# Walter Fontana

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## PERSONAL DATA

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| Born | November 3rd 1960 |
| Citizenship | Italian |
| Visa status | Permanent resident of the USA |
| Languages | German, Italian, English, French; fluent |

## EDUCATION

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|---|---|
| 1987 | **PhD**, *Theoretical Chemistry*<br>University of Vienna, Vienna, Austria<br>Thesis supervisor: Prof. Peter Schuster<br>graduated with highest honors |
| 1984 | **MSc**, *Biochemistry*<br>University of Vienna, Vienna, Austria<br>Thesis supervisor: Prof.Peter Schuster |
| 1978 - 1983 | *Studies in Biochemistry*<br>University of Vienna, Vienna, Austria |

## RESEARCH AND PROFESSIONAL EXPERIENCE

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|---|---|
| 2004 - present | **Professor of Systems Biology**<br>Department of Systems Biology<br>Harvard Medical School, Boston, MA |
| 2004 - present<br>1994 - 1998 | **External Faculty**<br>Santa Fe Institute, Santa Fe, NM |
| 1998 - 2004 | **Research Professor**<br>Santa Fe Institute, Santa Fe, NM |
| 2001 | **Visitor**, Program in Statistical Physics and Biological Information<br>Institute for Theoretical Physics<br>UCSB, Santa Barbara, CA |
| 1999 - 2000 | **Member,** Program in Theoretical Biology<br>Institute for Advanced Study<br>Princeton, NJ |

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|---|---|
| 1997 – 2000 | **Associate Professor**<br>Institute for Theoretical Chemistry<br>University of Vienna, Vienna, Austria<br>• *venia legendi* (theoretical chemistry) 04/16/1997<br>• resigned tenure on 12/31/ 2000 |
| 1994 – 1997 | **Assistant Professor**<br>Institute for Theoretical Chemistry<br>University of Vienna, Vienna, Austria |
| 1995 – 1997 | **Research Scholar**<br>IIASA – Intl. Institute for Applied Systems Analysis<br>Laxenburg, Austria |
| 1994 | **Visiting Scientist**<br>Interval Research Corporation<br>Palo Alto, CA |
| 1991 – 1993 | **Postdoctoral Fellow**<br>Santa Fe Institute, Santa Fe, NM |
| 1989 – 1991 | **Postdoctoral Fellow** (Director's Fund)<br>Theoretical Division and Center for Nonlinear Studies<br>Los Alamos National Laboratory<br>Los Alamos, NM |
| 1987 – 1989 | **Research Assistant**<br>Institute for Theoretical Chemistry<br>University of Vienna, Vienna, Austria |

## RESEARCH GRANTS

| | |
|---|---|
| pending | *The Variability of the lifespan phenotype in C. elegans*<br>NIH R01 PA-07-070 |
| 2009 – 2010 | *Automated Acquisition of C. elegans Survival Curves with a Flatbed Scanner* [ARRA Competitive Revision Supplement]<br>NIH 1 R03 AG032481-02S1 |
| 2008 – 2010 | *Automated Acquisition of C. elegans Survival Curves with a Flatbed Scanner*<br>NIH 1 R03 AG032481-01 |
| 2008 – 2009 | *A systems approach to the dynamics of aging in C.elegans*<br>Paul F. Glenn Labs Pilot Project grant |
| 2002 – 2003 | *Models of Signaling Networks* (with D.Krakauer)<br>The Proteus Foundation |
| 2001 – 2003 | *A Founding Program in the Study of Robustness*<br>The David and Lucile Packard Foundation<br>Principal scientist with J.P.Crutchfield, S.Forrest, E.Jen and S.A.Levin. PI: Erica Jen |

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|---|---|
| 2002 – 2004 | *Innovation in Natural, Experimental and Applied Evolution*<br>The David and Lucile Packard Foundation<br>Co-PI with F.Arnold, D.Erwin and R.Lewontin.<br>PI: Tom Kepler |
| 1999 – 2001 | *Biology of Information*<br>The Rose-Legett Foundation |
| 1999 – 2001 | *Functional Organization in Molecular Systems*<br>Austrian Science Foundation<br>Project P13565-MAT (Principal Investigator) |
| 1997 – 1999 | *Adaptive Dynamics and Self-Organization*<br>Austrian Ministry of Science and Transport<br>Contract No. GZ 308.951/4-IV/B/3/96<br>Co-PI with U.Dieckmann and K.Sigmund |

## PROFESSIONAL ACTIVITIES

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|---|---|
| 2006 – present | **Science Board**, Santa Fe Institute, Santa Fe, NM |
| 1997 – present | **Counseling Scientist**, Konrad Lorenz Institute for Research in Evolution and Cognition<br>Altenberg, Austria |
| 2005 – present | **Board of Directors,** Plectix BioSystems Inc., Cambridge, MA |
| 2005 | **Founder**, Plectix BioSystems Inc., Cambridge, MA<br>Instrumental in raising 2 rounds of venture capital from premium investors. |
| 2004 – present | **Editorial Board**, *LNCS Transactions on Computational Systems Biology* |
| 1998 – present | **Editorial Board**, *Complexity* |
| 1993 – 2005 | **Editorial Board**, *Artificial Life* |
| 1998 – 2003 | **Editorial Board**, *Journal of Theoretical Biology* |
| past 3 years | **ad hoc Referee** for: NIH, PLoS, *Journal of Theoretical Biology, Proceedings of the Royal Society, Science, Nature, Physical Review Letters, The American Naturalist, Proceedings of the National Acdemy of Science USA, Bioinformatics, Journal of Molecular Evolution, RNA, Nucleic Acids Research, Gene, Advances in Complex Systems, Artificial Life* |
| 2006 – present | **Committees**<br>*Search Committee Brigham and Women's Hospital (Professor of Medicine in Quantitative Systems Biology)*<br>*Promotions, Reappointments, and Appointments Committee, Harvard Medical School* |

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| | *Standing Committee on Higher Degrees in Systems Biology, Harvard University* |
| | *Appointments and Review Committee, Santa Fe Institute* |
| | **NIH Study Sections** |
| 2005 | *RFA-RM-04-022: National Centers for Biomedical Computing.* |
| 2007 | *Modeling and Analysis of Biological Systems (MABS).* |

## TEACHING

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|---|---|
| Spring 2005, Spring 2006 | SB101 – Systems Biology<br>(with Jeremy Gunawardena, Lew Cantley, and Marc Kirschner) |
| Fall 2006, Fall 2007, Fall 2008, Fall 2009 | SB200 – Systems Biology<br>(with Jeremy Gunawardena and Johan Paulsson) |

SB101 (later SB200) is a new course aimed at seniors / first year graduate students from engineering and the natural sciences with the goal of conveying a working knowledge of mathematical and computational techniques that are applied in simple biological situations to produce models and explore their behavior. Mathematical thinking is used to appreciate the shape of ideas and to agree with others about the meaning of concepts. The course is being developed and co-taught with Professors Gunawardena, Cantley, Kirschner and Paulsson.

## EXTRACURRICULAR ACTIVITIES

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|---|---|
| 1996 – present | Paraglider pilot (USA P4, Austria P4) |
| 2001 – 2005 | Private pilot (airplane single-engine land, VFR) |

## PUBLICATIONS

- E. J. Deeds, J. Krivine, J.Feret, V.Danos, and W.Fontana
  Dynamic individuality in protein-protein interaction Networks
  submitted (2009)

- J. Apfeld and W. Fontana
  Mutually Independent Aging Processes in *C. elegans*
  submitted (2009)

- T. Kolokotrones, V. Savage, E. Deeds, and W. Fontana
  Curvature in metabolic scaling
  submitted (2009)

- S. E. Hulme, S. S. Shevkoplyas, A. P. McGuigan, J. Apfeld, W. Fontana, G. M. Whitesides
  Lifespan-on-a-Chip: microfluidic chambers for performing lifelong observation of *C. elegans*
  *Lab on a Chip,* in press (2009)

- Danos V, Feret J, Fontana W, Harmer R, Krivine J. Rule-based Modelling and Model Perturbation. Transactions on Computational Systems Biology. **11**:116-137 (2009)

- J.Feret, V.Danos, J.Krivine, R.Harmer and W.Fontana
  Internal coarse-graining of molecular systems
  *Proc. Natl. Acad. Sci. USA,* **106**, 6453-6458 (2009)

- V.Danos, J.Feret, W.Fontana, R.Harmer, and J.Krivine
  Investigation of a biological repair scheme
  *Lecture Notes in Computer Science*, **5391**:1-12 (2009)

- V.Danos, J.Feret, W.Fontana, R.Harmer, and J.Krivine
  Rule-based modeling, symmetries, refinements
  *Lecture Notes in Bioinformatics*, **5054**:103-122 (2008)

- V. Savage, E. Deeds, and W. Fontana
  Sizing up allometric scaling theory
  *PLoS Computational Biology*. 4(9): e1000171 (2008)

- V.Danos, J.Feret, W.Fontana, and J.Krivine
  Abstract interpretation of cellular signalling networks
  *Lecture Notes in Computer Science*, **4905**:83–97 (2008)

- S. E. Hulme, S. S. Shevkoplyas, J. Apfeld, W. Fontana, and G. M. Whitesides
  A Microfabricated Array of Clamps for Immobilizing and Imaging *C. elegans*
  *Lab on a Chip,* **7**, 1515-1523 (2007)

- V.Danos, J.Feret, W.Fontana, R.Harmer, and J.Krivine
  Rule-based Modelling of Cellular Signalling
  Concurrency Theory 2007, *Lecture Notes in Computer Science*, **4703**:17-41 (2007)

- V.Danos, J.Feret, W.Fontana, and J.Krivine
  Scalable simulation of cellular signaling networks

APLAS 2007, *Lecture Notes in Computer Science,* **4807**:139-157 (2007)

- S.Krishnamurthy, E.Smith, D.Krakauer, and W.Fontana
  The stochastic behavior of a molecular switching circuit with feedback
  *Biology Direct*, 2007, **2**:13 (31 May 2007)

- W.Fontana
  [Perspective:] Pulling Strings
  *Science,* **314**. 1552-1553 (2006)

- W.S.Hlavacek, J.R.Faeder, M.L.Blinov, R.G.Posner, M.Hucka, and W.Fontana
  Rules for Modeling Signal Transduction Systems
  *Science STKE,* Vol. 2006, Issue **344**, pp. re6, 18 July 2006

- W.Fontana
  The Topology of the Possible
  in: "Understanding Change: Models, Methodologies and Metaphors."
  A.Wimmer and R.Kössler (eds.), Palgrave Macmillan, (2005)

- L.W.Ancel-Myers and W.Fontana
  Evolutionary Lock-in and the Origin of Modularity in RNA Structure,
  in *Modularity -Understanding the Development and Evolution of Natural Complex Systems*, W.Callebaut and D.Rasskin-Gutman, editors, pp.129-141, MIT Press, Cambridge, MA (2005)

- W.Fontana, J.Karkanias, L.G.Meredith, and M.Radestock
  Lab-to-lab connectivity and semantics in the life sciences
  Position Paper for the W3C workshop on "Semantic Web for Life Sciences", 27-28 October 2004, Cambridge, MA. Published online (2004)

- J.Arjan, G.M.de Visser, J.Hermisson, G.P.Wagner, L.W.Ancel, H.Bagheri, J.L.Blanchard, L.Chao, J.M.Cheverud, S.F.Elena, W.Fontana, G.Gibson, T.F.Hansen, D.Krakauer, R.C.Lewontin, C.Ofria, S.H.Rice, G.von Dassow, A.Wagner, and M.C.Whitlock
  Perspective: Evolution and Detection of Genetic Robustness
  *Evolution*, **57**(9), 1959-1972 (2003)

- W.Fontana
  Modelling 'Evo-Devo' with RNA
  *BioEssays*, **24**, 1164-1177 (2002)

- N.V.Fedoroff and W.Fontana
  Small numbers of big molecules
  *Science*, **297**, 1129-1131 (2002)

- B.M.R.Stadler, P.F.Stadler, G.Wagner and W.Fontana
  The topology of the possible: Formal spaces underlying patterns of evolutionary change
  *J. theor. Biol.*, **213**(2), 241-274 (2001)

- L.W.Ancel and W.Fontana
  Plasticity, Evolvability and Modularity in RNA,
  *J. Exp. Zool. (Mol. Dev. Evol.),* **288**, 242-283 (2000)

- C.Flamm, W.Fontana, I.Hofacker and P.Schuster
  RNA Folding at Elementary Step Resolution,
  *RNA*, **6**, 325-338 (2000)

- P.Schuster and W.Fontana
  Chance and Necessity in Evolution: Lessons from RNA,
  *Physica D: Nonlinear Phenomena*, **133**, 427-452 (1999)

- S.Wuchty, W.Fontana, I.Hofacker and P.Schuster
  Complete Suboptimal Folding of RNA and the Stability of Secondary Structures,
  *Biopolymers*, **49**, 145–165 (1999)

- W.Fontana and P.Schuster
  Shaping Space: The Possible and the Attainable in RNA Genotype-Phenotype Mapping,
  *J. Theor. Biol.*, **194**, 491–515 (1998)

- W.Fontana and P.Schuster
  Continuity in Evolution: On the Nature of Transitions,
  *Science*, **280**, 1451–1455 (1998)

- W.Fontana and L.W.Buss
  The Barrier of Objects: From Dynamical Systems to Bounded Organizations,
  in: *Boundaries and Barriers*, J.Casti and A.Karlqvist (eds.), pp.56–116, Addison-Wesley, 1996

  The tutorial appendices on λ-calculus (Appendix A), type theory (Appendix B) and proof-theory (Appendix C) can be obtained with the main text from my homepage. A brief summary has appeared as:
  - Walter Fontana, “On organization” in *The future of science has begun: Approaches to Artificial Life and Artificial Intelligence*, Fondazione Carlo Erba, volume 4, 23-40 (1996)
  - Reprinted in the report on the workshop *Emergence, Entropy, and the Creative Universe*, T. Bernold (editor), pages 207–222 (1998), Swiss Science Council, Advance Detection in Research Policy (FER) publication 182/1998.

- M.Huynen, P.F.Stadler and W.Fontana
  Smoothness within Ruggedness: The role of neutrality in adaptation,
  *Proc. Natl. Acad. Sci. USA*, **93**, 397–401 (1996)

- W.Fontana
  Molekulare Semantik: Evolution zwischen Variation und Konstruktion,
  in: *Evolution: Entwicklung und Organisation in der Natur*,
  V.Braitenberg and I.Hosp (eds.), rororo -science 1 9706 5, 69–106 (1994)

  - Reprinted in: *Origenes de la vida. En el centenario de Aleksandr Ivanovich Oparin*, F.Moran, J. Pereto and A. Moreno (eds.), pp. 269–302, Editorial Complutense, 1995

- W.Fontana, G.Wagner and L.W.Buss
  Beyond Digital Naturalism,
  *Artificial Life*, **1/2**, 211-227 (1994)

  - Reprinted in: *Artificial Life: an Overview*, Chris Langton (editor), pp. 211-227, MIT Press, Cambridge, MA, 1995

- I.L.Hofacker, W.Fontana, P.F.Stadler, L.S.Bonhoe□er, M.Tacker and P.Schuster
  Fast Folding and Comparison of RNA Secondary Structures,
  *Chemical Monthly*, **125**, 167–188 (1994)

- W.Fontana and L.W.Buss
  'The Arrival of the Fittest': Toward a Theory of Biological Organization
  *Bull. Math. Biol.*, **56**, 1–64 (1994)

- P.Schuster, W.Fontana, P.F.Stadler and I.Hofacker
  From Sequences to Shapes and Back: A Case Study in RNA Secondary Structures
  Proc. Roy. Soc. (London) B, **255**, 279–284 (1994)

- M.Tacker, W.Fontana, P.F.Stadler and P.Schuster
  Statistics of RNA Melting Kinetics
  *European Journal of Biophysics*, **23**, 29–38, (1994)

- W.Fontana and L.W.Buss
  What would be conserved if 'the tape were played twice'?
  *Proc. Natl. Acad. Sci. USA*, **91**, 757–761 (1994)
  - Reprinted in: *Complexity: Metaphors, Models, and Reality*,
    George A. Cowan, David Pines, and David Meltzer (eds.),
    pp. 223–244, Addison-Wesley, Reading, MA, 1994

- W.Fontana, D.A.M.Konings, P.F.Stadler, and P.Schuster
  Statistics of RNA Secondary Structures
  *Biopolymers*, **33**, 1389–1404 (1993)

- W.Fontana, P.F.Stadler, E.Bauer, T.Griesmacher, I.L.Hofacker, M.Tacker, P.Tarazona, E.D.Weinberger and P.Schuster
  RNA Folding and Combinatory Landscapes
  *Phys.Rev.E*, **47**, 2083–2099 (1993)

- P.F.Stadler, W.Fontana and J.H.Miller
  Random Catalytic Reaction Networks
  *Physica D*, **63**, 378–392 (1993)

- W.Fontana
  Algorithmic Chemistry
  in: *Artificial Life II*, C.G.Langton et al. (eds.),
  pp. 159–209, Addison-Wesley, 1991

- R.J.Bagley, J.D.Farmer and W.Fontana
  Evolution of a Metabolism
  in: *Artificial Life II*, C.G.Langton et al. (eds.),
  pp. 141–158, Addison-Wesley, 1991

- W.Fontana
  Functional Self-Organization in Complex Systems
  in: *1990 Lectures in Complex Systems*, SFI Studies in the Sciences of Complexity, Lecture Notes Vol. III, L.Nadel and D.Stein (eds.),

pp. 407–426, Addison-Wesley, 1991

- Reprinted in: *Pattern Formation in the Physical and Biological Sciences*, H. F. Nijhout, L. Nadel, and D. Stein (eds.), pp. 43–63, Addison-Wesley, Reading, MA, 1997

- W.Fontana, T.Griesmacher, W.Schnabl, P.F.Stadler and P.Schuster
  Statistics of Landscapes based on Free Energy, Replication and Degradation Rate Constants of RNA Secondary Structures
  *Chemical Monthly*, **122**, 795–819 (1991)

- W.Fontana, W.Schnabl and P.Schuster
  Physical Aspects of Evolutionary Optimization and Adaptation
  *Phys.Rev.A*, **40**, 3301–3321 (1989)

- W.Fontana and P.Schuster
  A Computer Model of Evolutionary Optimization
  *Biophysical Chemistry*, **26**, 123–147 (1987)

Essays and Commentary

- W.Fontana and S.Ballati
  Complexity: An Essay
  *Complexity*, **4**, 14–16 (1999)

- W.Fontana
  Keine Information ohne Evolution
  *Ethik-und Sozialwissenschaften*, **9**, 198–200 (1998)

Book Reviews

W.Fontana
The Theory of Evolution and Dynamical Systems
by J.Hofbauer and K.Sigmund
*Mathematical Biosciences*, **96**, 135–137 (1989)

Theses

W.Fontana
A Computer Model of Evolutionary Optimization
PhD Thesis (in German), University of Vienna, Austria (1987)

W.Fontana
Molecular Replication and Random Selection: On a Simple Stochastic Model of Non-Darwinian Behavior
Master Thesis (in German), University of Vienna, Austria (1984)

Public Domain Software Packages

I.L.Hofacker, W.Fontana, P.F.Stadler, L.S.Bonhoeffer, M.Tacker and P.Schuster

*Vienna RNA Package* (http://www.tbi.univie.ac.at/RNA)

Patents

W.Fontana, L.G.Meredith,
"Using Biological Models", US 2007/0100558 A1
patent application

S. Hulme, S. S. Shevkoplyas, J. Apfeld, W. Fontana, G. M. Whitesides
"Containment of Objects within a Microfluidic Device"
provisional filed 08/10/07

J. Feret, V. Danos, J. Krivine, R. Harmer, W. Fontana
"Biological Models", provisional application No. 61/101,970 (2008)