CURRICULUM VITAE

May 3, 2023

Giuseppe Longo
Directeur de Recherches Emeritus,
`http://www.di.ens.fr/users/longo`
CNRS - Ecole Normale Supérieure, Paris
Former "Professore Ordinario di Informatica", Università di Pisa, Italy

EDUCATION:

- February 1971, "Laurea" (cum laude) in Mathematics (September 1970 - May 1971, CNR grant for "dottorandi"), University of Pisa. *Thesis: Complessità di calcolo delle funzioni ricorsive.*
- June 1971, three years of a "Borsa triennale di Perfezionamento" in "Logica e calcolabilita' "; from October: active participation "Seminario di Logica" organized by E. De Giorgi, Scuola Normale Superiore, Pisa.

ACADEMIC APPOINTMENTS AT THE UNIVERSITY OF PISA:

- November 1971 – March 1973 Assistant Professor (Methods of Optimisation for Differential Equations).
- March 1973 – August 1980 Assistant Professor (tenured).
- November 1976 – August 1980 Professor "Incaricato" (Associate Professor) of Mathematical Methods in Computer Science.
- August 1980 – October 1987 Associate Professor (tenured) of Mathematical Logic (on leave January 1980 – October 1981: Oxford, Berkeley and M.I.T., see below).
- November 1987 – October 1990 Full Professor of Computer Science. (on leave 1987/88 (Carnegie Mellon University) and 1989/90 (E.N.S., Paris), see below).

ACADEMIC AND RESEARCH APPOINTMENTS IN FRANCE:

- October 1989 – May 1990 Invited Professor **École Normale Supérieure**, Paris (Dept. of Mathematics and Computer Science) (teaching: *I sem.*: Langages Fonctionnels ; *II sem.*: cours of D.E.A. – Master's cours)
- June – August 1990 Directeur de Recherches Associé **CNRS École Normale Supérieure**, Paris (Laboratoire of Computer Science, Dept. of Mathematics and Computer Science)
- November 1990 – September 2011 Directeur de Recherches **CNRS** – **École Normale Supérieure**, Paris (Laboratoire of Computer Science, Dept. of Mathematics and Computer Science), 2ème cl.; 1ère cl. since Nov. 1994
- October 2011 – July 2012 Directeur de Recherches **CNRS** – **École Polytechnique**, Paris (Centre d'épistémologie appliquée, CREA)
- July 2012 – July 2027 Directeur de Recherches Emérite **CNRS** – **École Normale Supérieure**, Paris (Centre Cavaillés)
- 1991 – 1993 **Dec-Prl** (Digital, Paris Research Laboratory): Consultant.

MORE RESEARCH AND ACADEMIC APPOINTMENTS:

1. OTHER THAN ITALY AND FRANCE (three years and four months total):

- **Utrecht University** (Math. Dept.): Visiting Scientist, Nederlandse Z.W.O. grant, Decembre 1978; Visiting Professor, guest of the dept., September and October 1979.
- **Oxford University** (Math. Inst.): Visiting Scholar, British Council grant, January and February 1980.
- **U.C.Berkeley** (Math. Dept.): Research Associate, grant of the italien CNR, March – December 1980.
- **M.I.T.** (Lab. for Computer Science (LCS)): Research Associate, CNR grant and LCS - M.I.T. grant, January – October 1981.
- **E.T.H.** Zurich (Math. Forshungsinst.): Visiting Scientist, host of Forshungsinst., October 1982.
- **Carnegie Mellon Univ** (Computer Science): Invited Professor (teaching: *I sem.*: Formal Lang. and Comp.; *II sem.*: graduate course on Recursion, Categories and Polymorphism), academic year 1987/88. June and August 1988, "research summer salary".
- **Dec-Src** (Digital, System Research Center, Palo Alto, California): July 1988, consultant.
- **School of Medicine**, Tufts University, Boston, USA, Adjunct Professor, 2013 – 2019.

2. IN ITALY:

- **University of Pisa and CNR** (Dept. Math. et Ist. Elaborazione dell'Informazione, Pisa): scholarship of C.N.R., 1970/71.
- **C.N.R.** (Ist. Applicazioni del Calcolo, Roma): collabor. of research, 1971 - 1975 (MdC in Pisa).
- **University of Genova** (Dept. Math.): "Prof. Incaricato" of Mathematical Logic, 1975/76 (assistant prof in Pisa).

AWARDS:

- Unione Matematica Italiana, National Award for young mathematicians, 1974.
- Member of the **Academia Europaea**, the European Academy of Sciences, since 1992.

EDITOR OF SCIENTIFIC JOURNALS:

- Founder and Editor-in-chief, **Mathematical Structures in Computer Science**, Cambridge University Press, main editorial activity, 1990 – 2015; Editor since 2016.
- Editor, **Information and Computation**, since 1982.
- Editor, **Theoretical Computer Science and Applications** (previuosly: **R.A.I.R.O.**), since 1985.

- Editor, **La Nuova Critica**: rivista di Filosofia della Scienza, since 1993.
- Editor, **The Journal of Universal Computer Science**, a Springer electronically available journal, since 1994.
- Editor, **Journal of Mind Theory**, UPM, since 2010.
- Editor, **European Review**, the interdisciplinary journal of the Academia Europaea, since 2010.
- Editor, **Philosophical Enquires**, Philosophy of Science, since 2011.
- Editor, **Advances in Historical Studies (AHS)**, History of Sciences, since 2012.
- Editor, **Biophysics** (American Inst. Math. Sci.), since 2012.
- Editor, **Epistemologica**, Mimesis, Milano, since 2013.
- Editor, **Organisms. A journal in Biological Sciences**, Roma, since 2016.
- Editor, **Biology Forum**, since 2011 (former "Rivista di biologia"), since 1919.
- Founding Member and Editor, **Annals of Mathematics and Philosophy**, since 2021.

EDITOR, BOOK SERIES:

- Co-founder and current director of the book series, **Vision des Sciences**, Hermann, Paris, from 2006 to 2016; currently **Nouvelles Visions des Sciences**, with Spartacus IDH.
- Editor, **Studies in Applied Philosophy, Epistemology and Rational Ethics**, Springer, since 2011.

EDITOR, INDIVIDUAL VOLUMES:

- **Logic Colloquium '82**. G. Lolli, G. Longo, and A. Marcja (Editors), Studies in Logic and the Foundations of Mathematics n. 112 (pp. 1 - 358), North-Holland, 1984.
- **Selected papers of the 5th biennial meeting on Category Theory and Computer Science '93**. G. Longo and A. Pitts (Editors), MSCS 5 (4), Cambridge University Press, 1995.
- **Lambda-calculus and Logic**. M. Dezani, G. Longo, and J. Seldin (Editors), Volume in honor of Roger Hindley, MSCS 9 (4), Cambridge University Press, 1999.
- **On Computer Science**. G. Longo (editor), Special issue of the Monist, Journal in Philosophy of Science, vol. 82, n. 1, 1999.
- **The Difference between Concurrent and Sequential Computations**, Special issue of Mathematical Structures in Computer Science, L. Aceto, G. Longo, B. Victor (Editors), MSCS 13, n.4 and 5, Cambridge University Press, 2003.
- **New Programs and open problems in the Foundations of Mathematics**, Special issue of The Bulletin of Symbolic Logic, G. Longo and P. Scott (Editors), ASL, vol. 9, n. 2, June 2003.

- **Geometry and Cognition**, G. Longo (Editeur), special issue, Revue de Synthese, Editions de la rue of Ulm, tome 124, 2004.
- **Images and Reasoning**, P. Grialou, G. Longo, M. Okada (Eds), Keio University Press, Tokio, 2005.
- **Developments of the Concepts of Randomness, Statistic, and Probability**, Special issue of Mathematical Structures in Computer Science, G. Longo, M. Mugur-Schachter (Editors), Cambridge University Press, vol. 24, n. 3, 2014.
- **From the century of the genome to the century of the organism: New theoretical approaches**, Special issue of Progress in Biophysics and Molecular Biology, A.M. Soto, G. Longo (Guest Editors), Vol. 122, Issue 1, October 2016.

INTERVIEWS:

1 - **Radio, France Culture**, La place de la Toile: "Au tour de la notion de modèle, mathématique vs. informatique", Radiofrance, Paris: 14h, September 13, 2007.
2 - **Radio, France Culture**, La place de la Toile: (seul intervenant) : "Internet, logique et finance" (audio téléchargéable de la page de l'auteur), March 12, 2010.
3 - **Bulletin of European Assoc. Theoretical Computer Science**, April 2010: Interview by Cristian Calude.
4 - **Radio, France Culture**, La place de la Toile : "Alan M. Turing", December 26, 2010.
5 - **National Public Radios**, U. S. A. : Science and Philosophy, posting of June 13, 2011 : "Are Financial and Scientific Views of the World Related?"
6 - **Conseil National du Numérique** : "Information digitale en biologie ? Conséquences d'une "philosophie" du numérique", (enregistrement vidéo, 25 minutes), April 2014.
7 - **Les entretiens du nouveau monde**, Centre Pompidou, Paris : "De la mesure physique au dénombrement : les très grandes bases de données et les régularités sans sens" (enregistrement vidéo), December 14 – 15, 2015
8 - **Entretien: "Complexité, science et démocratie"**, paru en français dans Glass Bead; orginal en italien dans MEGA chip, democrazia nella comunicazione, periodico online, 10 maggio 2016 : "Intervista: Complessità, scienza e democrazia", November 23, 2016.
9 - **Les entretiens du nouveau monde**, Centre Pompidou, Paris : "La machine à états discrets et les images du monde" (enregistrement vidéo), December 13, 2016.
10 - **France Culture** : La Méthode scientifique, émission radiophonique : "Alan Turing : l'homme derrière la machine" (59min), June 15, 2017.

MAIN RESEARCH GRANTS (inverse order):

- Partecipant, Project *Stability and variability*, Univ. Paris I, 2015 - 2017.
- Responsable du projet, *Lois des dieux, des hommes et de la nature*, at Institut Etudes Avancées de Nantes (one post-doc is affected to the project), `http://www.iea-nantes.fr/rtefiles/File/projet-giuseppe-longo-2014.pdf`, 2014 - 2018.
- Partecipant, European "Cost" Project, *The Origin of Life*, 2014 - 2018.
- IRSES, CE-FP7, European consortium extra CE, with K. Svozil, Physics, U. Vienna, and C. Calude, Maths, U. Aukland, NZ, 2011 – 2014.

- Financement annuel, Réseau Nat. Systèmes Complexes, RNSC: *Biological time and rythms*, with J. Champagnat, biology, CNRS et Paris Sud, and M. Buiatti, Biology, Univ. Firenze, 2011 – 2012.
- Bonus Qualite' Recherche, ENS, 2008.
- Responsable de projet ANR : *Singularités physiques et calculabilité effective* (Etats critiques, singularités and calcul digital : théorie and applications), 2006 – 2009.
- From 2004 to 2011, part time researcher (20/100) at **CREA** (Centre of Epistémologie Appliquée), Ecole Polytechnique, Paris.
- Projet *Invertibilité des termes and programmes en Théorie des Types and applications*, financement CNRS (in charge: S. Soloviev), 2004 – 2005.
- Projet *Neurogeometry of the visual cortex*, financement ACINIM (in charge: B. Teissier), 2004 – 2007.
- Projet MyThS: *Modèles and Types pour la Sécurité dans le systèmes distribués with mobilité*, action IST de l'Union Européenne dans le cadre de FET Global Computing. Contrat IST-2001-32617. (Dotation globale 4.9MF, dont 1.5MF pour l'équipe; in charge locally: G. Castagna), 2002 – 2004.
- Programme MATH/STIC CNRS (OSV BS): Projet *Isomorphism of types: nouveaux developpements.* Responsable national : S. Soloviev (Univ. Toulouse), 2002 – 2003.
- Action "Cognitique" de MENRST: en charge de l'atelier interdisciplinaire *Geometry and Cognition: le problème mathématique de l'espace physique et du vivant*, (14 participants: maths., biology, physics and philosophy), 2000 – 2002.
- ECOS-Sud (Cooperation with l'Uruguay): projet *Types and programming (multi paradigmes).* in charge, 1999 – 2004.
- Action of scientific and technical collaboration franco-italian, Ministères des affaires étrangères and Éducation Nationale, 1999 – 2000.
- Esprit Working Group 26142: *Applied Semantics* (APPSEM), 1998 – 2001.
- INTAS: contract CE/Russie, 1995 – 1998.
- Académie Polonaise des Sciences/Ambassade de France: research exchange contract, 1995 – 1997.
- Human Capital and Mobility (CHM): in charge for the group ENS-INRIA-PARIS VII de projet "TYPES" (J.Y. Girard, Marseille, in charge européen), 1993 – 1998.
- Esprit working group 21900: *Types for Proofs and Programs* (TYPES), 1993 – 1998.
- European community research training project:*European institute in the logical Foundations of Computer Science* (EUROFOCS), 1993 – 1997.
- CHM, CE: Responsable pour la region parisienne de Reseau Européen pour la recherche fondamentale en Computer Science (EUROFOCS), with centre principal à Edinburg (G. Plotkin), 1993 – 1997.
- NSF (USA) - Esprit (CE): Workshop on *Functional and Object Oriented Programming Languages* (in charge USA: K. Bruce), 1993 – 1996.

- Groupe De Recherche *Programmation* (GDR 690 du CNRS), 1991 – 1997.
- CNR: Italian Universities /Stanford University (with S. Feferman and J. Mitchell (Stanford)), 1989 – 1992.
- BRA-Esprit project n. 3020: *Integration*, 1989 – 1990.
- Communauté Européenne (CE-Science): projet "Lambda-calcul" J.Y. Girard (Paris VII, chargé de projet européen), 1988 – 1991.
- NSF (USA) - CNR: joint grant (with K. Bruce, Albert R. Meyer (M.I.T.)), 1982 – 1986.
- Member, CNR (It) Gruppo Nazionale Strutture Algebriche e Geometriche, 1976 – 1990.

SETTING UP AND DIRECTION OF:

CENECC: "CENtre D'Etudes" of Complex systems and of Cognition, inter-Departements Unity de l'ENS, with J.-P. Nadal (Physics), B. Victorri (Linguistics), since 2000.

CIM: Nouvelle équipe au LIENS: Morphological Complexity and information, October 2002.

Direction of regular seminars:
- At ENS

- "Philosophie and mathématiques", 2000 – 2015.
- "Geometry and Cognition", 2000 – 2002.

- At CREA

- "Biologie théorique" (with M. Mossio and N. Perret), 2007 – 2012.

ANNIVERSAIRY CONFERENCE:
28-29 June 2007, Paris: **From Type Theory to Morphologic Complexity: A Colloquium in Honor of Giuseppe Longo's 60th birthday**

RESEARCH EVALUATION COMMITTEES

- Russian Science Foundation, expert, since 2015.
- KAIST (Korean Advanced Institute for Science and Technology), Member of Academic Peer Review Survey, since 2012.
- FET - Open, European Com. research projects, since 2009.
- Advisory Committee, Centre for Logic and Computation, Lisbon, Portugal, since 2004.
- ACI Nouvelles Interfaces des Mathématiques, CNRS, 2003 and 2004.
- Member, International Panel for the evaluation of Research in Mathematics and Computer Science in Portugal, Ministry of Science and Technology (réunions: February 1998 and January 1999, Lisbon).

- Member of Scientific Committee of Centre d'Analyses et de Mathématiques Sociales (CAMS) of l'EHESS, 1997.
- Member of conseil de coordination régionale des activités en Cogniscience (CogniSeine, présidé par A. Berthoz of Collège of France), 1997 and 1998.
- Member of Coordination Committee of Jumelage, CNRS - Académie des Sciences of Russie.

Referee and reviewer for the Projets ESPRIT, U.S. NSF and NSERC of Canada (Computer Science Grant Selection Commettee); for Ministry of Universities, Italy.
Author of reviews for Mathematical Reviews, for the Journal of Symbolic Logic, Philosophy of Science and other international journals.

CONFERENCE PROGRAM COMMITTEES:

1. Member, Program Committee, **Lambda Calculus Conference**, Swansea (G.B.), 1979.
2. Member, Program Committee, **Logic Colloquium 82**, Florence 1982 and Editor, **Proceedings**, North Holland (Studies in Logic, vol. 112), 1984.
3. Member, Program Committee, **Symposium on Theoretical Aspects of Computer Science (STACS 86)**, Paris 1986.
4. Member, Program Committee, **2^{nd} IEEE Conference on Logic in Computer Science (LICS 87)** , Cornell (Ithaca, N.Y.), June 1987.
5. Member, Program Committee, **CAAP '90**, Copenhagen, March 1990.
6. Member, Program Committee, **Category Theory and Computer Science** (**CT&CS 91**), Paris, September 1991.
7. Member, Program Committee, **6^{th} IEEE Conference on Logic in Computer Science (LICS 91)**, Amsterdam, June 1991.
8. Co-organizer, **La nouvelle vie de la Logique Mathématique** (Logique entre fondement and Computer Science), Paris, April 1992.
9. Member, Program Committee, **Category Theory and Computer Science** (**CT&CS 93**), Amsterdam, September 1993.
10. Member, Comittée de Programme, **Rationalité Logique et Intuition Géometrique**, Paris, June 1994.
11. Organizer, **Constructivité, in Mathematics and in Vision**, ENS, Paris, March 1995.
12. Member, Program Committee, **Typed Lambda Calculus and Applications**, Edinburgh, April 1995.
13. Member, Program Committee, **World Conference on Fundamentals of A.I.**, Paris, July 1995.
14. Member, Program Committee, **Category Theory and Computer Science** (**CT&CS 95**), Cambridge, August, 1995.
15. Member, Program Committee, **Logic Methodology and Philosophy of Science**, Florence, August 1995.

16. Organizer, **Mathematics, Machines and Cerveau**, ENS, Paris, Mai 1996.
17. Member, Program Committee, **Functional and Object-Oriented Programming Languages**, Rutgers University, N.Y., USA, July 1996.
18. Member, Organising Committee of the **IEEE Conference on Logic in Computer Science, LICS**, from 1997 till 2001 (2000 : Santa Barbara, Ca.; 2001 : Boston, Mass.; 2002 : Copenhagen (DK)).
19. Member, Steering Committee, **Functional and Objet-Oriented Programming Languages**, Paris, January 1997.
20. Co-organizer, **Construction de l'objectivité : entre intuition et raisonnement**, ENS, Paris, January 1997.
21. Member, Organising Committee, **HCM meeting on Denotational Semantics**, Siena, March 1997.
22. Member, Program Committee, **Logical Foundations of Computer Science** (LFCS97), Yaroslavl, Russia, July 1997.
23. Member, Program Committee, **Category Theory and Computer Science** (**CT&CS 97**), S. Margherita Ligure, September 1997.
24. Co-organizer, **Wittgenstein et les fondements des Mathématiques**, ENS, Paris, April 1998.
25. Member, Program Committee, **13^{th} IEEE conference on Logic in Computer Science**, Indianapolis (In., USA), June 1998.
26. Member, Program Committee, **Computer Science Logic**, Brno, Czech Republic, September 1998.
27. Member, Program Committee, **Journées Francophones des Langages Applicatifs, JFLA'98**, October 1998.
28. Member, Organising Committee, **Workshop on Realizability Semantics**, Trento, Italie, June 1999.
29. Chairman of the Program Committee, **15^{th} IEEE Conference on Logic in Computer Science, LICS'99**, Trento, Italie, July 1999.
30. Member, Program Committee, **Foundations of Software Science and Computation Structures, FOSSACS'00**, Berlin, D., March 2000.
31. Organizer of Program, **New programs and open problems in the foundation of mathematics and of its applications**, Paris, November 13 – 14, 2000.
32. Co-organizer local, **Genesis of perception and the notion of space in machines and humans**, Paris, ENS, October 18 – 19, 2001.
33. Co-organizer local, **Is the dynamics of forms at the core of cognition?**, Paris, 5 - 6 April, 2002.
34. Member, Program Committee, **Forme et objet du logique**, Rome, May 2 – 4, 2002.

35. Member, Program Committee, **Isomorphisms of Types**, International workshop at IRIT, Toulouse (Fr.), November 8 – 9, 2002.

36. Organizer, Colloque: **Geometry, continu et théorie de la connaissance / Workshop on Geometry, continuum and theory of knowledge**, Ecole Normale Supérieure, June 2, 2003.

37. Organizer, Colloque: **Images, reason and reasoning / Images, raison et raisonnement**, Ecole Normale Supérieure, March 15, 2004.

38. Member, Program Committee, Workshop: **Logique et Interaction: vers une Geometry de la Cognition**, Aix-en-Provence , May 9 – 11, 2004.

39. Member, Program Committee, Colloque: **3 corps, classique-quantique et discret-continu mathématiques**, Ecole Normale Supérieure, Paris, September 28 – 29, 2004.

40. Member, Program Committee, Colloque **Qu'est-ce qui est réel?** , Ecole Normale Supérieure, Paris, September 27, 2005.

41. Member, Program Committee, Conference **The impact of categories**, Ecole Normale Supérieure, Paris, October 10–14, 2005.

42. Member, Program Committee, International Workshop on **Invertibility of Lambda-Terms**, Toulouse (France), October 28 – 29, 2005.

43. Co-organizer, **Geometrie et complexité : la logique et ses images**, Ecole Normale Supérieure, Paris, Réunion annuelle de groupe : "Logique et Intéraction: vers une Geométrie de la Cognition", November 18 – 19, 2005.

44. Organizer, Conference **Continuous Dynamics and Computability**, Ecole Normale Supérieure, Paris, May 3, 2006.

45. Member, Program Committee, Ecole **Constructivisme and énaction. Un nouveau paradigme pour les sciences cognitives**, Ile de Oléron, May 29 – June 3, 2006.

46. Member, Program Committee, Conference **Computability in Europe, CiE, 2006: New Computational Paradigms**, Swansea, GB, June 30 - July 5, 2006.

47. Co-organizer, Colloque **Ouvrir la logique au monde**, Ecole Normale Supérieure, Paris, September 29, 2006.

48. Co-organizer, **Giornate di studio, Continuo e discreto: dall'esper-ienza percettiva alle costruzioni di razionalita**, Villa Feltrinelli, Gargnano (It.), October 5 – 7, 2006.

49. Co-organizer, Deuxième rencontre annuelle "More Geometrico":
"**Changement d'échelle - changement de niveau**", Paris, May 2 – 4, 2007.

50. Member, Program Committee, 4th annual Conference on **Theory and Applications of Models of Computation (TAMC07)**, Shanghai, China, May 22-25, 2007.

51. Member, Program Committee, Conference **Computability in Europe, CiE, 2007: Computation and Logic in the Real World**, Siena, Italy, June 18-23, 2007.

52. Member, Program Committee, 5th annual Conference on **Theory and Applications of Models of Computation (TAMC08)**, Shanghai, China, April, 2008.

53. Member, Program Committee, Workshop, **Logic, Language, Information and Computation**, Edinburgh, June 1 – 4, 2008.

54. Member, Program Committee, Giornate di studio, **Le dinamiche del vivente**, Villa Feltrinelli, Gargano (It.), September 28 – 30, 2008.

55. Member, Program Committee, Colloque **Négation, Dualité, Polarité** du Groupe LIGC, Carry le Rouet (Marseille), October 16 – 19, 2008.

56. Workshop : **The physical singularity of life phenomena. Extending concepts and techniques from Physics to Life Science**, Ens, Paris, April 10, 2009.

57. 6th annual Conference on **Theory and Applications of Models of Computation (TAMC09)**, Changsha, China, May 26 – 30, 2009.

58. Colloque **Quelque part : entre biologie et philosophie**, Ens, Paris, June 12 – 13, 2009.

59. Workshop : **Games, Dialogue and Interaction**, University Paris VII, Paris, September 28-29, 2009.

60. Conference: **Computability in Europe, CiE, 2010:**
Programs, Proofs, Processes, Ponta Delgada (Acores), Portugal, June 2010.

61. Worshop, **Logic, Language, Information and Computation**, Brasilia (Br), July 6 – 9, 2010.

62. Colloque, **Les fondements à l'ère post-fondationnelle**, Groupe LIGC, Paris, November 18 – 19, 2010.

63. Workshop, **Physics and Computation**, Turku, Finland, June 6 – 10, 2011.

64. Conference, **Engineering of Complex Computer Systems**, Las Vegas, USA, April 27 – 29, 2011.

65. Workshop, **The present phase of development of the concept of probability and randomness**, based on a special issue of MSCS, ENS, Paris, October 28, 2011.

66. Journée sur la **La biologie de synthèse**, CREA, Paris, April 12, 2012.

67. 9th annual Conference on **Theory and Applications of Models of Computation (TAMC12), part of the Turing Year in China**, Beijing, China, May 16 – 21, 2012.

68. Conference on **Model based reasoning in science and technology: Theoretical and Cognitive issue**, Sestri Levante, Italy, June 21 – 23, 2012.

69. International Workshop on **Statistical Physics and Mathematics for Complex Systems** (SPMCS2012), Kazan University (Kazan, Russia) August 25 – 30, 2012.

70. International Conference on **COMPUTATION TOOLS 2013** - Valencia, Spain, May 27 – June 1, 2013.

71. International Conference on **Science and Information**, London, October 2013.

72. International Conference on **History And Philosophy of Computing** (HAPOC 2013), Paris, at Ecole Normale Supérieure., October 28 – 31, 2013.

73. co-organizer, **Pascal Conference: Biology and organisms: revisiting the systemic approach**, Paris, May 5 – 6, 2015.

74. International Conference on **Model-Based Reasoning**, Sestri Levante, June 25-27, 2015.

75. Colloque **Lois des dieux, des hommes et de la nature**, Institut Etudes Avancées de Nantes, October 15 – 16, 2015.

76. Colloque **Mathematical models and previsions, use and abuse in natural and human sciences**, Institut Etudes Avancées de Nantes, February 15-16, 2017.

77. Colloque **Puissance, mécanicisme et limites du numérique : ontologie, mathématiques, éthique**, Collège de Philosophie et Centre Cavaillès, Ens, 29 mars, 2021.

1 Scientific Activity

The first part of my research activities has focused on the study of the syntactic and semantic properties of "basic" functional programming languages (Combinational Logic, Lambda Calculus and their extensions). However, I have always integrated these studies into a broader perspective on the relationships between various mathematical theories which are at the core of such languages serving as logical and computer science tools. It is in this view that I have devoted myself to works spanning from Axiomatic Recursion Theories (for example, papers such as [Longo, 1976], [Ferrari and Longo, 1978]), to Recursion in Higher Types ([Longo, 1979], [Barendregt and Longo, 1982], [Longo and Moggi, 1984a]), and to Category Theory ([Asperti and Longo, 1991], [Longo and Moggi, 1990], [Asperti and Longo, 1987], [Longo and Moggi, 1984b]). Outside of this framework, there are also papers such as [Longo and Venturini-Zilli, 1974] and [Longo, 1972], in which we assess various measures of computational complexity, as well as [Berestovoy and Longo, 1981], which provides a semantic demonstration of the Paris-Harrington Independence Theorem for Arithmetics (a subject which I explored at Berkeley, in 1980, before my research experience at M.I.T., in 1981, steered me back towards the Theory of Programming Languages).

In short, in my papers, I tried to explain how the fallouts of the aforementioned mathematical theories, with respect to Computer Science, come in great part from the relationships between these various disciplines, in particular through the study of the mathematical semantics of programming languages. The purpose of this is to contribute to the construction of a rigorous mathematical framework for the theory of programming. These researches gave rise, on the one hand, to results which relate syntax to semantics (see [Hindley and Longo, 1980] and [Barendregt and Longo, 1980] on the general notion of model and of full abstractness) and, on the other hand, to a deepening of the structural properties of the models (e.g. [Longo, 1983a] and [Giannini and Longo, 1984]). They have also allowed to establish new links with a very rich and important field of Logic which is that of Recursion in Higher Types, in particular, thanks to papers such as [Barendregt and Longo, 1982] and [Giannini and Longo, 1984].

The [Longo and Moggi, 1984a] and [Longo and Martini, 1986] papers are the most representative of the latter topic. They are based on notions presented in [Longo, 1982b] and give an original characterization of calculability in higher types, which enabled to relate Scott domains to computability in the higher types of Kleene and Kreisel. This work was enhanced by a very stimulating exchange with Georg Kreisel, during a visit at ETH in Zuerich, in 1982, followed by a correspondence lasting two years (four letters by Kreisel may be found here: https://www.di.ens.fr/users/longo/files/FourLettersKreisel.pdf). The mathematical methods thus

studied (Recursion in Higher Types, Semantics of Typefree Lambda Calculus) provided the technical tools for the following works (as well as for those by my students) concerning the categorical structures for the semantics of very current constructions in the Theory of Functional Languages:

- Typing and Type checking (see [Longo and Martini, 1986] and [Coppo et al., 1984], which demonstrate, among other things, the completeness of certain typing systems).
- Polymorphism (see [Asperti and Longo, 1991], [Bruce and Longo, 1990], [Longo and Moggi, 1991], [Cardelli and Longo, 1991], [Amadio et al., 1986], [Amadio and Longo, 1987]).

The importance of polymorphism in programming comes from its ability to capture a part of the notion of "modularity" in programming (see the Edinburgh ML language or the systems applications F by J.Y. Girard). In the study of polymorphism, the power of the logical methods such as those mentioned above becomes essential. My work in this field has established new links between notions which are very often used in Computer Science (types as parameters, records, inheritance, etc.) and the mathematical structures which come from Generalized Recursion, Demonstration Theory and Category Theory.

Papers such as [Longo and Moggi, 1990], [Asperti and Longo, 1987] and [Longo and Moggi, 1984b], to name but a few, use the traditional tools of Category Theory, as well as new concepts (spaces of partial morphisms, complete objects) for the semantic analysis of the "functional completeness" of typefree languages and of divergence. Following these researches, I felt the need to contribute to a systemization of certain aspects of Category Theory which I found interesting in terms of computer science applications. This systematization is what drives the book [Asperti and Longo, 1991], published by M.I.T. Press, which serves as both an introduction to categories for computer scientists and as a tool for researchers interested in advanced fields dealing with the interaction between categories and Programming Theory. The book presents, for example:

- The notion of Cartesian Closure in the framework of Denotational Semantics
- Monoidal Categories and their relationships with Linear Logic
- Internal Categories as tools for the Semantics of Polymorphism (and of second order λ-calculus).

As regards applications, we should mention that these studies have had some influence, not only in terms of semantic investigation but also in the design of prototypical programming languages. The Quest language, for example, implemented at Digital (Dec-src, Palo Alto), is based on a very rich field of types and on a very strong use of polymorphism, formalized by higher order systems enriched with a notion of sub-type (essentially, the notion of inheritance in object-oriented languages). The extension of the language's type kernel, with records and sub-types, was inspired by the semantics of polymorphism and by inheritance in terms of "internal categories" in a constructive categorical framework (described in [Cardelli and Longo, 1991], written while visiting the Digital Research Center in Palo Alto). The influence of the year I spent teaching and conducting research at the University of Carnegie Mellon in addition to my work as a Consultant for Digital at Palo Alto, in 1987 and 1988, have had a great impact on my subsequent work in the functional analysis of object-oriented languages.

Returning to work as a Consultant for Digital in Paris (Dec-prl), from 1991 to 1993, gave me the opportunity to better appreciate the practical significance of an aspect of polymorphism which has not benefited from sufficient theoretical attention: "ad hoc" polymorphism. On the one hand, the study of this problem lead me to demonstrate the characteristics of "parametricity" of

second order systems, widely used in programming ([Longo et al., 1993], [Longo, 1995a]) and, on the other hand, I developed with former and current students an extension of classical functional systems which enriches such systems with uniform and mathematically coherent forms of ad hoc polymorphism ([Castagna et al., 1995], [Castagna et al., 1993]). In the first case, the Genericity Theorem ([Longo et al., 1993]) is considered to be an important result with respect to the Theory of Proof of λ-calculus. In the second case ([Castagna et al., 1993]), we proposed an original solution to the relationships between Functional Programming and "Object-Oriented Programming", thanks to the functional treatment of notions such as the "passing of messages" and "overloading".

The study of the links between parametricity, subtyping and inheritance is at the basis of the collaboration with S. Soloviev and K. Milsted (Digital Research, Paris, and, later on, CNET, France Télécom), which continued until 1999. Within this framework, we proposed a simple computation of "perfectly expressive" sequences of points, that is, sequences which are complete with respect to the properties of subtypes in functional languages (see the preliminary version [Longo et al., 1995]). Recent developments of these systems are found in [Longo et al., 2000] and [Chen and Longo, 1999].

An original analysis of the "invariance levels" of proofs is proposed with the notion of Prototype Proofs, in Type Theory. It is a question of understanding what is the "skeleton" of a proof or that which makes it invariant with respect to the genericity of its arguments/variables (see [Fruchart and Longo, 1999] and [Longo, 2000a]). This tool for the analysis of proof as a term or as a program (prototype) is applied to the study of certain ("concrete") incompleteness theorems in [Longo, 2011b]. The first version of this paper, written in 2000, all the while remaining within the framework of Logic (Type Theory and Proof Theory) and of its applications, opens up new avenues which will be at the core of the thematic change which will follow. It has been reprinted (and revised) upon invitation.

Thematic Change: From "Geometry and Cognition" to the "Complexity and Morphological Information" Team, CIM

From 1993 to 1999, I coordinated the interdisciplinary meetings of the Cogniscience Group at ENS, created upon the initiative of J.-P. Nadal (Physics), D. Lestel (Psychology) and myself (see above the interdepartmental "Center for the Study of Complex Systems and Cognition", CenECC, which has picked up the group's work, since 2000).

The group's activities, as well as invitations to Philosophy of Mathematics or to Cognitive Science Conferences and seminars (see for example [Longo, 2001e], [Longo, 1999f], [Longo, 1997d], [Longo, 1999e]), reflect the engagement in reflections of an interdisciplinary nature; although this was done at first on a part-time basis, this work became increasingly important. It was about elaborating a "foundation of mathematical knowledge", relating cognitive phenomena to the foundations of mathematics. One of the motivations of this new direction (which is not the first "thematic change" to occur during my career as a researcher) is the "crisis" undergone today by the relationships between Mathematical Logic and Computer Science: Computer Science, born during the 30s and 40s out of the formal (sequential!) computability systems (Herbrand, Gödel, Church, Kleene, Turing ...), today introduces problems mainly relative to space and time. Distributed, concurrent and asynchronous systems must first be analyzed in "spatio-temporal" terms. The investigation of our phenomenal relationship to space and to time is part, in my opinion, of a discussion concerning these very principles which enabled the birth of our logical and computational systems that were then expanded thanks to new principles. My engagement in this direction was first epistemological (and mathematical), as part of the analysis of correlations between the foundations of mathematics and (spatial) cognition.

The first papers regarding these matters constitute a reflection on mathematical continuity

and infinity and their logical and computational formalizations [Longo, 1999b], [Longo, 1999d], as well as on the role of action and of movement in the constitution of the geometric intelligibility of sensible space, [Longo, 1997a]. It continued by further insights into the role of order and symmetries in the cognitive foundations of Mathematics, [Longo and Viarouge, 2010], and on the relation of the invention of the perspective in painting vs. the foundation of geometry and of the concept of infinity in Mathematics, [Longo, 2011c].

From cognition, a dialog with biologists soon became part of this project (see the presentations at the Collège de France and at the Vatican, in 1998, as well as [Longo, 1997c], [Longo, 1997b], [Longo, 2001c], [Longo, 2001b]), but also with physicists. Indeed, two working groups, one in the field of the Epistemology of Mathematics and of Physics, the other in the field of Geometry and Cognition, have constituted an important component of my scientific activity: the results produced by the first group have appeared in a volume (see [Longo, 2002c]), and the other served as a starting point for a research project, "Geometry and Cognition"
(see `http://www.di.ens.fr/users/longo/geocogni.html`). This project under my responsibility was funded at the level of our request by MENRST (there was also the organization of eleven seminars on these topics, between 1994 and 2003, and of joint seminars with colleagues in the fields of Biology, Physics and Philosophy). The volumes edited as part of this project ([Aceto et al., 2003], [**?**], [Longo et al., 2005]), and the thesis by A. Viarouge, co-directed by S. Dehaene (Collège de France), defended in October 2008, contains the most important results among our work on these topics.

In short, we believe, on the one hand, that the geometric intelligibility of space poses a fundamental problem which is independent from (adds itself to) those addressed by Logic, and, on the other hand, that any "informational content" also depends on the geometric structure which encodes the information as well as on its context (measurement, scale). One of the objectives of the "Geometry and Cognition" working group consisted, in particular, in a preliminary analytical work regarding the functional structure of the primary visual cortex and of its geometry, as the locus of the elaboration of information (under the direction of J. Petitot, Director of CREA, and B. Teissier, CNRS-Maths, Paris VII). Some of the most interesting advances in understanding perception concern the way in which the processing of a signal can produce morphological structuring, that is, an organization into forms (these topics are part of the objectives of the "Neurogeometry" project, directed by B. Teissier, and funded by ACINIM '04, 2004 – 2007).

In general, we can note that, traditionally, the theory of computability and of information are based on the analysis of sequences of 0s and 1s. From Turing to Shannon, information has been encoded in binary sequences and their transformations constitute the material support and the mathematical structure at the center of these two theories which have changed our world (and I have devoted a great deal of work to the first of them). A critique on the use of these notions in Biology may be found in [Longo and Tendero, 2007].

Now, the processing of information in biological entities can follow other schemas, which also include "changes in form". From proteins to neural networks, it increasingly seems evident that modifications in form (in the three-dimensional folding of amino acids or in network structures) form an integral part of the process, that some continue to consider an "elaboration of information". Our new viewpoint corresponds to an approach which integrates the mathematical organization of space with causality in Physics and in Natural Science (see [Bailly and Longo, 2004c] and [Longo, 2008], [Bailly and Longo, 2008a]). All the while developing this framework, the thesis of Boris Saulnier (Computer Science), under my direction and an important culmination of the CIM team's work (in conjunction with the thesis of M. Mossio, Cognition, see below), provides a synthesis and an original framework for a "morphological" analysis of information by its various entropic correlates and their scale invariants, in Physics and in Biology.

On the basis of the remarkable work which has already been done in the analysis of two traditional aspects of computation (digital), but by taking new paths, if possible, we are thus

developing a mathematical theory of "complexity and of information in geometric structures" or, in the case of life phenomena, in the geometry of levels of organization (see [Bailly and Longo, 2004a]). The general quality of the approach should enable to grasp other aspects of this problem, beyond the two examples we mentioned, which may very well refer to both the physics of dynamical systems as well as to the analysis of intracellular communication. The essential incompleteness of the purely formal approaches in Mathematics, their correlations with the incertitude of physical measurements (see [Bailly and Longo, 2004b]), as well as the "impossible geometry" of certain computational modelizations (see [Longo, 2008], [Longo, 2003a]) motivate our approach. These reflections, of the "exploratory-interdisciplinary" type, enabled to launch the activities of the new team at LIENS called "Complexity and Morphological Information" (CIM, October 2002).

As part of the funding received but regarding one of the themes which were the original motivation for this long term project (Geometrization in Computability and Programming), a special issue of the MSCS journal published by Cambridge University Press, which I directed, was published in 2000: "Geometry and Concurrency", vol. 10, n. 4. Advances regarding the foundational aspects of the project are presented in [Longo, 2001d]; other papers, by numerous authors, can be found in the three volumes / special issues edited from 2003 to 2005 (see the collective publications [Aceto et al., 2003], [Longo and Scott, 2003], [**?**], [Longo et al., 2005]); the papers in this latter volume summarize, from various standpoints, the work initiated with "Geometry and Cognition" and carried on by the new CIM team.

A Few of the Research Areas of the New "Complexity and Morphological Information" Team (CIM, October 2002)

To present a synthetic framework, we can place a physico-mathematical notion at the center of the team's activity, that of *critical transition*, a particular form of physical singularity. This notion is elaborated throughout various projects and correlates the work undertaken regarding the computational structure of certain physical dynamics with the analysis we develop concerning life phenomena, seen as "extended critical transition".

The project "Physical singularities and effective computability"

Singularities and critical transitions play a key role in modern physics. By a project, supported by the french ANR, a collaboration with a mathematician from the University of Pisa, S. Galatolo, a physicist of CNRS, A. Lesnes, and two PhD theses have been made possible (M. Hoyrup and C. Rojas, whose theses have been defended in 2008). Beyond some stability theorems in numerical analysis, we investigated the effectiveness of renormalization methods, compared various forms of randomness (Birkhoff vs Martin-Loef), in physics and in Algorithmic Information Theory; we analyzed divergence and undecidability. Besides the work in the two theses (in Mathematics and Informatics), some results are in [Hoyrup et al., 2008], [Bailly and Longo, 2007]. A more recent survey may be found in [Longo, 2010a].

2 Towards Biology: the physical singularity of the living state of matter

In our perspective, the methods of physics should be directly borrowed in biology, in particular as for the key role they had in constructing new "objectivities", such as new pertinent observables (consider thermodynamics, with its P, V, T as observables and the trajectories in their phase space or quantum physics, whose objects are co-constituted in the experience, thus as a result of a theoretical construction). In no way, by the concepts we hint to, we intend to define or characterize

life. We just try to focus on some phenomenalities which seem particularly preeminent and try to treat them in a possibly conceptually robust fashion, with some mathematics when this may help. The three points below briefly outline the work developed over several articles, to which we refer when appropriate.

2.1 Extended Criticality

The biological interest of physical theories of criticality is due first to the fact that, in physics, *critical phase transitions* are processes of change of state where, by the sudden change (a singularity w. r. to a control parameter), the global structure is involved in the behavior of its elements: the local situation depends upon (is correlated to) the global situation. Mathematically, this may be expressed by the fact that the correlation length formally tends towards infinity (the case with second order transitions, such as para-/ferromagnetic transition); physically, this means that the determination is global and not local. In other words, a critical transition is related to a change of phase and to the appearing of critical behaviors of some magnitudes of the system's states — magnetization, density, for example — or of some of its particular characteristics — such as correlation length. It is likely to appear at equilibrium (null fluxes) or far from equilibrium (non-null fluxes). In the first case, the physico-mathematical aspects are rather well-understood (renormalization as for the mathematics, see [Longo and Montévil, 2012a], thermodynamics for the bridge between microscopic and macroscopic description), while, in the second case, we are far from having theories as satisfactory.

Some specific cases, without particular emphasis on the far from equilibrium situation, have been extensively developed and publicized by Bak, Kauffman and others (see [Bailly and Longo, 2008c]). The sand hips, whose criticality reduces to the angle of formation of avalanches in all scales, percolation or even the formation of a snowflake are interesting physical examples. The perspective assumed is, in part, complementary to Prigogine's: it is not fluctuations within a weakly ordered situation that matter in the formation of coherence structures, but the "order that stems from chaos". Yet, in both cases potential correlations are suddenly made possible by a change in one or more control parameters for a specific (point-wise) value of this parameter. For example, the forces attracting water molecules towards each other, as ice, are potentially there: the passage below a precise temperature, as decreasing Brownian motion, at a certain value of pressure and humidity, allows these forces to apply and, thus, the formation of a snow flakes, typically.

The critical transitions must be also understood as sudden symmetry changes (symmetry breaking and formation of new symmetries), and a transition between two different macroscopic physical objects (two different states), with a conservation of the symmetries of the components. The specific, local and global symmetry breaking give the variety of organized forms and their regularities (the new symmetries) as these transitions are (very) sensitive to fluctuations in the vicinity of criticality. In physics, the point-wise nature of the "critical value" of the control parameter is an essential mathematical issue, as for the treatment by the relevant mathematics of "renormalization" in theories of criticality, see [Longo and Montévil, 2012a].

Along the lines of the physical approaches to criticality, but within the frame of far from equilibrium thermodynamics, we consider living systems as "coherent structures" in a continual (extended) critical transition. The permanent state of transition is maintained, at each level of organization, by the integration/regulation activities of the organism.

In short, in recent work [Bailly and Longo, 2008c], [Longo and Montévil, 2012a] and [Bailly and Longo, 2011], we propose to analyze the organization of living matter as "extended critical transitions". These transitions are extended in spacetime and with respect to all pertinent control parameters (pressure, temperature, etc.), their unity being ensured through global causal relations between levels of organization (integration/regulation). More precisely, our main physical paradigm is provided by the analysis of critical phase transitions, as this

peculiar form of critical state presents two particularly interesting aspects for biological situation: the formation of extended correlation lengths and coherence structures, as mentioned above, by the divergence of some observables with respect to the control parameter(s) and the change of symmetry associated to potentially swift organizational changes. However, the "coherent critical structures" which are the main focus of our work cannot be reduced to existing physical approaches, since phase transitions, in physics, are treated as "singular events", corresponding to a specific well-defined value of the control parameter, just one (critical!) point as we said. Whereas our claim is that in the case of living systems, these coherent critical transitions are "extended" and maintained in such a way that they persist in the many dimensional space of analysis. A living object is not only a dynamics or a process, in the various possible senses analyzed by physical theories, but it is permanent *critical transition*: it is always on the border of a change, of symmetries changes in particular, as analyzed in [Longo and Montévil, 2012a]. One then has an extended, permanently reconstructed and transforming *global* organization in an interaction with *local* structures, as the global/local interplay is proper to critical transitions (by singularities). Some radical consequences of our approach are derived in [Longo et al., 2012b]. The a priori unpredictability of the pertinent phase space (of phenotypes) radically changes the theoretical framework needed for biology: the very space of possibilities undergoes an unpredictable (random) evolution, in contrast to the ordinary approaches to physical (both quantum and classical) indetermination or randomness.
So far, our analysis, in the papers quoted above, has been only in part mathematical and largely conceptual, since, by the loss of the mathematics of renormalization, there seem to be little known Mathematical Physics that applies to this physically singular, far from equilibrium situation. The second major conceptual and technical difficulty is also clearly the instability of the symmetries involved. The question is then how to objectivize them, since, in contradiction with the physical situations they do not seem to be theoretically determined to be in a specific, pre-given set, [Longo et al., 2012b].

2.2 Anti-entropy

In [Bailly and Longo, 2009] our systemic perspective for biological complexity in both phylogenesis and ontogenesis is developed by an analysis of organization in terms of "anti-entropy", a notion we defined and which conceptually differs from the common use of "negative entropy". Note that both the formation and maintenance of organization (a permanent reconstruction of the coherent structure) go in the opposite direction of entropy increase. This is also Schrödinger's concern in the second part of his 1944 book, where he considers the possible decrease of entropy by the construction of "order from order", that he informally calls negative entropy. In our approach, anti-entropy is mathematically presented as a new observable, not just entropy with a negative sign (negative entropy, as more rigorously presented in Shannon and in Brillouin). Typically, when added, equal entropy and negative entropy give 0: in our approach, entropy and anti-entropy are found simultaneously only in the non-void (extended) interval of criticality, proper to the living state of matter. A purely conceptual analogy may be done with anti-matter in Quantum Physics: this is a new observable, relative to new particles, whose properties (charge, energy) have opposite sign. Along our wild analogy, matter and anti-matter never give 0, but a new energy state (double energy production as gamma rays).
To this purpose, we introduced two principles ("existence and maintenance of anti-entropy"), in addition to the thermodynamic ones, which are (mathematically) compatible with traditional principles but which have no meaning with regard to inert matter. A traditional balance equation for the metabolism is then been extended to the new notion as specified by these principles. This equation is inspired by Gibbs analysis of free energy, which is hinted as a possible tool for the analysis of biological organization in Schrödinger's classic "What is Life?". We examined far from

equilibrium systems and we focused in particular on the production of global entropy associated to the irreversible character of the processes. In [Bailly and Longo, 2009], a close analysis of anti-entropy has been performed from the perspective of a diffusion equation of biomass over phenotypic complexity along evolution. That is, we could reconstruct, on the grounds of general principles, Gould's complexity curve of biomass over complexity in evolution (see his "Full House", 1989 book). Moreover, a quantitative evaluation of phenotypic complexity in embryogenesis is proposed, in relation to some empirical data (Caenorhabditis elegans). Once more, Quantum Mechanics indirectly inspired our mathematical approach: we borrowed Schrödinger's operatorial approach in his famous equation but in a classical framework. Classically, that equation may be understood as a diffusion equation (as a matter of fact, we used real coefficients instead of complex ones, thus outside of the mathematical framework of quantum theories): we used to analyze the growth of phenotypic complexity along species evolution, [Bailly and Longo, 2009], [Longo and Montévil, 2012b].

2.3 Biological time

The usual physical (linear) representation of time is insufficient, in our view, for the understanding of some phenomena of life. An extended form of present seems more adequate for the understanding of memory, since this is an essential component of learning, for the purposes of future action (based on "protention", as pre-conscious expectation). In particular, while memory, as retention, is treated in some physical theories (relaxation phenomena), protention seems outside the scope of Physics. We then suggested some simple functional representation of biological rentention and protention [Longo and Montévil, 2011].
Similarly, the role of biological rhythms does not seem to have any counterpart in mathematical formalizations of physical clocks, which are based on frequencies along the usual (possibly thermodynamical) time. By this, in [Bailly et al., 2011a] a two-dimensional manifold as a "mathematical frame" for accommodating autonomous biological rhythms is presented: the second dimension is "compactified", that is, it is a circular fiber orthogonal to the oriented representation of physical time. The addition of a new (compactified) dimension for biological time is justified by the peculiar dimensional status of *internal* biological rhythms. Life is temporally scanned by both external (physical) rhythms (cicardian, typically), which are frequencies, and internal ones (metablism, respiration, cardiac rhythms). These are pure numbers, not frequencies: they become frequencies and produce the time of life span, when used as coefficient in scaling laws.
The two new aspects of biological time allowed us to introduce the abstract notion of "biological inertia", as a component of the conceptual time analysis of extended criticality.
Another aspect of biological time, introduced in [Longo and Montévil, 2012a], is the time constituted by the cascade of symmetry changes which takes place in extended critical transitions. In other terms, this time is defined by the ubiquitous organizational transformations occurring in biological matter. This time corresponds therefore to the *historicity* of biological objects and to the process of biological individuation (both ontogenetic and phylogenetic). Thus, on top of the physical irreversibility of thermodynamical time, of course proper also to biological phenomena, one has to consider another form of irreversible time (another observable in the same dimension of time, like the dimension of energy has more than one observable in physics, potential, kinetic ...). This form of time better corresponds to our view of the increasing complexity in phylo (and onto-)genesis.

3 From 2002 to 2012: Conclusion and Opening

Broadly speaking, except for the consideration in terms of extended criticality and symmetry changes, the laws which we propose while addressing the peculiar observables and quantities,

specific to life phenomena, constitute a simple *extension* of existing physical laws: they preserve the same formal mathematical structure and, if we set the value of the considered observables or parameters to 0 (protention, second temporal dimension, value of anti-entropy), they return the theories of inert. Our theoretical propositions are thus compatible, although irreducible, to "existing physical theories". That is, they are reducible to these laws *only* if, but *as soon as* we are outside of the extended critical zone having its own temporality and its own anti-entropy, or as soon as these specific quantities go to 0.
In our perspective, closely developed in the book [Longo and Montévil, 2014a], the phenomenality of life deserves some new observables (extended critical transition, biological organization, proper time, in our attempts). The point we treated is the pertinence of these treatments, "*per se*". Those who claim that all these concepts should be reduced to physical (existing?) theories are welcome to try. But they should first look at the history of Physics itself, where novel theoretical frames are marked by the invention of new concepts and new perspectives. Their pertinence had to be judged "as such", not on the grounds of their reducibility to existing, thus "safe", explanatory grounds: the unity in Physics and, a fortiori, in natural sciences is a difficult conquest, not a metaphysical a priori. The point of view of extended critical transitions, in association with ubiquitous symmetry changes, may, however, lead to more radical methodological changes, as associated to the specificity of objects and genericity of trajectories. This epistemological critique and positive proposal is in [Longo and Montévil, 2014a].

3.1 Remarks Concerning the Method: From Information to Organization

The ambition of this part of our work is not only to reconstruct the physico-mathematical complexity of certain aspects of Biology, but to first and foremost propose a change of perspective. We believe that the theoretical differentiation between the theory of inertia and those of the *living state of matter* requires, among other things, a change in the relevant parameters and observables. Now, the mathematization of physics has been centered around invariants, among which the great constants (g, c, h), but also those of the "objective determinations" which we address in length in the book [Bailly and Longo, 2011][1]. In our view, we must base ourselves on the rare invariants, including constants and rhythms, for example, which we find in time in Biology, because beyond the physico-chemical, the structural stability of life phenomena is not so invariant, physically speaking: it is deeply riddled with variability. In order to grasp this state, extended criticality, which is difficult to mathematize, we started with these invariants, these rhythmic constants, and we constructed the outline of a non-trivial geometry of biological time, even if it does not make physical sense.
To this was added a quantitative analysis of the structural invariant which is organization, quantified as anti-entropy, with its own balance equations, a very recent approach, albeit a preliminary one, which we believe to be novel (also see [Bailly and Longo, 2009], [Longo and Montévil, 2012c] for references and comparisons).
To conclude, over the last years, we have compared dynamic randomness with algorithmic randomness (which is at the center of algorithmic theories of information); we have modified criticality (which becomes extended, for Biology); we have added anti-entropy to fundamental (in)equalities and thermodynamic balance equations; we have started to produce models of biological rhythms and time in two-dimensional manifolds. The basic idea was that the notion of information, in Biology, must be enriched by that of organization, as a proper biological observable. This new observable, which we grasp in particular with the "intertwining and coupling of levels of organiza-

[1] This book was first published in French by Hermann, in 2006; incidentally, when this book was sent to the publisher for its possible publication, I was invited to co-direct a new collection, "Visions des Sciences", of which this book was the first.

tion", is at the center of our formal analyses.
We therefore aimed to enrich the widespread notions of "information", "complexity", etc., so as to more closely account for the phenomenology of the living state of matter. The risk taken by the establishment of the CIM team consisted in the title itself, of which the challenge was to propose scientific ideas which were different from Shannon's as well as from Kolmogorof's computational complexity and information. These are highly important notions, but, in our opinion, they are insufficient for the study of biological phenomena, just to mention their abuse in Molecular Biology (about what "information" are we talking about? They differ or are in contraposition as regards "complexity", see ongoing work with two biologists, A. Soto, C. Sonnenshein, Tufts U., Boston). The notion of anti-entropy formalizes phenotypic complexity (morphology) in phylogenesis and in ontogenesis and constitutes a strong point of our work (and a firm one, we think).
From the methodological standpoint, our undertaking in Biology consists in developing elements for a theory which is specific to life phenomena, even if it does not find any correspondence or make sense in current physical theories. The proposed reversal which makes an operator of time and a parameter of energy, for example (the dual of that which is done in Physics, in Quantum Physics in particular), is one of the propelling elements of this change of observables and of parameters we are pursuing. In a very general way, the laws we use when addressing these particular quantities and which were introduced specifically for purposes of analyzing life phenomena constitute extensions of usual physical theories (thermodynamic theory, in particular): they preserve the same formal mathematical structure and, if we set the value of the considered observables or parameters to 0 (extension of the critical interval, second temporal dimension, value of anti-entropy), they return the theories of inertia. As a true extension, our theoretical propositions are therefore compatible with, albeit irreducible to, "existing physical theories".

4 Introduction to the work 2012 – 2015: Epistemology of new scientific interfaces

The epistemological commitment of our scientific work is very strong and has been made explicit in several papers. It is at the root of several invitations to co-edit epistemology journals and collections as well as to speak in Philosophy of Science Conferences and seminars (see below). It motivated the co-direction of two PhD Thesis in Philosophy (Frezza and Perret), the invitation as referee and/or jury member of several Thesis and Habilitations in Philosophy.
In a sense, all papers, including those published in scientific journals are "conceptual" analyses, that focus on the epistemological frame as a "conditions of possiblity" also as for the technical developments. This frame mostly focuses on the interfaces of Computing, Physics and Biology, always in collaboration with colleagues from these disciplines. Yet, in view of the collaboration with biologists and philosophers of biology, a relevant component of the work is within biology and of a theoretical nature.

4.1 Theoretical Biology

The evolutionary history of life produces occasionally "simple" structures through complex paths, the "simplexity" analysed in [Longo et al., 2013a]. Yet, it also produces increasing organismal complexity as the result of an asymmetric random diffusion from a "wall" of minimal complexity (conventionally considered to be bacteria), as discussed in [Longo and Montévil, 2012b]. The stress on the role of randomness in biology is first made in [Buiatti and Longo, 2013], a collaboration with a genetician which surveys and frames the abbundant evidence of the various sorts of physical randomness in cellular activities (classical and quantum) and insist on the functional role of it. Randomness is not "noise" in biology, but a fundamental component of variability, thus of diversity,

which contributes to the "stability" of populations and species, as well as of organisms (see below). This is one of the motivations for the critique of the use of the notion of information in biology, addressed in [Longo et al., 2012a]. In [Longo and Montévil, 2013a], we argue that one major aspect of biological evolution is the continual change of the pertinent phase space (the space of the observables and parameters) and the unpredictability of these changes. This analysis is based on the theoretical symmetries in biology and on their critical instability along evolution. We discuss two notions to the purposes of this analysis: differential causality and *enablement* (see below). A turning point of our many years investigation, is the synthesis of two converging life research histories presented in [Longo et al., 2015a]. As a matter of fact, the approach to cancer by Sonneschein and Soto, has found in our collaboration a way to be correlated to a view of the organism that gives to their approach a novel sense. These biologists of cancer since long understand this disease as an organismal problem in the organism's relation to the ecosystem. By our joint work, we could propose some new strong principles that allow to see development as part of phylogenesis ("descent with modification", a Darwinian principle that we apply also to ontogenesis), under the idea that there is "never identical iteration of a morphogenetic process", both at the level of organs and of organisms (which include cells in multicellular organisms). In our paper, we extensively motivate our approach by empirical evidence. The role of history in the formation of present biological structures and the intrinsic unpredictability of future is stressed in [Longo, 2017]. In particular, to the properties of synchronic measurement in physics, the relevance of diachronic measurement in biology is evidentiated, as well as the way this contributes to the very formation of the biological phase space.

4.2 Interfaces of Physics, Biology and Computing

From an epistemological point of view, the focus of my work (mostly in collaboration with biologists and physicists, but also with a mathematician of Computing, C. Calude) on the historicity of the biological object (the organism) as well as on indeterminacy, in the timing of evolution, of its phase space (the pertinent observables and parameters – the phenotypes and the ecosystem), poses a challenge to the "a priori" spaces that has been at the heart of the very fruitful interaction between physics and mathematics. Note first that both the mathematical and the physical object are generic (they are invariant w.r. to the theory and experiments), and that the physical trajectories are specific, that is they are geodetics in suitable and pre-given phase spaces. Dually, in biology, on the one hand, the objects are specific, inasmuch as they are historical, in that (for us) their theoretical symmetries (the analogues of the conservation properties in physics) are constituted over time in the process of individuation (phylogenesis, ontogenesis). On the other hand, their trajectories are generic in the sense that they cannot be deduced mathematically from stable symmetries, since these form a possible and changing space (in fact, the ecosystem), which is a co-constitutive of the dynamic. In this framework, we understand the Darwinian principle of inheritance, "reproduction with modification", as a principle of non-conservation of the phenotype. We may summarize our comparison between what is at the heart of biological theory (of organisms) in relation to what is specific to physics in the following table:
This table is an example of how we have proceeded and will proceed, from a methodological point; this is, by engaging in an intense dialogue between the foundations of both mathematical physics and theoretical biology, where the crosscurrents take place by analogies and passageways, but also by dualities, as in this case.
We have introduced this play of analogies and dualities in many articles, most recently thanks to a critical review of empirical results on symmetries in biology, specifically symmetries of scale (including allometry, the variability of biological rhythms and in the form of certain structures, [Longo and Montévil, 2014a]). We have remarked on their descriptive interest but also on the omnipresent and important gap within the current biological understanding, where for example

PHYSICS	**BIOLOGY**
randomness is **non deterministic** or deterministic non predictability **within a pre-given phase space**	**randomness** is **intrinsic indetermination** given also by changing phase spaces (ontogenesis and phylogenesis)
specific trajectories (geodetics) and **generic objects**	**generic trajectories** (possible/compatible with ecosystem) and **specific objects**
point-wise criticality	**extended criticality**
reversible time (or irreversible for degradation - e. g. thermodynamics)	**double irreversibility of time** (thermodynamics plus phenotypic complexity constitution)

Table 1: A possible theoretical differentiation between inert and living state of matter is described through some conceptual dualities, based on the work in Longo and Montévil (the 2014 book and several papers).

the fractal dimensions involved are not invariant. This hypothesis has major epistemological consequences, since the instability of theoretical symmetries does not permit recourse to the same method of objectification of phenomena as it does in the mathematics of physics. Hence it is a matter of establishing other modes of objectivation by starting with this difficulty, which I have done in the method hinted in the table above, in particular in my book with Montévil, 2014. The philosophical interest of this approach has also been evaluated from an historical perspective in Perret's thesis (see below). One of the consequences of my approach, which maintains that theoretical symmetries of biology are unstable, is that the phase space (or space of description) of an object must change over time. This is our way of apprehending biological (evolutionary) novelty. By contrast, in physics, the phase space is always stable in the sense that it is described by a finite number of theoretical symmetries. This corresponds in terms of mathematical logic with mathematical incompressibility (in the sense of Kolmogorov) of the description of phenotypes in evolution: it is impossible to enumerate them before their occurrence.
This idea of the instability of the phase space was independently proposed by Stuart Kauffman (USA), on different bases, and so we have worked to mutually enrich our approaches in a collaborative article, [Longo and Montévil, 2013a], that was further developed with Montévil ([Longo and Montévil, 2013b]) and taken up in the 2014 book. In a theoretical framework in which symmetries are unstable, a trajectory can no longer be determined as a consequence of a combination of factors that can be formally stated. Thus, it is the causal regime that has changed here by adding the notion of enablement to the field of physical causality. For example, the appearance of swim bladders enables specific bacteria, which colonize it, and the formation of novel interactions between these bacteria and the fish, if not a new microbiome, but it does not cause these interactions in the sense that one cannot deduce their structures before they are established.

Note that a notion of differential causality of a physical type does remain valid, in the sense that the introduction of a difference leads to one or more differences. In relation to the role of phase spaces, in natural sciences, an epistemological and historical reflection on the origin of the infinite mathematical space of modern physics may be found in the article on "perspective in Italian painting" that was inspired by the work of D. Arasse, an historian of Art, [Longo, 2011c].
This work, lying between science and epistemology, also led us to a comparative discussion of the practices of computational simulation and modeling. In particular, we investigate the relation between simulations and mathematized theoretical frameworks by examining several case studies, [Longo and Montévil, 2015]. In fact, it is remarkable that some types of simulation do not correspond to predefined spaces of description (in particular in object-oriented programming - around 1990, I was the co-author, with K. Bruce and L. Cardelli, of its mathematical foundation in Type Theory, still very cited today).
My epistemological claim, technically substanciated in [Longo and Montévil, 2015], is that randomness in physics may be understood theoretically as a change of symmetry, usually in pre-defined spaces (in particular, the breaking of symmetry). In effect the breaking of symmetry presupposes a prior and given equivalence between possibilities that are not present in the final result. In contrast to the various forms of randomness encountered in physics, the originality of biology in our framework is due to the fact that the implied theoretical symmetries themselves have a random component – hence the unpredictable character of the phase space and of the theoretical description, typically, of the ecosystem to come about. The mathematical analysis – conceptual and epistemological – of randomness in both physics and biology lies at the heart of many articles I have written in collaboration with Buiatti, a biologist ([Buiatti and Longo, 2013]), Bravi, a physicist ([Bravi and Longo, 2015]) and Calude, a mathematician ([Calude and Longo, 2015], [Calude and Longo, 2017]), and is also central to Abbott's doctoral thesis (defended in 2015), as well as featured in the volume edited in 2014, [Longo and Mugur-Schachter, 2014]. The second paper with Calude, a critique of the abuses of Big Data, [Calude and Longo, 2017], rivitalized some early work done in Berkeley in 1980, [Berestovoy and Longo, 1981]: Ramsey Theorem provided then a concrete example of incompleteness (at the time analized in model theoretic terms), it now helped us to show the presence of spurious correlations in all sufficiently large data bases.
To our great surprise, our work on the unpredictability of the space of possibilities in the historical sciences, as in evolutionary biology, has interested two economists (T. Felin of Oxford, R. Koppl of Syracuse University), with whom Kauffman and I have collaborated on two articles ([Felin et al., 2014], [Koppl et al., 2014]). Our analysis of evolutionary dynamics as co-constitutive of the space of possibilities indeed appears well adapted to an innovative epistemology of economics. The second of these articles was awarded the prize for best paper appearing in JOIE in the previous calendar year - this prize is entitled to Elinor Ostrom, 2009 Nobel Award winner in Economy in Boston in September 2016.
Almost all the articles of this period are conceptual analyses starting from original scientific propositions, on the basis of which I always try to make explicit an epistemology constructed from direct contact with biological practice (see in particular articles written in collaboration with biologists Buiatti, Sonnenschein, Soto and Villoutreix's dissertation). This followed long years of collaboration, up to 2012, that were first centered on epistemological analyses in physics with physicists Bailly and Paul.

4.3 Team and Main International Activities, 2012 – 2015

Leading a team (CIM, see my web page) has enabled a permanent exchange with three post-docs and three PhD students mentioned below (plus two more current ones), with former doctoral students (Mossio and Montévil) and at least four other older and younger scholars, including V. Thomas-Vaslin (biology of the immune system), A. Soto and C. Sonnenschein (biology of cancer

at Tufts, Boston). At my proposal, A. Soto was appointed to the Blaise Pascal chair at ENS, for twelve months spread between 2014 and 2016. A. Soto is the director of the Boston laboratory at which I have been Adjunct Professor since 2012. Before her regular stays at ENS, I spent long work periods there, which will resume starting in the autumn of 2016.
After a stay of three very stimulating months at the IEA in Nantes in 2014, the directors of this institute (S. Jubé, A. Supiot) proposed that I launch a three-year renewable project. This project, under the rather ambitious title "Laws of gods, humans, and nature", started by a dialogue between disciplines and cultures, which got underway in the course of these stays, with a Chinese jurist (A. Zheng), an historian of Muslim law (Y. Aykan), and an Indian historian (A. Bhalla). On the bases of a colloquium I organized in Nantes in October 2015, I will edit a volume to be published by Hermann, which will compare the various meanings and different histories of the delicate and central notion of "law" in the natural and the social sciences. Each year a post-doc is assigned by the IEA to this project (see N. Perret below).
Leadership of the MSCS (Cambridge U.P.) and participation in ten editorial teams of international journals are only one component of my activity at the international level. In fact, since July 2012, I have been invited to give twenty-some lectures (seminars or colloquia) abroad, particularly in the USA, Great Britain, Sweden,... and during a trip "around the world in 40 days", from west to east as a result of linking three invitations, to China, New Zealand, and Chile (2014-15) (see: `http://www.di.ens.fr/users/longo/exposes-tous.html\#INTRODUCTION14`).
The most important international exchange, however, is the one made possible by my commitment as adjunct professor at Tufts University in Boston. On the occasion of these visits, I accepted invitations to give talks at M.I.T. (September 2012) and in New York (CUNY, September 2013). The influence of our theoretical explorations in biology for the epistemology of economy, in Great Britain and the USA, is a novelty that I may decide to pursue.

4.4 Scientific activity since 2017

The axis of my work continues to be oriented towards an "epistemology of new interfaces" (mathematics/physics/biology), based on my experience of work and scientific collaborations, albeit to very different degrees, in these disciplines. First of all, my involvement in the mathematics of logic and computer science, then transformed in a long collaboration with physicists (F. Bailly, T. Paul, M. Mugur-Schachter, 1998 – 2008, about), finally, since 2008, with biologists (C. Sonnenschein, A. Soto in Boston and thanks to co-directing PhD students in biology). The 2017 – 2021 period has been particularly fruitful because, on the one hand, it has allowed to synthesize different aspects of the previous work, to open new avenues and to collect a further international eco of the previous results, as evidenced by the invitations around the world (see: `https://www.di.ens.fr/users/longo/exposes-tous.html\#INTRODUCTION17`),
and, on the other hand, it stimuled new research activities and directions. The most recent (2020) are the invitation to be part of the promoting core of the *European Network of Scientists for Social and Environmental Responsibility* (ENSSER) and the invitation to chair the *Association of Friends of the Thunberg Generation for the Biosphere* (AAGT).
The epistemology of mathematics is still present in my work, a research theme often encouraged by invitations (see [Islami and Longo, 2017] and [Longo, 2020d]). With an Iranian researcher at Stanford, we have reflected on the East/West contaminations in the invention of geometry and its spaces during the scientific revolution, posing the problem of the inadequacy of these tools for the analysis of biological dynamics ([Islami and Longo, 2017]). This opens up the ideas of article [Longo, 2020d] about new constructions of meaning, which, by going beyond the logicist and formalist foundations of mathematics, propose an "informal rigor" ingrained in the historicity of mathematics. At the heart of my questioning in biology is the analysis of the historicity of the biological object; this is described by the indetermination, in evolutionary time, of its phase space

(the observables and relevant parameters) and by the role of rare events in any phylogenetic trajectory ([Longo, 2017]). This questions the "a priori" (space, time, observables, etc.) which are at the heart of the very fruitful interaction between physics and mathematics. The challenge is thus in the passage from mathematics for physics, often born, in the course of history, in turn and thanks to the problems of physics, to conceptual frameworks, of a (pre-)mathematical type, adequate to historical dynamics, such as those of the living (articles [Longo and Montévil, 2017c] and [Longo, 2018a]). This change implies a reflection on causality, so well framed in physics by principles of conservation - symmetries, Noether's theorems tell us, but which requires a much richer look in biology. Beyond physical principles, principles of "non-preservation" (of the phenotype) are at the heart of a Darwinian approach that we are extending to ontogeny. Reproduction with variation, Darwin's first principle is that we apply this principle also to somatic cells of a multicellular cell (it is evident in unicellular cells). Ten years of collaboration with biologists whose work is strongly focused on cancer (C. Sonnenschein and A. Soto, Tufts U. Boston) have allowed me to contribute to an epistemological framework for their empirical work as well as to a theoretical vision of this disease (article [Longo, 2018a]). At the heart of this framework is the difficult play between "reproduction with variation" and "enablement", or even, in a dual way, control/canalization of reproduction and variation by the tissue, the organism, the ecosystem. Cancer would be the failure of one of the many systems controlling reproduction with somatic cell variation - a vision at the heart of our collaboration (see the volume co-edited and co-authored in 2016, outside the list below). In this, we share a strongly critical approach to genocentrism that dominated organism biology in the 20^{th} century and that can be rigorously compared to geocentrism in the past (article [Longo and Mossio, 2020]).

The practice of modeling is crucial in the applications of mathematics and computer science. However, an analysis in terms of symmetries allows the differences between equational modeling and computational implementation to be analyzed: equilibrium analyses as well as analyses of flows, in the continuum, are based on principles of conservation, therefore symmetries in the equations. The breaking of these symmetries by computational approaches in the discrete changes the way phenomena are viewed (article [Longo and Montévil, 2017b]). In fact, predictability changes as well as the relationship between dynamic predictability and algorithmic decidability. In this respect, a cross-analysis of three major "negative results" is presented in paper [Longo, 2018b]. The theorems of the "three bodies" (Poincaré), of indecidability (Gödel) and of incompleteness or inconsistency of quantum mechanics (Einstein, EPR) are presented and correlated from a methodological point of view. The technical and epistemological interfaces are highlighted, underlining, in particular, how each of these results has opened new avenues for scientific analysis in its field. The limits of knowledge structure knowledge and pose new problems, which reorient scientific theorizing. On the contrary, knowledge that is only "positive", often based on passive transfers of tools from one discipline to another, prevents the invention of a new and more appropriate technical view of the phenomena studied. This is indeed what happens in the abuses of the notion of information in life sciences, analyzed in article [Longo, 2020f]. Two very solid theories of information in the discrete (elaboration of information, Turing, say, and transmission of information, Shannon) are emptied of their meaning and evoked in a pre-scientific vagueness by molecular biology "main stream". Soft principles, never well defined, concerning information and genetic programs, have produced strong consequences in the analysis of the living, including the Central Dogma and the exact (stereo-)specificity of macromolecular interactions, necessary, we are told, for the transmission and elaboration of biological information. In this article, we start from an analysis of the role of interpretation (semantics) in these two major theories of information (one of which was the framework of my first scientific life) and we highlight the role of the biological context (organism, ecosystem) as the place of biological meaning for all molecular dynamics, a "semantics", therefore historical, which requires a systemic view of the organism and its environment. Scientific transfer is far from grasping, for example, the duality between quantity of information-complexity vs.

entropy (which are contra-variant in one of the two theories above, co-variant in the other), with serious consequences such as the deformation, or even inversion, of causality in biology that we analyze in article [Longo, 2018a].
Two other interface articles are based on two major debates that marked the 20^{th} century. The one on time, in physics and biology, of which the Einstein-Bergson controversy was a high point ([**?**]), and the more general one on the possible/necessary "reduction" of biology to physics ([Longo, 2020h]). On the one hand, biological time must be scientifically objectified as an invariant of the knowing subject and thus pass, as in physics, "from the subjective-absolute to the objective-relative" (following the Einstein-Weyl approach, extended to time). On the other hand, the article proposes a "geometry" of biological rhythms and an "extended present" that radically differs from the spatialization of time that prevails in physics and that Bergson rightly criticizes. The intrinsic irreversibility and the central, "operative" role of time in biology is emphasized, because nothing in biology can be understood except in the light of a temporal perspective, both phylogenetic and ontogenetic. At the heart of the article is the highlighting of the difference between physical frequencies (of clocks) and biological rhythms (of "durations"). It shows that current eco-systemic changes induce perturbations in the evolutionary adjustment of biological rhythms and physical frequencies that can be better understood by highlighting their theoretical differences and their environmental interactions.
Article [Longo, 2020h] overturns the gaming table. It is not a question of reducing biology to physics, but of immersing, in a precise mathematical sense (that of (non-)conservative extensions) the relevant physical theories (there are several, often incompatible with each other) in a more general theoretical framework, which can also allow us to speak of the living. To this end, the emphasis is placed on an epistemology of "perspective" that favors the dialogue of theories, in search of bridges or even unity, inspired by the method of "unification" at the heart of the great theoretical inventions of physics. The main motivation is the need to overcome the dualistic separation of matter from space (or from the more general "phase space") as a pre-given container of the dynamics of matter, which has biased physics from Aristotle to Newton and, in a technically different way, even to Einstein.
I then consider the texts [Longo and Perret, 2018, Longo, 2019a, Longo, 2020e, Longo, 2020h, Lassègue and Longo, 2020, Longo, 2020c, Longo, 2020g, Longo and Longo, 2020a, Longo and Longo, 2020b, Longo, 2020b] more "philosophically oriented". Their aim is a critical reflection on certain aspects of the work undertaken. This is done by comparing our vision of biological time in [Longo and Perret, 2018] with Kantian notions; by reflecting with Turing, in a letter that goes back over its results and some of its consequences today, in [Longo, 2019a]. Turing had the immense talent of "knowing how to immerse himself in phenomena": to "become a machine" in 1936, to put himself in a game of imitation woman/machine in 1950, to show us the deformations of matter without software that engendered the forms of the living (morphogenesis, 1952). This critical analysis then allows us to understand the difficulties that even the machines of the new AI have in recognizing a caricature, article [Longo, 2020e], and even the abuses of the search for correlations without questioning the "causal structures", article [Longo, 2020b].
Two articles in collaboration with my daughter Sara, an art historian, open in a completely different direction. In the first one, a short critical essay on a book of photographs, compares these photographs to fractal structures and to some paintings of the 20^{th} century ([Longo and Longo, 2020b]). Article [Longo and Longo, 2020a] analyzes the theological-pictural origin (a term dear to D. Arasse, a major Art historian) of the first symbolic form of infinity, the projective point in fourteenth-century painting in Italy, and its role in the birth of the geometry of space that would mark the scientific revolution. It also reflects on the limits of the "a priori" of this space, which, since then, have set the conditions of possibilities for any physical theory. This a priori sets an unsuitable frame for understanding novelty in biology, where evolutionary historicity prohibits a space of pre-given possibilities - an approach that establishes a link with the articles

above on the historicity of biology.
The critical analysis of the use of the notion of information in biology, within the framework of a reflection between science and democracy, is proposed in [Longo, 2020g]. It highlights the role of control, an alleged piloting of organisms, from plants to humans, through manipulation of the genetic "information" – the paper syntheses an interview of 2016 in Italian, translated into French and English. A one-page note underlines the possibility of acting on the basis of historical knowledge, that of the "epidemic of epidemics" known for twenty years, even in the presence of a radical unpredictability of evolutionary phenomena ([Longo, 2020c]). An article with a philosopher, J. Lassègue, ([Lassègue and Longo, 2020]), explores the fundamental unity between the different forms of the writing of the laws of nature and of man, of which computer science is the last avatar. The power and limits of these forms of writing are discussed, as well as their role in the transformation of law, until the recent eclipse of the differences between "fact" and "law". Following the highlighting of the formalist divorce between alphabetic marks and meaning, we attempt to lay the groundwork for a debate in which the status of law, whether scientific or human, is recognized as crucial in an era of ubiquitous governance by computer networks and digital coding.

5 Teaching activity

- **University of Pisa** (about four years leave, GB, USA, Holland): "Teoria e Metodi di Ottimizzazione", "Metodi Matematici per l'Informatica", "Logica Matematica", from assistant to Full Professor, from 1971 to 1989.
- **Carnegie Mellon Univ**: "Formal Languages and Computability" (undergraduate) and "Recursion, Categories and Polymorphism" (graduate course), academic year 1987 – 1988.
- **Ecole Normale Supérieure**, Paris (Invited Professor, Dept. Math. and Computer Science): Languages Functionnels et un cours de D.E.A., October 1989 – May 1990.
- **ENS-ParisVII- Polytechnique**: cours **D.E.A.** in Computer Science, with P.-L. Curien, 1990 – 1994.
- **ENS-ParisVII-Polytechnique-ParisXI-CNAM**: an introductory and an advanced course "Types et calculabilité" of **D.E.A.** (later Master) in Computer Science, from 1995/96 to 2006.
- **ENS-ParisVI/VII-Polytechnique**: **DEA, Master** en Science Cognitives : cours en Théorie de la Démonstration et des Types, from 1998 to 2004, on different aspects of modelization and of calculability (discrete vs. continua) to 2007.
- **ENS**, cours introductif à la logique: "Eléments de Théorie de la démonstration" pour élèves en maths et en philosophie, January and February 1996.
- **ENS**, cours libres: "Six leçons sur l'incomplétude : logique, mécanique quantique", en collaboration avec T. Paul, mathématiques, CNRS-ENS, January and February, 2008 – 2011.
- **Univ. Roma III**: cours de doctorat, April – May 2009.
- **ENS**, cours libre : "Indécidabilité logique, et aléatoire physique", February and March 2010 (vidéo-enregistré à l'ENS, Savoirs en multimedia).
- Ecoles de Printemps, GDR de programmation: cours à Nice (March 1991), Bordeaux (April 1992), St. Malo (April 1993) and Toulouse (March 1994).
- Intensive Course of Doctorate (10 hours in a week); Turin (June 1993) and Rome (February 1994).
- Summer School, Logic, Language and Computation (10 hours in a week), Copenhagen, August 1994.
- Scuola Superiore dell'Universita' di Catania (10 hours in a week) April, 2000.
- Exposés à l'**ENS** (research and teaching):
  "Logique and Calculabilité" (Journée introductive à la Cognition, November 1992); "Les irrationalités de la Logique" (Séminaire de Philosophie des Mathematics, organisé par P. Cartier, F. Loi, R. Thom, February 1993); "Mémoire et systèmes déductifs" (Exposé faisant partie d'un cycle sur la Mémoire en Biologie, Computer Science et Philosophie, February 1994); "Pour un fondement de la connaissance mathématique" (Séminaires d'Hist-oire and Epistémologie des Mathematics, March 1996); "Les Fondements de l'Arithmétiques et 'la teneur de phosphore dans le Cerveaux' (Frege)" Journée de l'ELSAP, Jourdan, January 1997; "Sur les démon-strations des Théorèmes indémontrables" (Séminaire de Philosophie des Mathematics, May 1997); "L'infini mathémathique, les machines and les métha-phores"

(Groupe "La Pensée des Sciences"), May 27, 1998;
"Mathematics and Cognition: since l'intelligibilité géometrique de l'espace sensible" (with B. Teissier), February 17, 1999 (voir web Longo: Geometry and Cognition); "Mémoire and objectivité en mathématiques" (Séminaire de Philosophie des Mathematics, March 2000); "Expressivité and incomplétude logique" (Cours bref, 2 ou 4 heures, dans le cadre de l'Option Intermagistère ENS en *Science Cognitives*, November 1996, 1997 and 1999, February 2000, November 2000, January 2002); "Les fondements des Maths and la metaphore for cerveau" (Séminaire de Philosophie des Mathematics, June 2002).
Les exposés suivants sont enrégistés (audio et video) et téléchargéables de site de l'ENS (Savoirs en multimedia): La philosophie des mathématiques, October 24, 2003; Table-ronde autour de la notion de Trois corps, classique-quantique, discret-continu, September 29, 2004; Dynamiques de pensée en mathématiques : principes de preuves vs. principes de construction, April 29, 2006; Continuum vs. discrete: Physics, Mathematics, Computing, May 3, 2006; Présentation de la version fraçaise du livre [Bailly and Longo, 2011], november 20, 2006; le cours de 2010.

- Membre du Conseil Pédagogique du **DEA** en Science Cognitives (2000 – 2004).

6 Theses Supervised

6.1 "Tesi di Laurea", University of Pisa *(only research theses are mentioned (cum laude)):*

P.Giannini "Calcolabilita' su strutture astratte" Dip. di Informatica, Pisa, 1979. *(Enseign.-chercheur, Univ. Torino)*

A.Bosisio "Operatori di enumerazione e topologie deboli" Dip. di Matematica, 1979 *(Chercheur dans l'industrie)*.

B.Mugnani "Metodi deduttivi per l'assegnamento di tipi" Dip. di Informatica, Pisa, 1982 *(Chercheur dans l'industrie)*.

S.Martini "I funzionali di Kleene e Kreisel e gli operatori ricorsivi" Dip. di Informatica, Pisa, 1983. *(Ph. D., Informatica Pisa; Prof. Ordinario, Udine et Bologna, since 1996)*

E.Moggi "Categorie cartesiane chiuse in teoria dell'enumerazione" Dip. di Informatica and Scuola Normale Superiore, Pisa, 1983. *(Ph. D., Computer Sci. Edinburgh Univ.; lecturer, Edinburgh Univ.; Professore Ordinario, Genova, since 1992)*

F.Ruggeri "Convergenza in spazi di filtri ed operatori di Turing" Dip. di Matematica, Pisa, 1984. *(1985 – 1988: Ph. D., Computer Sci. Univ. of Chicago; chercheur Olivetti, Pisa)*

E.Paglia "Il secondo ordine nel polimorfismo dei tipi di dato" Dip. di Informatica, Pisa, 1984.

A.Asperti "Strutture categoriali per la semantica denotazionale" Dip. di Informatica, Pisa, 1985. *(Ph. D., Informatica Pisa; Chargé de Rech. INRIA, 1990 – 1992; Prof. Associato puis Ordinario, Bologna, since 1993)*

G.Monteleoni "Alcuni aspetti semantici della programmazione funzionale" Dip. di Informatica, Pisa, 1985. *(1987 – 1988: bourse CNR, Computer Sci., CMU; chercheur IRI, Pisa)*

R.Amadio "Semantica dei tipi parametrici" Dip. di Informatica, Pisa, 1985. *(Ph. D., Informatica Pisa; Chargé de Rech., CNRS, Nancy, puis, Professor, U. Marseille, puis Paris VII)*

R. Di Cosmo "Isomorfismo fra tipi e type-checking" Dip. di Informatica and Scuola Normale Superiore, Pisa, 1986. *(Ph. D., Informatica Pisa; Maître de Conf., Computer Science , E.N.S., Prof. Paris VII)*

P. Di Gianantonio "La semantica degli intervalli per il polimorfismo espilcito" Dip. di Informatica and Scuola Normale Superiore, Pisa, 1986. *(Ph. D., Informatica Pisa; I.B.M. award for Computer Science Thesis; Enseign.-chercheur, Univ. Udine, since 1991).*

F. Barbanera "Intuizionismo e la nozione di formula come proposizione" Dip. di Informatica, Pisa, 1987. *(Ph. D., Informatica, Torino; Enseign.-chercheur, Univ. Torino, since 1991)*

A. Bucciarelli "Teoria generalizzata della ricorsivitá in alcuni modelli del lambda-calcolo" Dip. di Informatica, Pisa, 1987. *(Ph. D., Informatica Pisa; bourse CHM, E.N.S.; Enseign.-chercheur à Rome, puis Paris VII, 1999)*

D. Lepore "Convergenze non topologiche, stabilitá, sequenzialitá" Dip. di Informatica, Pisa, 1987. *(chercheur dans l'industrie).*

G. Castagna "Teoria dei tipi per 'Object Oriented Programming"' Dip. di Informatica, Pisa, 1990. *(CR, puis DR, CNRS, LIENS, since 1994).*

6.2 Mémoires de DEA ou Master II

G. Santini **Domaines et systèmes dynamiques**. DEA Sémantique Preuves Programmation. Année 1996 – 1997.

C. Truchet (ENS)**Continuité non-topologique**. DEA Sémantique Preuves Programmation. Année 1997 – 1998.

S. Vacca **La forme finie du théorème de Kruskal**. DEA Sémantique Preuves Programmation. Année 1996 – 1997.

P.-S. Graillou, **Aspects cognitifs des preuves visuelles**. DEA Sciences Cognitives. Année 1998 – 1999.

G. Halimi, (ENS) **Sémantique de polymorphisme**. DEA Philosophie. Année 1999 – 2000.

M. Mossio, **Constitution d'invariants spatiaux**. DEA Sciences Cognitives. Année 2001 – 2002.

P. Bucholc (co-direction de stage), **Les suites de Godstein and la prouvabilité**. DEA Sciences Cognitives. Année 2001 - 2002.

E. Tendero, **Démontrabilité and indémontrabilité : un théorème de Friedman**. DEA Logique Mathematics. Année 2001 – 2002.

B. Saulnier, **Information and entropie topologique**. DEA d'Computer Science , SPP. Année 2001 – 2002.

J. Narboux, **Généricité dans les systèmes polymorphes**. DEA d'Computer Science , SPP. Année 2001 – 2002.

A. Viarouge, **Cognition Mathematics: nombres and espace**, DEA Sciences cognitives, Année 2003 – 2004.

G. Hoyrup, **Calculabilité and systèmes dynamiques**, DEA Computer Science - SPP, Année 2003 – 2004.

A. Kolcak **Indécidabilité computationnelle and imprédictibilité dynamique**, DEA Computer Science - SPP, Année 2004 – 2005.

M. Montevil **Etats critiques étendus**, Master II en Sciences Cognitives, Année 2005 – 2006.

G. Delalleau **Bifurcations of Hopf and dynamiques irriversibles**, Master II en Mathematics, Paris VII, Année 2007 – 2008.

6.3 Doctoral Thesis, *dates of the Defense (Le Doctorat de Recherche a été institué en 1982, en Italie):*

S. Martini **"Modelli non estensionali del polimorfismo in programmazione funzionale"** Dip. di Informatica, Pisa, 1988 *(Ricercatore puis Professore Ordinario, Udine, 1996; Bologna 2002)*

A. Asperti "**Categorical methods in the theory of functional, logic and parallel languages**" Dip. di Informatica, Pisa, 1989. *(post-doc puis chercheur INRIA, 89-92; Professore ordinario, Bologna, 2001)*

G. Ghelli "**Data types for an higher-order database language: semantics and type-checking**" Dip. di Informatica, Pisa, 1989. *(Ricercatore puis Professore ordinario, Pisa, 2002)*

S. Berardi (suivi en collaboration with M. Dezani) "**Proof Theoretic aspects of system F**" Dip. di Matematica, Torino, 1989. *(Ricercatore puis Professore ordinario, Torino, 2002).*

R. Amadio "**Recursion and subtyping in lambda calculi**" Dip. di Informatica, Pisa, 1991. *(post-doc LIENS, 90-91; chercheur CNRS, Nancy, puis Professor , U. Marseille, puis Paris VII)*

R. DiCosmo "**Isomorphisms of types**" Dip. di Informatica, Pisa, 1993. *(MdConf., ENS; Prof. Paris VII, since 1999).*

G. Castagna "**fondements fonctionnelles de la Programmation Orientée Objets**" Paris VII, January 1994. *(Cr, puis DR, CNRS, LIENS, since 1994).*

A. Bucciarelli (suivi principalement par P.L. Curien) "**Coherence et Stabilité for langages sequentiels**" LRI, Orsay, Octobre 1994. *(bourse CE-CHM 1993-95; Enseign.-chercheur à Rome, puis Paris VII, 1999).*

R. Bellucci "**Sistemi formali e Modelli per il Polimorfismo parametrico**" Universitá di Siena (et LIENS), January 1996 *(Chercheur chez Eurosat).*

Chen Gang (suivi en collaboration with G. Castagna) "**Sous-typage et conversions de types**" University of Paris VII (et LIENS), Décembre 1998 *(Associate researcher, Univ. South Australia, puis Boston Univ.).*

F. DeJaeger "**Calculabilité sur les réels**" University of Paris VII (etLIENS), novembre 2003 *(chercheur chez Apple).*

B. Saulnier, "**Aspects multi-échelles de l'information : de la physique à la biologie**", septembre 2006 *(post-doc, Univ. Leiden, puis "quant" chez Merryl Lynch).*

M. Mossio, "**Adéquation théorique et maîtrise expérimentale : un enquête interscisplinaire en sciences cognitives**", octobre 2006 *(post-doc, CR, sect. 35 de CNRS).*

M. Hoyrup "**Computability, randomness and ergodic theory on metric spaces**" juin 2008 *(CR-CNRS, INRIA, Nancy).*

C. Rojas "**Computability and Information in models of randomness and chaos**" juin 2008 *(Bourse Ecole Polytechnique, Mathematics, puis post-doc 4 ans au Fields Institute, Canada; professor, U. Santiago, Chile).*

P.-G. Sbrissa "**Simulations informatiques, histoire d'un constructivisme**" janvier 2011 *(en co-direction, Philosophie, EHESS; Journaliste)Ò*

G. Frezza "**The concept of Interaction: crossovers among biology, logic and philosophy**" April 2011 *(en co-direction, Philosophie, Univ. Roma III; post-doc Rome III).*

M. Montévil "**Temps Biologique et Transitions Critiques Etendues**", octobre 2011, *Ecole Doctorale Frontière du Vivant, Paris Descartes; post-doc, Biology Dept., Tufts University, Boston, and Paris VII, Paris, .*

N. Perret "**Epistémologie constitutive pour les sciences du vivant ; sur la catégorie de causalité en biologie**", juin 2013, co-direction avec M. Bitbol, *Ecole Doctorale Lettre/Sciences - 540, Ens, Paris; post-docs Pascal Chair, ensuite IEA Nantes, jusqu'en 2016.*

P. Villoutreix "**Aléatoire et variabilité dans l'embryogenèse animale ; une approche multi-échelle**", Juillet 2015, co-direction avec N. Peyriéras, *Ecole Doctorale Frontière du Vivant, Paris Descartes; post-doc, Biology Princeton.*

A. Abbott "**Value Indefiniteness, Randomness and Unpredictability in Quantum Foundations**", November 2015, co-direction avec C. Calude, *Ecole Doctorale Lettre/Sciences - 540, Ens, Paris, et Mathematics/Computer Science Auckland University, NZ; post-doc, Institut Néel, Physique, Université de Grenoble .*

Thèses en cours : JM. Catherin (Thèse en codirection avec JM. Besnier, Ecole doctorale P. IV, à partir de octobre 2011: fondements des Mathématiques – M. Catherin died in 2016); S. Biasoni

(Thèse en codirection avec J. Lassègue, Ecole doctorale Lettre/Sciences - 540, Ens, Paris, à partir de octobre 2015 : épistémologie des mathématiques de la finance).

Direction de post-docs :
G. Pulcini (bourse Ville de Paris), 2008 – 2009 ;
A. Marinucci (bourse Ville de Paris), 2012 – 2013 ;
E. Pagni (bourse Ville de Paris), 2013 – 2014 ;
N. Perret, auprès de la Chair B. Pascal et, ensuite, de l'IEA de Nantes, projet *Lois des dieux, des hommes et de la nature*, 2014 – 2016.

Rapporteur ou examinateur d'Habilitation:
R. Amadio (June 94), S. Soloviev (September 1994), L. Boi (Decembrer 1997), R. Di Cosmo (Mars 98), A. Carbone (January 1999), L. Colson (January 1999), M. Fernandez (September 2000), G. Castagna (January 2002), O. Bournez (december 2006), O. Michel (Decembre 2007), J.B. Joinet (Decembre 2007), A. Bucciarelli (November 2009). J. Lassègue (October 2010, Paris 5), P. Uzam (November 2013, Paris 7).

Theses referee or examiner, since 1990:
Couronné (December 1990), Fouda (December 1992), Jiang (June 1993), Chillan (September 1993), Monsuez (January 1994), Compagnoni (Nijmegen NL, January 1995), Boldini (February 1995), Jacquet (September 1995), Xavier Gouy (December 1995, Paris VII), Crolard (December 1996, Paris VII), Bastonero ((December 96, Paris VII), Pravato (February 1997, Torino), Pocholczyk (April 1997, Paris VI), Lenzi (June 1997, SNS, Pisa), Macjik (May 1998, Roma), Saibi (March 1999, INRIA-Paris VII), Thiénot (June 1999, Paris VI), V. Schachter (December 1999, Paris-Orsay), D. Chemouil (Toulouse, September 2004), D. Hainri (december 2006, Nancy), A. Hazan (december 2007, Paris XIII), G. Giannini (April 2008, Urbino), M. Caponigro (April 2008, Camerino), M. Toscano (March 2009, Bergamo), C. Chalons (September 2014, Paris 7), M. Pistone (July 2015, Philosophie, Roma III, et Institut de Mathématiques de Marseille (I2M)), I. Wilkins (January 2016, Goldsmiths Univ., London).

Director of several Thesis minors at ENS (Magistère, in Mathematics and Computer Science).

7 Invited lectures and seminars

University College of Swansea, G.B. (Mini Lambda-Conference, Mathematics Dept.; hôte: R. Hindley), September 1974: "Non-strict functions and their representation in Axiomatic Recursion Theories",
February 1980: "The countable functionals and lambda calculus models".

Scuola Normale Superiore, Pisa : cycles de séminaires:
(A.A. 1974 – 1975): "Ricorsivita' generale e la gerarchia aritmetica",
(A.A. 1975 – 1976): "Introduzione al lambda-calcolo ed alla sua semantica",
(A.A. 1976 – 1977): "I teoremi di incompletezza di Gödel e Gödel-Rosser",
(A.A. 1981 – 1982): "Strutture di tipi e senza tipi per la calcolabilitá".
January 1990: "Strumenti logico-matematici per i linguaggi di programmazione".
January 1992: "Realismo matematico ed immagini mentali, discussione in scienze della conoscenza".

C.N.R., Roma (I.A.C.; hôte: M. Venturini-Zilli),
June 1978: "Verso una Teoria dei Modelli del Lambda-calcolo"

October 1981: 1) "Il teorema di Paris-Harrington e le incompletezze matematiche dell'Aritmetica";
2) "Alberi di Böhm e la caratterizzazione semantica di proprieta' del lambda-calcolo".

Utrecht University, Holand (Mathematisches Instituut; hôte: H. Barendregt), December 1978: "Plotkin's models of lambda calculus and type two Recursion Theory"
October 1982: "The hereditary partial recursive functionals".

Universita' di Torino (Dip. Informatica; hôte: M. Dezani), January 1979: "Un'introduzione alla Ricorsivita' nei tipi superiori";
December 1981: "Semantica operazionale vs denotazionale in lambda-calcolo".
June 1993: "Il Teorema di Genericita' "
June 1993 (Dip. di Fisica; hôte: F. Pegoraro): "Poincare' e Weyl fra Fisica e fondaz. della matem.: oggi".

Amsterdam University, Holand (Mathematisches Instituut, Intercity Seminar; hôte: D. Van Dalen), September 1979: "Effectiveness in some Ershov spaces for the partial continuous functionals".

Oxford University, G.B. (Mathematical Institute; hôte: R. Gandy), February 1980: "Generalized Myhill-Shepherdson theorem and its applications to lambda-calculus models".

University of Chicago, U.S.A. (Mathematics Dept.; hôte: R. Soare), March 1980: "An overview of recent results in lambda-calculus syntax and semantics".

Universitad Aut. Nac. de Mexico, C. de Mexico (dept. de Matematica; hôte: F. Bracho), Decembre 1980: "Set-theoretical lambda-models and their applications".

M.I.T., U.S.A. (Lab. for Computer Science; hôte: A. Meyer), February 1981: "Recursion Theory in higher types: relating Ershov and Hyland approaches",
October 1984: "Categories of partial morphisms and the semantics of types".
October 1985: "The semantics of types and terms for (higher-order) λ-calculi".
January 1987: "Lambda-calculus: *the* Theory of Computable Functions".
July 1987: "The denotational meaning of impredicative Type Theories".

University of Indiana, Bloomington, U.S.A. (Computer Sci. Dept.; hôte: M. Wand),
September 1981: "The Lambda-calculus : its syntax, its semantics and how they relate".

Yale University, New Haven, U.S.A. (Mathematics Dept.; hôte: A. Macintyre), September 1981: "An introduction to the model-theory of lambda calculus".

E.T.H., Zurich, C.H. (Math.-Comp. Sci.; hôte: E. Engeler), October 1982: "Some connections between lambda-calculus models and computability in abstract structures".

Oberwolfach Forschungsinstitut, R.F.T. (Organizers: Felscher, Schwichtemberg), April 1983: "Relative gödel-numberings and recursion theory in higher types".

Universita' di Padova (Ist. Matematico; hôte: R. Ferro), May 1983: "Informatica e Matematica: metodi di indipendenza in problemi combinatori".

Universitat Dortmund, R.F.T. (Leh. Informatik; hôte: E. Börger), April 1984: "Analytic methods in Computer Science".

University of Maryland, U.S.A. (Workshop on Semantics, Special Year in Logic and Computer Science; organizers: K. Lopez-Escobar, C. Smith), October 1984: "Provable isomorphisms, invertible terms and continuous models".

Imperial College, London, G.B. (Computer Sci. Dept.; hôte: S. Abramski), April 1985: "Solvable domain equations in all models of typed and second order lambda-calculus".

University of Edinburgh, G.B. (Computer Sci. Dept.; hôte: G. Plotkin), April 1985: *same as at the Imperial College.*

Carnegie Mellon University, U.S.A. (Computer Sci. Dept.; hôte: D.S. Scott), November 1985: "Categories and models of various lambda-calculi";
June 1986 (hôte: R. Statman): "From Gödel-numberings to higher types and higher order".
Octobre 1987 (hôte: D.S. Scott): "Some aspects of impredicativity".

Stanford University, U.S.A. (CSLI; hôte: J. Meseguer), November 1985: *same as at M.I.T. (October 1985);*
January 1988 (Mathematics Dept.; hôte: S. Feferman): "Modest Models and Motivations of impredicative Type Theories".

Banach Mathematical Center, Warsaw (hôte: H. Rasiowa), December 1985: 1)*voir article [Asperti and Longo, 1987];*
2) "The higher-type Banach-Mazur functionals in recursion theory".

Paris VII, Paris (L.T.I.P.; hôte: P.L. Curien), January 1986: 1) *same as at M.I.T. (Octobre 1985)* ; 2) "Modèles sans types pour les calculs d'ordre supérieur".
(Equipe de Logique; hôte: J.Y. Girard) January 1987: "Calculabilié sur les domaines de Scott et sur les espaces coherents".
(Equipe de Logique; hôte: C. Berline) Janvier 1995: "Paramétricité, Théorème de Généricité et Soustypage".

Chalmers University, Göteborg (Programming Methodology Group; hôte: B. Nordstrom), September 1986: "Models for explicit polymorphism in Functional Languages"
Juin 1987 (delivered in Mastrand, *Workshop on Logic of Programming*)**:** *same as at M.I.T. (Juillet 1987)* **.**

Pennsylvania State University (Math. Dept.; *Mid-Atlantic Mathematical Logic Seminar*; hôte: S. Simpson), December 1987: "The Curry-Howard 'Types-as-Formulas' analogy and the Models of Combinatory Logic".

University of Pennsylvania, Philadelphia (Computer Sci.; hôte: V. B.-Tannen), May 1988: *same as Stanford, Janvier 1988*.

Université de Marseille (Fac. Science Luminy; hôte: G. Blanc and A. Preller), April 1990: "The categorical meaning of various lambda-calculi: from type-free to higher order".

I.N.R.I.A., Rocquencourt -Paris (hôte: J.J. Levy), December 1989: "Quest: polymorphism and subtyping";
February - May 1990 seminaires ébdomadaires organizés (et parfois présentés) par J.Y. Girard, G. Huet and G. Longo.

DEC-PRL, Digital - Paris Research Lab., Rueil-Malmaison (hôte: H. Aitkaci), June 1990: "An introduction to Quest: its types and its semantics".

IIIème Réunion CE - Jumelage "Typed lambda-calculus", Paris, January 1991: "Type Theory and Object Oriented Programming".

Universita' di Milano (dip. di Informatica; hôte: N. Sabadini), January 1992: "Tipi, categorie e calcoli".

Universita' di Napoli (dip. di Fisica Teorica; hôte: G. Trotteur), April 1993: "Logica, rappresentazioni mentali ed Informatica".

Stanford Research Institute (SRI, Computer Science; hôte: Workshop of the American Jumelage "Lambda"), October 1993: "Invariant and Effective Polymorphism".

Ière Réunion, NSF - Esprit Workshop on **"Functional and Object Oriented Programming"**, Stanford University, October 1993: "Overloading as Message passing".

Ière Réunion "Lambda-calcul" CHM (CE) Projet **"Typed lambda-calculus"**, Univers. de Rome, November 1993: "Computations in Theories and Models".

Académie des Sciences de Chine, Pekin (Dept. of Comp. Sci.; hôte: Wong Ju), April 1994: "Types, Categories and Functional Languages" + "Overloading in a functional frame".

JiaoTong University Shanghai, Chine (Dept. of Comp. Sci.; hôte: Sun Yong), April 1994: "Recent advances in Type Theories".

CNRS et I.N.R.I.A. Lorraine, Nancy (CRIN; hôte: R. Amadio), June 1994: "Théories équationnelles du lambda-calcul et leur sémantique".

LMD, CNRS, Marseille (hôte: J.Y. Girard; réunion CHM, Typed Lambda), November 1994: "A (linear) Logic for Subtyping".

Institut Henri Poincaré, Paris (hôte: J. Petitot), January 1995: "De la théorie de la Démonstrations aux Programmes et aux Morphismes".

Informatika, Katholic Universitaat, Nijmegen (hôte: H. Barendregt), January 1995: "Polymorphism and the functional behaviour of terms applied to types: universality properties and subtyping".

CNR, Roma (Istituto di Psicologia, hôte: D. Parisi), February 1995: "Memoria e Matematica".

Universita' di Rome I (Dip. di Informatica, hôte: R. DeNicola), February 1995: "Impredicativita': teorie, semantica e risultati recenti in Teoria dei Tipi".
November 1995 (Dip. di Matematica, hôte: M. Fattorosi): "Sulle dimostrazioni di Teoremi indimostrabili".
(Dip. di Informatica, hôte: C. Boehm), Avril 1996: "Applicazioni ed osservazioni sul Cut-elimination".

Universidad de Vina del Mar, Chile (Escuela de Ingenieria, hôte: E. Perez Santi), April 1995: I. "Logic and Computer Science: from cloks to Proof Theory" and II. "Impredicativity: the general notion and some recent consequences in Type-Theory".

Universidad de Chile, Santiago (Depto. de Ciencias de la Computacion, hôte: R. Baeza-Yates), April 1995: "Proofs and programs: an introductory survey".

City University of N.Y., New York (Dept of Computer Sci.; hôte: R. Parikh), June 1995: I. "Categories, programs and impredicative definitions" and II. "Reflections on Logic and Cognition".

University of Warsaw, Warsaw (Dept of Computer Sci.; hôte: J. Tiuryn), July 1995: "Recent results in constructive proofs and categories".

ENST, Paris, September 1995: "Types et Objets pour le polymorphisme".

Universita' di Torino (HCM meeting, hôte: S. Ronchi), November 1995: "On the regularity of generic proofs".

ENS de Lyon (hôte: C. Paulin-Mohring), Mars 1996: "Le Polymorphisme dans les langages fonctionnels".

ENS, Jourdan, Paris (hôte: D. Dubois), May 1996: "Invariants et Notations en Mathématiques".

Centro Fiorentino per la Filosofia della Scienza, Florence (hôte: A. Cantini), October 1996: "Logica e Tempo in Informatica" (voir [Longo, 1999c]).

EHESS, Paris (CAMS; hôte: J.-P. Desclés), June 1996: "Types Intuitionnistes et Structures Géometriques".
May 1997 (hôte: J. Petitot): "Imprédicativité et Théorie des Types: enjeu logique et résultats récents".

Instituto Superior Tecnico, Lisboa, PORTUGAL (Dep. de Matematica; hôte: A. Sernadas): "Proofs, morphisms and programs: a survey", February 12, 1998.

Universita' di Bologna (Dip. di Informatica; hôte: A. Asperti): "Circoli vizioni: dalla logica ai sistemi dinamici", February 20, 1998.

Collège de France, Paris (LPPA; hôte: A. Berthoz): "Réflexions sur les fondements cognitifs de la géométrie", March 24, 1998.

Laboratoire des Maths Discrètes, CNRS, Marseille (Colloque HCM "Types"; coordinateur: I.Y. Girard): "From Logical circularities to Mathematical expressiveness. Impredicativyt and dynamical systems", April 10, 1998.

Universita di Roma I, Roma (Informatica, Scienze; hôte: C. Boehm): "Circolarita' ed Impredicativita' in Logica ed in Matematica: dalla Teoria dei Domini a quella dei Sistemi Dinamici. April 21, 1998.

Universita' di Roma II, Roma (Dip. di Filosofia: hôte: A. Carsetti): "Logica e tempo in Informatica", 19 Maggio; "Infinito e dimostrazioni in Aritmetica", 21 Maggio 1998.

Brandeis University, Boston (Department of Computer Science; hôte: H. Mairson): "Computability in Dynamical Systems via Domain Theory"", June 25, 1998.

Conference on "Operations, Sets and Types". Invited lecture: "Vicious circles: in Logic and in Mathematics", Castiglioncello (It.), October 3 – 6, 1998.

Universita' di Pisa, Pisa (Dip. di Informatica; hôte: G. Levi): "Topologie e geometria in Informatica", October 26, 1998.

Pontificia Universitas Lateranensis, (Centro di Studi Fenomenologici; hôte: A. Ales Bello): "Formalismi ed incompletezza, oggi, dopo Friedman e Girard: riflessioni di un matematico applicato, a partire delle osservazioni di Weyl (Il Continuo, 1918; La Simmetria, 1953), Wittgenstein (1928 – 1936) ed Husserl (Le Origini della Geometria, 1936)", November 28, 1998.

Workshop on "Methodology in Cognitive Sciences", lecture on "Mathematical invariance and coding-dependence in Logic and Computer Science, an issue in knowledge representation", Fondation des Treilles, Nice, December 7 – 13, 1998.

Primo Incontro Annuale del Progetto Cofinanziato "Tecniche formali per la specifica, l'analisi, la verifica, la sintesi e la trasformazione di sistemi software". Conferenziere straniero invitato: "Circolarita' ed equazioni, invarianza e geometria, dalla Teoria dei Tipi ad altri aspetti dell'Informatica", Roma, December 21 – 23, 1998.

Universita' di Genova, Genova (Dipartimento di Matematica; hôte: P. Boero): "Assiomatica e deduzione: dalla lettura degli assiomi di Euclide al teorema di Kruskal-Friedman (FFF)"; Comune: "La resistibile ascesa della metafora: il cervello e' un calcolatore digitale", March 11 – 12, 1999.

Colloque "L'existence en Mathématiques". Conférence invitée: "Existence, coherence et constructions mathématiques possibles", Paris, March 27, 1999.

EHESS, Paris, Seminaire "Histoires des Géometries" (hôte: D. Flement). Exposé: "Les limites du formalisme: l'intelligibilité géometrique de l'espace", May 10, 1999.

University of Kyoto, Japan (Computer Sci. Dept., Workshop on Proof-checking; hôte: S. Hayashi): "Impredicativity: the general notion and some recent consequences in Type-Theory", May 15, 1999.

University of Keio, Tokyo, Japan (Philosophy Dept., hôte: M. Okada): "Categories, types and programs, in the context of mathematical knowledge" and "Some remarks of Husserl's and Wittgenstein's and the understanding of recent incompleteness results in Proof-Theory.", May 8 – 19, 1999.

Tokyo Inst. of Technology, Japan (Computer Sci. Dept, hôte: M. Takahashi): "On the proofs of unprovable theorems.", May 20, 1999.

Scuola "Matematica e Musica": "Costruzioni di mondi sonori". Conferenza invitata: "Costruzioni nello spazio e nel tempo, in Logica ed in Informatica", Maratea, August 29 – 31, 1999.

Colloque "Le réel en Mathématiques". Conférence invitée: "Objectivité et construction en Mathématiques", Cérisy, September 03 – 10 1999.

The **1999 meeting of the British Logic Colloquium**. Invited lecture: "Prototype Proofs and Genericity in Type Theories", Swansea, Wales, September 23 – 25, 1999.

Universita' di Bologna, Bologna (Dipartimento di Matematica ed Informatica; hôte: A. Asperti): "Sulle dimostrazioni dei teoremi indimostrabili", September 27, 1999.

III scuola estiva di Logica, AILA-SILFS: "Circolarita' logiche ed espressivita' matematica" Cesena, Italie, September 28 – 30, 1999.

Centro di Filososfia della Scienza, Firenze: "I fondamenti della matematica e la metafora: il cervello e' un calcolatore digitale (II)", November 5, 1999.

Colloque "Le rationnalisme: science et philosophie en France et en Italie", Istituto Italiano per gli Studi Filosofici, Napoli: "Il costituirsi del "piano fenomenale" in Matematica, con la Matematica", December 10 – 11, 1999.

Universita' di Torino, Torino (Dipartimento di Informatica; hôte: M. Dezani): "Riflessioni sull'incompletezza: risultati recenti", December 20, 1999.

University of Lisbon, Lisboa (Department of Informatics; hôte: V. Vasconcelos): "Continuous Structures in Computer Science: from domain equations to computations in dynamical systems", January 9, 2000.

Universita' di Roma III, Roma (Dipartimenti di Filosofia e di Matematica; hôte: M. Abrusci): "L'intelligibilita' geometrica dello spazio ed i fondamenti della conoscenza (matematica)", February 7, 2000.

Universita' di Roma I, Roma (Dipartimento di Informatica; hôte: A. Labella): "Incompletezze "concrete" in Aritmetica: dall'induzione formale al problema del carico induttivo", March 7, 2000.

Colloque "Epistemologia aperta e filosofia della mente", Catania (Istituto di Studi Filosofici ed Epistemologici): "L'epistemologia della matematica e la filosofia della mente, fra geometria e linguaggi.", April 3 – 4, 2000.

Istituto Italiano di Cultura, Paris: "Il costituirsi dei concetti di numero e di spazio nella prassi della matematica", April 12, 2000.

Collège de France, Paris (Atelier Espace, hôte: M. Denis): "Les fondements cognitifs des mathématiques, entre espace et langage", April 17, 2000.

Olimpiadi Nazionali di Matematica, Cesenatico, It.: "Concetti e Deduzioni in Matematica", May 6, 2000.

Imperial College, London (Departement of Computing; hôte: A. Edalat) "The geometric intelligibility of space and the foundation of mathematical knowledge", May 10, 2000.

Université de Paris VII, Paris (Equipe de Logique; hôte: P. Ressayre): "Le problème mathématique de l'espace et les fondements des mathématiques", May 15, 2000.

Colloque "Mathématiques 2000: Mathématiques, calcul, ordinateurs", Paris (ENS): "The Difference between Diderot's clocks, Turing machines and concurrent systems", May 24, 2000.

Université de Paris VII, Paris (Labo. Preuves, Programmes et Systèmes; hôte: P.L. Curien, A Bucciarelli): "Réflexions sur les incomplétudes "concrètes" de l'Arithmétique et les preuves prototypes", June 8, 2000.

Colloque "Conoscenza e cognizione", Firenze (It.): "Sulla natura della logica", November 7, 2000.

Colloque "Geometria, intuizione ed esperienza", Castiglioncello (It.): "Concetti matematici ed oggetti della fisica", December 1 – 2, 2000.

Journées d'épistémologie (physique, logique, mathématiques), I H P, Paris : "Principes de preuve et principes de construction: la notion de preuve, en mathématiques, est-elle recursive?", December 5 – 6, 2000.

Annual Conference TYPES'2000. Invited lecture: "Formal unprovability of provable properties of numbers and prototype proofs in Type Theory", Durham, UK, December 8 – 12, 2000.

INRIA, Roquencourt (Colloquium; hôte: M. Kern): "Des fondements mathématiques possibles pour la prochaine machine", January 16, 2001.

Colloque Mathematics and Cognition, University of Rome II: "Mathematics, intentionality and meaning", February 9 and 10, 2001.

Universita' di Rome I, Rome (Dip. di Filosofia, hôte: C. Cellucci) :"I fondamenti della Matematica, le macchine, il cervello", February 15, 2001.

Séminaire Heidelberg-Nancy-Strasbourg, Nancy (hôte: P. Nabonnand): "Le problème de l'espace, les fondements des mathématiques et l'informatique", March 30, 2001.

Universita' dell'Aquila, Aquila, It. (Dip. di Informatica, hôte: B. Intrigila) :"Codifiche e calcoli: alcune differenze fra gli "orologi" di Diderot, le Macchine di Turing ed il cervello",

April 9, 2001.

Colloque "The categorial researches: Husserl's Logic", (Archives Husserl, ENS, Paris): "From the "genealogy of concepts" (Riemann) to the "epistemological elucidation" (Husserl) in the foundations of Mathematics, today", April 27 – 28, 2001.

Cambridge University, Cambridge, GB (Computer Science Dept., hôte: A. Pitts): "On the formal unprovability of some provable properties of numbers", May 17, 2001.

Journée "Le concept de modèle interne en neurosciences", Collège de France, Paris : "Représentations de l'espace et du temps en mathématiques et en physique, leur rôle en cognition", June 15, 2001.

Colloque "En honneur de Gilles CHATELET", Paris : "La métaphore et le geste dans la preuve: relire l'incomplétude mathématique des formalismes avec Gilles Ch telet, au-dela de la Gödélite", June 27 – 29, 2001.

AMS/SMF Meeting *(American Mathematical Society / Societé Mathématique de France)*, Lyon: "Foundations of mathematics: some challenges in the interaction with other sciences", July 17 – 20, 2001.

Colloque international "Géométrie au vingtième siècle : 1930-2000", Institut Henri Poincaré, Paris: "Les fondements géométriques du calcul et de la logique; les fondements cognitifs de la géométrie", September 24 – 29, 2001.

Colloque international "The Mathematics of Ennio De Giorgi", Scuola Normale Superiore, Pisa: "Concepts and conjectures vs axioms and proofs: reflections and results on and from De Giorgi's foundational approach". October 24 – 27, 2001.

Queen Mary and Westfield College, London (Computer Science Dept., hôte: E. Robinson): "Unprovability and Prototype Proofs in Type Theory", January 18, 2002.

Universita' di Pisa, Pisa (Dip. di Informatica., hôte : G. Ghelli): "Indimostrabilita' "concreta" in Aritmetica e "giudizi geometrici"", February 19, 2002.

Colloque international **Cognition, Meaning and Complexity. Self-Organization in Cognitive Systems**, Universite' de Rome II, Rome: "Complexity as the nesting and interaction of levels of organization", June 14 – 15, 2002.

Colloque international **The cognitive foundations of mathematics** (Epistemology and Cognition as foundational issues in Mathematics), Villa Mirafiori, Univ. Roma I, Rome: "Naturalizing Mathematics: the cognitive roots of Mathematics' constructed effectiveness", September 9 – 10, 2002.

Colloque **Giulio Preti a trent'anni dalla scomparsa**, Castello Pasquini, Castiglioncello (LI) : "Rationality, computations and forms: a critique of a scientific experience/ Razionalita', calcoli e forme: riflessioni su una esperienza scientifica", October 17 – 19, 2002.

University of Nijmegen, Nijmegen, The Netherlands (Mathematics and Computer Science Depts., hôte : H. Barendregt): "Forms, Complexity and Information in some Natural Phenomena", December 9, 2002.

ENS, Paris (Séminaire "Formes Symboliques"; hôte: J. Lass 'egue): "Abstraction, symbolisme et rigueur : l'objectivité construite des Mathématiques", Salle des Actes 16h - 19h, December 17, 2002.

Incontro Annuale del **Progetto Cofinanziato "CoMeta - Computational Metamodels"**. Conferenziere straniero invitato: "Al di la' della codifica: un quadro concettuale per l'informazione e la complessita' nei fenomeni naturali", Venezia, December 19 – 21, 2002.

Universita' di Milano, Milano, (Dip. di Filosofia, hôte : R. Fabbrichesi-Leo): "Fondamenti delle Matematica e filosofia delle scienze naturali", January 27, 2003.

Tata Institute of Fundamental Research, Bombay, INDIA (School of Tech and Computer Science, host : R. Shyamasundar): Lecture I: "Reflections on concrete incompleteness". Lecture II: "Foundations of Mathematics and Philosophy of Natural Sciences", February 20 and 21, 2003.

International Conference on Theoretical Neurobiology, National Brain Research Centre, New Delhi, INDIA, invited lecture: "A conceptual frame for Complexity, Information and Causality", February 24 – 26, 2003.

Indian Institute of Technology, Delhi, INDIA (Dept. of Computer Science, host : S. Prasad): Lecture I: "Some topologies for computations." Lecture II: "Physical Space and Time and the Foundations of Mathematics", February 27, 2003.

Ministero degli Affari Esteri e CNR: convegno degli scienziati italiani all'estero, Roma, : "Riflessioni sulla diaspora scientifica italiana", March 10 – 12, 2003.

ENS, Paris (Laboratoire "La Pensée des Sciences"; hôte: C. Alunni): "Catégories et dynamiques de la pensée : l'importance d'un cadre conceptuel ouvert et quelques applications spécifiques", March 26, 2003.

Centro Enriques ed Universitá di Pisa, Livorno, "Matematica e scienze della natura, a partire da Enriques", April 4, 2003.

Workshop: **Mathématique, Informatique, Philosophie**, Univ. Paris VII et Paris I, Paris : "Discret vs. continu mathématiques et causalité physique", April 24 – 26, 2003.

Universita' di Pisa, International School of Graduate Studies, Pisa: "Intelligibility of Space, the Continuum and Theories of Knowledge", May 9, 2003.

Université de Marne la Vallée, (Dépts. de Mathématiques et d'Informatique; hôte: M. Cannone) , Marne la Vallée: "Le rôle de l'espace dans les fondements des mathématiques et de l'informatique", May 27, 2003.

Conference on **Cognition, Meaning and Reality**, Rome, invited lecture: "Mathematical structuring of causality", June 6 – 7, 2003.

European Software Engineering Conference and ACM SIGSOFT Symposium, Helsinki, Finland, invited lecture: "Complexity as nesting and interaction of organization levels in some natural phenomena", September 1 – 5, 2003.

Journée **Intrications philosophie - sciences de la nature**, ENS, Paris: "La philosophie des mathématiques : de la scholastique platonisme/formalisme une composante d'une philosophie de la nature", October 24, 2003.

University of Sao Paulo, Brasil, (Dept. of Computer Science,hôte : M. Finger): "A cognitive investigation of concrete incompleteness", November 3, 2004.

University of Campinas, Brasil, (Center for Logic and Cognition, hôte : W. Carnielli): "Some aspects of information and complexity in natural phenomena", November 5, 2004.

University of Rio de Janeiro, Brasil, (Dept. of Computer Science,hôte : I. de Castro Dutra): "On the formal unprovability of some provable properties of numbers", November 10, 2004.

Ramifications of Category Theory, a Workshop in honour of W. Lawvere, Universita' di Firenze: "Categories against the absolute: relitivising constructions and "l'esprit de géométrie"", November 18 – 23, 2003.

Incontro Annuale del Progetto Cofinanziato **CoMeta - Computational Metamodels**. Conferenziere straniero invitato: "Computer Modelling and Imitation in Natural Sciences", Udine, December 15 – 18, 2003.

King's College, London, (Computer Science Dept., hôte : T. Maibaum): "Computational vs continuous models and causal relations", January 28, 2004.

Incontro Annuale di **Didattica della Matematica**. Conferenziere invitato: "Linguaggio e gesto: dai fondamenti alla cognizione", Pisa, February 5 – 6, 2004.

Universita' di Milano, Milano, (Dipartimento di Filosfia, hôte : C. Sini): 1 - "L'incompletezza concreta dei formalismi logici ed il senso nel segno (matematico)"; 2- "Determinazione fisica e formalismi logici: da Laplace a Turing, passando per Poincare' (cenni ad una artificialita' incompleta)", March 10 – 11, 2004.

Journée **Intérêt de la notion de symétrie : comme paradigme interdisplinaire** , conférence invitée: "Symétries et structures causales", Paris, March 18, 2004.

Universita' di Roma I, Roma, (Dipartimento di Matematica, hôte : C. Berardi): "Fondamenti della matematica, fra processi cognitivi e filosofia della natura", May 4, 2004.

Journées sur la **Philosophie de la Nature : les mathématiques, la physique et la biologie en question** , conférence invitée: "Niveaux d'organisation et relations causales en science de la nature", Paris, May 13 – 14, 2004.

Conference on **Computing and Philosophy**, invited lecture: "Computer imitation and mathematical understanding", Pavia, Italie, June 3 – 5, 2004.

Colloque **Détermination et compléxité**: "Aléas, déterminisme et programmes: les enjeux du continu vs. le discret mathématique", Cérisy, Fr., June 22 – 29, 2004.

Conference on **Dynamic Ontology: an enquire into systems, levels of reality and causality**, invited lecture: "The structures of causality and computer vs. mathematical modelling", Trento, Italie, September 8 – 12, 2004.

Colloque **Non-linéarité, irréversibilité et complexité**, conférence invitée: "Complexité structurelle: le continu vs. le discret", Paris EHESS, October 7 – 8, 2004.

Conférence **Alan M. Turing, pour le cinquantenaire de sa mort**, conférence invitée : "De la difficulté de se mettre dans la peau d'un ordinateur: la Machine et le Vivant", Metz, October 15, 2004.

Convegno **Alan Mathison Turing. L'uomo, la macchina, l'enigma**, conférence invitée : "Dalla catastrofe della scrittura alla "Discrete State Machine": espressivita' e limiti del tagliare il mondo con l'accetta", Milano, November 3 – 4, 2004.

Imperial College, London, (Computer Science Dept., host : A. Edalat): "Continuous vs discrete dynamics; some history, some concepts, one theorem", January 26, 2005.

XXII incontro della **Associazione Italiana di Logica e sue Applicazioni (AILA)**, conferenza di apertura: "Dai fondamenti della matematica alle scienze della natura: l'importanza dei risultati negativi." Pisa, February 10 – 13, 2005.

Workshop on "**Theoretical Biology**", at the National Brain Research Centre, New Delhi, INDIA, invited lecture: "From local physical criticality to the extended criticality of life", February 14 – 15, 2005.

Journée sur **La preuve et le raisonnement : visualization et structures**, REHSEIS - CNRS, Paris, (organizateur : M. Panza): "Intuition et construction en mathématique", March 14, 2005.

Universita' La Sapienza, Roma, (Dip. di Informatica, ospite: S. Guerrini): "Calcolabilita' e dinamiche: predittibilita' vs. decidibilita'", March 18, 2005.

Colloque **Le logique et le biologique**, Paris, conférence invitée : "L'originalité de nos formalismes laplaciens vs. la criticité dynamique du vivant", April 22, 2005.

Colloque **A partir de l'Origine de la géométrie de Husserl**, Paris, conférence invitée : "Fondements des mathématiques: arithmétique vs géométrie, les enjeux pour une philosophie des sciences de la nature", May 14, 2005.

Colloque **La preuve mathématique : logique, histoire, philosophie**, Lille, invitation au débat: "L'incomplétude mathématique des formalismes et la complexité intrinsèque de la preuve", May 24 – 28 2005.

Ecole **Mathématiques et cerveau**, Paris, coordination et introduction au débat: "Mathématiques, cognition et espace", June 14, 2005.

Colloque **Intelligence de la complexité : science et pragmatique**, Cerisy, conférence invitée : "Complexité critique : le discret vs. le continu mathématiques", June 23 – 30, 2005.

Laboratoire de Génomique Fonctionnelle (CNRS et Université Pierre et Marie Curie, hôte: C. Auffray), Villejuif : "L'incomplétude causale du paradigme du programme génétique et la singularité physique du vivant", September 29, 2005.

Colloque **Turing, Goedel et Von Neumann: entre logique et biologie**, Nice, conférence invitée : "Turing et Goedel au milieu du gué : de la détermination laplacienne vers la

morphogénèse et le sens", November 9 – 10, 2005.

Laboratoire de Neurosciences Cognitives (LENA, CNRS et la Salpétrière, hôte: S. Baillet), Paris : "Imitations et modèles : le cerveau à la Turing et la situation critique du vivant", November 28, 2005.

Leiden University, Leiden (NL), (Biology Dept., host : H. van Mill): "Extended critical situations: physical causality vs. singularity and autonomy of life", January 10, 2006.

Universita di Siena, Siena, (Dip di Matematica, host : A. Ursini): "Da Poincare' a Turing: l'impredittibilita' dei sistemi dinamici e l'indecidiblita' computazionale sono nozioni correlate?", February 20, 2006.

Convegno sul **Rilievo culturale della Matematica**, Accademia di Livorno e centro F. Enriques, Livorno, conferenza su: "Fondamenti della matematica, fra processi cognitivi e filosofia della natura, a partire da Enriques", March 23 – 25, 2006.

Conference **Logic, Models and Computer Science**, Camerino, invited lecture: "Physical Determination, Unpredictability and Undecidability in Critical Processes", April 20 – 22, 2006.

ENS, Paris, **Séminaire interdisplinaire: La passerelle des Arts** : "Dynamiques de pensée en mathématiques: principes de preuve vs. principes de construction", Salle des Actes, 10h, April 29, 2006.

ENS, Paris **Séminaire "Formes Symboliques**; hôte: J. Lassègue : "Mathématiques et sciences de la nature. La singularité physique du vivant", au 45, salle des Résistants, 14h - 17h, May 2, 2006.

EHESS, Paris, Journée **Interfaces géométrie, physique et biologie** : "Géométrie du temps biologique", June 8, 2006.

Universita' di Torino, Torino, (Dip di Informatica, host : M. Dezani): "Correlazioni fra impredittibilita' dinamica ed indecidiblita': alcuni concetti, a partire da Poincaré, ed alcuni risultati recenti su dinamiche unidimensionali", June 23, 2006.

Colloque/Ecole **Logique et Interaction: vers une géométrie du cognitif**, Cerisy-la-salle : "Structures causales et géométrie du temps biologique", September 19 – 26, 2006.

Convegno di **Neurofenomenologia**, Milano: "Processi cognitivi e la ragionevole efficacia della Matematica", October 4, 2006.

Convegno franco-italiano: **Continuo e discreto**, Gargnano (Milano, It.) : "La determinazione fisica ed il continuo matematico (discussione)", October 5 – 7, 2006.

Université de Orsay, Orsay, (Dept d'Informatique, Grand Séminaire): "Que nous dit l'ordinateur du monde : entre informatique et sciences de la nature", October 11, 2006.

Università di Pisa, Pisa, (Lezione Galileana): "Dall'informatica alla biologia: la singolarità fisica del vivente", October 25, 2006.

Colloque : **Federico Enriques et la science européenne**, Paris : "Principes de construction entre arithmétique et géométrie", December 8, 2006.

Colloque de biologie théorique : **A quoi sert la modélisation ?**, Centre Cavallès, Paris : "Imitations, modèles, schèmes", January 23, 2007.

Université de Nice, Nice, (Séminaire interdept., hôte : J. Kouneiher): "La question de la modélisation et la singularité physique du vivant", February 6, 2007.

Athens University, Athens, (Graduate Program in Logic, host : C. Dimitracopoulos): "Undecidability in Logic vs dynamical unpredictability", February 19, 2007.

Conference: **Mathematics and Truth: Fundamental Issues in Logical Research**, Pisa: "From Logic to the Natural Sciences: knowledge constructions and mathematical models", March 28, 2007.

Conference: **Deduction, Computation, Experiment. Exploring the notion of proof and model**, Bologna: "Processes as Deductions and Programs, a successful paradigm for Computing, a misleading metaphor in Molecular Biology", April 3 – 4, 2007.

Journée : **Schématiser la constitution de l'espace (et du temps)**, Collège de France, Paris: "Schèmes spatiaux du temps, continuité temporelle de l'espace", April 5, 2007.

Journée : "Epistémologie et mathématiques des systèmes complexes", CREA, Paris : "De la critique des principes physico-mathématiques aux changements de regard et d'espace des phases en biologie", June 5, 2007.

Colloque : **La question des enchevêtrements hiérarchiques, en mathématiques et en biologie.**, Nice : "Différences et analogies entre autoréférences logiques et enchevêtrements-bouclages causaux chez le vivant", June 7 – 8, 2007.

France Culture: **Présentation du livre avec Francis Bailly**, Radiofrance, Paris: "Mathématiques et sciences de la nature. La singularité physique du vivant", June 14, 2007.

Conference: **From Type Theory to Morphological Complexity: A Colloquium in Honor of Giuseppe Longo**, CNAM, Paris: "From exact sciences to life phenomena: a few concluding remarks on Bohr and Schrödinger", June 28 – 29, 2007.

The 2007 meeting: **ISHPS Studies in Biology**, Exeter (GB): "From the "DNA is a Program" paradigm towards the role of randomness and extended criticality in Biology", July 25 – 29, 2007.

Simposio: **Fondamenti delle Scienze: settorializzazione e unitarietá della conoscenza**, Arcidosso: "Critica dei principi delle scienze esatte e riflessioni teoriche in biologia", 6-8 settembre, 2007.

Conference: **Types and Computations**, Roma: "Symmetries in Foundations", October 3, 2007.

Rencontre publique: **La révolution numérique : écriture, monnaie, information**, Palazzo Farnese, Ambassade de France, Roma : "L'ordinateur et les sciences de la nature/La macchina digitale e le scienze della Natura", October 5, 2007.

Conference: **Logica e...**, Pisa: "La Logica, i Programmi ed il DNA", October 19, 2007.

Conference: **Neurophysiological memory: time and space**, Strasbourg: "Geometric schemes for retension, protension and biological rhythms over physical time", October 23, 2007.

Dipartimento di Informatica, Univ. Firenze, (Séminaire interdept., hôte : R. De Nicola): "Il DNA e' un programma?", 11h 30, October 25, 2007.

Conference: **Logica e...**, Pisa: "La Logica, i Programmi ed il DNA", October 26, 2007.

Rehseis, Paris, : "Poincaré, Goedel et l'ADN : questions de détermination et de formalismes", 17h, November 20, 2007.

Centre Cavaillès, ENS, Paris, : "Critique de la raison physico-mathématique en sciences du vivant. Quelques extensions théoriques du physico-mathématique", 13h30, November 21, 2007.

Convegno: **Il filosofo e le pratiche scientifiche**, Milano: "L'elementare complesso e l'etica della conoscenza", December 5, 2007.

Colloque 2007 du **Groupe "Logique et Interaction: vers une géométrie du cognitif**, Roma: "Poincaré, Goedel et l'ADN", December 13 – 16, 2007.

Conference: **Type Theory, Lambda Calculus and Life**, Neijmegen (NL): "DNA, differential methods and the Boehm-out technique". (Personal attendance cancelled, but text in the proceedings).

Centre de Mathématiques Appliquées, EHESS (hôte : H. Berestycki), Paris, : "Quelques résultats négatifs, l'incomplétude et la modélisation " (avec T. Paul), 15-18h, January 22, 2008.

Convegno: **La vita come fenomeno globale multilivello: origini, emergenze, evoluzioni**, Bergamo (It.): "La singolarita' fisica del vivente, entropia negativa e criticita' estesa ", February 27, 2008.

Dipartimento di Filosofia, Universita' di Pavia (hôte : L. Magnani), Pavia, : "L'importanza dei risultati negativi. Comparazioni inter-teoriche di grandi programmi scientifici errati.",

April 3, 2008.

Colloque: **La thèse de Church hier, aujourd'hui, demain**, Paris : "L'arithmétique vs. l'enjeu du mobile et de la mesure", April 11, 2008.

Dipartimento di Filosofia, Universita' di Roma I (hôte : E. Gagliasso), Roma, : "I miti alfabetici della logica e del programma, in cognizione e biologia", 14h, April 21, 2008.

Colloque: **Enchevêtrements et action du temps dans les systèmes vivants**, Nice : "L'organisation comme anti-entropie et la double irréversibilité du temps biologique", June 4 – 6, 2008.

Workshop : **XXVIIIème Séminaire de la Société Francophone de Biologie Théorique** , Saint-Flour (Cantal, France) : "Géométrie du temps biologique", June 8 – 11, 2008.

Conference: **Values and Logic in I. Royce**, Opole (Poland): "The role of order, relational invariants and infinity in modern foundations of Mathematics: some reflections following Royce", June 24 – 28, 2008.

Colloque: **Temps Long. De la physique aux sciences humaines**, ENS, Paris : "L'aléatoire à temps court, long et infini", September 25 – 26, 2008.

Colloque: **Négation, Dualité, Polarité** du Groupe LIGC, Carry le Rouet (Marseille) : "Antinomies et polarités dans les analyses de l'état vivant de la matière", October 16 – 19 2008.

Colloque international: **Science, épistémologie, société**, Venezia : "L'activité du vivant dans l'espace: des fondements cognitifs des mathématiques aux dynamiques biologiques", October 29 – 31, 2008.

Colloque : **Maladies multifactorielles et état de santé qui les précède : comprendre l'interface, challenge de la médecine préventive du 21e siècle**, Paris : "Organisme/organes : schèmes abstraits d'intégration/régulation dans un état critique étendu", November 15 – 16, 2008.

Convegno : **Metafore del vivente**, Roma : "L'informazione in Biologia: dal modello matematico al fascino discreto della metafora", November 27 – 29, 2008.

35th International Conference on: **Current Trends in Theory and Practice of Computer Science**, Spindleruv mlyn (Czech Republic): "Randomness and determination in Computing and Physics. Some reflections on Biology.", January 24-30, 2009.

19 World Conference on: **Proof and Proving in Mathematics Education**, Taipei (Taiwan): "The constructed objectivity of Mathematics and its cognitive roots", May 10-15, 2009.

Convegno sul: **Naturalismo e antinaturalismo**, Firenze (It): "Dall'alfabeto al senso: verso i fondamenti cognitivi della matematica e verso una matematica dello stato vivente della materia", May 28 – 29, 2009.

Convegno: **Quale scienza per quale societa'**, Palazzo Ducale, Lucca (It), sezione Pensare la scienza: "La scienza di fronte al limite: l'importanza scientifica, etica e politica dei risultati negativi", June 25 – 26, 2009.

The 2009 meeting: **ISHPS Studies in Biology**, Brisbane (Australia): "Complexity and Evolution, an analysis in terms of Entropy production", July 12 – 16, 2009.

Second Workshop on: **Informatic Phenomena**, *Information beyond Informatics*, New Orleans (USA): "Information in Biology : metaphor or model? Anti-entropy and a model of phenotypic complexity along Evolution", October 5 – 9, 2009.

School of Engineering and Applied Sciences, Harvard University, Boston, USA (host: D. Weitz): "Building bridges: from the Mathematics of Information to Biological Organization", at 14h, October 14, 2009.

Baxter Lectures 2006-2009: **1809-2009. Il futuro di Darwin**, Pisa, It.: "Complessita' degli organismi, Evoluzione delle specie ed ... equazione di Schrödinger", November 27 – 28, 2009.

Conférence: **Visualisation et mathématisation**, Université de Liège, Be.: "*Voir* les mathématiques, des fondements aux applications", December 3 – 4, 2009.

Convegno: **Nature, Selection and Biology**, Firenze, It.: "La singolarita' fisica dello stato vivente della materia", December 4 – 8, 2009.

Ceperc, CNRS, Aix en Provence (host: P.-A. Miquel): "Criticité étendue et cycles biologiques", December 16, 2009.

Institut d'Etudes Avancées, Nantes (host: A. Supiot): "Penser et prouver en mathématiques et en physique. Et en biologie?", February 9, 2010.

Convegno in **memoria di: Aldo Gargani**, Pisa: "La critica dei fondamenti e le correlazioni fra saperi scientifici", March 2, 2010.

Conference in **honor of: Erwin Engeler's 80th birthday**, the Swiss Logic Society, Berne, Switzerland: "From Logic to Randomness and Organization, as Anti-entropy, in Darwin's Evolution", March 4-5, 2010.

Ecole Interdisciplinaire de biologie, Berder, Fr.: "L'information et ses théories, de Turing à Chaitin. Et en biologie?", March 29 – April 2, 2010.

Conference: **Models of Cognition**, Roma, It.: ""Protension and biological rhythms", May 14 – 15, 2010.

Philmath Intersem 2010, Paris (host: M. Detlefsen): "Symmetries and principles of constructions, from Mathematics towards Biology", March 11, 2010.

Summer School: **Biology and Cognition**, San Sebastian, Spain: "Biological and Cognitive Times", June 22 – 26, 2010.

Conference: **Computability in Europe**, Ponta Delgada (Azores), Portugal: "Incomputability in Physics and in Biology", June 30 – July 5, 2010.

Conference: **11th International Symposium on Frontiers of Fundamental Physics**, Paris: "Some Mathematics for Biological Theories: Randomness and Organisation, as Anti-entropy, in Darwin's Evolution", July 6 – 9, 2010.

Journée: **Simplicité – complexité du vivant** (au tour du livre de A. Berthoz), Collège de France, Paris: "La complexité du temps et la simplicité de l'action protensive du vivant", September 28, 2010.

Seul National University, Seul, Korea (host: Sh. Kim): "The physical singularity of life phenomena", November 2, 2010.

KAIST (Korea Advanced Institute of Science and Technology), Daedeok Science Town, Daejeon, South Korea (host: Woosuk Park); "Foundational analyses in science and conceptual crossing-over", November 5, 2010.

Université Paris XIII, Paris (dépt d'Informatique, host: S. Guerrini); "Une critique de la notion d'information en biologie et un modèle de la complexité phénotypique au cours de l'évolution", November 29, 2010.

Convegno: **Filosofia e Biologia**, Universita' di Bologna, Forli' ; "Dai fondamenti della matematica ai fondamenti teorici della biologia", December 3 – 4, 2010.

Deuxième rencontre: **PhénoMath: Concepts purs / Concepts appliqués**, Nice : "Le geste, la trajectoire et l'infini dans la constitution de l'objet mathématique", December 9 – 10, 2010.

Interview, **France Culture**, La place de la Toile : Ã 17h : " Alan M. Turing", December 26, 2010.

Espace Mendès France, Poitiers (hôte : A. Bonnefoy): "Brève histoire de l'infini, du continu et du discret", January 11, 2011.

Université Montpellier 2, Montpellier (Dépt. de mathématiques ; hôte : V. Durand-Guerrier): "La preuve et le sens dans les fondements des mathématiques", le 17 février; une rencontre avec les doctorants et discussion au sujet du **cours vidéo-enregistré** "Six leçons sur l'indécidabilité logique et l'aléatoire physique", February 18, 2011.

Universita' di Verona, Verona (It.), Manifestazione pubblica: Infinita ... mente: "Sapere dire 'no' in scienza, o l'importanza dei risultati negativi", March 19, 2011.

Ecole normale supérieure, Paris (Centre Cavaillès) : "Symétries et dualités : de la physique Ã la biologie par extensions théoriques", April 6, 2011.

Workshop: **The concept of Interaction: Biology, Logic and Philosophy**, Univ. Roma III, Roma : "Ever since Darwin: conceptual oppositions in Biology", April 27, 2011.

Convegno: **Il benevolo disordine delle stato vivente della materia**, Pisa : "Simmetrie ed aleatorio in biologia", April 29, 2011.

Atelier: **Information et stochasticité en biologie**, Paris : "Codages, codages, codages ... les mythes du signal alphabétique et de l'information sans forme", May 4 – 6, 2011.

Workshop: **Self-Organization in Biology: Scope and Limits**, Aix-en-Provence: "Symmetries and symmetry-breakings in extended criticality", May 24 – 25, 2011.

Tufts University School of Medicine, Boston (Department of Anatomy and Cell Biology; host: A. Soto): "Information in Biology ?", June 7, 2011.

Brown University, Providence, RI, USA (Department of Computer Science; host: C. Kenyon): "Asymptotic (algorithmic/ergodic) Randomness vs. Randomness in Natural Sciences", June 9, 2011.

Interview, **National Public Radios**, U. S. A. : Science and Philosophy: "Are Financial And Scientific Views Of the World Related?" posting of June 13, 2011.

Journée: **Concepts**, Paris : "Symétries, entre mathématiques et sciences de la nature: un concept? une Gestalt?", June 29, 2011.

Convegno: **Possibilita' e determinazione**, Pisa : "Dalla determinazione dei sistemi di riferimento in fisica all'aleatorio biologico: quali evoluzioni possibili dell'eco-sistema?", September 19, 2011.

Incontro con: **M. Buiatti e G. Longo**, Universita' La Sapienza, Villa Mirafiori, Roma : "Ripensare la logica del vivente", 21 settembre, 2011.

Workshop: **The poised realm, between Physics and Biology**, Burlington, (Vermont, USA) : "Biology and the undefiniteness of the space of possibilities", October 1 - 2, 2011.

McGill University, Montréal, Canada (Department of Mathematics; host: R. Seely): "From Algorithmic Randomness to Randomness in Natural Sciences", October 4, 2011.

Colloque: **Le hasard au coeur de la cellule**, Lyon : "Aléatoire et irreversibilité du temps, physique/biologique", November 21 – 23, 2011.

Conference: **Theoretical Computer Science and Applications**, Auckland, New Zealand: "Interfaces of Randomness", February 21 - 24, 2012.

Colloque, **La temporalité en biologie**, Paris: "L' irreversibilité propre du temps biologique : protension et rythmes comme organizateurs de l'action, face à l'aléatoire", March 29 – 30, 2012.

Atelier Morphologie, **ENSAD**, rue d'Ulm, Paris: "A. M. Turing : les calculs et les formes", April 2 – 3, 2012.

Universita' di Firenze, Dipart. Filosofia (ospite: R. Lanfredini), Firenze: "Il vivente e' sempre "in transizione critica" ed in non-predefinibile spazio dei possibili. Quale teoria allora per la singolarita' fisica dello stato vivente della materia ?", April 24, 2012.

Conferenze pubbliche, 100 anni di A. M. Turing, 10 anni di S.J. Gould, La Limonaia, Pisa: alle 11: "A. M. Turing: la macchina a stati discreti, le dinamiche continue delle forme ed il caso"; dalle 15 alle 17, con M. Buiatti: "A partire da S.J. Gould: l'evoluzione del vivente, fra salti e caso", April 27, 2012.

Conference, **Stephen J. Gould heritage: Nature, History, Society**, Venezia, It.: "Randomness increases biological organization : a mathematical understanding of Gould's critique of evolutionary progress", May 10 – 12, 2012.

Workshop, **La Simplexité**, Paris: "Un grand enjeu de l' évolution: la simplification des bauplan, la complexification du phénotype", May 23 – 24, 2012.

Institut d'Etudes Avancées, Nantes, workshop: "Epistémologie, biologie, medecine", May 30 – 31, 2012.

Workshop of **The Turing year: The Incomputable**, Isaac Newton Institute programme - "Semantics and Syntax: A Legacy of Alan Turing" (SAS), Chicheley Hall, GB: "Turing, from the "Discrete State Machine" to the Òexponential driftÓ in continuous dynamics", June 12 – 15, 2012

King's College, London (Department of Computer Science; host: M. Fernandez): "A. M. Turing: from the "coding" of the human computer to the "genesis" of forms", June 18, 2012.

The Turing Centenary Conference (CiE 2012), Computational Models After Turing: The Church-Turing Thesis and Beyond, Isaac Newton Institute programme - "Semantics and Syntax: A Legacy of Alan Turing" (SAS), Cambridge: "Computing? a machine imitating a man who is playing an alpha-numeric game", June 19 – 23, 2012

Conférence grand public (organisée par l'ENS de Lyon), Turing: 100 ans, L' héritage de Alan Turing, ou comment la machine universelle a bouleversé notre société, Lyon: "A. M. Turing: de la machine à états discrets au modèle des dynamiques continues des formes", July 2, 2012.

Conférence grand public, Il Limite, Universita' e Comune di Torino: "La matematica, come scienza "al limite"", July 3, 2012.

Rencontre "PhénoMath": **Les mathématiques et la philosophie du presque**, Paris ; "Les fondements des mathématiques, entre le Scylla du "presque" dans la mesure physique et le Charybdis de l'indécidabilité logique", July 5 – 6, 2012.

European Logic Colloquium 2012, Manchester, GB: "Schrödinger (1944) and Turing (1952) on the Logic of Life: from the "coding" to the "genesis" of organization and forms.", July 12 – 18, 2012

Conférence grand public (organisée par le LORIA), La naissance de la Machine, Nancy: " De Goedel à Turing ou l'importance des résultats négatifs", September 13, 2012.

Tufts University School of Medicine, Boston (Department of Anatomy and Cell Biology; host: A. Soto): "Biological observables and "default states"", September 19, 2012.

NECSI - MIT, Cambridge, USA (host: Yanner Bar-Yam): "The Physical Singularity of the living state of matter: Symmetries and symmetry breakings, in Physics vs. Biology", September 20, 2012.

Scuola Normale Sup., Pisa, It. (ospite: M. Mugnai): "Turing: dalla Macchina alla morfogenesi o l'importanza dei risultati negativi", October 2, 2012.

Universita' di Roma III, Roma, It. (ospite: T. Numerico): "Turing: la macchina, l'imitazione della donna ed i modelli del vivente, ", 11 ottobre, ed incontro con M. Buiatti "Biologia fra scienza e metafore sociali" Registrazione Video, October 15, 2012.

Seminario Enriques, Milano, It. (Dipartimento di Matematica, ospite: U. Bottazzini): "Turing, fra l'artificiale ed il vivente: dal formalismo alla dinamica delle forme, la ricchezza dei punti di vista di un matematico molto originale", October 22, 2012.

Universita', Verona, It. (Conferenza pubblica, ospite: R. Giacobazzi): "I fondamenti della matematica, fra fisica e biologia", December 6, 2012.

Ens, Centre Cavaillès, Paris: "Aléatoire, irréversibilité du temps et imprédictibilité", 13h30 - 15h, January 30, 2013.

CNAM, Centre des systèmes complexes, Paris: "Echanges autour de "L'espace-temps en physique et en biologie", chapitre 3 du livre Bailly-Longo", 14h30-16h30, February 18, 2013.

Workshop, Origin of Life, CERN, Geneva, CH: "The Necessity of Contingency", February 26-28, 2013.

Ens, Séminaire Philosophie et Mathématiques, Paris: "Croisements aléatoire physique / incomplétude mathématique: Poincaré, Gödel, Monod". Texte de référence: Interfaces de l'incomplétude, March 11, 2013.

University College London, Bartlett International Lecture Series, London, GB: "Modelling: randomness makes the difference", March 15, 2013.

Convegno, Poincaré (1854-1912) a centouno anni dalla scomparsa, Università Roma 2, Roma, It.: "Aleatorietà e determinazione, necessita' e contingenza. L'insegnamento di Poincaré e la sua difficile assimilazione", March 21, 2013.

Ecole de Berder, Corrélation, causalité et régulation en biologie, Berder, Fr.: "Les causes et les possibles, entre physique et biologie", April 9 – 12, 2013.

Groupe, Evolution, Museum Nat. Histoire Naturelle, Paris: "Une critique de l'information: évolution de la complexité et de l'organisation biologique", April 23 – 25, 2013.

Symposium, Academia Europaea, Wenner-Gren Center, Stockholm, Sweden: "Science in our relational humanity: critical insights and knowledge construction", May 23 – 25, 2013.

Istituto Studi Avanzati (ISA), Bologna, It., (host: S. Martini) maggio e giugno 2013, ciclo di seminari: - Informatica: "Schrödinger (1944) e Turing (1952) sulla logica del vivente: dalla "codifica" alla "genesi" dell'organizzazione e delle forme", 8 maggio; - Filosofia: "Simmetrie e rotture di simmetrie: per una epistemologia all'interfaccia delle discipline", 16 maggio; - ISA: "The Relevance of Negative Results: Incomputability and Undecidability in Physics and in Biology", 21 maggio; - Istituto Ramazzini per i tumori e le malattie ambientali: "Caso e diversità in biologia: raffrontando complessità e organizzazione funzionale", 5 giugno; - Matematica (host: G. Citti): G. Longo (CNRS-ENS, Paris) e A. Sarti (CNRS-EHESS, Paris): "Discussione a piu voci: Rotture di simmetrie, dinamica di forme e singolarità fisica del vivente", 11 Giugno; - Filosofia (host: G. Pancaldi): M. Buiatti (Biologia, Firenze) e G. Longo (CNRS-ENS, Paris), intorno al loro articolo: "Randomness and Multi-level Interactions in Biology", 18 giugno.

4th International Workshop on Interactions between Computer Science and Biology (CS2Bio), Firenze, It.: "Randomness, variability and diversity in biological dynamics", June 6, 2013.

Conference, Thinking Shadows (Philosophy of Memory and Morphogenesis), Bologna, It.: "The shadows of lines and the dynamics of forms", June 13 – 14, 2013.

Groupe, Evolution, Arcachon: "Information, biologie, evolution", July 1 – 3, 2013.

Conference, PROTO/E/CO/LOGICS 2013, Srebreno, Croatia: "The architecture of biological time", August 24 – 25, 2013.

A scientific meeting In honor of Pierre-Louis Curien, Venezia, It.: "Is the Full Grace of the Madonna an actual infinity? Perspectives in Mathematics and in Biology", September 9 – 11, 2013.

City University New York (Computer Science Dept., host: R. Parikh), New York: "Schrödinger and Turing on the logic of life: from the "coding" to the genesis of forms", September 24, 2013.

Miguel Abreu Gallery, (Sequence Press: Lecture and discussion introduced by R. Mackay), New York: "The Invention of Space: from Metaphysics to Human and Biological Spaces, via Paintings", paper, video recording, September 26, 2013.

Tufts University (Anatomy and Cellular Biology Dept., host: A. Soto), Boston: "Contingency and diversity in biology: from anatomical complexity to functional organization", October 2013.

Colloque, Naturaliser le modèle, Chambord, Fr.: "Le modèle comme regard organisateur du réel", October 25, 2013.

Groupe, Evolution, Paris : "Diversification, hasard, evolution", November 5 – 8, 2013.

Berlin Doctoral School of Mind and Brain, Berlin, D. (host: M. Chaumon): "Modelling in natural sciences: continua vs discrete or the necessity of contingency", November 14, 2013.

Dipartimento di Filosofia, Universita' di Roma I (ospite: E. Gagliasso), Roma, : "Le simmetrie come principi di costruzione e di intelligibilita', in matematica ed in fisica ... ed in biologia?", November 18 – 19, 2013.

Dipartimenti di Filosofia e di Matematica e Fisica, Universita' di Roma III (ospiti: T. Numerico, M. Abrusci), Roma, : "La memoria ed la costruzione del "senso" in matematica", 20 novembre, e "Cambiamenti di simmetrie ed aleatorio: dalla fisica alla biologia", November 22, 2013.

Workshop, Epistemologia della matematica, Faenza: "Interfacce fondazionali e risultati negativi: il ruolo del sapere critico", November 23 – 24, 2013.

Institut d'Etudes Avancées, Nantes, exposés et projet de recherche : "La construction du sens et de l'objectivité scientifique: entre histoire et épistémologie" (présentation video, 15 min), from January to March, 2014.

Université de Nantes - INRIA, LINA, (hôte: N. Tabareau) Nantes: "L'aléatoire: physique, biologique, computationnel" (enregistrement video), March 26, 2014.

Conference, A plea for balance in Philosophy: essays in Honour of Paolo Parrini, Firenze: "Towards an epistemology of new interfaces: mathematics, physics, biology", April 15, 2014.

Università di Firenze (Dipartimento di Filosofia) e Scuola nazionale COOP, Firenze: "Teoria e filosofia del tempo biologico" e "Il senso dell'organicità", April 14 – 16, 2014.

Incontri, Dalla malattia alla "grande salute", Centro espositivo museale, S. Michele degli Scalzi, Pisa: "Organismo ed evoluzione biologica: come uscire da metafore fuorvianti ed integrare una teoria dell'organismo in quella dell'evoluzione?", April 23, 2014.

Université de Nice, Séminaire de philosophie des sciences, Nice: "La théorie, le modèle, le réel", May 19, 2014.

Ecole de printemps, Le Vivant Critique et Chaotique, Société Francophone de Biologie Théorique (SFBT), Saint Flour, (Fr.) : "Changements critiques de symétrie et aléatoire : quelques aspects biologiques", May 21 – 25, 2014.

Colloque, Epistémologie de l'informatique et de la numérisation, les conséquences en science de l'homme et de la nature, Paris: "La machine, sa logique, sa physique: du dualisme informationnel à un nouveau monisme sans matière", June 30 – July 2, 2014.

Conference, Luca Cardelli Fest (Informatics and Bio-informatics), Cambridge: "What happened after LUCA?", September 8 – 9, 2014.

Ens, Séminaire de la Chaire B. Pascal, Paris : "Logique et épistémologie de l'espace: de la "prospettiva" aux espaces théoriques de la biologie", September 30, 2014.

Rencontres Glass Bead (www.glass-bead.org), Paris : "La constitution du sens: des structures des mathématiques aux organismes (e ritorno)", October 3 – 4, 2014.

Ecole d'architecture Paris-Malaquais (hôte : P. Morel), Paris : "Modèles et simulations : le jeu continu discret et les brisures de symétries", October 9, 2014.

Colloque, L'évaluation face aux enjeux globaux: biologie, techniques et vulnérabilités, Paris: "Aléatoire, historicité et complexité biologique", October 14, 2014.

Universita' di Roma 2 ed 1, Dipartimenti di Filosofia e Centro Cognizione-Linguaggio-Conoscenzza, Roma 2 (ospiti: Perilli, Gagliasso), Roma, 23 - 29 ottobre : 23 "La Macchina a Stati Discreti: conseguenze scientifiche della "metafora digitale"" (CLaC), 28 "Il ruolo della storia nella determinazione del futuro in biologia" (Roma 1), 29 "Lo spazio e gli a priori, in fisica, in biologia", October 2014.

Universita' di Pisa, Dipartimento di Matematica (ospite: Maffei), Pisa : "L'invenzione dello spazio", October 30, 2014.

Université de Fribourg, Ecole Doctorale Suisse Occidentale, Fribourg : Série de séminaires "Modèles et méthodes : du computationnel au vivant", November 19 – 21, 2014.

Colloque, Entretiens du nouveau monde industriel, Centre Pompidou, Paris : "La machine à états discrets, sa logique, sa physique: du dualisme informationnel à un nouveau monisme sans matière", December 5 – 6, 2014.

University of Macau, Macau (China): Three lectures: "From computational formalisms, to biophysics and to the relevance of history in biological evolution", December 9 – 12, 2014.

Auckland University, Auckland, New Zealand (Dept. Informatics: C. Calude, host): "Classical, quantum and biological randomness", January 7, 2015.

Universidad Andres Bello, Santiago, Chili (Departmento de Matematicas: C. Rojas, host): "From physical to biological randomness: its role in enhancing life diversity and stability", January 13, 2015.

Series Digital Studies, Salle Triangle (Centre Georges Pompidou, Paris): "A partir de "L'origine de la géométrie" de Husserl", January 27, 2015.

Colloque, Le vivant et sa représentation: usages de l'image dans les sciences de la vie, Liège, Belgique: "Des dynamiques évolutives aux diagrammes de contraintes pour l'ontogenèse à la Montévil et Mossio", April 1, 2015.

Conference, Blaise Pascal Chair, Paris: "Conceptual dualities at the interfaces Mathematics/Physics/Biology", May 6 – 7, 2015.

Université Paris I, IHPST, Paris : "Modèles vs. simulations: cadres philosophiques et comparaisons techniques - le rôle des symétries", May 11, 2015.

Convegno in onore di Marco Forti, Pisa: "Il "senso delle strutture", dalla matematica agli organismi", May 22 – 23, 2015.

Goldsmiths University, London (host: L. Parisi): "What do equations and computations do?", June 2, 2015.

Conference, Model Based Reasoning, Sestri Levante, Italy: "Models vs. Simulations: a comparison by their Theoretical Symmetries", June 25 – 27, 2015.

Conference, Unconventional Computation and Natural Computation 2015, Auckland, New Zealand: "The unconventionality of nature: Biology from Noise to Functional Randomness", August 31 – September 4, 2015. (Video recording)

European Conference on Pragmatism on "Gesture, reasoning, mathematics", Paris: "The use of "geometric judgments" as meaningfull gestures in space and time in the proofs of recent unprovable propositions of Arithmetic", September 9 – 11, 2015.

Colloque, Diversité biologique et résilience dynamique des systèmes complexes organisés multi-échelles : du système immunitaire aux macro-écosystèmes, ISC, Paris: "Comment le futur dépend du passé dans les systèmes du vivant", October 12 – 14, 2015.

Colloque, "Lois des dieux, des hommes et de la nature", IEA, Nantes: "Introduction au colloque : Le rôle de l'histoire: biologie vs. sciences humaines et l'idéologie des Big Data", October 15 – 16, 2015.

Universita' di Firenze, Dipart. Filosofia (ospite: R. Lanfredini), Firenze: "Costruzioni di conoscenza: fenomenologia dell'interazione matematica/fisica/biologia", October 26, 2015.

CAPHES, Ens, Paris, "L'espace comme carrefour épistémologique et phénoménologique": "Symétries et mesures en sciences de la nature, à partir de H. Weyl", November 13, 2015.

Colloque, "Du web sémantique au web herméneutique", Centre Pompidou, Paris : "De la mesure physique au dénombrement : les très grandes bases de données et les régularités sans sens", December 14 – 15, 2015.

Colloque, "La liberté de l'improbable", Collège de France, Paris : "Histoire et créativité ou l'aléatoire sans probabilités", Decembre 15, 2015.

Goldsmiths University, London (host: L. Parisi): "Classical, Quantum and Biological Randomness: on causality and continua", January 14, 2016.

Workshop, "Morphology at the crossroads of the empirical, the formal and the logical", Lisboa, Portugal: "Le ""savoir-être" qualitatif dans les phénomènes" comme a priori de la modélisation quantitative des formes", February 10 – 12, 2016.

Scuola invernale, "Scienza e società", Rivarolo (To), Italie : "Considerazioni scientifiche contro lo scientismo, oggi", February 26 – 28, 2016.

INS HEA, Strasbourg: Séminaire: Images des savoirs pratiques: "Informatique: origines logiques et images du monde ", April 25, 2016.

Thematic trimester, "Current Issues in the Philosophy of Practice of Mathematics and Informatics", Toulouse, France : "Counting vs. measuring: the foundational turn and some of its scientific consequences", May 25 – 27, 2016.

IMERA, Université Aix-Marseille: Séminaire : "Modèles et théories : du physique au biologique", May 31, 2016.

Conference, "Building Theories, Sciences and Hypotheses", Roma: "Theoretical challenges in biology: from cancer to organisms", June 16 – 18, 2016.

Colloque, "Sciences de la vie, sciences de l'information", Cerisy-la-Salle : "L'information sans sens ni structures", September 19 – 26, 2016.

Giornata di studi, "Esperienze della continuità", Verona: "La misura e la questione dell'"accesso" ai fenomeni: il discreto e la frattura cognitiva con il reale", November 3 – 4, 2016.

Colloque, "La liberté de l'improbable", Collège de France, Paris : "Histoire et créativité ou l'aléatoire sans probabilités", November 29, 2016.

Universita' di Firenze, Dipart. Filosofia (ospite: R. Lanfredini), Firenze: "L'importanza del qualitativo nell'era del digitale", November 30, 2016.

Conference, "Revisting Nature: a dialogue among forms of knowledge", Firenze: "Conceptual dualities in physics vs biology and their role in relating phylogenesis and ontogenesis", December 1 – 3, 2016.

Centre Pompidou, Les entretiens du nouveau monde industriel, Paris : "La machine à états discrets et les images du monde", December 13, 2016.

EHESS, Paris: Séminaire: Morphodynamiques : "Comment le futur dépend du passé et des événements rares dans les systèmes du vivant", January 9, 2017.

Conference, "Sliding Doors: Prediction and Contingency in bio-sciences. 20th Res Viva's anniversary", Roma: "Historicity in Biology. The peculiarity of "Principles" and of Randomness from Darwin to a possible Theory of Organism", February 2 – 4, 2017.

Conference, "Mathematical models and previsions, use and abuse in natural and human sciences", Vidéo de la "Table ronde de présentation du colloque" (38 minutes), IEA (G. Longo, organizer), Nantes: "L'importance des résultats négatifs ... pour des théories solides. Les théories floues de l'information biologique: le cas du cancer", February 14 – 16, 2017.

Arizona State University, Phoenix (AZ, USA): Seminar: Emergence, Ontogenesis, Individuation: "Phylogenesis, ontogenesis and the formation of 'sense'", series of six lectures, February 27 - March 19, 2017.

Chapman University, Philosophy Dept, Claremont (CA), USA: "The invention of physico-mathematical spaces and the italian "prospettiva"", March 7, 2017.

U.C. Berkeley, Philosophy Dept, Berkeley (CA), USA: "Discussion on phylo-ontogenesis", T. Deacon's team, March 22, 2017.

Università la Sapienza, Dip. di Filosofia, Roma: "Cosa è oggi "What is life?" di Schrödinger?", April 12, 2017.

Palais Malaquais, Dép. de Architecture, Paris: "Le geste continu qui découpe et organise le monde vs. les Big Data qui le désarticulent", May 11, 2017.

ENS, Séminaire "Philosophie et Mathématiques", Paris: "Irréversibilité du temps, brisures de symétries, aléatoire : une relation triangulaire qui marque l'imprédictibilité, physique et biologique", May 15, 2017.

Centre Pompidou, Séminaire "Intelligence artificielle et épistémologie des 'boites noires'", Paris: "L'intelligence de et dans l'espace et le calcul sans espace", June 29 – 30, 2017.

Scuola estiva Praxis, "Il possibile ed il reale", Forli': "Il ruolo del passato e degli eventi rari nella costruzione del possibile evolutivo del vivente", "Considerazioni matematiche sulla causalità in biologia: il continuo vs il discreto e la biologia del cancro", interventi, July 29, 2017.

Workshop "Digital Culture and the Limits of Computation", British Academy/University of Sussex: "A major use and a major abuse of Information Sciences", September 21, 2017.

Colloque "Corrélation et causalité dans l'univers des big data", Neurospin, Paris: "Aléatoire et grandes bases de données", October 18, 2017.

Convegno "Dai fattori di rischio ai Big Data: Prevedere per Prevenire", XVIII edizione, Giornate della Scuola Medica Salernitana, Fac. di Medicina: "Usi ed abusi matematici dei Big Data, in biologia e medicina", October 20 – 21, 2017.

Conference "Organisms: a journal, a project", Univ. Sapienza, Roma: "Biological variation and stability in an organismal perspective", October 25 – 27, 2017.

Convegno"Scienza aperta e integrità della ricerca", Milano: "Scienza e senso: deformazioni scientiste del rapporto al reale", November 9 – 10, 2017.

Seventh Conference on Systems Sciences, Università Cattolica, Milano, opening lecture: "The difficult interplay between theory, modeling and simulation. The relevance of negative results", November 16 – 17, 2017.

Présentation du livre "La singularité du vivant", par M. Benasayag (post-face par G. Longo), Maison de l'Amérique Latine, Paris, 21h, November 17, 2017.

Conference "1948: Technosphere", Haus der Kulturen der Welt (HKW), Berlin: "TBA", November 30 – December 2, 2017.

Technical University (host: V. Buhlmann), Vienna: "The different ways discrete vs continuous mathematics organize reality", December 8 – 9, 2017.

Colloque "Les mathématiques entre normativité et imagination : historicité, finance et sémiogenèse", Ens, Paris: "La friction difficile entre mathématiques et sciences historiques, à partir de la biologie", December 14, 2017.

Centre Pompidou, Les entretiens du nouveau monde industriel, "La "bêtise et l'intelligence artificielle"", Grande Salle, Paris: "Elaboration et transmission de l'information : deux sciences plaquées abusivement sur le réel. Dualisme et perte de sens", December 19 – 20, 2017.

Scuola di didattica e fondamenti della matematica, "Corpo e movimento in matematica: Incontri, intrecci e sviluppi", Rimini: "Gesti e senso in matematica", January 25 – 28, 2018.

IRCAM, "Séminaire mathesis", Paris: "La singularité physique du vivant, où en sommes nous ?", February 10, 2018.

ENS, "Séminaire sur l'imagination artificielle", Paris: "Bruit et aléatoire. Bruit dans l'élaboration de l'information vs aléatoire dans les sciences de la nature", February 12, 2018.

IHPST, "Séminaire Philmath", Paris: "La différence entre généralisation et transfert conceptuel, à partir des réflexions de Georg Kreisel sur la calculabilité", February 19, 2018.

Workshop **"Will Science Remain Human? Frontiers of the Incorporation of Technological Innovations in the Biomedical Sciences"**, University Campus Bio-Medico, Roma: "Some bias on knowledge induced by the digital networks. The case of biology", March 5 – 6, 2018.

Universita' di Pisa', AISA (host M.C. Pievatolo), Pisa: "Conoscenza come "ignoranza degli esperti" ed il governo del numero", March 16, 2018.

Stanford University, Philosophy Dept. (host T. Ryckman), CA: Seminar talks on "The Role of History and Rare Events in Systems of Life, some Mathematical Challenges", April 3 – 10, 2018.

U.C. Berkeley, Anthropology Dept, Berkeley (CA), USA: "Discussion on the origin of life, evolution, historicity", T. Deacon's team, April 9, 2018.

Tufts University, Immunology Dept. (host C. Sonnenschein), Boston: "Building Theories and Hypotheses: lessons from Physics, challenges in Biology, from cancer to organisms", April 12, 2018.

Incontri **"Officina delle idee"**, Istituto Universitario Federale, Lugano, CH: "Il sapere scientifico, oggi, fra Big Data e produzione di senso", April 25, 2018.

Second international conference on **"Exaptation and innovation"**, Villa Feltrinelli, Lake Garda, Italy: "Agency and enablement in biology and in historical sciences", April 26 – 28, 2018.

Colloque **"Le paradoxe de la finitude"**, Université Sorbonne I, Paris: "Eloge de la ligne mathématrique et de l'infini dans le fini ; pour une critique de la temporalité", May 2 – 3, 2018.

Débat à partir du livre **"Lois des dieux, des hommes et de la nature"**, IEA, Nantes: "Réponses aux remarques de Yaovi Akakpo", May 14, 2018.

Workshop **"Le hasard dans les sciences de la nature"**, Ens, Paris: "Le hasard sans probabilités dans les sciences historiques, à partir de la biologie", May 18, 2018.

Colloque **"Weyl : la philosophie des mathématiques et des sciences de la nature"**, Collège de philosophie, Paris: "Les fondements des mathématiques, d'une annexe de la philosophie du langage à une composante d'une philosophie de la nature", (audio), May 25, 2018.

Round Table **"On Law and Nature"** within the conference "The Right Use of the Earth: Knowledge, Power and Duties within a Finite Planet", Ens, Paris, May 30, 2018.

Bi-annual international congress of the **"Italian Society of Applied and Industrial Mathematics"**, Roma: "Conceptual Bridges and Mathematical Dualities: Physics vs. Biology", July 2 – 6, 2018.

Workshop **"Emergence, open-ended process, novelty, ontogenesis"**, Institute for Advanced Studies, Amsterdam: "Complexity, Information and Diversity, in Science and in Democracy" and "What is randomness?", September 6 – 7, 2018.

ISC-CNRS, Paris: Kauffman-Longo Happy Hours, at 19h: "The challenge of Time: rhythms and time in Biology", September 11, 2018.

Workshop **"Preparing the UNO 2020 Geneva Conference"**, Serpentine Gallery, London: "Theories in Biology and the Anthropocene", September 22, 2018.

Workshop **"CRYPTIC"**, Centro Internazionale di Studi Umanistici Umberto Eco, Bologna, It.: "Encrypting Knowledge as Big Data", October 10, 2018.

Université Lyon 3, Dépt. de Philosophie (hôte: J.-B. Joinet), Lyon: La différence entre généralisation et transfert conceptuel (ou comment mieux comprendre et ne pas "plaquer" la calculabilité sur le réel)", October 11, 2018.

X-SHS, Salle de Classe de l'ancienne école Polytechnique, Paris: "Les enjeux du hasard : maths, physique, biologie", October 18 2018 (video).

Cardano meets at **Zuerich's ETH**, Symposium: **"The Science of Systems and Life: Alternative Philosophies, new Mathematics"**, Zuerich, CH: "Talks by N. Bouleau, G. Longo, M. Montévil, A. Sarti", October 25 – 26, 2018.

Università di Torino, Seminario "Mathesis", Dip. di Matematica (ospite: F. Arzarello), Torino: "Algoritmi, Big Data, codifiche ... : strumenti per capire o per governare il vivente ed il mondo?" (audio), November 8, 2018.

16me rencontre **"Physique et Interrogations Fondamentales"** sur **"Quels algorithmes pour comprendre la Nature ?"**, Bibliothèque nationale de France, F. Mitterand, Paris: "Algorithmes pour comprendre ou pour normer le monde ? Outils ou formatages de l'action et de la science ?", November 10, 2018.

Ecole Nationale Magistrature (hôte: A. Garapon), Paris: "Les Big Data, les règles et les machines ou comment ne pas perdre le sens des lois de la nature et des hommes", December 6, 2018 (vidéo).

Colloque **"Géométries et phénoménologies du vivant"**, Paris: "Historicity at the heart of biology: a challenge for mathematical thinking" (avec M. Montévil), December 12 – 14, 2018.

Conference **"Das Neue Alphabet (DNA)"**, Haus der Kulturen der Welt (HKW), Berlin: "Alphabets, Axioms, DNA: On human knowledge and the myth of alpha-numeric coding", January 10 – 12, 2019.

Colloque **"Biomorphisme"**, IMéRA, Marseille : "Dynamiques organismes-ecosystèmes et production de la diversité biologique", January 23 – 25, 2019.

Convegno, **"Sull'analogia"**, Firenze: "Dalla fisica alla biologia: analogie fra sistema geo-centrico e sistema geno-centrico", February 4, 2019 (Audio).

Université de Paris-Est, Dépt. de Mathématiques (hôte: M. Cannone), Paris: "Usages et biais de l'instrument mathématique : le jeu continu/discret, des dynamiques à l'équilibre en économie aux Big Data", February 6, 2019.

SNCF - Centre réseaux, Paris: "Machines numériques : imitation ou "modèle" du cerveau, de l'intelligence? Et l'action dans l'espace?", February 7, 2019.

PointCulture, Bruxelles, une introduction: "La science et ses limites vs. le scientisme", February 19, 2019 (Postponed).

Colloque du centenarie de la OIT, **"Le travail au XXIème siècle : Droit, technique, écoumène (section : la révolution informatique)"**, Collège de France : "Des réseaux d'ordinateurs pour la connaissance au champ moyen pour la gouvernance du comportements et du travail" (Article), February 26 – 27, 2019. (Vidéos : La matinée; Longo (25 min); Table ronde)

Workshop Caus(yn)e: **"CAUSAL Systems Neuroscience"**, Cascais, Portugal: "The differential method, from physics to computing and biology", March 4, 2019 (Video recorded).

Archives Jean Piaget, Genève, CH: "Physique et biologie, entre l'espace et le temps", March 5, 2019. Cancelled: (paper).

EHESS, Centre de Mathématiques, CAMS, dans le cadre du séminaire: "Dynamiques post-structurelles : devenir hétérogène, intensif, singulier", Paris: "Temps des dynamiques physiques vs. temps de l'histoire biologique", 15h, April 1, 2019.

International Conference, 10 years after the earthquake, **"What is time? Einstein and Bergson 100 years later"**, Aquila, It.: "Realitivizing the Time of Relativity. A Theory of Biological Time", April 4 – 6, 2019.

Scuola Normale Superiore, Pisa, ciclo di lezioni: "L'importanza dei risultati negativi in scienza: impredittibilità ed indecidibilità, per capire aleatorio e tempo", April 8 and 9, 2019.

Formation Universitaire **"Justice prédictive"**, Collège des Bernardins, Paris: "Le hasard dans la prédiction", May 3, 2019.

Workshop **On modelling**, Toulouse, Fr.: "Models vs Imitations. Geometric schemata for biological time", June 20 – 21, 2019 (Video recorded).

Conférence, **"RIGUEUR"**, Paris: "La rigueur difficile de l'imagination mathématique vs la bêtise facile de la rigueur formelle", July 2 – 3, 2019.

Annual Conference of the AIPS (International Academy of the Philosophy of Science): **"The Human Being Facing New Biomedical Technology, Including the Subject of Big Data, the role of Artificial Intelligence for their Analysis, Genome Editing and Personal Medicine"**, Prague: "When "information" replaces causality, Big Data replace knowledge", August, 12 – 14, 2019 (pertinent papers: InfoInterpretation, InfoCausesCancer).

International Conference, **Stuart Kauffman's Fest**, Santa Fe, New Mexico: "What is Time?", August 21 – 22, 2019 (Video recorded).

Colloque, **"Le Hasard, le calcul et la vie"**, Cerisy-la-Salle : "La spécificité du temps et du hasard dans les sciences de la vie", August 28 – September 4 , 2019.

Thales, AICPRAT, Paris: "Diversité du hasard mathématique en science de la nature", October 7, 2019.

Colloque, **"Temps physique, temps biologique : actualité du bergsonisme"**, Toulouse : **"Naturaliser la physique, vers l'espace et le temps pour la biologie"** , October 24 – 25, 2019.

Università di Pisa, Dipartimento di Filosofia, ciclo di lezioni: "Interfacce dell'incompletezza: dai formalismi liguistici alla struttura del DNA, grandi idee scientifiche divenute forme della brutalità (e corruzione) scientista - o come mostrarne i limiti per meglio seguir virtute e canoscenza. La questione del tempo." (Sunto e riferimenti), October 28 – November 8, 2019.

EHESS, Centre de Mathématiques, CAMS, dans le cadre du séminaire: "Dynamiques post-structurelles", Paris: "Naturaliser la physique : l'espace-temps biologique et la constitution historique de l'espace des possibles", November 18, 2019.

Workshop, **"Complexity, Inter-Connectivity**, and Resilience", Bologna: "Extended Present, Extended Criticality and Time Resilience in Biology", December 5 – 6, 2019 (CANCELLED).

Colloque, **Les entretiens du nouveau monde industriel**: Sciences, savoirs et droit dans le Néguentropocène, Centre Pompidou, Paris : "Mécaniques de la nature, ou comment on a désarticulé les écosystèmes. Pistes pour une autre compréhension", December 17 – 18, 2019.

Conference **"Hacking the Computable"**, Stuttgart: "Limits of the dualism and mechanicism of algorithmic reasoning", related text, January 16, 2020.

Convegno per i **"60 anni di Simone Martini"** (primo tesista di GL), Bologna: "L'importanza del "modello standard" per l'Informatica come scienza, contro lo scientismo del "tutto è informazione"" (testo preliminaire), January 17 – 18, 2020.

ENS, séminaire "De l'image, et qu'elle pense", Paris: "L'image digitale du monde vs. l'imagination des configurations de sens" (quelques références: Theorems as Constructive Visions et Mathematical intuition and the cognitive roots of mathematical concepts), February 6, 2020.

Colloque **"Mathesis du vivant"**, Série Mamuphi, IRCAM, Paris : "Les enjeux du temps et de l'aléatoire, entre mathématiques et biologie", February 29, 2020.

Università Cattolica, Ciclo di seminari: "Systemics of Incompleteness", Milano: "Coscienza dei limiti: la forza dell'essere "borderline" per capire meglio, in scienza", April 2, 2020. (POSTPONED)

Conference **"Trust: a Philosophical Approach"**, Pisa: "The constructed objectivity of science and the ethic of knowledge. Biology as a battlefield", May 11 – 12, 2020. (POSTPONED)

Università dell'Insubria, Dipartimento di Biologia (ospite: A. Vianelli), Varese: "Le sfide del tempo e del caso", May 14, 2020. (POSTPONED)

Conference **"Language, History, Gender and Science: Celebrating the work of Evelyn Fox Keller"**, Toronto, Ca: "Metaphors and Theories: From Geocentrism to Genocentrism", May 22 – 23, 2020. (POSTPONED)

Colloque **"Puissance, mécanicisme et limites du numérique : ontologie, mathématiques, éthique"**, Paris : "Théories implicites, corrélations biaisées ou fallacieuses et Big Data", June 4, 2020. (POSTPONED)

Convegno **"La qualità spaziale tra matematica e fenomenologia"**, Firenze: "Naturalizzare lo spazio/tempo della fisica", June 12, 2020. (POSTPONED)

Conference **"The Humanities and the Rise of AI: Implications of Cultural and Societal Engineering"**, Université du Luxembourg: "Humans and Machines: How to Understand a Caricature?", June 14 – 18, 2020. (POSTPONED)

Rencontre **"Agir pour le vivant"**, Arles: "Reinventer les algorithmes, contre les algocrâtes", august 26 – 28, 2020.

Instituto Italiano di Bioetica, Piacenza: "Meccaniche della natura o come abbiamo disarticolato l'ecosistema. Percorsi possibli per pensare il vivente in altro modo", October 1, 2020. (POSTPONED)

ENSSER general Meeting, **Web-Panel (video-recorded) on "SARS-CoV-2 and COVID-19: science in the spotlight"**, Berlin: "Organisms and ecosystems like machines: some consequences of the mechanistic bias on nature", October 5 – 6, 2020.

U. C. Berkeley, Dept of Environmental Science (host: I. Chapela), Two hours web-teaching: "On mechanicisms and life, today", Octobre 22, 2020.

Université de Grenoble, Laboratoire d'Informatique et webinar: "Big Data, entre science et scientisme" (Texte de départ et LIG keynote-speeches), November 5, 2020.

Università di Udine, Dipartimento Studi Umanistici, seminario web su CONTINUO E DISCRETO, FONDAMENTI PER UNA FILOSOFIA DEL DIGITALE: "Il continuo, il discreto e le macchine: da scelte teoriche a tecniche per la manipolazione del vivente - cellule, virus ed OGM come "meccanismi cartesiani ... [su] algebre booleane "." (Testo di riferimento), November 21, 2020.

Colloque de la Fondation Res Publica, **La politique de Recherche, enjeu pour l'avenir"**, Paris: "Travail "en mode projet" et bibliométrie, ou comment on casse la pensée scientifique", November 26, 2020 (**section reportée**).

Colloque **"Approche complexe des effets du changement global"**, Web-meeting: "Comment les systèmes naturels sont-ils organisés ? Au delà de la mécanique de la nature, les principes de restriction et de permissivité", November 30, 2020.

Colloque de démarrage d'un séminaire périodique **"Vie – numérique - santé"**, Institut d'Etudes Avancées, Nantes et Web-meeting : "Introduction au colloque et au séminaire", December 4, 2020.

Conference **"Trust. A Philosophical Approach"**, Pisa and Web-meeting : "Information, science and democracy, for an ethics of scientific knowledge", December 10, 2020.

Colloque **"Entretiens du Nouveau Monde Industriel": "PRENDRE SOIN DE L'INFORMATIQUE ET DES GÉNÉRATIONS"**, Web-meeting et Centre Pompidou, Paris : "La résistible ascension de la métaphore informationelle en sciences de la nature : comment bifurquer ?", December 22 – 23, 2020.

Conference **"Philosophy and Mathematics"**, Web-meeting, Princeton, USA: "From Axiomatic Systems to the Dogmatic Gene and beyond", January 28 – 29, 2021.

Conference **"What is critical science?"**, Web-meeting, Bern, CH: "Science and Democracy", February 26, 2021.

8 Publications (most papers below, published after 1990, and others not yet listed may be downloaded from Longo's web page: https://www.di.ens.fr/users/longo/ Go to this web page also for an update of the published papers)

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[Longo, 1973] Longo, G. Semantica dei sistemi formali: i modelli di Scott per il lambda-calcolo, seminari di informatica teorica. Pubblicazione I.A.C. - C.N.R., 1973. Roma (pp. 41-82).

[Longo, 1974] Longo, G. I problemi di decisione e la loro complessitá seminari di informatica teorica 2. Pubblicazione I.A.C. - C.N.R., 1974. Roma(pp. 87-108).

[Longo and Venturini-Zilli, 1974] Longo, G. and Venturini-Zilli, M. Complexity of theorem-proving procedures: some general properties. *Revue francaise d'Automatique Informatique et Recherche Operationelle (R.A.I.R.O.) (serie rouge de Math.: Informatique Théorique)*, (3):5–18, 1974.

[Longo, 1976] Longo, G. On the problem of deciding equalities in Theories of Objects and in a formal system. *Studia Logica*, 35(4):335–348, 1976.

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[Ferrari and Longo, 1978] Ferrari, P. and Longo, G. Axiomatic Theory of Enumeration: a note on the axiom of extensionality. *Studia Logica*, 37(3):261–268, 1978.

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[Longo, 1979] Longo, G. Ricorsivita' nei tipi superiori: un'introduzione alle caratterizzazioni di Ershov ed Hyland. Rendiconti del Seminario Matematico di Torino, vol. 37, 2, pages 1-29., 1979.

[Barendregt and Longo, 1980] Barendregt, H. and Longo, G. Equality of lambda-terms in the model T-omega. *To H.B. Curry: essays in Combinatory Logic, Lambda Calculus and Formalism*, pages 303–337, 1980. Volume of essays, refereed as for a journal.

[Hindley and Longo, 1980] Hindley, R. and Longo, G. Lambda-calculus models and extensionality. *Zeitschrift für Mathemathische Logik und Grundlagen der Mathematik*, 26(2):289–310, 1980. Abstract: Journal of Symbolic Logic n. 2, vol. 45, 1980 (p. 392), Proceedings of the Logic Colloquium 78, Mons,1978.

[Longo and Venturini-Zilli, 1980] Longo, G. and Venturini-Zilli, M. A lambda-delta-calculus with an algorithmic delta. *Zeitschrift für Mathemathische Logik und Grundlagen der Mathematik*, 26(2):289–310, 1980. Abstract: Journal of Symbolic Logic n. 2, vol. 42, 1977 (pp. 458-459), Proceedings of the Logic Colloquium 76, Oxford, 1976.

[Berestovoy and Longo, 1981] Berestovoy, S. and Longo, G. Il risultato di Paris-Harrington per l' aritmetica di Peano: una dimostrazione con il metodo degli indicatori. *Modelli del Lambda-calcolo e della Aritmetica di Peano (Quaderni dei Gruppi di Ricerca in Matematica del CNR)*, pages 75–95, 1981. Monograph, refereed as for a journal.

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[Longo, 1982b] Longo, G. Hereditary partial effective operators in any finite type. Forshungsinstitut für Mathematik E.T.H. Zuerich, 1982b.

[Bruce and Longo, 1983] Bruce, K. and Longo, G. An elementary approach to the solution of recursive domain equations. 1983. Williams College.

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