

Curriculum Vitae for Emmanuel David Tannenbaum

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Department of Chemistry
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Current research interests: Evolution and maintenance of sexual reproduction in unicellular and multicellular organisms. Genetic repair, Horizontal Gene Transfer (HGT), quasispecies theory. Network evolution and the origin-of-life. Stem and cancer cell systems and evolutionary biology. Anti-bacterial and anti-cancer treatment strategies.

Basic Information

Date and Place of Birth: June 28, 1978 in Jerusalem, Israel.
Marital Status: Married with one child.
Name of Spouse: Maria Litvan-Tannenbaum.
Names of Children: Tom Tannenbaum (b. October 4, 2007).
Languages Spoken: Fluent in English and Hebrew, some knowledge of French and Russian.
Programming Languages: C, Pascal, BASIC, Fortran, Matlab, Mathematica.

Education

1. **1995-1998**
B.S. in Mathematics and B.ChE in Chemical Engineering, University of Minnesota.
2. **1998-2002**
Ph.D. in Chemical Physics, Harvard University.
Advisor: Prof. Eric J. Heller.
Title of Thesis: *Topics in Semiclassical Quantum Dynamics: Phase-Space Deformations, Energy Redistribution, and Vibrational Predissociation*

Research Positions

1. **August, 2007 - Present**
Senior Lecturer, Department of Chemistry, Ben-Gurion University of the Negev.
2. **August, 2006 - July, 2007**
Assistant Professor (tenure-track), School of Biology, Georgia Institute of Technology.
3. **August, 2005 - July, 2006**
Senior Lecturer, Department of Chemistry, Ben-Gurion University of the Negev.

4. **March, 2003 - July, 2005**
 NIH Postdoctoral Fellow, Department of Chemistry and Chemical Biology, Harvard University.
 Research in evolutionary dynamics.
 Supervisor: Professor Eugene I. Shakhnovich.
5. **July-September, 2002**
 Summer postdoc, Department of Chemistry and Biochemistry, Georgia Institute of Technology.
 Developed pattern recognition algorithms to study canonical motifs in globular RNAs, and statistically analyze the locations of magnesium binding sites.
 Supervisor: Professor Loren D. Williams.
6. **September 1998 - May, 2002**
 Graduate student, Department of Chemistry and Chemical Biology, Harvard University.
 Research in semiclassical quantum mechanics.
 Supervisor: Professor Eric J. Heller.
7. **June-August, 1996**
 Summer student, Department of Mathematics, Weizmann Institute of Science.
 Research in game theory.
 Supervisor: Professor Yakar Kannai.
8. **September 1995 - June, 1998**
 Undergraduate Research Assistant, Department of Chemical Engineering and Materials Science, University of Minnesota.
 Percolation in electrical and fluid networks.
 Supervisor: Professor H. Ted Davis.

Awards and Honors

1. National Merit Scholar, 1995.
2. Presidential Scholarship, University of Minnesota, 1995.
3. Undergraduate Research Assistant Scholarship, University of Minnesota, 1995.
4. Mathematics Undergraduate Scholarship, University of Minnesota, 1997.
5. Graduated *summa cum laude* in Chemical Engineering and *magna cum laude* in Mathematics from the University of Minnesota, 1998.
6. NSF Graduate Research Fellowship, 1998.
7. Karplus Prize in Chemical Physics, Harvard University, 1998.
8. Nominated by PhD advisor for a Harvard Junior Fellowship, 2002.
9. NIH Postdoctoral Research Fellow, Harvard University, 2003-2005.

10. Personally invited by Prof. Manfred Eigen to attend his Winter School in Klosters, Switzerland (2005).
11. Alon Fellowship, Israel Science Foundation (2005).
12. Contributed lecture was selected for the American Physical Society March Meeting Press Release (2006). Interviewed for the American Association for the Advancement of Science's (AAAS) radio show Science Update (2006).
Contributed lecture title: "Selective Advantage for Sexual Reproduction."
13. Paper entitled "Temporal Differentiation and the Optimization of System Output" (*Phys. Rev. E* **77**, 011922 (2008)) was the subject of an article in *Physical Review Focus* entitled "Why Sleep?" (<http://focus.aps.org/story/v21/st1>).

Research Grants

1. Binational Science Foundation Start-Up Grant – \$60,000 (2006).
Project Title: "Developing a Theory of Mutagen-Response for Cellular Organisms".
2. Boeing – \$30,000 (2010).
Project Title: "Gravity-Based Detection of Moving Objects: Feasibility and Potential Applications".

Teaching

1. Freshman Chemistry, Harvard University (Fall 1998 - Spring 1999).
2. Graduate Quantum Chemistry, Harvard University (Fall 2003).
3. Introduction to Physical Chemistry, Ben-Gurion University of the Negev (Spring 2006, 2008).
4. Mathematical Models in Biology, Georgia Institute of Technology (Fall 2006).
5. Freshman Chemistry, Ben-Gurion University of the Negev (Fall 2008).

Professional Activities

1. The American Conference of Theoretical Chemistry (ACTC) in Boulder, CO (1999).
Contributed poster title: "Dynamical Tunneling As A Mechanism of Intramolecular Vibrational Relaxation."
2. The Pitzer Memorial Symposium in Berkeley, CA (2000).
Contributed poster title: "Statistical Properties of Vibrational States of Polyatomic Molecules."

3. The Gentner Symposium on Quantum Chaos in Ein Gedi, Israel (2001).
Contributed poster title: "Semiclassical Quantization Using Invariant Tori: A Gradient-Descent Approach."
4. The Canadian Symposium of Theoretical Chemistry, Ottawa (2001).
Contributed poster title: "Semiclassical Quantization Using Invariant Tori: A Gradient-Descent Approach."
5. The Conference of the Israel Chemical Society in Jerusalem, Israel (2002).
Contributed poster title: "A Perturbative Approach to Vibrational Predissociation Rates: Application to ArHF."
6. The Gordon Research Conference in Bioinformatics at Oxford, England (2003).
Contributed poster title: "The Error and Repair Catastrophes: A Two-Dimensional Phase Diagram in the Quasispecies Model."
7. The Fourth Georgia Tech and UGA International Conference on Bioinformatics in Atlanta, GA (2003).
Contributed poster title: "Semiconservative Replication in the Quasispecies Model: Modeling Evolution at Arbitrary Mutation Rates."
8. The Fifth International Conference on Biological Physics in Gothenburg, Sweden (2004).
Contributed poster title: "Semiconservative Replication in the Quasispecies Model."
9. Center for Studies in Physics and Biology Seminar, The Rockefeller University (2005).
Invited lecture title: "Equilibrium Distribution of Mutators in the Single-Fitness-Peak Model."
10. Workshop on "Aspects of Self-Organization in Evolution," The Mathematical Biosciences Institute at Ohio State University (2005).
Invited lecture title: "Solution of the Quasispecies Model for an Arbitrary Gene Network."
11. The Gordon Conference on DNA Damage, Mutation, and Cancer, Ventura, CA (2006).
Contributed poster title: "Evolutionary Dynamics of Asymmetric Chromosome Segregation and the Emergence of Cancer."
12. The American Physical Society March Meeting in Baltimore, MD (2006).
Contributed lecture title: "Selective Advantage for Sexual Reproduction."
13. The joint SMB-SIAM conference on the Life Sciences, Raleigh, North Carolina (2006).
Contributed poster title: "Selective Advantage for Sexual Reproduction."
14. Conference on Mathematical and Population Dynamics II, Campinas, Brazil (2007).
Plenary lecture title: "Selective Advantage for Sexual Reproduction."
15. The American Physical Society March Meeting in New Orleans, LA (2008).
Contributed lecture title: "A Comparison of Various Asexual and Sexual Replication Strategies."

16. The Gordon Research Conference on Theoretical Biology and Biomathematics at Il Ciocco Hotel and Resort, Italy (2008).
Contributed poster titles:
 - (1) “The Effect of the SOS Response on the Mean Fitness of Unicellular Populations: A Quasispecies Approach.”
 - (2) “The Effect of Mutators on Adaptability in Time-Dependent Fitness Landscapes.”
 - (3) “Associative Learning and the Emergence of Polycistronic RNA.”
17. Society for Mathematical Biology Annual Meeting at Rio de Janeiro, Brazil (2010).
Invited lecture title: “Diploidy and the Selective Advantage for Sexual Reproduction in Unicellular Organisms.”
18. Given numerous invited talks at various departments in both Israel and the United States.

Books

1. E. Tannenbaum, *Evolutionary Dynamics and Quasispecies Theory*, Springer-Verlag (in preparation).

Publications

1. Y. Kannai and E. Tannenbaum, “Paths Leading to the Nash Set for Non-Smooth Games,” *The International Journal of Game Theory* **27**, 393-405 (1998).
2. E. Tannenbaum and E.J. Heller, “Semiclassical Quantization Using Invariant Tori: A Gradient-Descent Approach,” *The Journal of Physical Chemistry A* **105**, 2803-2813 (2001).
3. E. Tannenbaum, “Partial-Differential-Equation-Based Approach to Classical Phase-Space Deformations,” *Physical Review E* **65**, 066613 (2002) (*10 pages*).
4. E. Tannenbaum, K.J. Higgins, W. Klemperer, B. Segev, and E.J. Heller, “A Perturbative Approach to Vibrational Predissociation Rates: Application to ArHF,” *The Journal of Physical Chemistry B* **106**, 8100-8107 (2002).
5. E. Tannenbaum and E.J. Heller, “Determination of Bound-Free Dissociative Couplings Via Classical Fourier Coefficients,” *The Journal of Chemical Physics* **117**, 9574-9579 (2002).
6. E. Tannenbaum, E.J. Deeds, and E.I. Shakhnovich, “Equilibrium Distribution of Mutators in the Single Fitness Peak Model,” *Physical Review Letters* **91**, 138105 (2003) (*4 pages*).

7. E. Hershkovitz, E. Tannenbaum, S.B. Howerton, A. Sheth, A. Tannenbaum, and L.D. Williams, "Automated Identification of RNA Conformational Motifs: Theory and Application to the HM LSU 23S rRNA," *Nucleic Acids Research* **31**, 6249-6257 (2003).
8. E. Tannenbaum and E.I. Shakhnovich, "The Error and Repair Catastrophes: A Two-Dimensional Phase Diagram in the Quasispecies Model," *Physical Review E* **69**, 011902 (2004) (*11 pages*).
9. E. Tannenbaum, E.J. Deeds, and E.I. Shakhnovich, "Semiconservative Replication in the Quasispecies Model," *Physical Review E* **69**, 061916 (2004) (*14 pages*).
10. E. Tannenbaum and E.I. Shakhnovich, "Solution of the Quasispecies Model for an Arbitrary Gene Network," *Physical Review E* **70**, 021903 (2004) (*15 pages*).
11. S. Kallush, E. Tannenbaum, and B. Segev, "Local Group Velocity and Path-delay: Semiclassical Propagators for the Time Evolution of Wigner Functions in Deep Tunneling and in Dispersive Media," *Chemical Physics Letters* **396**, 261-267 (2004).
12. E. Tannenbaum, J.L. Sherley, and E.I. Shakhnovich, "Imperfect DNA Lesion Repair in the Semiconservative Quasispecies Model: Derivation of the Hamming Class Equations and Solution of the Single-Fitness-Peak Landscape," *Physical Review E* **70**, 061915 (2004) (*15 pages*).
13. E. Tannenbaum, J.L. Sherley, and E.I. Shakhnovich, "Evolutionary Dynamics of Adult Stem Cells: Comparison of Random and Immortal Strand Segregation Mechanisms," *Physical Review E* **71**, 041914 (2005) (*9 pages*).
14. E. Tannenbaum and E.I. Shakhnovich, "Semiconservative Replication, Genetic Repair, and Many-Gened Genomes: Extending the Quasispecies Paradigm to Living Systems," *Physics of Life Reviews* **2**, 290-317 (2005).
15. E. Tannenbaum, "Selective Advantage for Multicellular Replicative Strategies: A Two-Cell Example," *Physical Review E* **73**, 010904 (2006) (*4 pages*).
16. E. Tannenbaum, "An RNA-Centered View of Eukaryotic Cells," *Biosystems* **84**, 217-224 (2006).
17. E. Tannenbaum, "Selective Advantage for Sexual Reproduction," *Physical Review E* **73**, 061925 (2006) (*9 pages*).

18. E. Tannenbaum, J.L. Sherley, and E.I. Shakhnovich, "Semiconservative Quasispecies Equations for Polysomic Genomes: The Haploid Case," *The Journal of Theoretical Biology* **241**, 791-805 (2006).
19. E. Tannenbaum, "Extracting Viability Landscapes from Mutagen-Response Experiments," *The Journal of Theoretical Biology* **245**, 37-43 (2007).
20. E. Tannenbaum, "When Does Division of Labor Lead to Increased System Output?" *The Journal of Theoretical Biology* **247**, 413-425 (2007).
21. B. Lee and E. Tannenbaum, "Asexual and Sexual Replication in Sporulating Organisms," *Physical Review E* **76**, 021909 (2007) (*9 pages*).
22. N. Gandhi, G. Ashkenasy, and E. Tannenbaum, "Associative Learning in Biochemical Networks," *The Journal of Theoretical Biology* **249**, 58-66 (2007).
23. E. Tannenbaum, "Comparison of Three Replication Strategies in Complex Multicellular Organisms: Asexual Replication, Sexual Replication with Identical Gametes, and Sexual Replication with Distinct Sperm and Egg Gametes," *Physical Review E* **77**, 011915 (2008) (*16 pages*).
24. E. Tannenbaum, "Temporal Differentiation and the Optimization of System Output," *Physical Review E* **77**, 011922 (2008) (*14 pages*).
25. E. Tannenbaum and J.F. Fontanari, "A Quasispecies Approach to the Evolution of Sexual Replication in Unicellular Organisms," *Theory in Biosciences* **127**, 53-65 (2008).
26. P. Gorodetsky and E. Tannenbaum, "Effect of Mutators on Adaptability in Time-Varying Fitness Landscapes," *Physical Review E* **77**, 042901 (2008) (*4 pages*).
27. E. Tannenbaum, "A Comparison of Sexual and Asexual Replication Strategies in a Simplified Model Based on the Yeast Life Cycle," *Theory in Biosciences* **127**, 323-333 (2008).
28. E. Tannenbaum, "Speculations on the Emergence of Self-Awareness in Big-Brained Organisms: The Roles of Associative Memory and Learning, Existential and Religious Questions, and the Emergence of Tautologies," *Consciousness and Cognition* **18**, 414-427 (2009).

29. E. Tannenbaum, "Selective Advantage for Sexual Reproduction with Random Haploid Fusion," *Theory in Biosciences* **128**, 85-96 (2009).
30. M. Kleiman and E. Tannenbaum, "Diploidy and the Selective Advantage for Sexual Reproduction in Unicellular Organisms," *Theory in Biosciences* **128**, 249-285 (2009).
31. N. Wagner, A. Pross, and E. Tannenbaum, "Selection Advantage of Metabolic Over Non-Metabolic Replicators: A Kinetic Analysis," *Biosystems* **99**, 126-129 (2010).
32. Y. Raz and E. Tannenbaum, "The Influence of Horizontal Gene Transfer on the Mean Fitness of Unicellular Populations in Static Environments," *Genetics* **185**, 327-337 (2010).
33. N. Wagner, E. Tannenbaum, and G. Ashkenasy, "Second-Order Quasispecies Yields Discontinuous Mean Fitness at the Error Threshold," *Physical Review Letters* **104**, 188101 (2010) (*4 pages*).
34. E. Itan and E. Tannenbaum, "Semiconservative Quasispecies Equations for Polysomic Genomes: The General Case," *Physical Review E* **81**, 061915 (2010) (*14 pages*).
35. A. Kama and E. Tannenbaum, "Effect of the SOS Response on the Mean Fitness of Unicellular Populations: A Quasispecies Approach," *PLoS ONE* **5**, e14113 (2010) (*9 pages*).
36. E. Tannenbaum, T. Georgiou, and A. Tannenbaum, "Signals and Control Aspects of Optimal Mass Transport and the Boltzmann Entropy," *IEEE Conference on Decision and Control* (2010).