This special volume of *Theory and Applications of Categories* is dedicated to the memory of F. William (Bill) Lawvere (1937–2023), in appreciation of his profound and lasting contributions to category theory and, in a broad sense, logic and geometry.

Ever since the completion of his Ph.D. thesis in 1963, Bill's visionary work deeply influenced major developments in those mathematical fields. In fact, it reached into subjects far beyond them, from philosophy to physics. His passionate approach to mathematics extended into many aspects of public life, from education to politics. People who had the privilege to collaborate with Bill, or to just casually interact with him, benefitted from his great generosity in sharing his insights.

Bill's legacy in mathematics and beyond rests primarily on having made several fundamental concepts explicit—not the least of which were the notions of algebraic theory, elementary topos (with Myles Tierney), and (hyper)doctrine. Bill's ability to see ideas and concepts through the lens of adjunction was extraordinary. His mathematical interpretation of Hegel's *Aufhebung* was only one of many stellar examples in this regard.

For a full appreciation of Bill's life and work, we recommend Anders Kock's excellent article: https://ems.press/journals/mag/articles/11170869. This and many other resources may also be found in *The Lawvere Archives* at: https://lawverearchives.com. Below we include a list of Bill's publications that is as complete as we were able to make it; we acknowledge *The Lawvere Archives* and the github page of Matt Earnshaw.

We thank the editors of *Theory and Applications of Categories* for the opportunity to prepare this volume, and Geoff Cruttwell, the Managing Editor, for his guidance. The articles have been carefully referred according to the usual *TAC* standards. We are confident that they fall within the realm of Bill's wide interests and thank the authors and the referees for their contributions.

The Guest Editors:

Matías Menni, Bob Rosebrugh, Jiří Rosický and Walter Tholen

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Works of F. William Lawvere

BOOKS

- 1. Algebra Step by Step. Buffalo Workshop Press, Buffalo, 1997.
- 2. (with Stephen H. Schanuel) Conceptual Mathematics, A First Introduction to Categories. Cambridge University Press, First edition 1997, Second edition 2009.
- 3. (with Stephen H. Schanuel) Teoria delle categorie, Un'introduzione alla matematica. Muzzio Editore, Padova, Italy, 1994. (Italian translation of Conceptual Mathematics by Mara Mondolfo).
- 4. (with Stephen H. Schanuel) Matemáticas Conceptuales, 1era ed., Siglo XXI, Mexico City, 2002. (Spanish translation of Conceptual Mathematics, first edition, by Francisco Marmolejo).
- 5. (with Robert Rosebrugh) Sets for Mathematics. Cambridge University Press, 2003.

ARTICLES, REVIEWS, ABSTRACTS ETC.

- 1. Functorial Semantics of Algebraic Theories. Proceedings of the National Academy of Science 50, No. 5, 869-872, 1963.
- 2. Functorial Automata Theory (abstract). Notices Amer. Math. Soc., 10, 477-478, 1963.
- 3. The group ring of a small category (abstract). Notices Amer. Math. Soc., 10, 280, Errata, Notices Amer. Math. Soc., 10, 516, 1963.
- 4. An Elementary Theory of the Category of Sets, Proceedings of the National Academy of Science 52, No. 6, 1506-1511, 1964. See also *TAC* long version with commentary, 2005.
- 5. Algebraic Theories, Algebraic Categories, and Algebraic Functors. Theory of Models, North-Holland, Amsterdam, 413-418, 1965.
- 6. Functorial Semantics of Elementary Theories (abstract). J. Symb. Logic, 31, 294-295, 1966.
- 7. The Category of Categories as a Foundation for Mathematics. La Jolla Conference on Categorical Algebra, Springer-Verlag, 1-20, 1966.
- 8. Theories as Categories and the Completeness Theorem (abstract). J. Symb. Logic, 32, 562, 1967.

- 9. Some Algebraic Problems in the Context of Functorial Semantics of Algebraic Theories. Springer Lecture Notes in Mathematics No. 61 (Reports of the Midwest Category Seminar II), Springer-Verlag, 41-61, 1968.
- 10. Ordinal Sums and Equational Doctrines. Springer Lecture Notes in Mathematics No. 80, Springer-Verlag, 141-155, 1969.
- 11. Diagonal Arguments and Cartesian Closed Categories. Springer Lecture Notes in Mathematics No. 92, Springer-Verlag, 134-145, 1969.
- 12. Adjointness in Foundations. Dialectica 23, 281-296, 1969.
- 13. Equality in Hyperdoctrines and Comprehension Schema as an Adjoint Functor. Proceedings of the American Mathematical Society Symposium on Pure Mathematics XVII, 1-14 1970.
- 14. Quantifiers and Sheaves. Proceedings of the International Congress on Mathematics, Nice 1970, Gauthier-Villars, 329-334, 1971.
- 15. Introduction to "Toposes, Algebraic Geometry and Logic". Proceedings of the Halifax Conference, Springer Lecture Notes in Mathematics No. 274, New York: Springer, 1–12, 1971.
- 16. Theory of Categories over a Base Topos. Lectures given at Università di Perugia, 1972.
- 17. Metric Spaces, Generalized Logic, and Closed Categories. Rendiconti del Seminario Matematico e Fisico di Milano 43, 135-166, 1973. Republished in *TAC* Reprints, No.1 2002 pp. 1-37.
- 18. Introduction to "Model Theory and Topoi". Springer Lecture Notes in Mathematics No. 445, Springer-Verlag, 3-14, 1975.
- 19. Variable Sets Etendu and Variable Structure in Topoi. Notes by Steven Landsburg of Lectures and Conversations, Spring 1975, University of Chicago 1975.
- 20. Continuously Variable Sets: Algebraic Geometry=Geometric Logic. Studies in Logic and the Foundations of Mathematics, Volume 80, 135-156, 1975.
- 21. Variable Quantities and Variable Structures in Topoi. Algebra, topology, and category theory (a collection of papers in honor of Samuel Eilenberg), 101–131, 1976.
- 22. Categorical Dynamics. Proceedings of Aarhus May 1978 Open House on Topos Theoretic Methods in Geometry, 1978.
- 23. Toward the Description in a Smooth Topos of the Dynamically Possible Motions and Deformations of a Continuous Body. Cahiers de Topologie et Géométrie Différentielle Catégoriques XXI, 377-392, 1980.

- 24. On C^{∞} functions. Preprint, State Univ. of New York, Buffalo, 1981.
- 25. Review of P. M. Cohn's Universal Algebra, 2nd Edition. American Scientist (May-June, 1982), 329.
- 26. State Categories, Closed Categories, and the Existence of Semicontinuous Entropy Functions. IMA Research Report No. 86, University of Minnesota, 1986.
- 27. Functorial Remarks on the General Concept of Chaos. IMA Research Report No. 87, University of Minnesota, 1986.
- 28. Introduction to "Categories in Continuum Physics". Springer Lecture Notes in Mathematics No. 1174, Springer-Verlag, 1986.
- 29. State Categories and Response Functors. Preprint, 1986.
- 30. Categories of Spaces may not be Generalized Spaces as Exemplified by Directed Graphs. Revista Colombiana de Matemáticas XX, 179-185, 1986.
- 31. Taking Categories Seriously. Revista Colombiana de Matemáticas XX, 147-178, 1986.
- 32. Concepts and Problems in Mathematical Toposes (abstract). CMS Winter Meeting, Toronto, Special Session on Category Theory, 1988.
- 33. Toposes generated by codiscrete objects in combinatorial topology and functional analysis. TAC Reprint 27 (2021) of notes for Colloquium lectures given at North Ryde, New South Wales, Australia 1988-89, 1989.
- 34. (with G.M. Kelly) On the Complete Lattice of Essential Localizations. Bull. Société Mathematique de Belgique, XLI, 289-319, 1988.
- 35. Display of Graphics and their Applications Exemplified by 2-Categories and the Hegelian Taco. Proceedings of the First International Conference on Algebraic Methodology and Software Technology, The University of Iowa, 51-75, 1989.
- 36. Qualitative Distinctions Between Some Toposes of Generalized Graphs. Proceedings of AMS Boulder 1987 Symposium on Category Theory and Computer Science, Contemporary Mathematics, 261-299, 1989.
- 37. Intrinsic Co-Heyting Boundaries and the Leibniz Rule in Certain Toposes, Category Theory, Proceedings Como 1990, A. Carboni, M. C. Pedicchio, G. Rosolini (Eds). Springer Lecture Notes in Mathematics 1488, Springer-Verlag (1991) pp. 279-281, 1991.
- 38. More on Graphic Toposes. Proceedings of the 1989 Bangor Category Theory Meeting, Cahiers de Topologie et Géométrie Différentielle Catégorique XXXII, 5-10, 1991.

- 39. Some Thoughts on the Future of Category Theory. Category Theory, Proceedings Como 1990, A. Carboni, M. C. Pedicchio, G. Rosolini (Eds). Springer Lecture Notes in Mathematics 1488, Springer-Verlag, 1-13, 1991.
- 40. Categories of Space and Quantity. The Space of Mathematics: Philosophical, Epistemological and Historical Explorations, International Symposium on Structures in Mathematical Theories (1990), San Sebastian, Spain, DeGruyter, Berlin, 14-30, 1992,
- 41. Introduction to Linear Categories and Applications. Course lecture notes, 1992.
- 42. Cohesive Toposes and Cantor's Lauter Einsen. Philosophia Mathematica, The Canadian Society for History and Philosophy of Mathematics, Series III, Vol. 2, 5-15, 1994.
- 43. Tools for the Advancement of Objective Logic: Closed Categories and Toposes. The Logical Foundations of Cognition, J. Macnamara and G. E. Reyes (Eds). Oxford University Press, 43-56, 1994.
- 44. Adjoints in and among Bicategories. Logic and Algebra, Proceedings of the 1994 Siena Conference in Memory of Roberto Magari, Lecture Notes in Pure and Applied Algebra 180, 181-189, Ed. Ursini/Aglianò, Marcel Dekker Inc., Basel, New York, 1996.
- 45. Grassmann's Dialectics and Category Theory. Hermann Günther Grassmann (1809-1877): Visionary Mathematician, Scientist and Neohumanist Scholar, 255-264, Boston Studies in the Philosophy of Science Series (187), 1996.
- 46. Unity and Identity of Opposites in Calculus and Physics. Proceedings of ECCT 1994 Tours Conference, Applied Categorical Structures 4, 167-174, 1996.
- 47. Volterra's Functionals and Covariant Cohesion of Space. Supplemento ai Rendiconti del Circolo Matematico di Palermo, Serie II, 64, R. Betti, F. W. Lawvere (Eds.), 201-214, 1997.
- 48. Outline of Synthetic Differential Geometry, Buffalo Geometry Seminar notes, 1998.
- 49. Categorie e Spazio: Un Profilo. Lettera matematica PRISTEM 31, Springer, Italy, 35-50, 1999. [Reprinted in La Mathematica a cura di Bartocci, Claudio, Giulio Einaudi editore vol. 4, 107-135, 2010.]
- 50. Kinship and Mathematical Categories. Language, Logic, and Conceptual Representation, P. Bloom, R. Jackendoff, and K. Wynn (Eds), MIT Press, 411-425, 1999.
- 51. Comments on the Development of Topos Theory. Development of Mathematics 1950-2000, J.-P. Pier (Ed), Birkhäuser Verlag, Basel, 715-734, 2000.

- 52. Explicit foundational concepts in the teaching of mathematics. Matematica e filosofia: il problema dei fondamenti oggi PRISTEM/Storia 14-15 Translation: Filosofia, scienza e bioetica nel dibattito contemporaneo a cura di Minazzi, Fabio, Instituto Poligrafico e Zecca dello Stato, Roma, 2001.
- 53. (with J. Adámek and J. Rosický) How Algebraic is Algebra?. Theory and Applications of Categories 8, No. 9, 252-282, 2001.
- 54. Linearization of Graphic Toposes via Coxeter Groups. Journal of Pure and Applied Algebra 168, 425-436, 2002.
- 55. Categorical Algebra for Continuum Micro Physics. Journal of Pure and Applied algebra 175, 267-287, 2002.
- 56. (with J. Adámek and J. Rosický) On the Duality Between Varietes and Algebraic Theories. Algebra Universalis 49, 35-49, 2003.
- 57. Foundations and Applications Axiomatization and Education. The Bulletin of Symbolic Logic 9, No. 2, 213-224, 2003.
- 58. (with J. Adámek and J. Rosický) Continuous Categories Revisited. Theory and Applications of Categories 11, No. 11, 252-282, 2003.
- 59. Incontro con Ludovico Geymonat, anno 1977. Filosofia, scienza e vita civile nel pensiero di Ludovico Geymonat (a cura di Minazzi, Fabio), La città del sole, Napoli, 181-185, 2003. [English: Encounter with Ludovico Geymonat in 1977.]
- 60. Functorial Semantics of Algebraic Theories and Some Algebraic Problems in the Context of Functorial Semantics of Algebraic Theories. Reprints in Theory and Applications of Categories, No. 5, 1-121, 2004.
- 61. Functorial Concepts of Complexity for Finite Automata. Theory and Applications of Categories 13, No. 10, 164-168. 2004.
- 62. Left and Right Adjoint Operations on Spaces and Data Types. For Dana Scott's Seventieth Birthday, Copenhagen 2002, Theoretical Computer Science 316, 105-111, 2004.
- 63. Essay Review of: A new branch of mathematics, "The Ausdehnungslehre of 1844", and other works by Hermann Günther Grassmann (translated by Lloyd C. Kannenberg, with foreword by Albert C. Lewis, Open Court Publishing Company, 1995) and of Extension Theory, "The Ausdehnungslehre of 1862" by Hermann Günther Grassmann (translated and with a foreword and notes by Lloyd C. Kannenberg, History of Mathematics 19, American Mathematical Society and London Mathematical Society, 2000). Historia Mathematica 32, 101-106, 2005.

- 64. Reprint with new author commentary, Taking Categories Seriously (1986). Reprints in Theory and Applications of Categories, No. 8, 1-24, 2005.
- 65. Reprint with new author commentary Categories of Spaces may not be Generalized Spaces, as Exemplified by Directed Graphs (1986). Reprints in Theory and Applications of Categories, No. 9, 1-7, 2005.
- 66. Long version with new commentary by the author and by Colin McLarty of: An Elementary theory of the category of sets (1964), Reprints in Theory and Applications of Categories, No. 11, 1-35, 2005
- 67. Reprint with new author commentary of: Diagonal Arguments and Cartesian Closed Categories (1969). Reprints in Theory and Applications of Categories, No. 15, 1-13, 2006.
- 68. Reprint with new author commentary of: Adjointness in Foundations (1969). Reprints in Theory and Applications of Categories, No. 16, 1-16,2006.
- 69. John Isbell's Adequate Subcategories. Topological Commentary, Vol. 11 No. 1, 2006.
- Review of: Synthetic Differential Geometry Second Edition by Anders Kock. SIAM Review, Vol 49, 349-350, 2007.
- 71. Axiomatic Cohesion. Theory and Applications of Categories 19, Special volume from the CT2006 Conference, 41-49, 2007.
- 72. Core Varieties Extensivity and Rig Geometry. Theory and Applications of Categories 20, No. 14, 497-503, 2008.
- 73. Open Problems in Topos Theory, For Martin Hyland and Peter Johnstone in honor of their sixtieth birthdays (updated July 2016), 2009.
- 74. (with M. Menni) The Hopf Algebra of Möbius Intervals. Theory and Applications of Categories 24, No. 10, 221-265, 2010.
- 75. Euler's Continuum Functorially Vindicated Logic, Mathematics, Philosophy: Vintage Enthusiasms, Essays in Honour of John L. Bell, D. DeVidi et al. (Eds), Western Ontario Series in Philosophy of Science 75, 2011.
- Foreword to "Algebraic Theories". Cambridge Tracts in Mathematics 184, J. Adámek, J. Rosický and E. M. Vitale, 2012.
- 77. Reprint with new author commentary of: Comments on the Development of Topos Theory (2000). Reprints in Theory and Applications of Categories, No. 24, 1-22, 2014.

- 78. (with M. Menni) Internal Choice Holds in the Discrete Part of any Cohesive Topos Satisfying Stable Connected Codiscreteness, Theory and Applications of Categories 30, No. 26, 909-932, 2015.
- 79. Birkhoff's Theorem from a Geometric Perspective: A Simple Example. Categories and General Algebraic Structures with Applications 4, no. 1, 1-7, 2016.
- 80. Everyday physics of extended bodies or why functionals need analyzing. Categories and General Algebraic Structures with Applications 6, 9-19, 2017.

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