Theory in Biology, Biological Journal of the Linnean Society, Journal of Theoretical Biology, Geology*, *American Mineralogist, ACTA Biotheoretica, Studies in the History and Philosophy of Science, Philosophy. Theory, and Practice in Biology.*

Professional Organizations (Member):

PSA (Philosophy of Science Association),
AAAS (American Association for the Advancement of Science)
American Geological Union