John C. Baez

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Citizenship: USA

Education:

Ph.D., Mathematics, **Massachusetts Institute of Technology**, 1986.
Thesis: *Conformally Invariant Quantum Fields*. Advisor: Irving Segal.

- National Science Foundation Fellowship, 1982–1985.

B.A., Mathematics, **Princeton University**, 1982.
Thesis: *Recursivity in Quantum Mechanics*. Advisor: John Burgess.

Employment:

University of California at Riverside, Department of Mathematics. Visiting Research Professor, **Centre for Quantum Technologies**.

- Leverhulme Fellow at the **University of Edinburgh**, 2022–2023.
- Professor of the Graduate Division, **University of California at Riverside**, Department of Mathematics, 2021–now. Jones Chair, 2021–2022.
- On leave, visiting the **Centre for Quantum Technologies**, 2010–2012.
- Full Professor, 1995–2021.
- Associate Professor, 1991–1995.
- On leave, visiting **Wellesley College**, 1990–1992.
- Assistant Professor, 1988–1991.

Yale University, Department of Mathematics, Gibbs Instructor, 1986–1988.

Courses Taught: Applications of Mathematics without Calculus, First Year Calculus, Discrete Stuctures, Vector Calculus, Differential Equations, Linear Algebra, Game Theory, Number Theory, Advanced Calculus, Foundations of Mathematics, Mathematical Physics, Methods of Theoretical Physics, Graduate Real Analysis, Graduate Complex Analysis, Graduate Algebraic Topology, Quantum Theory and Analysis, Symbolic Computation, Knots and Quantum Gravity, Low-Dimensional Topology and Physics, Quantum Gravity Seminar, Geometric Representation Theory Seminar, Mathematics of the Environment, Category Theory, Network Theory.

Service: Served as Ph.D. advisor for 19 students. Served on Executive Committee, Committee on Preparatory Education, Library Committee, faculty hiring committees in mathematics and physics, and other committees.

Honors:

1999, Elected Fellow of the American Association of Science.

2013, Levi L. Conant Prize for the best expository paper published in the *Notices* or *Bulletin* of the American Mathematical Society.

2020, Doctoral Dissertation Advisor/Mentoring Award, U.C. Riverside.

2022, Elected Fellow of the American Mathematical Society.

GRANTS

co-PI for 'n-Categories: Foundations and Applications' with Peter May, $50,000, Institute for Mathematics and its Applications, June 2004.

PI for 'Feynman Diagrams and the Semantics of Quantum Computation', NSF program on Quantum Information and Revolutionary Computing, $148,938, August 2007 – August 2010.

PI for 'Categorifying Fundamental Physics', Foundational Questions Institute, $131,865, August 2008 – August 2010.

Subcontractor for Metron Scientific Solutions, 'Complex Adaptive System Composition and Design Environment', DARPA, $549,742, August 2016 – August 2019.

BOARDS

Steering board, *Compositionality*

Steering board, Applied Category Theory conference series.

Senior advisor, Topos Institute.

CONFERENCES ORGANIZED

Knots and Quantum Gravity workshop, U. C. Riverside, May 14–16, 1993.

Knots and Quantum Gravity session of the Seventh Marcel Grossmann Meeting on General Relativity, Stanford, July 26, 1994.

Low-dimensional Topology and Quantum Gravity session of Workshop on Canonical and Quantum Gravity II, Stephan Banach Institute, Warsaw, May 26 – June 6, 1997.

Low-dimensional Topology and Quantum Gravity session of Joint Mathematics Meetings, Baltimore, January 7–8, 1998.

n-Categories: Foundations and Applications, workshop at Institute for Mathematics and its Applications, Minneapolis, June 7–18, 2004.

Higher Categories and Their Applications, workshop as part of the Thematic Program on Geometric Applications of Homotopy Theory, Fields Institute, Toronto, January 9–13, 2007.

Categorical Methods at the Crossroads, Dagstuhl Perspectives Workshop, Dagstuhl, Germany, April 27–May 2, 2014.

Information and Entropy in Biological Systems, National Institute of Mathematical and Biological Synthesis, Knoxville, April 8–10, 2015.

Categorical Foundations of Network Theory, Institute of Scientific Interchange, Turin, May 25–28, 2015.

Applied Category Theory 2018, conference and school, Lorentz Center, Leiden, April 23–May 4.

Applied Category Theory, AMS Western Sectional Meeting, Riverside, November 24–25, 2018.

Riverside Mathematics Workshop for Excellence and Diversity, October 19–21, 2018.

Riverside Mathematics Workshop for Excellence and Diversity, November 8, 2019.

Applied Category Theory, AMS Western Sectional Meeting, Riverside, November 9–10, 2019.

Non-equilibrium Thermodynamics in Biology: from Chemical Reaction Networks to Natural Selection, sesssion of Society for Mathematical Biology 2021, June 14, 2021.

BOOKS

An Introduction to Algebraic and Constructive Quantum Field Theory, with Irving Segal and Zhengfang Zhou, Princeton University Press, 1992.

Knots and Quantum Gravity, editor, Oxford University Press, 1994.

Gauge Fields, Knots, and Gravity, with Javier Muniain, World Scientific Press, 1994.

Infinite-Dimensional Representations of 2-Groups, with Aristide Baratin, Laurent Freidel and Derek Wise, Memoirs of the American Mathematical Society **1032**, Providence, Rhode Island, 2012.

Quantum Techniques for Stochastic Mechanics, with Jacob Biamonte, World Scientific Press, Singapore, 2018.

PAPERS

1. Recursivity in quantum mechanics, *Trans. Amer. Math. Soc.* **280** (1983), 339-350.
2. Bell's inequality for C*-algebras, *Lett. Math. Phys.* **13** (1987), 135–136.
3. Is life improbable?, *Found. Phys.* **19** (1989), 91–95.
4. The global Goursat problem on $R \times S^1$, with Zhengfang Zhou, *Jour. Funct. Analysis* **83** (1989), 364–382.
5. Scattering and the geometry of the solution manifold of $\Box f + \lambda f^3 = 0$, *Jour. Funct. Analysis* **83** (1989), 317–332.
6. Analyticity of scattering for the ϕ^4 theory, with Zhengfang Zhou, *Comm. Math. Phys.* **124** (1989), 9–21.
7. Scattering for the Yang-Mills equations, *Trans. Amer. Math. Soc.* **315** (1989), 823–832.
8. Wick products of the free Bose field, *Jour. Funct. Analysis* **86** (1989), 211–225.
9. Scattering and complete integrability in conformally invariant nonlinear theories, *Jour. Math. Phys.* **31** (1990), 757–762.
10. The global Goursat problem and scattering for nonlinear wave equations, with Irving Segal and Zhengfang Zhou, *Jour. Funct. Analysis* **93** (1990), 239–269.
11. Conserved quantities for the Yang-Mills equations, *Adv. Math.* **82** (1990), 126–131.
12. Scattering and complete integrability in the massive ϕ^4 theory, with Zhengfang Zhou, *Jour. Funct. Analysis* **94** (1990), 397–414.
13. Topological lower bound on the energy of a twisted rod, with Rossen Dandoloff, *Phys. Lett. A* **155** (1991), 145–147.
14. The vacuum and lightcone quantization of interaction Hamiltonians, *Lett. Math. Phys.* **21** (1991), 117–121.
15. Differential calculi on quantum vector spaces with Hecke-type relations, *Lett. Math. Phys.* **23** (1991), 133–141.
16. Renormalized oscillator Hamiltonians, with Zhengfang Zhou, *Adv. Math.* **92** (1992), 106–127.
17. On quantum fields satisfying a given wave equation, with Zhengfang Zhou, *Jour. Funct. Analysis* **106** (1992), 439–453.

18. On the Hopf term in a 2-dimensional sigma model for antiferromagnets, with Alan Bishop and Rossen Dandoloff, *Mod. Phys. Lett. B* **5** (1991), 2003–2005.

19. R-commutative geometry and quantization of Poisson algebras, *Adv. Math.* **95** (1992), 61–91.

20. Scattering and complete integrability in four dimensions, in *Mathematical Aspects of Classical Field Theory*, eds. Mark Gotay, Jerrold Marsden and Vincent Moncrief, Contemp. Math. **132**, American Mathematical Society, Providence, Rhode Island, 1992, pp. 99–116.

21. Link invariants of finite type and perturbation theory, Lett. Math. Phys. **26** (1992), 43–51.

22. Quantum gravity and the algebra of tangles, *Class. Quantum Grav.* **10** (1993), 673–694.

23. An algebraic approach to discrete mechanics, with James Gilliam, *Lett. Math. Phys.* **31** (1994), 205–212.

24. Generalized measures in gauge theory, *Lett. Math. Phys.* **31** (1994), 213–223.

25. Diffeomorphism-invariant generalized measures on the space of connections modulo gauge transformations, in *Proceedings of the Conference on Quantum Topology*, ed. David N. Yetter, World Scientific Press, Singapore, 1994, pp. 21–43.

26. Strings, loops, knots and gauge fields, in *Knots and Quantum Gravity*, ed. J. Baez, Oxford U. Press, Oxford, 1994, pp. 133–168.

27. Hochschild homology in a braided tensor category, *Trans. Amer. Math. Soc.* **344** (1994), 885–906.

28. Strings and two-dimensional QCD for finite N, with Washington Taylor IV, *Nucl. Phys. B* **426** (1994), 53–70.

29. Link invariants, holonomy algebras and functional integration, *Jour. Funct. Analysis* **127** (1995), 108–131.

30. Topological aspects of spin and statistics of solitons in nonlinear sigma-models, with Michael Ody and William Richter, *Jour. Math. Phys.* **36** (1995), 108–131.

31. Higher-dimensional algebra and topological quantum field theory, with James Dolan, *Jour. Math. Phys.* **36** (1995), 6073–6105.

32. Quantum gravity hamiltonian for manifolds with boundary, with Javier P. Muniain and Dardo Píriz, *Phys. Rev. D* **52** (1995), 6840–6845.

33. Spin networks in gauge theory, *Adv. Math.* **117** (1996), 253–272.

34. Spin networks in nonperturbative quantum gravity, in *The Interface of Knots and Physics*, ed. Louis Kauffman, American Mathematical Society, Providence, Rhode Island, 1996, pp. 167–203.

35. Four-dimensional BF theory as a topological quantum field theory, *Lett. Math. Phys.* **38** (1996), 129–143.

36. Knots and quantum gravity: progress and prospects, in *Proceedings of the Seventh Marcel Grossman Meeting on General Relativity*, ed. Robert T. Jantzen and G. Mac Keiser, World Scientific Press, Singapore, 1996, pp. 779–797.

37. Higher-dimensional algebra I: braided monoidal 2-categories, with Martin Neuchl, *Adv. Math.* **121** (1996), 196–244.

38. An introduction to n-categories, *7th Conference on Category Theory and Computer Science*, eds. Eugenio Moggi and Giuseppe Rosolini, Lecture Notes in Computer Science vol. 1290, Springer, Berlin, 1997, pp. 1–33.

39. Higher-dimensional algebra II: 2-Hilbert spaces, *Adv. Math.* **127** (1997), 125–189.

40. Functional integration on the space of connections, with Stephen Sawin, *Jour. Funct. Analysis* **50** (1997), 1–27.

41. 2-Tangles, with Laurel Langford, *Lett. Math. Phys.* **43** (1998), 187–197.

42. Quantum geometry and black hole entropy, with Abhay Ashtekar, Alejandro Corichi and Kirill Krasnov, *Phys. Rev. Lett.* **80** (1998), 904–907.

43. Higher-dimensional algebra III: n-categories and the algebra of opetopes, with James Dolan, *Adv. Math.* **135** (1998), 145–206.

44. Spin foam models, *Class. Quantum Grav.* **15** (1998), 1827–1858.

45. Degenerate solutions of general relativity from topological field theory, *Commun. Math. Phys.* **193** (1998), 219–231.

46. Diffeomorphism-invariant spin network states, with Stephen Sawin, *Jour. Funct. Analysis* **158** (1998), 253–266.

47. Quantization of diffeomorphism-invariant theories with fermions, with Kirill Krasnov, *Jour. Math. Phys.* **39** (1998), 1251–1271.

48. Categorification, with James Dolan, in *Higher Category Theory*, eds. Ezra Getzler and Mikhail Kapranov, Contemp. Math. 230, American Mathematical Society, Providence, Rhode Island, 1998, pp. 1–36.

49. The quantum tetrahedron in 3 and 4 dimensions, with John Barrett, *Adv. Theor. Math. Phys.* **3** (1999), 815–850.

50. An introduction to spin foam models of BF theory and quantum gravity, in *Geometry and Quantum Physics*, eds. Helmut Gausterer and Harald Grosse, Lecture Notes in Physics, Springer, Berlin, 2000, pp. 25–93.

51. From finite sets to Feynman diagrams, with James Dolan, in *Mathematics Unlimited - 2001 and Beyond*, vol. 1, eds. Björn Engquist and Wilfried Schmid, Springer, Berlin, 2001, pp. 29–50.

52. Higher-dimensional algebra and Planck-scale physics, in *Physics Meets Philosophy at the Planck Length*, eds. Craig Callender and Nick Huggett, Cambridge U. Press, Cambridge, 2001, pp. 177–195.

53. Quantum geometry of isolated horizons and black hole entropy, with Abhay Ashtekar and Kirill Krasnov, *Adv. Th. Math. Phys.* **4** (2001), 1–94.

54. Integrability for relativistic spin networks, with John Barrett, *Class. Quantum Grav.* **18** (2001), 4683–4700.

55. The octonions, *Bull. Amer. Math. Soc.* **39** (2002), 145–205.

56. Positivity of spin foam amplitudes, with J. Daniel Christensen, *Class. Quantum Grav.* **19** (2002), 2291–2306.

57. Spin foam models of Riemannian quantum gravity, with J. Daniel Christensen, Thomas R. Halford and David C. Tsang, *Class. Quantum Grav.* **19** (2002), 4627–4648.

58. Uncertainty in measurements of distance, with S. Jay Olson, *Class. Quantum Grav.* **19** (2002), L121–L125.

59. Asymptotics of $10j$ symbols, with J. Daniel Christensen and Greg Egan, *Class. Quantum Grav.* **19** (2002), 6489–6513.

60. Spin foam perturbation theory, in *Diagrammatic Morphisms and Applications*, eds. David Radford, Fernando Souza, and David Yetter, Contemp. Math. **318**, American Mathematical Society, Providence, Rhode Island, 2003, pp. 9–21.

61. Higher-dimensional algebra IV: 2-tangles, with Laurel Langford, *Adv. Math.* **180** (2003), 705–764.

62. Higher-dimensional algebra V: 2-groups, with Aaron D. Lauda, *Theor. Appl. Categ.* **12** (2004), 423–491.

63. Higher-dimensional algebra VI: Lie 2-algebras, with Alissa S. Crans, *Theor. Appl. Categ.* **12** (2004), 492–528.

64. The meaning of Einstein's equation, with Emory F. Bunn, *Amer. Jour. Phys.* **73** (2005), 644–652.

65. Quantum quandaries: a category-theoretic perspective, in *Structural Foundations of Quantum Gravity*, eds. Steven French, Dean Rickles and Juha Saatsi, Oxford U. Press, Oxford, 2006, pp. 240–265.

66. Higher gauge theory, with Urs Schreiber, in *Categories in Algebra, Geometry and Mathematical Physics*, eds. Alexei Davydov, Michael Batanin, Michael Johnson, Stephen Lack and Amnon Neeman, Contemp. Math. **431**, American Mathematical Society, Providence, Rhode Island, 2007, pp. 7–30.

67. Quantization of strings and branes coupled to BF theory, with Alejandro Perez, *Adv. Theor. Math. Phys.* **11** (2007), 1–19.

68. From loop groups to 2-groups, with Alissa S. Crans, Danny Stevenson and Urs Schreiber, *Homotopy, Homology, and Appl.* **9** (2007), 101–135.

69. Exotic statistics for strings in 4d BF theory, with Alissa S. Crans and Derek Wise, *Adv. Theor. Math. Phys.* **11** (2007), 707–749.

70. Lectures on n-categories and cohomology, with Michael Shulman, in *Towards Higher Categories*, eds. John Baez and Peter May, Springer, Berlin, 2009.

71. The classifying space of a topological 2-group, with Danny Stevenson, in *Algebraic Topology: the Abel Symposium 2007*, eds. Nils Baas, Eric Friedlander, Bjørn Jahren and Paul Arne Østvær, Springer, Berlin, 2009.

72. Categorified symplectic geometry and the classical string, with Alexander E. Hoffnung and Christopher L. Rogers, in *Comm. Math. Phys.* **293** (2010), 701–715.

73. Categorified symplectic geometry and the string Lie 2-algebra, with Christopher L. Rogers, in *Homotopy, Homology and Applications* **12** (2010), 221–236.

74. The algebra of grand unified theories, with John Huerta, *Bull. Amer. Math. Soc.* **47** (2010), 483–552.

75. Divsion algebras and supersymmetry I, with John Huerta, in *Superstrings, Geometry, Topology, and C^*-algebras*, eds. Robert Doran, Greg Friedman, and Jonathan Rosenberg, *Proc. Symp. Pure Math.* **81**, AMS, Providence, Rhode Island, 2010, pp. 65–80.

76. Physics, topology, logic and computation: a Rosetta Stone, with Mike Stay, in *New Structures for Physics*, ed. Bob Coecke, Lecture Notes in Physics vol. 813, Springer, Berlin, 2011, pp. 95–174.

77. Higher-dimensional algebra VII: groupoidification, with Alexander E. Hoffnung and Christopher D. Walker, *Theor. Appl. Categ.* **24** (2010), 489–553.

78. A prehistory of n-categorical physics, with Aaron D. Lauda, in *Deep Beauty: Mathematical Innovation and the Search for an Underlying Intelligibility of the Quantum World*, ed. Hans Halvorson, Cambridge U. Press, Cambridge, pp. 13-128.

79. Convenient categories of smooth spaces, with Alexander E. Hoffnung, *Trans. Amer. Math. Soc.* **363** (2011), 5789–5825.

80. An invitation to higher gauge theory, with John Huerta, *General Relativity and Gravitation* **43** (2011), 2335–2392

81. A characterization of entropy in terms of information loss, with Tobias Fritz and Tom Leinster, *Entropy* **13** (2011), 1945–1957.

82. Division algebras and supersymmetry II, with John Huerta, *Adv. Math. Theor. Phys.* **15** (2011), 1373–1410.

83. Division algebras and quantum theory, *Found. Phys.* **42** (2012), 819–855.

84. Algorithmic thermodynamics, with Mike Stay, *Math. Struct. Comp. Sci.* **22** (2012), 771–787.

85. A Noether theorem for Markov processes, with Brendan Fong, *Jour. Math. Phys.*, **54** (2013), 013301.

86. Quantum techniques for studying equilibrium in chemical reaction networks, with Brendan Fong, *Jour. Complex Networks* **3** (2014), 22–34.

87. A Bayesian characterization of relative entropy, with Tobias Fritz, *Theor. Appl. Categ.* **29** (2014), 421–456.

88. G_2 and the rolling ball, with John Huerta, *Trans. Amer. Math. Soc.* **366** (2014), 52570–5293.

89. Wormholes and entanglement, with Jamie Vicary, *Class. Quant. Grav.* **31** (2014), 214007.

90. Quantropy, with Blake Pollard, *Entropy* **17** (2015), 772–789.

91. Teleparallel gravity as a higher gauge theory, with Derek Wise, *Comm. Math. Phys.* **333** (2015), 153–186.

92. Categories in control, with Jason Erbele, *Theor. Appl. Categ.* **30** (2015), 836–881.

93. The Lebesgue universal covering problem, with Karine Bagdasaryan and Philip Gibbs, *Jour. Comp. Geom.* **6** (2015), 288–299.

94. Relative entropy in biological systems, with Blake S. Pollard, *Entropy* **18** (2016), 46.

95. A compositional framework for Markov processes, with Brendan Fong and Blake S. Pollard, *Jour. Math. Phys.* **57** (2016), 033301.

96. A compositional framework for reaction networks, with Blake S. Pollard, *Rev. Math. Phys.* **29** (2017), 1750028.

97. Operads and phylogenetic trees, with Nina Otter, *Theor. Appl. Categ.* **32** (2017), 1397–1453.

98. Props in network theory, with Brandon Coya and Franciscus Rebro, *Theor. Appl. Categ.* **33** (2018), 727–783.

99. Quantum techniques for reaction networks, *Adv. Math. Phys.* (2018), 7676309. (9 pages.)

100. A compositional framework for passive linear networks, with Brendan Fong, *Theor. Appl. Categ.* **33** (2018), 1158–1222.

101. Coarse-graining open Markov processes, with Kenny Courser, *Theor. Appl. Categ.* **33** (2018), 1223–1268.

102. Network models from Petri nets with catalysts, with John Foley and Joe Moeller, *Compositionality* **1**, 4 (2019). (15 pages.)

103. Open Petri nets, with Jade Master, *Math. Struct. Comp. Sci.* **30** (2020), 314–341.

104. Network models, with John Foley, Blake S. Pollard and Joe Moeller, *Theor. Appl. Categ.* **35** (2020), 700–744.

105. Enriched Lawvere theories for operational semantics, with Christian Williams, *Electron. Proc. Theor. Comp. Sci.* **323** (2020), 106–135.

106. Structured cospans, with Kenny Courser, *Theor. Appl. Categ.* **35** (2020), 1771–1822.

107. Struggles with the continuum, in *New Spaces in Physics: Formal and Conceptual Reflections*, eds. Mathieu Anel and Gabriel Catren, Cambridge U. Press, Cambridge, 2021, pp. 281–326.

108. Open systems in classical mechanics, with David Weisbart and Adam M. Yassine, *Jour. Math. Phys.* **62** (2021), 042902. (24 pages.)

109. Operads for designing systems of systems, with John Foley, *Notices Amer. Math. Soc.* **68** (2021), 1005–1007.

110. Categories of nets, with Fabrizio Genovese, Jade Master and Michael Shulman, in *2021 36th Annual ACM/IEEE Symposium on Logic in Computer Science (LICS)*, IEEE, Rome, 2021, pp. 1–13.

111. The fundamental theorem of natural selection, *Entropy* **23** (2021), 1436. (6 pages.)

112. Structured versus decorated cospans, with Kenny Courser and Christina Vasilakopoulou, *Compositionality* **4**, 3 (2022). (39 pages.)

113. Rényi entropy and free energy, *Entropy* **24** (2022), 706. (5 pages.)

114. Getting to the bottom of Noether's theorem, in *Philosophy and Physics of Noether's Theorems: A Centenary Conference on the 1918 Work of Emmy Noether*, eds. James Read and Nicholas Teh, Cambridge U. Press, Cambridge, 2022, pp. 66–99.

115. Compositional modeling with stock and flow diagrams, with Xiaoyan Li, Sophie Libkind, Nathaniel D. Osgood and Evan Patterson, *Proceedings Fifth International Conference on Applied Category Theory*, *Electronic Proceedings of Theoretical Computer Science* **380** (2022), 77–96.

116. Compositional thermostatics, with Owen Lynch and Joe Moeller, *Jour. Math. Phys.* **64** (2023), 023304. (16 pages.)

117. A categorical framework for modeling with stock and flow diagrams, with Xiaoyan Li, Sophie Libkind, Nathaniel D. Osgood and Eric Redekopp, in *Mathematics of Public Health: Mathematical Modelling from the Next Generation*, eds. Jummy David and Jianhong Wu, Springer, 2023, pp. 175–207.

118. Motivating motives. To appear in *Proceedings of the Grothendieck Conference*, Chapman University, May 24-28, 2022. (15 pages.)

119. Schur functors and categorified plethysm, with Joe Moeller and Todd Trimble. To appear in *Higher Structures*. (55 pages.)

Popularizations

1. The quantum of area?, *Nature* **421** (2003), 702–703.

2. Social structures that enable inventions, in *The Greatest Inventions of the Past 2000 Years*, ed. John Brockman, Simon and Schuster, 2000, pp. 68–69.

3. The string-loop war, in *What Have You Changed Your Mind About?*, ed. John Brockman, Harper, 2009, pp. 156–158.

4. The Earth—for physicists, *PhysicsWorld*, July 2009.

5. The strangest numbers in string theory, with John Huerta, *Scientific American*, May 2011, pp. 60-65. Reprinted in *The Best Writing on Mathematics 2012*, ed. Mircea Pitici, Princeton U. Press, Princeton, New Jersey, 2013.

6. Monte Carlo methods in climate science, with David Tweed, *Math Horizons***21** (2013), 5–8.

7. From the icosahedron to E_8, *London Math. Soc. Newsletter* **476** (2018), 18–23.

8. The math that takes Newton into the quantum world, Nautilus, February 28, 2019. Reprinted in *The Best Writing on Mathematics 2020*, ed. Mircea Pitici, Princeton U. Press, Princeton, 2020.

9. Qué es la teoría de categorías y cómo se ha convertido en tendencia, *El País*, November 8, 2019.

10. Is net zero emissions an impossible goal?, *Nautilus*, November 28, 2019.

11. The tenfold way, *Notices Amer. Math. Soc.* **67** (2020), 1599–1601.

12. The joy of condensed matter physics, *Nautilus*, February 25, 2021.

13. The Brownian map, *Notices Amer. Math. Soc.* **68** (2021), 801–803.

14. The Gauss–Lucas theorem, *Notices Amer. Math. Soc.* **68** (2021), 1988–1989.

15. Applied category theory in chemistry, computing and social networks, with Simon Cho, Daniel Cicala, Nina Otter and Valeria de Paiva, *Notices Amer. Math. Soc.* **69** (2022), 292–296.

16. The Kuramoto–Sivashinsky equation, with Steve Huntsman and Cheyne Weis, *Notices Amer. Math. Soc.* **69** (2022), 1581–1583.

17. Isbell duality, *Notices Amer. Math. Soc.* **70** (2022), 140–141.

18. The icosidodecahedron, *Notices Amer. Math. Soc.* **70** (2023), 821–823.

19. The beauty of roots, with J. Daniel Christensen and Sam Derbyshire, *Notices Amer. Math. Soc.* **70** (2023), 1495–1497.

Book Reviews

1. *The Physical Basis of the Direction of Time*, by H. D. Zeh, review in *Math. Intelligencer* **16** (1994), 72–75.

2. *On Quaternions and Octonions: Their Geometry, Arithmetic, and Symmetry*, by John H. Conway and Derek A. Smith, review in *Bull. Amer. Math. Soc.* **42** (2005), 229–243.

3. *Cakes, Custard and Category Theory: Easy Recipes for Understanding Complex Maths*, by Eugenia Cheng, review in *London Math. Soc. Newsletter***451** (2015), 34.

4. *Foundations of Mathematics and Physics One Century After Hilbert: New Perspectives*, ed. Joseph Kouneiher, review in *Notices Amer. Math. Soc.* **66** (2019), 1690–1692.

Talks

1. "Spin Networks in Nonperturbative Quantum Gravity," AMS Short Course, San Francisco, January 1995.

2. "Spin Networks in Gauge Theory" and "Knots and Quantum Gravity," Universidad Autonoma Metropolitana, Iztapalapa, Mexico, January 1995.

3. "Higher-dimensional Algebra and Topological Quantum Field Theory," Mathematics Department, University of Munich, 1-month lecture series, February 1995.

4. "Knots and Quantum Gravity, Spin Networks in Gauge Theory," and "Higher-dimensional Algebra," Physics and Mathematics Departments, University of Milan, March 1995.

5. "Higher-dimensional Algebra and Topological Quantum Field Theory," ICTP, Trieste, March 1995.

6. "Higher-dimensional Algebra and Topological Quantum Field Theory," Department of Mathematics, University of Wales, Bangor, April 1995.

7. "Gauge-invariance and Diffeomorphism-invariance in Canonical Quantum Gravity," Workshop on Canonical and Quantum Gravity, Stephan Banach International Mathematical Center, Warsaw, May 1995.

8. "Spin Networks in Gauge Theory," Department of Physics, University of Nottingham, June 1995.

9. "Higher-dimensional Algebra and Topological Quantum Field Theory" (3 lectures) and "Spin Networks in Gauge Theory," IVth Oporto Meeting on Knot Theory and Physics, Portugal, June 1995.

10. "Spin Networks in Gauge Theory," Department of Physics, Imperial College, London, July 1995.

11. "Higher-dimensional Algebra and Topological Quantum Field Theory" and "Generalizing the Quantum Double Construction," Department of Mathematics, University of Arizona, October 1995.

12. "n-Categories in Logic, Topology and Physics," workshop on New Connections between Mathematics and Computer Science, Isaac Newton Institute, Cambridge, November 1995.

13. "Quantum Gravity and BF Theory in Four Dimensions," Department of Physics, U. C. Santa Barbara, December 1995.

14. "What is Quantum Gravity?" Sacramento Area Physics and Astronomy Colloquium, February 1996.

15. "A Brief History of Knots," Department of Mathematics, California State University, Fullerton, February 1996.

16. "Higher-dimensional Algebra and Physics," Department of Mathematics, California State University, San Bernardino, March 1996.

17. "Four-dimensional Algebra, Topology and Geometry," Department of Mathematics, and "Quantum Gravity and BF Theory in Four Dimensions," Center for Gravitational Physics and Geometry, Pennsylvania State University, March 1996.

18. "Quantum Gravity and BF Theory in Four Dimensions," 11th Geometry Festival, University of Maryland, April 1996.

19. "Topological Quantum Field Theory" and "Entropy of 2-Part Systems," Mathematical Problems of Quantum Gravity workshop, Erwin Schroedinger Institute, Vienna, July 1996.

20. "The Ladder of Dimensions," Bard College, September 1996.

21. "The Ladder of Dimensions," Pomona College, October 1996.

22. "n-Categories in Topology and Physics", Department of Mathematics, and "Spacetime Aspects of the Loop Representation of Quantum Gravity" (2 lectures), Center for Gravitational Physics and Geometry, Pennsyvlania State University, February 1997.

23. "Weak n-Categories", Workshop on Higher Category Theory and Physics, Northwestern University, March 1997.

24. "Spin Foam Models" (3 lectures), Workshop on Canonical and Quantum Gravity II, Stephan Banach International Mathematical Center, Warsaw, May 1997.

25. "An Algebraic Approach to Discrete Mechanics", Center for Computational Science Center, Boston University, August 1997.

26. "An Algebraic Approach to Discrete Mechanics", Physics of Computation Seminar, Massachusetts Institute of Technology, August 1997.

27. "An Introduction to n-Categories", 7th Conference on Category Theory and Computer Science, Santa Margherita Ligure, September 1997.

28. "Higher-dimensional Algebra and Quantum Gravity", University of California, Santa Cruz, October 1997.

29. "Higher-dimensional Algebra and Quantum Gravity", California State University, San Bernardino, November 1997.

30. "Higher-dimensional Algebra and Quantum Gravity", University of California, Irvine, November 1997.

31. "2-Tangles", SUNY Stony Brook, January 1998.

32. "Higher-dimensional Algebra and Quantum Gravity", CUNY Graduate School and University Center, January 1998.

33. "Spin Networks in Gauge Theory", CUNY Graduate School and University Center, March 1998.

34. "Higher-dimensional Algebra and Quantum Gravity", University of Memphis, March 1998.

35. "Spin Foam Models of Quantum Gravity" (2 lectures), Center for Gravitational Physics and Geometry, Pennsylvania State University, April 1998.

36. "Higher-Dimensional Knot Theory", Johns Hopkins University, May 1998.

37. "Higher-Dimensional Knot Theory", University of Chicago, May 1998.

38. "Spin Foam Models of Quantum Gravity", Enrico Fermi Institute, University of Chicago, May 1998.

39. "Spin Foam Models of Quantum Gravity" (3 lectures), VIIth Oporto Meeting on Geometry, Topology and Physics, Portugal, June 1998.

40. "Quantum Geometry and Black Hole Entropy", University of Arizona, Tucson, October 1998.

41. "Spin Foam Models of Quantum Gravity" (3 lectures), 38th International School of Nuclear and Particle Physics, Schladming, Austria, January 1999.

42. "Quantum Geometry and Black Hole Entropy", California State Polytechnic University, Pomona, March 1999.

43. "Quantum Geometry and Black Hole Entropy", Institute of Theoretical Physics, University of California, Santa Barbara, April 1999.

44. "Spin Networks, Spin Foams, and Quantum Gravity", Minnowbrook Symposium on Space-Time Structure, Syracuse University, May 1999.

45. "Higher-dimensional Algebra and Planck-Scale Physics", Toward a New Understanding of Space, Time, and Matter, conference at the University of British Columbia, Vancouver, June 1999.

46. "Spin Networks, Spin Foams, and Quantum Geometry", Conference on Physics of Strong Gravitational Fields, Institute of Theoretical Physics, University of California, Santa Barbara, June 1999.

47. "n-Categories" (7 hours of lectures), School on Category Theory and Applications, University of Coimbra, Portugal, July 1999.

48. "n-Categorical Physics", Category Theory 99, University of Coimbra, Portugal, July 1999.

49. "The Quantum Tetrahedron in 3 and 4 Dimensions," Instituto Superior Tecnico, Lisbon, July 1999.

50. "The Geometric Quantization of Geometry," Stanford University, November 1999.

51. "Simplicial Quantum Geometry," CUNY Graduate School and University Center, March 2000.

52. "From Finite Sets to Feynman Diagrams," University of Memphis, April 2000.

53. "Quantum Geometry and Black Hole Entropy", 13th International Congress on Mathematical Physics, Imperial College, London, July 2000.

54. "n-Categorical Physics", Department of Physics, University of California, Santa Barbara, October 2000.

55. "n-Categorical Physics", American Mathematical Society Meeting, San Francisco State University, October 2000.

56. "Spin Networks, Spin Foams and Quantum Gravity", Department of Physics, University of Wisconsin, Milwaukee, February 2001.

57. "The Meaning of Relativity", Departments of Mathematics and Physics, University of Wisconsin, Milwaukee, February 2001.

58. "Spin Networks in Canonical Quantum Gravity" and "The Quantum Tetrahedron", Department of Mathematics, Pennsylvania State University, March 2001.

59. "Lorentzian Spin Networks," Center for Gravitational Physics and Geometry, Pennsylvania State University, March 2001.

60. "The Meaning of Einstein's Equation," Physics Department, University of Texas at Brownsville, April 2001.

61. "Real Numbers, Complex Numbers, Quaternions and Octonions", Mathematics Department, California State San Bernardino, May 2001.

62. "New Developments in Canonical Quantum Gravity", plenary talk, 9th Canadian Conference on General Relativity and Relativistic Astrophysics, Edmonton, Canada, May 2001.

63. "Discrete Riemannian Geometry and Gauge Theory" (4 lectures), Graphs and Patterns in Mathematics and Theoretical Physics, a conference at SUNY Stony Brook in honor of Dennis Sullivan's 60th birthday, June 2001.

64. "Categorification and Computation", Conference on Algebraic Topological Methods in Computer Science, Stanford University, July 2001.

65. "Normed Division Algebras: A Categorical Perspective", Category Theory Seminar, Department of Pure Mathematics and Mathematical Statistics, Cambridge University, August 2001.

66. "Spin Foam Models of Quantum Gravity", conference on Discrete Random Geometries and Quantum Gravity, Spinoza Institute, Utrecht, October 2001.

67. "n-Categories in Algebraic Topology", Algebraic Topology Seminar, Mathematics Department, University of Chicago, March 2002.

68. "The World of n-Categories", Mathematics Department, University of Chicago, March 2002.

69. "Quantum Riemannian Geometry and Gauge Theory" (6 hours of lectures), Korea Institute of Advanced Studies, Seoul, March 2002.

70. "The World of n-Categories", Mathematics Department, University of California, Santa Cruz, April 2002.

71. "n-Categories in Homology Theory", Workshop on Nonabelian Hodge Theory and Higher Categories, Mathematical Sciences Research Institute, April 2002.

72. "Categorified Gauge Theory," Joint Meeting of the Pacific Northwest Geometry Seminar and Cascade Topology Seminar, University of Washington, Seattle, May, 2002.

73. "n-Categories and Homotopy Theory" (5 lectures), Department of Pure Mathematics and Mathematical Statistics, Cambridge University, July, 2002.

74. "The Vector Cross Product in Dimensions 0, 1, 3 and 7", Department of Mathematics, George Washington University, September 2002.

75. "Building Spacetime from Spin", Dirac Centenary Conference, Baylor University, Texas, October 2002.

76. "Higher-Dimensional Algebra and Quantum Gravity", Philosophy of Science Association, Milwaukee, November 2002.

77. "The Vector Cross Product in Dimensions 0, 1, 3 and 7", Department of Mathematics, University of California, San Diego, December 2002.

78. "Categorified Lie Algebras and Lie Groups", Algebra Mini-Conference, Department of Mathematics, University of New South Wales, Australia, January 2003.

79. "A Categorical Approach to Division Algebras", Australian Category Seminar, Department of Mathematics, Macquarie University, Australia, January 2003.

80. "Categorifying Quantum Mechanics" (4 lectures), Australian Category Seminar, Mathematics Department, Macquarie University and University of Sydney, Australia, February 2003.

81. "The Octonions", Pure Mathematics Department, University of Adelaide, Australia, February 2003.

82. "Lie 2-Groups and Lie 2-Algebras", Pure Mathematics Department, University of Adelaide, Australia, February 2003.

83. "From the Octonions to E_8", Mathematics Department, University of Western Ontario, London, Canada, March 2003.

84. "New Directions in Spin Foam Theory", Spin Foam Seminar, Perimeter Institute of Theoretical Physics, Waterloo, Canada, March 2003.

85. "Categorified Gauge Theory", Perimeter Institute of Theoretical Physics, Waterloo, Canada, March 2003.

86. "Quantum Geometry and Its Applications", plenary talk at Gravitation: a Decennial Perspective, Center of Gravitational Physics and Geometry, Pennsylvania State University, June 2003.

87. "Categorified Lie Groups, Lie Algebras, Bundles and Connections", plenary talk at the Workshop on Higher-Order Geometry and Categorification, Superior Tecnico, Lisbon, Portugal, July 2003.

88. "Struggles with the Continuum", plenary talk at the Young Researcher's Symposium of the ICMP, Instituto Superior Tecnico, Lisbon, Portugal, July 2003.

89. "Euler Characteristic versus Homotopy Cardinality", Fields Institute Program on Applied Homotopy Theory, University of Western Ontario, London, Ontario, September 2003.

90. "Categorification", Workshop on the Ramifications of Category Theory, University of Florence, Florence, Italy, November 2003.

91. "Spin Foam Models", Nonperturbative Quantum Gravity: Loops and Spin Foams, Centre Internationale de Recontres Mathématiques, Luminy, Marseille, May 2004.

92. "Why n-Categories?", "What n-Categories Should be Like", and "Space and State, Spacetime and Process", talks at n-Categories: Foundations and Applications, IMA, Minneapolis, June 2004.

93. "n-Categorical Physics", 4 lectures at the Department of Applied Mathematics and Theoretical Physics, Cambridge University, England, July 2004.

94. "Loop Quantum Gravity, Quantum Geometry and Spin Foams", plenary talk at 17th Conference of the International Society of General Relativity and Gravitation (GR-17), Dublin, Ireland, July 2004.

95. "The Problem of Dynamics in Quantum Gravity", plenary talk at Workshop on Quantum Gravity in the Americas, Perimeter Institute, Waterloo, Ontario, Canada, October 2004.

96. "Categorified Gauge Theory", Arithmetic, Geometry and Topology, a conference in honor of Larry Breen's 60th birthday, Institute Galilée, Université Paris 13, France, December 2004.

97. "Loop Quantum Gravity", plenary talk at the ACM-SIAM Symposium on Discrete Algorithms (SODA), Vancouver, British Columbia, January 2005.

98. "From Loop Groups to 2-Groups", Algebra Seminar, Mathematics Department, University of California at Irvine, May 2005.

99. "The Mysteries of Counting: Euler Characteristic Versus Homotopy Cardinality", public lecture at Categories in Algebra, Geometry and Mathematical Physics, a conference in honor of Ross Street's 60th birthday, Sydney, Australia, July 2005.

100. "Higher Gauge Theory", two talks at Categories in Algebra, Geometry and Mathematical Physics, a conference in honor of Ross Street's 60th birthday, Sydney and Canberra, Australia, July 2005.

101. "Higher Gauge Theory, Homotopy Theory and n-Categories", four lectures at a graduate summer school on Topics in Homotopy Theory at the Pacific Institute of Mathematical Sciences, Calgary, Canada, August 2005.

102. "Higher Gauge Theory: 2-Connections", plenary talk at the Union College Mathematics Conference, Union College, Schenectady, New York, December 2005.

103. "Universal Algebra and Diagrammatic Reasoning", nine lectures at Geometry of Computation 2006, Centre International de Recontres Mathématiques, Marseille, France, February 2006.

104. "Fundamental Physics: Where We Stand Today", Faculté des Sciences de Luminy, Marseille, France, February 2006.

105. "Loop Quantum Gravity", Physics Department of California State University, Long Beach, March 2006.

106. "Higher Gauge Theory, Higher Categories", three lectures, 24th annual Unni Namboodiri Lectures in Geometry and Topology, University of Chicago, April 2006.

107. "n-Categories and Cohomology", three talks in the Category Theory Seminar, Department of Mathematics, University of Chicago, April 2006.

108. "Higher Gauge Theory", three lectures, 2006 Barrett Lectures, University of Tennessee, Knoxville, April 2006.

109. "Higher-Dimensional Algebra: a Language for Quantum Spacetime", Perimeter Institute, Waterloo, Canada, May 2006.

110. "Fundamental Physics: Where We Stand Today", Department of Physics, University of Western Ontario, June 2006.

111. "Zooming Out in Time", Seminars on Long-Term Thinking, San Francisco, October 2006.

112. "Tales of the Dodecahedron", Reese Prosser Memorial Lecture, Mathematics Department, Dartmouth College, November 2006.

113. "Higher Gauge Theory", joint physics/mathematics colloquium, Louisiana State University, November 2006.

114. "Higher Gauge Theory", Mathematics Department, Stanford University, December 2006.

115. "The Homotopy Hypothesis", lecture at Higher Categories and Their Applications, Fields Institute, Toronto, January 2007.

116. "Quantum Quandaries: a Category-Theoretic Perspective", lecture at Philosophical and Formal Foundations of Modern Physics, Les Treilles, France, April 2007.

117. "Cartan Geometry and MacDowell–Mansouri Gravity: the Work of Derek Wise", lecture at the AstroParticule et Cosmologie (APC) group at Université Paris 7, July 2007.

118. "Why Mathematics is Boring", lecture at Mathematics and Narrative, Delphi, July 2007.

119. "Higher Gauge Theory and Elliptic Cohomology", lecture at the 2007 Abel Symposium, Oslo, August 2007.

120. "Higher Gauge Theory and the String Group", lecture at Poisson Geometry and Sigma Models, Erwin Schr´odinger Institut, Vienna, August 2007.

121. "2-Hilbert Spaces", London Analysis and Probability Seminar, University College, London, September 2007.

122. "Higher Gauge Theory and the String Group", plenary talk, 22nd British Topology Meeting, Sheffield University, England, September 2007.

123. "Spans in Quantum Theory", keynote talk at Deep Beauty: Mathematical Innovation and the Search for an Underlying Intelligibility of the Quantum World, Princeton University, October 2007.

124. "Fundamental Physics: Where We Stand Today", James Madison University, Harrisonburg, Virgina, November 2007.

125. "5", Mathematics Department, George Washington University, Washington DC, May 2008.

126. "Groupoidification", Groupoids in Analysis and Geometry Seminar, Department of Mathematics, U. C. Berkeley, May 2008.

127. "5", Google, Mountain View, California, May 2008.

128. "Topological 2-Groups and Their Classifying Spaces", Workshop on Categorical Groups, Universitat de Barcelona, Spain, June 2008.

129. "Lie 2-Algebras", two lectures, Department of Algebra, University of Granada, Spain, June 2008.

130. "Groupoidification", invited lecture, Homotopy Theory and Higher Categories 2008, Centre de Recerca Matemàtica, Barcelona, Spain, June 2008.

131. "Computation and the Periodic Table", plenary talk at Algebraic Topological Methods in Computer Science 2008, Université Paris Diderot, Paris, July 2008.

132. "Classifying Spaces for Topological 2-Groups", talk at the Instituto Superior Tecnico, Lisbon, Portugal, July 2008.

133. "Groupoidification", talk at the Preuves, Programmes et Systemes group at Université Paris Diderot, Paris, July 2008.

134. "My Favorite Numbers", 3 lectures, 2008 Rankin Lectures, University of Glasgow, Scotland, September 2008.

135. "Classifying Spaces for Topological 2-Groups", and "Groupoidification", talks at the 2009 Joint Mathematics Meetings, Washington, D.C., January 2009.

136. "Lectures on Higher Gauge Theory", 3 talks at Higher Structures in Topology and Geometry II, a workshop at the Mathematisches Institut of the Georg-August-Universität Göttingen, February 2009.

137. "Categorification and Topology", invited talk at Categorification and Geometrisation from Representation Theory, University of Glasgow, April 2009.

138. "Categorification and Topology", plenary talk at Graduate Student Topology and Geometry Conference, University of Wisconsin, April 2009.

139. "Why Smooth Spaces?", invited talk at the Fields Institute workshop on Smooth Structures in Logic, Physics and Category Theory, University of Ottawa, May 2009.

140. "Computation and the Periodic Table", invited talk at the 24th Annual IEEE Symposium on Logic in Computer Science (LICS 2009), UCLA, July 2009.

141. "My Favorite Numbers" (3 talks), "Fundamental Physics: Where We Stand Today", and "Zooming Out in Time", lectures given as Cecil & Ida Green Honors Chair, Mathematics Department, Texas Christian University, Forth Worth, Texas, September 2009.

142. "Categorification in Mathematical Physics", 5-lecture course given at the 2nd School and Workshop on Quantum Gravity and Quantum Geometry, Corfu Summer Institute, Greece, September 2009.

143. "Who Discovered the Icosahedron?", invited talk at the History and Philosophy of Mathematics special session of the 2009 Fall Western Section Meeting of the AMS, U.C. Riverside, November 2009.

144. "Quantum Gravity", Southern California Reading Group in the Philosophy of Physics, January 2010.

145. "8", Mathematics Department, Fullerton College, California, March 2010.

146. "5" and "Physics, Topology, Logic and Computation: a Rosetta Stone", Mathematics and Physics Departments, California State University, Fresno, April 2010.

147. "Electrical Circuits", Einstein Chair Mathematics Seminar, City University of New York, May 2010.

148. "Duality in Logic and Physics", Quantum Physics and Logic 10, Oxford University, May 2010.

149. "Energy, the Environment, and What Mathematicians Can Do", Department of Mathematics, Hong Kong University, March 2011.

150. "8", Institute of Mathematical Sciences, Chinese University of Hong Kong, March 2011.

151. "Higher Gauge Theory, Division Algebras and Superstrings," Workshop on Geometry and Lie Groups, Department of Mathematics, Hong Kong University, March 2011.

152. "Higher Gauge Theory, Division Algebras and Superstrings," Quantum Theory and Gravitation, ETH Zurich, June 2011.

153. "Operads and the Tree of Life", Combinatorics Seminar, Department of Mathematics, Université du Québec é Montréal, July 2011.

154. "Probabilities versus Amplitudes", invited talk, CQT Annual Symposium, Centre for Quantum Technologies, Singapore, December 2011.

155. "Network Theory", four lectures at Expository Quantum Lecture Series 5 at the Institute for Mathematical Research, Universiti Putra Malaysia, January 2012.

156. "Energy, the Environment and What We Can Do", public lecture at the Universiti Putra Malaysia, January 2012.

157. "Probabilities versus Amplitudes", invited talk, Coogee '12 Sydney Quantum Information Theory Workshop, Sydney, Australia, February 2012.

158. "Probabilities versus Amplitudes", Mathematics Department, Macquarie University, Australia, February 2012.

159. "Energy, the Environment and What We Can Do", Macquarie University, Australia, February 2012.

160. "Symmetric Monoidal Categories in Chemistry and Biology", Australian Category Seminar, Mathematics Department, Macquarie University, Australia, February 2012.

161. "Energy, the Environment and What We Can Do", Google, Mountain View, California, February 2012.

162. "The Beauty of Roots", Topology Seminar, Mathematics Department, National University of Singapore, February 2012.

163. "G_2 and the Rolling Ball" and "Teleparallel Gravity and Higher Gauge Theory", Mathematics Department, University of Hong Kong, May 2012.

164. "Stochastic Petri Nets and Chemical Reactions", Preuves, Programmes et Systèmes group at Université Paris 7, June 2012.

165. "Diversity, Entropy and Thermodynamics", invited talk at Mathematics of Biodiversity, Centre de Recerca Matemàtica, Barcelona, July 2012.

166. "The Mathematics of Planet Earth", Mathematics Department, University of Southern California, October 2012.

167. "The Mathematics of Planet Earth", plenary talk at the 55th Annual Congress of the South African Mathematical Society, Stellenbosch University, South Africa, October 2012.

168. "The Mathematics of Planet Earth", Serge Lang Lecture, Mathematics Department, University of California at Berkeley, November 2012.

169. "The Azimuth Project: an Open-Access Educational Resource", American Geophysical Union Fall Meeting, December 2012.

170. "Network Theory", Econometrics Colloquium, Economics Department, University of California, Riverside, January 2013.

171. "The Mathematics of Planet Earth", Mathematics Institute, Warwick University, United Kingdom, January 2013.

172. "Bicategories and Tricategories of Spans", 94th Peripatetic Seminar on Sheaves and Logic, University of Sheffield, March 2013.

173. "The Mathematics of Planet Earth", public lecture, British Mathematical Colloquium, University of Sheffield, United Kingdom, March 2013.

174. "Spans and the Categorified Heisenberg Algebra", University of Nottingham, United Kingdom, March 2013.

175. "Energy and the Environment - What Physicists Can Do", colloquium, Perimeter Institute, April 2013.

176. "Energy and the Environment - What Physicists Can Do", Moreno Valley College, California, April 2013.

177. "Key Developments in Category Theory", Department of Logic and Philosophy of Science, University of California, Irvine, May 2013.

178. "The Foundations of Applied Mathematics", Category-Theoretic Foundations of Mathematics Workshop, University of California, Irvine, May 2013.

179. "Spans and the Categorified Heisenberg Algebra", 3-hour course, Higher Structures in China IV, Lanzhou University, China, June 2013.

180. "Spans and the Categorified Heisenberg Algebra", Quantum Mathematics and Computation Symposium, Mathematical Institute, University of Oxford, October 2013.

181. "Learning to Live on a Finite Planet" TEDxCrocetta, Turin, Italy, October 2013.

182. "What is Climate Change?" and "What To Do About It?", invited lectures at What is Climate Change and What To Do About It?, Balsillie School of International Affairs, University of Waterloo, Canada, October 2013.

183. "Petri Nets, Chemistry, and Quantum Theory", Department of Computer Science, California Institute of Technology, October 2013.

184. "The Mathematics of Planet Earth", Open University, United Kingdom, November 2013.

185. "Life's Struggle to Survive", SETI Institute, Mountain View, California, December 2013.

186. "Categories in Control", Mathematical Physics Seminar, Friedrich-Alexander-Universität Erlangen-Nürnberg, February 2014.

187. "Network Theory", four lectures at the Department of Computer Science, University of Oxford, February-March 2014.

188. "Operads and the Tree of Life", Topology Seminar, Mathematical Institute, University of Oxford, February 2014.

189. "The Mathematics of Planet Earth", Department of Computer Science, University of Birmingham, February 2014.

190. "Fock Space Techniques for Stochastic Physics", Quantum Field Theory Seminar, Institute of Mathematics, University of Oxford, March 2014.

191. "The Mathematics of Planet Earth", Department of Pure Mathematics and Mathematical Statistics, University of Cambridge, March 2014.

192. "Network Theory", lecture as part of Category Theory at the Crossroads, Schloss Dagstuhl, Germany, May 2014.

193. "Operads and the Tree of Life", Topology Seminar, Université de Lille, Lille, France, May 2014.

194. "Operads and the Tree of Life", invited lecture, Institut Henri Poincaré, Paris, May 2014.

195. "Spans and the Categorified Heisenberg Algebra", Catégories, Logiques, Etc., Université Paris Diderot, Paris, May 2014.

196. "Network Theory", Computer Science Seminar, Friedrich-Alexander-Universität Erlangen-Nürnberg, Erlangen, Germany, May 2014.

197. "Biodiversity, Entropy and Thermodynamics", invited lecture at Biological and Bio-Inspired Information Theory, Banff International Research Station, October 2014.

198. "Networks in Climate Science", plenary talk at Neural Information Processing Systems 2014, Montréal, Canada, December 2014.

199. "Information and Entropy in Biological Systems", introductory talk at the Investigative Workshop on Information and Entropy in Biological Systems at the National Institute for Mathematical and Biological Synthesis, Knoxville, Tennessee, April 2015.

200. "Split octonions and the rolling ball", Geometry-Analysis-Physics Seminar, Mathematics Department, Pennsylvania State University, April 2015.

201. "The exceptional Jordan algebra and the Leech lattice", Geometry Luncheon Seminar, Mathematics Department, Pennsylvania State University, April 2015.

202. "8", University of York Mathematics Society, April 2015.

203. "Categories in Control" and "Circuits, Categories and Rewrite Rules", invited lectures at Higher-Dimensional Rewriting and Applications, Warsaw, June 2015.

204. "Probabilities versus Amplitudes", invited lecture at Workshop on Mathematical Trends in Reaction Network Theory, University of Copenhagen, June 2015.

205. "Categories in Control", invited lecture at Broadcom, Irvine, California, November 2015.

206. "Categories in Control", session on Logic, Category Theory and Computation at the winter meeting of the Canadian Mathematical Society, Montreal, December 2015.

207. "The Answer to the Ultimate Question of Life, the Universe, and Everything", invited public lecture at the winter meeting of the Canadian Mathematical Society, Montreal, December 2015.

208. "The Octonions", $4\frac{1}{2}$-hour minicourse at the 8th Minimeeting on Differential Geometry, Centro de Investigacíon en Matemáticas, Guanajuato, Mexico, December 2015.

209. "My Favorite Number", Pure Mathematics and Combinatorics and Optimization joint colloquium, University of Waterloo, Waterloo, Canada, February 2016.

210. "Harmonic Vibrations", Bridges Lecture, St. Jerome University, Waterloo, Canada, February 2016.

211. "My Favorite Number: 24", Physics/Astronomy Colloquium, California State University Los Angeles, May 2016.

212. "The Answer to the Ultimate Question of Life, the Universe, and Everything", Fall Mathematics Association of American Southern California-Nevada Section meeting, California State Los Angeles, October 2016.

213. "The Mathematics of Networks", Colloquium, Santa Fe Institute, November 2016.

214. "Computation and Thermodynamics", Santa Fe Workshop on Statistical Physics, Information Processing and Biology, Santa Fe Institute, November 2016.

215. "The Mathematics of Networks", workshop on Compositionality, Simons Institute for the Theory of Computing, Berkeley, December 2016.

216. "Biology as Information Dynamics", invited lecture at Biological Complexity: Can it be Quantified?, Beyond Center, Arizona State University, February 2017.

217. "Biology as Information Dynamics", invited talk at the Stanford Complexity Group, April 2017.

218. "The Dodecahedron, the Icosahedron and E_8", plenary talk at the Annual General Meeting of the Hong Kong Mathematical Society, May 2017.

219. "The Mathematics of Open Reaction Networks" invited talk at Dynamics, Thermodynamics and Information Processing in Chemical Networks, University of Luxembourg, June 2017.

220. "Tales of the Dodecahedron: from Pythagoras through Plato to Poincaré", Department of Mathematics, University of Genoa, June 2017.

221. "Applied Category Theory", Department of Mathematics, University of Genoa, June 2017.

222. "The Rise and Spread of Algebraic Topology", plenary talk at Applied Algebraic Topology 2017, Hokkaido University, Sapporo, Japan, August 2017.

223. "Biology as Information Dynamics", General Biology Seminar, Caltech, November 2017.

224. "Compositional Deisgn and Tasking of Networks", Applied Category Theory: Bridging Theory & Practice, NIST, Gaithersburg Maryland, March 2018.

225. "The Mathematics of Networks", Collloquium, University of Wisconsin Madison, April 2018.

226. "Props in Network Theory", Applied Category Theory 2018, Lorentz Center, Leiden, Netherlands, April 2018.

227. "Getting to the Bottom of Noether's Theorem", Physics Department and Centre for Quantum Technologies joint talk, National University of Singapore, Singapore, September 2018.

228. "Unsolved Mysteries of Fundamental Physics", Cambridge University Physics Society, Cambridge, October 2018.

229. "Getting to the Bottom of Noether's Theorem", High Energy Physics Seminar, DAMTP, Cambridge, October 2018.

230. "Getting to the Bottom of Noether's Theorem", Philosophy and Physics of Noether's Theorems: A Centenary Conference on the 1918 Work of Emmy Noether, Fischer Hall, London, October 2018.

231. "Getting to the Bottom of Noether's Theorem", SoCal Philosophy of Physics Group, U. C. Irvine, February 2019.

232. "Biology as Information Dynamics", Redwood Center for Theoretical Neuroscience, U.C. Berkeley, March 2019.

233. "Hidden Symmetries of the Hydrogen Atom", Colloquium, Mathematics Departments, Georgia Institute of Technology, April 2019.

234. "Mysteries of the Periodic Table", Frontiers in Science Lecture, Georgia Institute of Technology, April 2019.

235. "The Answer to the Ultimate Question of Life, the Universe, and Everything", Mathematics Department, Whittier College, California, April 2019.

236. "Young Diagrams", Math Connections 2019, University of California, Riverside, May 2019.

237. "Props in Network Theory", Fourth Symposium on Compositional Structures, Chapman University, California, May 2019.

238. "Structured Cospans", Quantum Physics and Logic 2019, Chapman University, California, May 2019.

239. "Structured Cospans", Category Theory 2019, University of Edinburgh, Scotland, July 2019.

240. "Unsolved Mysteries of Theoretical Physics", Cal State Long Beach, California, October 2019.

241. "From Classical to Quantum and Back", 2nd Workshop of the São Paulo Journal of Mathematical Sciences: J.-L. Koszul in São Paulo, His Work and Legacy, São Paulo, Brazil, November 2019.

242. "Structured Cospans and Open Petri Nets", MIT Category Seminar, Massachusetts Institute of Technology, Massachusetts, April 2020.

243. "Coarse-Graining Open Markov Processes", Applied Category Theory 2020, Massachusetts Institute of Technology, Massachusetts, July 2020.

244. "Fock Space Techniques for Stochastic Physics", Seminario de Categorías UNAM, Universidad Nacional Autónoma de México, Mexico, October 2020.

245. "Schur Functors", Mathematics Department, Ohio State University, November 2020.

246. "Ramanujan's Easiest Formula," Whittier College Math Club, California, November 2020.

247. "Structured versus Decorated Cospans," Yorkshire and Midlands Category Seminar, Februrary 2021.

248. "Theoretical Physics in the 21st Century," Zürich Theoretical Physics Colloquium, ETH Zürich, March 2021.

249. "Mathematics in the 21st Century," Topos Institute Colloquium, March 2021.

250. "Can We Understand the Standard Model?" and "Can We Understand the Standard Model Using Octonions?", Octonions and the Standard Model, Perimeter Institute, April 2021.

251. "The Answer to the Ultimate Question of Life, the Universe and Everything", PIMS 25th Anniversary Network-Wide Colloquium, Pacific Institute for the Mathematical Sciences, April 2021.

252. "Symmetric Monoidal Categories: a Rosetta Stone", Finding the Right Abstractions Summit 2021, Topos Institute, May 2021.

253. "Category Theory and Systems", Compositional Robotics: Mathematics and Tools, International Conference on Robotics and Automation 2021, May 2021.

254. "Structured versus Decorated Cospans", Categories and Companions 2021, June 2021.

255. "The Answer to the Ultimate Question of Life, the Universe and Everything", Google Tech Talk, June 2021.

256. "Structured vs Decorated Cospans", Berkeley Seminar, Topos Institute, July 2021.

257. "Theoretical Physics in the 21st Century", Physics Seminar, Universidad de Santiago de Chile, August 2021.

258. "The Fundamental Theorem of Natural Selection", Colloquium, Perimeter Institute, September 2021.

259. "Classical Mechanics versus Thermodynamics", Physics Colloquium, University of British Columbia, September, 2021.

260. "Visions for the Future of Physics", Basic Research Community for Physics, November, 2021.

261. "Schur Functors", Mathematics Colloquium, University of Denver, February, 2022.

262. "Categories: the Mathematics of Connection", workshop on The Mathematics of Collective Intelligence, Institute of Pure and Applied Mathematics, UCLA, February 2022.

263. "Shannon Entropy from Category Theory", tutorial at Categorical Semantics of Entropy, CUNY Graduate Center, May 2022.

264. "Motivating Motives", Grothendieck's Approach to Mathematics, Chapman University, May 2022.

265. "Shannon Entropy from Category Theory", Lisbon Webinar on Mathematics, Physics and Machine Learning, June 2022.

266. "Compositional Modeling with Decorated Cospans", Graph Transformation Theory and Practice seminar, June 2022.

267. "Structured Versus Decorated Cospans" and "Compositional Modeling with Stock-Flow Diagrams", Applied Category Theory 2022, University of Strathclyde, Glasgow, July 2022.

268. "Petri Nets as a Source of Mathematical Structures", BLAST 2022, Chapman University, August 2022.

269. "Seminar on This Week's Finds", ten lectures at the School of Mathematics, University of Edinburgh, September-December 2022.

270. "Compositional Modeling with Decorated Cospans", GEOTOP-A, September 2022.

271. "Category Theory in Epidemiology", African Mathematics Seminar, November 2022.

272. "Mysteries of Fundamental Physics", Leverhulme Lecture, International Centre of Mathematical Sciences, Edinburgh, November 2022.

273. "Information Theory in Population Dynamics", Statistics and Data Science Seminar, Queen Mary University of London, December 2022.

274. "Compositional Modeling with Decorated Cospans", Logic and Semantics Seminar, University College London, December 2022.

275. "Category Theory in Epidemiology", Mathematics Colloquium, University of Warwick, December 2022.

276. "Compositional Modeling with Decorated Cospans", SYCO10, Edinburgh, December 2022.

277. "The Tenfold Way", Algebras Particles and Quantum Theory, February 2023.

278. "The Tenfold Way", plenary talk at ANZAMP (Australian and New Zealand Association of Mathematical Physics) Annual Meeting, February 2023.

279. "The Tenfold Way", colloquium, Perimeter Institute, March 2023.

280. "Symmetric Spaces and the Tenfold Way", Algebras Particles and Quantum Theory, May 2023.

281. "The Future of Physics", Santa Fe Institute Community Lecture, May 2023.

282. "Algorithmic Thermodynamics", Workshop on Stochastic Thermodyamics IV, May 2023.

283. "Applied Category Theory", Seminar on Applied Category Theory, Centre for Reasoning, University of Kent, June 2023.

284. "Software for Compositional Modeling in Epidemiology", Applied Category Theory 2023, August 2023.

285. "Two of My Favorite Numbers: 8 and 24", seminar on Quantum Matter in Mathematics and Physics, Harvard University, August 2023.

286. "Life's Struggle to Survive", Leverhulme Lecture, International Centre for Mathematical Sciences, Edinburgh, September 2023.

287. "Schur Functors", Edinburgh Category Theory Seminar, October 2023.

288. "Software for Compositional Modeling", Logic and Semantics Seminar, Computer Laboratory, University of Cambridge, October 2023.

289. "Software for Compositional Modeling", Theoretical Computer Science Seminar, University of Birmingham, October 2023.

290. "What is Applied Category Theory?", TypeSig, University of Edinburgh, November 2023.

291. "The Answer to the Ultimate Question of Life, the Universe and Everything", Leverhulme Lecture, International Centre for Mathematical Sciences, Edinburgh, November 2023.

292. "Software for Compositional Modeling", CATNIP (The Categories Networking Project), University of Strathclyde, Glasgow, December 2023.