

MARTIN A. NOWAK

Curriculum Vitae

Personal Information

Name: Martin Andreas Nowak

Address: Program for Evolutionary Dynamics, Harvard University

One Brattle Square, Cambridge, MA 02138

Phone: (617) 496-4737 Fax: (617) 496-4629

Email: martin_nowak@harvard.edu

Web: www.ped.fas.harvard.edu & www.martinnowak.com

Degrees: M.Sc. Vienna, Ph.D. Vienna, M.A. (honoris causa) Oxford, A.M. (honoris causa) Harvard, Ph.D. (honoris causa) Cuza University of Iasi, Ph.D. (honoris causa) Dominican School of Philosophy and Theology

Current position

Professor of Mathematics and Biology, Harvard University

Director, Program for Evolutionary Dynamics, Harvard University

Education

1975-1983 Albertus Magnus Gymnasium in Vienna

1983-1989 University of Vienna, studying Biochemistry and Mathematics

1985 First Diploma: Biochemistry (first class honors)

1987 Diploma thesis: Theoretical Chemistry

1987 Second Diploma: Biochemistry (first class honors; finished one year faster)

1987-1989 Doctoral thesis: Mathematics

1989 Final exams for degree *Doctor rerum naturalium* (with highest honors)

Scientific career

Vienna:

1987-1988 Institute for Theoretical Chemistry, Peter Schuster

1987-1989 Institute for Mathematics, Karl Sigmund

1988 Max Planck Institute for Biophysical Chemistry, Göttingen, Manfred Eigen

1993 "Habilitation" at the Institute of Mathematics, University of Vienna

Oxford:

1989-1990 Erwin Schrödinger Scholarship to work with Robert May (Lord May of Oxford)

1990-1992 Guy Newton Junior Research Fellow, Wolfson College

1991 Royal Society Research Grant

1992-1998 Wellcome Trust Senior Research Fellow in Biomedical Sciences

1993-1996 E. P. Abraham Junior Research Fellow, Keble College

1995-1998 Head of Mathematical Biology Group

1996-1998 Senior Research Fellow, Keble College

1997-1998 Professor of Mathematical Biology

Princeton:

1998-2003 Head, Program in Theoretical Biology, Institute for Advanced Study

1999-2003 Associated Faculty, Princeton University, Ecology and Evolutionary Biology

2000-2003 Associated Faculty, Princeton University, Program in Applied and Computational Mathematics

Harvard:

2003- Professor of Biology and Mathematics,
Director, Program for Evolutionary Dynamics

Prizes, Named Lectures, Memberships

- 1990 *Promotion sub auspiciis praesidentis rei publicae* (a distinction given to those who have passed all major exams during school and university with the best mark)
- 1990 Prize from the Austrian Science Minister
- 1995 Richardson Lecture, Keble College
- 1996 Weldon Memorial Prize (given every 2-3 years for outstanding contributions to Biometric Science; previous winners include: Ronald Fisher, JBS Haldane, Sewall Wright, Motoo Kimura, Robert May, David Cox)
- 1997 Shanks Lecture, Vanderbilt University, Nashville, Tennessee
- 1998 Albert Wander Prize and Memorial Lecture, University of Bern, Switzerland
- 1999 Porter Lecture, Rice University, Houston, Texas
- 1999 Erwin Schroedinger Lecture, University of Vienna, Austria
- 1999 Akira Okubo Prize, International and Japanese Society for Mathematical Biology
- 1999 Roger F. Murray Prize, Institute for Quantitative Research in Finance
- 2000 Gergen Lecture, Duke University
- 2001 Benjamin Pinkel Lecture, University of Pennsylvania
- 2001 Corresponding Member, Austrian Academy of Sciences
- 2001 Rainich Lectures, University of Michigan, Ann Arbor
- 2001 David Starr Jordan Prize, Stanford University, Cornell University, Indiana University
- 2003 Henry Dale Prize, The Royal Institution, London
- 2006 Invited Lecture, Congress for Mathematics, Madrid
- 2006 R.R. Hawkins Award for *Evolutionary Dynamics*, Professional and Scholarly Publishing Division of the American Association of Publishers
- 2007 Radon Lecture, Austrian Academy of Sciences
- 2008 Coxeter Lectures, Fields Institute, Toronto
- 2010 Templeton Lectures, Johns Hopkins University
- 2010 Doctor Honoris Causa, Alexandru Ioan Cuza University of Iasi, Romania
- 2011 Max Planck Lecture, Stuttgart, Germany
- 2012 MBI 10th Anniversary Keynote talk, Ohio State University
- 2012 Plenary speaker, Canadian Mathematical Society
- 2013 Plenary speaker, International Congress of Ecology, London, England
- 2013 Simons Lecture, Institute for Mathematics and its Applications, The Simons Foundation, Minneapolis
- 2013 Andre-Aisenstadt Chair, Centre de Recherches Mathématiques, Montreal
- 2014 Plenary Opening Talk, Nephrology Conference, Baden, Austria
- 2014 Keynote Lecture, 11th Austrian Research and Innovation Talk (ARIT), MIT Media Lab
- 2015 Plenary speaker, Collins Lecture Series, Massachusetts General Hospital
- 2015 Plenary speaker, Drug Discovery and World Therapy Congress, Boston
- 2016 Invited Lecture, Fermilab, Illinois
- 2016 Sewall Wright Speaker, University of Chicago
- 2016 Fannie Cox Prize for Excellence in Science Teaching
- 2017 AACR Team Science Award

Research Interests

Evolutionary dynamics
Cancer evolution and treatment
Infection dynamics
Quasispecies theory
Genetic redundancy
Evolutionary game theory

Adaptive dynamics
Finite populations
Evolutionary graph theory
Evolutionary set theory
Evolution of language
Cooperation, fairness, reputation
Indirect reciprocity
Group selection
Experimental games
Origin of evolution, prolife
Evolution of eusociality

Books

Nowak M, RM May (2000). *Virus Dynamics: Mathematical Principles of Immunology and Virology*. Oxford: Oxford University Press.

Nowak MA (2006). *Evolutionary Dynamics: Exploring the Equations of Life*. Cambridge, MA: Harvard University Press.

Nowak MA, R Highfield (2011). *SuperCooperators: Why We Need Each Other to Succeed*. Simon & Schuster.

Coakley S, MA Nowak, eds (2013). *Evolution, Games, and God: The Principle of Cooperation*. Harvard University Press.

Selected Publications

Noble C, J Olejarz, K Esvelt, G Church, MA Nowak (2017). Evolutionary dynamics of CRISPR gene drives. *Science Advances* Vol. 3, no. 4, e1601964. DOI: 10.1126/sciadv.1601964

Allen B, G Lippner, Y-T Chen, B Fotouhi, N Momeni, S-T Yau, MA Nowak (2017). Evolutionary dynamics on any population structure. *Nature* 544: 227–230. DOI: 10.1038/nature21723

Waclaw B, I Bozic, ME Pittman, RH Rhuban, B Vogelstein, MA Nowak (2015). A spatial model predicts that dispersal and cell turnover limit intratumour heterogeneity. *Nature*. DOI: 10.1038/nature14971

Hauser OP, DG Rand, A Peysakhovich, MA Nowak (2014). Cooperating with the future. *Nature* DOI: 10.1038/nature13530

Diaz LA Jr., RT Williams, J Wu, I Kinde, JR Hecht, J Berlin, B Allen, I Bozic, JG Reiter, MA Nowak, KW Kinzler, KS Oliner, B Vogelstein (2012). The molecular evolution of acquired resistance to targeted EGFR blockade in colorectal cancers. *Nature* 486 (7404): 537-540. DOI: 10.1038/nature11219

Nowak MA (2012). Evolving cooperation. *J theor Biol* 299: 1-8. DOI: 10.1016/j.jtbi.2012.01.014

Rand DG, JD Greene, MA Nowak (2012). Spontaneous giving and calculated greed. *Nature* 489 (7416): 427-430. DOI: 10.1038/nature11467

Rosenbloom DIS, AL Hill, SA Rabi, RF Siliciano, MA Nowak (2012). Antiretroviral dynamics determines HIV evolution and predicts therapy outcome. *Nat Med* 18 (9): 1378-1385. DOI: 10.1038/nm.2892

van Veelen M, J García, DG Rand, MA Nowak (2012). Direct reciprocity in structured populations. *Proc Natl Acad Sci USA* 109 (25): 9929-9934. DOI: 10.1073/pnas.1206694109

Michel JB, YK Shen, A Presser Aiden, A Veres, MK Gray, The Google Books Team, JP Pickett, D Hoiberg, D Clancy, P Norvig, J Orwant, S Pinker, MA Nowak, E Lieberman Aiden (2011). Quantitative analysis of culture using millions of digitized books. *Science* 331 (6014): 176-182. DOI: 10.1126/science.1199644

Nowak MA, R Highfield (2011). *SuperCooperators: Why We Need Each Other to Succeed*. Simon & Schuster. ISBN: 9781451626636

Bozic I, T Antal, H Ohtsuki, H Carter, D Kim, S Chen, R Karchin, KW Kinzler, B Vogelstein, MA Nowak (2010). Accumulation of driver and passenger mutations during tumor progression. *Proc Natl Acad Sci USA* 107: 18545–18550. DOI: 10.1073/pnas.1010978107

Nowak MA, CE Tarnita, EO Wilson (2010). The evolution of eusociality. *Nature* 466: 1057-1062. DOI: 10.1038/nature09205

Yachida S, S Jones, I Bozic, T Antal, R Leary, B Fu, M Kamiyama, RH Hruban, JR Eshleman, MA Nowak, VE Velculescu, KW Kinzler, B Vogelstein, CA Iacobuzio-Donahue (2010). Distant metastasis occurs late during the genetic evolution of pancreatic cancer. *Nature* 467: 1114–1117. DOI: 10.1038/nature09515

Antal T, H Ohtsuki, J Wakeley, PD Taylor, MA Nowak (2009). Evolution of cooperation by phenotypic similarity. *Proc Natl Acad Sci USA* 106: 8597-8600. DOI: 10.1016/j.jtbi.2008.11.023

Ohtsuki H, Y Iwasa, MA Nowak (2009). Indirect reciprocity provides only a narrow margin of efficiency for costly punishment. *Nature* 457: 79-82. DOI: 10.1038/nature07601

Rand DG, A Dreber, T Ellingsen, D Fudenberg, MA Nowak (2009). Positive interactions promote public cooperation. *Science* 325: 1272-1275. DOI: 10.1126/science.1177418

Tarnita CE, T Antal, H Ohtsuki, MA Nowak (2009). Evolutionary dynamics in set structured populations. *Proc Natl Acad Sci USA* 106: 8601-8604. DOI: 10.1073/pnas.0903019106

Dreber A, DG Rand, D Fudenberg, MA Nowak (2008). Winners don't punish. *Nature* 452: 348-351. DOI: 10.1038/nature06723

Nowak MA, H Ohtsuki (2008). Prevolutionary dynamics and the origin of evolution. *Proc Natl Acad Sci USA* 105: 14924-14927. DOI: 10.1073/pnas.0806714105

Hauert C, A Traulsen, H Brandt, MA Nowak, K Sigmund (2007). Via freedom to coercion: The emergence of costly punishment. *Science* 316: 1905-1907. DOI: 10.1126/science.1141588

Lieberman E, JB Michel, J Jackson, T Tang, MA Nowak (2007). Quantifying the evolutionary dynamics of language. *Nature* 449: 713-716. DOI: 10.1038/nature06137

Nowak MA (2006). *Evolutionary Dynamics: Exploring the Equations of Life*. Cambridge, MA: Harvard University Press. (Excerpt, Nature review, Science review, R.R. Hawkins Award). ISBN: 9780674023383

Nowak MA (2006). Five rules for the evolution of cooperation. *Science* 314: 1560-1563. DOI: 10.1126/science.1133755

Ohtsuki H, C Hauert, E Lieberman, MA Nowak (2006). A simple rule for the evolution of cooperation on graphs and social networks. *Nature* 441: 502-505. DOI: 10.1016/j.jtbi.2005.11.012

Lieberman E, C Hauert, MA Nowak (2005). Evolutionary dynamics on graphs. *Nature* 433: 312-316. DOI: 10.1038/nature03204

Michor F, TP Hughes, Y Iwasa, S Branford, NP Shah, CL Sawyers, MA Nowak (2005). Dynamics of chronic myeloid leukemia. *Nature* 435: 1267-1270. DOI: 10.1038/nature03669

Nowak MA, K Sigmund (2005). Evolution of indirect reciprocity. *Nature* 437: 1291-1298. DOI: 10.1038/nature04131

Nowak MA, F Michor, Y Iwasa (2004). Evolutionary dynamics of tumor suppressor gene inactivation. *Proc Natl Acad Sci USA* 101: 10635-10638. DOI: 10.1073/pnas.0400747101

Nowak MA, A Sasaki, C Taylor, D Fudenberg (2004). Emergence of cooperation and evolutionary stability in finite populations. *Nature* 428: 646-650. DOI: 10.1038/nature02414

Nowak MA, K Sigmund (2004). Evolutionary dynamics of biological games. *Science* 303: 793-799. DOI: 10.1126/science.1093411

Wei X, JM Decker, S Wang, H Hui, JC Kappes, W Xiaoyun, JF Salazar, MG Salazar, JM Kilby, MS Saag, NL Komarova, MA Nowak, BH Hahn, PD Kwong, GM Shaw (2003). Antibody neutralization and escape by HIV-1. *Nature* 422: 307-312. DOI: 10.1038/nature01470

Nowak MA, NL Komarova, P Niyogi (2002). Computational and evolutionary aspects of language. *Nature* 417: 611-617. DOI: 10.1038/nature00771

Nowak MA, NL Komarova, A Sengupta, PF Jallepalli, IM Shih, B Vogelstein, C Lengauer (2002). The role of chromosomal instability in tumor initiation. *Proc Natl Acad Sci USA* 99: 16226-16231. DOI: 10.1073/pnas.202617399

Nowak MA, NL Komarova, P Niyogi (2001). Evolution of universal grammar. *Science* 291: 114-118. DOI: 10.1126/science.291.5501.114

Nowak M, RM May (2000). *Virus Dynamics: Mathematical Principles of Immunology and Virology*. Oxford University Press. ISBN: 9780198504177

Nowak MA, KM Page, K Sigmund (2000). Fairness versus reason in the ultimatum game. *Science* 289: 1773-1775. DOI: 10.1126/science.289.5485.1773

Nowak MA, JB Plotkin, VAA Jansen (2000). The evolution of syntactic communication. *Nature* 404: 495-498. DOI: 10.1038/35006635

Nowak MA, D Krakauer (1999). The evolution of language. *Proc Natl Acad Sci USA* 96: 8028-8033. DOI: 10.1073/pnas.96.14.8028

Nowak MA, K Sigmund (1998). Evolution of indirect reciprocity by image scoring. *Nature* 393: 573-577. DOI: 10.1038/31225

Bonhoeffer S, RM May, GM Shaw, MA Nowak (1997). Virus dynamics and drug therapy. *Proc Natl Acad Sci USA* 94: 6971-6976. DOI: 10.1073/pnas.94.13.6971

Nowak MA, MC Boerlijst, J Cooke, J Maynard Smith (1997). Evolution of genetic redundancy. *Nature* 388: 167-171. DOI: 10.1038/40618

Nowak MA, CRM Bangham (1996). Population dynamics of immune responses to persistent viruses. *Science* 272: 74-79. DOI: 10.1126/science.272.5258.74

Nowak MA, S Bonhoeffer, AM Hill, R Boehme, HC Thomas, H McDade (1996). Viral dynamics in hepatitis B virus infection. *Proc Natl Acad Sci USA* 93: 4398-4402. DOI: 10.1073/pnas.93.9.4398

Nowak MA, RM May, RE Phillips, S Rowland-Jones, DG Lalloo, S McAdam, P Klenerman, B Köppe, K Sigmund, CRM Bangham, AJ McMichael (1995). Antigenic oscillations and shifting immunodominance in HIV-1 infections. *Nature* 375: 606-611. DOI: 10.1038/375606a0

Wei X, SK Ghosh, ME Taylor, VA Johnson, EA Emini, P Deutsch, JD Lifson, S Bonhoeffer, MA Nowak, BH Hahn, MS Saag, GM Shaw (1995). Viral dynamics in human immunodeficiency virus type 1 infection. *Nature* 373: 117-122. DOI: 10.1038/373117a0

Nowak MA, RM May (1994). Superinfection and the evolution of parasite virulence. *Proc R Soc B* 255: 81-89. DOI: 10.1098/rspb.1994.0012

Tilman D, RM May, CL Lehman, MA Nowak (1994). Habitat destruction and the extinction debt. *Nature* 371: 65-66. DOI: 10.1038/371065a0

Nowak MA, K Sigmund (1993). A strategy of win-stay, lose-shift that outperforms tit for tat in the Prisoner's Dilemma game. *Nature* 364: 56-58. DOI: 10.1038/364056a0

Nowak MA, RM May (1992). Evolutionary games and spatial chaos. *Nature* 359: 826-829. DOI: 10.1038/359826a0

Nowak MA, K Sigmund (1992). Tit for tat in heterogeneous populations. *Nature* 355: 250-253. DOI: 10.1038/355250a0

Nowak MA, RM Anderson, AR McLean, TFW Wolfs, J Goudsmit, RM May (1991). Antigenic diversity thresholds and the development of AIDS. *Science* 254: 963-969. DOI: 10.1126/science.1683006.

Articles in Scientific American, Natural History, and New Scientist

Nowak MA, RM May, K Sigmund (1995). The arithmetics of mutual help. *Sci Am* 272: 76-81.

Nowak MA, AJ McMichael (1995). How HIV defeats the immune system. *Sci Am* 273: 58-65.

Nowak MA (2000). Homo Grammaticus. *Nat Hist* 109: 36-44.

Sigmund K, K Fehr, MA Nowak (2002). The economics of fair play. *Sci Am* 286: 82-87.

Rand DG, MA Nowak (2009). Name and shame: How reputation could save the Earth. *New Scientist* 204 (2734): 28-29.

Nowak MA (2012). Why we help. *Sci Am* 307 (1): 34-39.

All Publications

1989

1. Nowak M, P Schuster (1989). Error thresholds of replication in finite populations: Mutation frequencies and the onset of Muller's ratchet. *J theor Biol* 137: 375-395. DOI: 1
2. Nowak M, K Sigmund (1989). Game-dynamical aspects of the prisoner's dilemma. *Appl Math Comp* 30: 191-213. DOI: 10.1016/0096-3003(89)90052-0
3. Nowak M, K Sigmund (1989). Oscillations in the evolution of reciprocity. *J theor Biol* 137: 21-26. DOI: 10.1016/S0022-5193(89)80146-8

1990

4. Nowak MA (1990). An evolutionarily stable strategy may be inaccessible. *J theor Biol* 142: 237-241. DOI: 10.1016/S0022-5193(05)80224-3
5. Nowak M (1990). HIV mutation rate. *Nature* 347: 522. DOI: 10.1038/347522a0
6. Nowak M (1990). Stochastic strategies in the prisoner's dilemma. *Theor Pop Biol* 38: 93-112. DOI: 10.1016/0040-5809(90)90005-G
7. Nowak MA, RM May, RM Anderson (1990). The evolutionary dynamics of HIV quasispecies and the development of immunodeficiency disease. *AIDS* 4: 1095-1103. DOI: 10.1097/00002030-199011000-00007
8. Nowak M, K Sigmund (1990). The evolution of stochastic strategies in the prisoner's dilemma. *Acta Appl Math* 20: 247-265. DOI: 10.1007/BF00049570

1991

9. Kwiatkowski D, M Nowak (1991). Periodic and chaotic host-parasite interactions in human malaria. *Proc Natl Acad Sci USA* 88: 5111-5113. DOI: 10.1073/pnas.88.12.5111
10. Magurran AE, MA Nowak (1991). Another battle of the sexes: the consequences of sexual asymmetry in mating costs and predation risk in the guppy, *Poecilia reticulata*. *Proc R Soc B* 246: 31-38. DOI: 10.1098/rspb.1991.0121
11. Nowak M (1991). The evolution of viruses. Competition between horizontal and vertical transmission of mobile genes. *J theor Biol* 150: 339-347. DOI: 10.1016/S0022-5193(05)80433-3
12. Nowak MA, RM Anderson, AR McLean, TFW Wolfs, J Goudsmit, RM May (1991). Antigenic diversity thresholds and the development of AIDS. *Science* 254: 963-969. DOI: 10.1126/science.1683006
13. Nowak MA, RM May (1991). Mathematical biology of HIV infections: Antigenic variation and diversity threshold. *Math Biosci* 106: 1-21. DOI: 10.1016/0025-5564(91)90037-J
14. Nowak MA, AR McLean (1991). A mathematical model of vaccination against HIV to prevent development of AIDS. *Proc R Soc B* 246: 141-146. DOI: 10.1098/rspb.1991.0136

1992

15. McLean AR, MA Nowak (1992). Competition between zidovudine sensitive and resistant strains of HIV. *AIDS* 6: 71-79. DOI: 10.1097/00002030-199201000-00009
16. McLean AR, MA Nowak (1992). Models of interactions between HIV and other pathogens. *J theor Biol* 155: 69-86. DOI: 10.1016/S0022-5193(05)80549-1
17. Nowak MA (1992). Variability in HIV infections. *J theor Biol* 155: 1-20. DOI: 10.1016/S0022-5193(05)80545-4
18. Nowak MA (1992). What is a quasispecies? *Trends Ecol Evol* 7: 118-121. DOI: 10.1016/0169-5347(92)90145-2
19. Nowak MA, RM May (1992). Coexistence and competition in HIV infections. *J theor Biol* 159: 329-342. DOI: 10.1016/S0022-5193(05)80728-3
20. Nowak MA, RM May (1992). Evolutionary games and spatial chaos. *Nature* 359: 826-829. DOI: 10.1038/359826a0
21. Nowak MA, K Sigmund (1992). Tit for tat in heterogeneous populations. *Nature* 355: 250-253. DOI: 10.1038/355250a0
22. Nowak MA, K Tarczy-Hornoch, JM Austyn (1992). The optimal number of major histocompatibility complex molecules in an individual. *Proc Natl Acad Sci USA* 89: 10896-10899. DOI: 10.1073/pnas.89.22.10896
23. Payne RJH, MA Nowak, BS Blumberg (1992). Analysis of a cellular model to account for the natural history of infection by the hepatitis B virus and its role in the development of primary hepatocellular carcinoma. *J theor Biol* 159: 215-240. DOI: 10.1016/S0022-5193(05)80703-9
24. Sherratt JA, MA Nowak (1992). Oncogenes, anti-oncogenes and the immune response to cancer: A mathematical model. *Proc R Soc B* 248: 261-271. DOI: 10.1098/rspb.1992.0071

1993

25. Nowak MA, RM May (1993). AIDS pathogenesis: Mathematical models of HIV and SIV infections. *AIDS* 7: S3-S18. DOI: 10.1097/00002030-199201001-00002
26. Nowak MA, RM May (1993). The spatial dilemmas of evolution. *Int J Bifurcat Chaos* 3: 35-78. DOI: 10.1142/S0218127493000040
27. Nowak MA, AR McLean (1993). Mathematical models for the pathogenesis of AIDS. In *Mathematics Applied to Biology and Medicine*, eds. J Demongeot, V Capasso. Winnipeg: Wuertz Publishing, 275-284.
28. Nowak MA, K Sigmund (1993). A strategy of win-stay, lose-shift that outperforms tit-for-tat in the Prisoner's Dilemma game. *Nature* 364: 56-58. DOI: 10.1038/364056a0
29. Nowak M, K Sigmund (1993). Chaos and the evolution of cooperation. *Proc Natl Acad Sci USA* 90: 5091-5094. DOI: 10.1073/pnas.90.11.5091

1994

30. Berry RM, MA Nowak (1994). Defective escape mutants of HIV. *J theor Biol* 171: 387-395. DOI: 10.1006/jtbi.1994.1242
31. Bonhoeffer S, MA Nowak (1994). Intra-host versus inter-host selection: Viral strategies of immune function impairment. *Proc Natl Acad Sci USA* 91: 8062-8066. DOI: 10.1073/pnas.91.17.8062
32. Bonhoeffer S, MA Nowak (1994). Mutation and the evolution of virulence. *Proc R Soc B* 258: 133-140. DOI: 10.1098/rspb.1994.0153
33. May RM, MA Nowak (1994). Superinfection, metapopulation dynamics, and the evolution of diversity. *J theor Biol* 170: 95-114. DOI: 10.1006/jtbi.1994.1171
34. Moxon ER, PB Rainey, MA Nowak, RE Lenski (1994). Adaptive evolution of highly mutable loci in pathogenic bacteria. *Curr Biol* 4: 24-33. DOI: 10.1016/S0960-9822(00)00005-1
35. Nowak MA (1994). The evolutionary dynamics of HIV infections. In *First European Congress of Mathematics: Paris, July 6-10, 1992, Vol. II*, eds. A Joseph, F Mignot, F Murat, B Prum, R Rentschler. Basel: Birkhauser, 311-326.
36. Nowak MA, S Bonhoeffer, RM May (1994). More spatial games. *Int J Bifurcat Chaos* 4: 33-56. DOI: 10.1142/S0218127494000046
37. Nowak MA, S Bonhoeffer, RM May (1994). Spatial games and the maintenance of cooperation. *Proc Natl Acad Sci USA* 91: 4877-4881. DOI: 10.1073/pnas.91.11.4877
38. Nowak MA, RM May (1994). Superinfection and the evolution of parasite virulence. *Proc R Soc B* 255: 81-89. DOI: 10.1098/rspb.1994.0012
39. Nowak MA, K Sigmund (1994). The alternating Prisoner's Dilemma. *J theor Biol* 168: 219-226. DOI: 10.1006/jtbi.1994.1101
40. Payne RJH, MA Nowak, BS Blumberg (1994). A cellular model to explain the pathogenesis of infection by the hepatitis B virus. *Math Biosci* 123: 25-58. DOI: 10.1016/0025-5564(94)90017-5
41. Tilman D, RM May, CL Lehman, MA Nowak (1994). Habitat destruction and the extinction debt. *Nature* 371: 65-66. DOI: 10.1038/371065a0

1995

42. Bonhoeffer S, EC Holmes, MA Nowak (1995). Causes of HIV diversity. *Nature* 376: 125. DOI: 10.1038/376125a0
43. Bonhoeffer S, EC Holmes, MA Nowak (1995). Varying selection pressures in HIV -1 infection. *J Acq Immun Def Synd* 10: 85.
44. Bonhoeffer S, MA Nowak (1995). Can live attenuated virus work as post-exposure treatment? *Immunol Today* 16: 131-135. DOI: 10.1016/0167-5699(95)80129-4
45. Lipsitch M, EA Herre, MA Nowak (1995). Host population structure and the evolution of virulence: A "law of diminishing returns." *Evolution* 49: 743-748. DOI: 10.2307/2410327

46. Lipsitch M, MA Nowak (1995). The evolution of virulence in sexually transmitted HIV/AIDS. *J theor Biol* 174: 427-440. DOI: 10.1006/jtbi.1995.0109
47. Lipsitch M, MA Nowak, D Ebert, RM May (1995). The population dynamics of vertically and horizontally transmitted parasites. *Proc R Soc B* 260: 321-327. DOI: 10.1098/rspb.1995.0099
48. May RM, S Bonhoeffer, MA Nowak (1995). Spatial games and evolution of cooperation. In *Advances in Artificial Life: Third European Conference on Artificial Life, Granada, Spain, June 4-6, 1995*, eds. F Moran, A Moreno, JJ Merelo, P Chacon. Berlin: Springer, 749-759.
49. May RM, MA Nowak (1995). Coinfection and the evolution of parasite virulence. *Proc R Soc B* 261: 209-215. DOI: 10.1098/rspb.1995.0138
50. McMichael AJ, S Rowland-Jones, P Klenerman, et al (1995). Epitope variation and t-cell recognition. *J Cell Biochem Suppl* 59 (S21A): 60.
51. Nowak MA (1995). AIDS pathogenesis: From models to viral dynamics in patients. *J Acq Immun Def Syn* 10: S1-S5. DOI: 10.1097/00042560-199510001-00002
52. Nowak M (1995). Evolutionary dynamics of HIV infections. In *Models for Infectious Human Diseases: Their Structure and Relation to Data*, eds. V Isham, G Medley. Cambridge: Cambridge University Press.
53. Nowak MA, S Bonhoeffer, C Loveday, P Balfe, M Semple, S Kaye, M Tenant-Flowers, R Tedder (1995). HIV results in the frame: Results confirmed. *Nature* 375: 193. DOI: 10.1038/375193a0
54. Nowak MA, RM May, RE Phillips, S Rowland-Jones, DG Laloo, S McAdam, P Klenerman, B Köppe, K Sigmund, CRM Bangham, AJ McMichael (1995). Antigenic oscillations and shifting immunodominance in HIV-1 infections. *Nature* 375: 606-611. DOI: 10.1038/375606a0
55. Nowak MA, RM May, K Sigmund (1995). Immune responses against multiple epitopes. *J theor Biol* 175: 325-353. DOI: 10.1006/jtbi.1995.0146
56. Nowak M A, RM May, K Sigmund (1995). The arithmetics of mutual help. *Sci Am* 272: 76-81. DOI: 10.1038/scientificamerican0695-76
57. Nowak MA, AJ McMichael (1995). How HIV defeats the immune system. *Sci Am* 273: 58-65. DOI: 10.1038/scientificamerican0895-58
58. Nowak MA, K Sigmund (1995). Invasion dynamics of the finitely repeated Prisoner's Dilemma. *Game Econ Behav* 11: 364-390. DOI: 10.1006/game.1995.1055
59. Nowak MA, K Sigmund, E El-Sedy (1995). Automata, repeated games and noise. *J Math Biol* 33: 703-722. DOI: 10.1007/BF00184645
60. Wei X, SK Ghosh, ME Taylor, VA Johnson, EA Emini, P Deutsch, JD Lifson, S Bonhoeffer, MA Nowak, BH Hahn, MS Saag, GM Shaw (1995). Viral dynamics in human immunodeficiency virus type 1 infection. *Nature* 373: 117-122. DOI: 10.1038/373117a0

1996

61. Antia R, MA Nowak, RM Anderson (1996). Antigenic variation and the within-host dynamics of parasites. *Proc Natl Acad Sci USA*. 93: 985-989. DOI: 10.1073/pnas.93.3.985
62. Boerlijst MC, S Bonhoeffer, MA Nowak (1996). Viral quasi-species and recombination. *Proc R Soc B* 263: 1577-1584. DOI: 10.1098/rspb.1996.0231
63. Bonhoeffer S, AVM Herz, MC Boerlijst, S Nee, MA Nowak, RM May (1996). Explaining "linguistic features" of noncoding DNA. *Science* 271: 14-15. DOI: 10.1126/science.271.5245.14b
64. Bonhoeffer S, AVM Herz, MC Boerlijst, S Nee, MA Nowak, RM May (1996). No signs of hidden language in noncoding DNA. *Phys Rev Lett* 76: 1977. DOI: 10.1103/PhysRevLett.76.1977
65. Herz AVM, S Bonhoeffer, RM Anderson, RM May, MA Nowak (1996). Viral dynamics in vivo: Limitations on estimates of intracellular delay and virus decay. *Proc Natl Acad Sci USA* 93: 7247-7251. DOI: 10.1073/pnas.93.14.7247
66. Klenerman P, RE Phillips, CR Rinaldo, LM Wahl, G Ogg, RM May, AJ McMichael, MA Nowak (1996). Cytotoxic T lymphocytes and viral turnover in HIV type 1 infection. *Proc Natl Acad Sci USA* 93: 15323-15328. DOI: 10.1073/pnas.93.26.15323

67. Lipsitch M, S Siller, MA Nowak (1996). The evolution of virulence in pathogens with vertical and horizontal transmission. *Evolution* 50: 1729-1741. DOI: 10.2307/2410731
68. McMichael AJ, P Goulder, S Rowland-Jones, MA Nowak, R Philips (1996). HIV escapes from cytotoxic lymphocytes. *Immunology* 89: 111.
69. Nowak MA (1996). Immune responses against multiple epitopes: A theory for immunodominance and antigenic variation. *Semin Virol* 7: 83-92. DOI: 10.1006/smvy.1996.0010
70. Nowak MA, RM Anderson, MC Boerlijst, S Bonhoeffer, RM May, AJ McMichael (1996). HIV-1 evolution and disease progression. *Science* 274: 1008-1011. DOI: 10.1126/science.274.5289.1008
71. Nowak MA, CRM Bangham (1996). Population dynamics of immune responses to persistent viruses. *Science* 272: 74-79. DOI: 10.1126/science.272.5258.74
72. Nowak MA, S Bonhoeffer, AM Hill, R Boehme, HC Thomas, H McDade (1996). Viral dynamics in hepatitis B virus infection. *Proc Natl Acad Sci USA* 93: 4398-4402. DOI: 10.1073/pnas.93.9.4398
73. Nowak MA, S Bonhoeffer, RM May (1996). Reply to Robustness of cooperation, A Mukherji, V Rajan, J Slagle. *Nature* 379: 126. DOI: 10.1038/379126a0
74. Payne RJH, MA Nowak, BS Blumberg (1996). The dynamics of hepatitis B virus infection. *Proc Natl Acad Sci USA* 93: 6542-6546. DOI: 10.1073/pnas.93.13.6542
75. Stekel DJ, MA Nowak, TRE Southwood (1996). Prediction of future BSE spread. *Nature* 381: 119. DOI: 10.1038/381119a0
76. Tilman D, C Lehman, R May, M Nowak (1996). Reply to Species fragmentation or area loss? S Budiansky. *Nature* 382: 216. DOI: 10.1038/382216a0

1997

77. Bittner B, S Bonhoeffer, MA Nowak (1997). Virus load and antigenic diversity. *B Math Biol* 59: 881-896. DOI: 10.1016/S0092-8240(97)00034-7
78. Boerlijst MC, MA Nowak, K Sigmund (1997). Equal pay for all prisoners. *Am Math Mon* 104: 303-305. DOI: 10.2307/297457
79. Boerlijst MC, MA Nowak, K Sigmund (1997). The logic of contrition. *J theor Biol* 185: 281-293. DOI: 10.1006/jtbi.1996.0326
80. Bonhoeffer S, JM Coffin, MA Nowak (1997). Human immunodeficiency virus drug therapy and virus load. *J Virol* 71: 3275-3278.
81. Bonhoeffer S, RM May, GM Shaw, MA Nowak (1997). Virus dynamics and drug therapy. *Proc Natl Acad Sci USA* 94: 6971-6976. DOI: 10.1073/pnas.94.13.6971
82. Bonhoeffer S, MA Nowak (1997). Pre-existence and emergence of drug resistance in HIV-1 infection. *Proc R Soc B* 264: 631-637.
83. Chun T-W, L Stuyver, SB Mizell, LA Ehler, JAM Mican, M Baseler, AL Lloyd, MA Nowak, AS Fauci (1997). Presence of an inducible HIV-1 latent reservoir during highly active antiretroviral therapy. *Proc Natl Acad Sci USA* 94: 13193-13197. DOI: 10.1073/pnas.94.24.13193
84. Cooke J, MA Nowak, MC Boerlijst, J Maynard-Smith (1997). Evolutionary origins and maintenance of redundant gene expression during metazoan development. *Trends Genet* 13: 360-364. DOI: 10.1016/S0168-9525(97)01233-X
85. Goulder PJR, RE Phillips, RA Colbert, S McAdam, G Ogg, MA Nowak, P Giangrande, G Luzzi, B Morgan, A Edwards, AJ McMichael, S Rowland-Jones (1997) Late escape from an immunodominant cytotoxic T-lymphocyte response associated with progression to AIDS. *Nat Med* 3: 212-217. DOI: 10.1038/nm0297-212
86. Goulder P, D Price, M Nowak, S Rowland-Jones, R Phillips, A McMichael (1997). Co-evolution of human immunodeficiency virus and cytotoxic T-lymphocyte responses. *Immunol Rev* 159: 17-29. DOI: 10.1111/j.1600-065X.1997.tb01004.x
87. Lifson JD, MA Nowak, S Goldstein, JL Rossio, A Kinter, G Vasquez, TA Wiltrout, C Brown, D Schneider, L Wahl, AL Lloyd, J Williams, WR Elkins, AS Fauci, VM Hirsch (1997). The

extent of early viral replication is a critical determinant of the natural history of simian immunodeficiency virus infection. *J Virol* 71: 9508-9514.

88. May RM, DJ Stekel, MA Nowak (1997). Antigenic diversity thresholds and hazard functions. *Math Biosci* 139: 59-68. DOI: 10.1016/S0025-5564(96)00141-1
89. Nowak MA, MC Boerlijst, J Cooke, J Maynard Smith (1997). Evolution of genetic redundancy. *Nature* 388: 167-171. DOI: 10.1038/40618
90. Nowak MA, S Bonhoeffer, GM Shaw, RM May (1997). Anti-viral drug treatment: Dynamics of resistance in free virus and infected cell populations. *J theor Biol* 184: 203-217. DOI: 10.1006/jtbi.1996.0307
91. Nowak MA, AL Lloyd, GM Vasquez, TA Wiltout, LM Wahl, N Bischofberger, J Williams, A Kinter, AS Fauci, VM Hirsch, JD Lifson (1997). Viral dynamics of primary viremia and antiretroviral therapy in simian immunodeficiency virus infection. *J Virol* 71: 7518-7525. DOI: 71/10/7515
92. Sigmund K, Nowak M A (1997) The natural history of mutual aid: An eye for an eye, and a meal for a meal. In *Wissenschaft als Kultur*, ed. F Stadler. New York: Springer, 259-272.
93. Stekel D, CE Parker, MA Nowak (1997). A model of lymphocyte recirculation. *Immunol Today* 18: 216-221. DOI: 10.1016/S0167-5699(97)01036-0
94. Wein LM, SA Zenios, MA Nowak (1997). Dynamic multidrug therapies for HIV: A control theoretic approach. *J theor Biol* 185: 15-29. DOI: 10.1006/jtbi.1996.0253

1998

95. Goh WC, ME Rogel, CM Kinsey, SF Michael, PN Fultz, MA Nowak, BH Hahn, M Emerman (1998). HIV-1 Vpr increases viral expression by manipulation of the cell cycle: A mechanism for selection of Vpr in vivo. *Nat Med* 4: 65-71. DOI: 10.1038/nm0198-065
96. Kilby JM, S Hopkins, TM Venetta, B DiMassimo, GA Cloud, JY Lee, L Alldredge, E Hunter, D Lambert, D Bolognesi, T Matthews, MR Johnson, MA Nowak, GM Shaw, MS Saag (1998). Potent suppression of HIV-1 replication in humans by T-20, a peptide inhibitor of gp41-mediated virus entry. *Nat Med* 4: 1302-1307.
97. Levin BR, R Antia, E Berliner, P Bloland, S Bonhoeffer, M Cohen, T DeRouin, PI Fields, H Jafari, D Jernigan, M Lipsitch, JE McGowan, P Mead, M Nowak, T Porco, P Sykora, L Simonsen, J Spitznagel, R Tauxe, F Tenover (1998). Resistance to antimicrobial chemotherapy: A prescription for research and action. *Am J Med Sci* 315: 87-94. DOI: 10.1097/00000441-199802000-00004
98. Nowak MA, DC Krakauer, A Klug, RM May (1998). Prion infection dynamics. *Integr Biol* 1: 3-15. DOI: 10.1002/(SICI)1520-6602(1998)1:1<3::AID-INBI2>3.0.CO;2-9
99. Nowak MA, K Sigmund (1998). Darwins Dynamik. *DMV-Mitteilungen* 4: 37-44.
100. Nowak MA, K Sigmund (1998). Evolution of indirect reciprocity by image scoring. *Nature* 393: 573-577. DOI: 10.1038/31225
101. Nowak MA, K Sigmund (1998). The dynamics of indirect reciprocity. *J theor Biol* 194: 561-574. DOI: 10.1006/jtbi.1998.0775
102. Nowak MA, K Sigmund (1998). What two legs can learn from four legs. Book review of *Foundations of Social Evolution*, SA Frank; *Cooperation Among Animals*, AL Dugatkin. *Nature* 395: 760-761. DOI: 10.1038/27368
103. Ogg GS, X Jin, S Bonhoeffer, PR Dunbar, MA Nowak, S Monard, JP Segal, Y Cao, SL Rowland-Jones, V Cerundolo, A Hurley, M Markowitz, DD Ho, DF Nixon, AJ McMichael (1998). Quantitation of HIV-1-specific cytotoxic T lymphocytes and plasma load of viral RNA. *Science* 279: 2103-2106. DOI: 10.1126/science.279.5359.2103
104. Ostrowski MA, DC Krakauer, Y Li, SJ Justement, G Learn, LA Ehler, SK Stanley, M Nowak, AS Fauci (1998). Effect of immune activation on the dynamics of human immunodeficiency virus replication and on the distribution of viral quasispecies. *J Virol* 72: 7772-7784.
105. Regoes RR, D Wodarz, MA Nowak (1998). Virus dynamics: The effect of target cell limitation and immune responses on virus evolution. *J theor Biol* 191: 451-462.

106. Ribeiro RM, S Bonhoeffer, MA Nowak (1998). The frequency of resistant mutant virus before anti-viral therapy. *AIDS* 12: 461-465. DOI: 0.1097/00002030-199805000-00006
107. Sigmund K, M Boerlijst, MA Nowak (1998). Automata and inner states for repeated games. In *Game Theory, Experience, Rationality*, ed. W Leinfeller, E Köhler. London: Kluwer Academic Publishers, 131-139.
108. Sigmund K, MA Nowak (1998). Cyber-sociology. Book review of *The Complexity of Cooperation: Agent-Based Models of Competition and Collaboration*, R Axelrod. *Nature* 392: 457. DOI: 10.1038/33069
109. Wodarz D, P Klenerman, MA Nowak (1998). Dynamics of cytotoxic T-lymphocyte exhaustion. *Proc R Soc B* 265: 191-203. DOI: 10.1098/rspb.1998.0282
110. Wodarz D, MA Nowak (1998). Mathematical models of virus dynamics and resistance. *J HIV Ther* 3: 36-41.
111. Wodarz D, MA Nowak (1998). The effect of different immune responses on the evolution of virulent CXCR4-tropic HIV. *Proc R Soc B* 265: 2149-2158. DOI: 10.1098/rspb.1998.0552

1999

112. Arnaout RA, AL Lloyd, TR O'Brien, JJ Goedert, JM Leonard, MA Nowak (1999). A simple relationship between viral load and survival time in HIV-1 infection. *Proc Natl Acad Sci USA* 96: 11549-11553. DOI: 10.1073/pnas.96.20.11549
113. Bangham CRM, SE Hall, KJM Jeffery, AM Vine, A Witkover, MA Nowak, D Wodarz, K Ususku, M Osame (1999). Genetic control and dynamics of the cellular immune response to the human T-cell leukaemia virus, HTLV-I. *Phil Trans R Soc B* 354: 691-700. DOI: 10.1098/rstb.1999.0422
114. Callaway DS, RM Ribeiro, MA Nowak (1999). Virus phenotype switching and disease progression in HIV-1 infection. *Proc R Soc B* 266: 2523-2530. DOI: 10.1098/rspb.1999.0955
115. Hockett RD, JM Kilby, CA Derdeyn, MS Saag, M Sillers, K Squires, S Chiz, MA Nowak, GM Shaw, RP Bucy (1999). Constant mean viral copy number per infected cell in tissues regardless of high, low, or undetectable plasma HIV RNA. *J Exp Med* 189: 1545-1554. DOI: 10.1084/jem.189.10.1545
116. Jefferey KJM, K Usuku, SE Hall, W Matsumoto, GP Taylor, J Proctor, M Bunce, GS Ogg, KI Welsh, JN Weber, AL Lloyd, MA Nowak, M Nagai, D Kodama, S Izumo, M Osame, CRM Bangham (1999). HLA alleles determine human T-lymphotropic virus-I (HTLV-I) proviral load and the risk of HTLV-1-associated myelopathy. *Proc Natl Acad Sci USA* 96: 3848-3853.
117. Krakauer DC, MA Nowak (1999). Evolutionary preservation of redundant duplicated genes. *Semin Cell Dev Biol* 10: 555-559. DOI: 10.1006/scdb.1999.0337
118. Krakauer DC, M Nowak (1999). T-cell induced pathogenesis in HIV: Bystander effects and latent infection. *Proc R Soc B* 266: 1069-1075. DOI: 10.1098/rspb.1999.0745
119. Masel J, VAA Jansen, MA Nowak (1999). Quantifying the kinetic parameters of prion replication. *Biophys Chem* 77: 139-152. DOI: 10.1016/S0301-4622(99)00016-2
120. Nowak MA (1999). The mathematical biology of human infections. *Conserv Ecol* 3: 12.
121. Nowak MA, DC Krakauer (1999). The evolution of language. *Proc Natl Acad Sci USA*. 96: 8028-8033. DOI: 10.1073/pnas.96.14.8028
122. Nowak MA, DC Krakauer, A Dress (1999). An error limit for the evolution of language. *Proc R Soc B* 266: 2131-2136. DOI: 10.1098/rspb.1999.0898
123. Nowak MA, JB Plotkin, DC Krakauer (1999). The evolutionary language game. *J theor Biol* 200: 147-162. DOI: 10.1006/jtbi.1999.0981
124. Nowak MA, K Sigmund (1999). Aux racines de la coopération. *Recherche* 325: 38-39.
125. Nowak MA, K Sigmund (1999). Phage-lift for game theory. *Nature* 398: 367-368. DOI: 10.1038/18761
126. Ogg GS, X Jin, S Bonhoeffer, P Moss, MA Nowak, S Monard, JP Segal, Y Cao, SL Rowland-Jones, A Hurley, M Markowitz, DD Ho, AJ McMichael, DF Nixon (1999). Decay kinetics of

- human immunodeficiency virus-specific effector cytotoxic T lymphocytes after combination antiretroviral therapy. *J Virol* 73: 797-800.
127. Sigmund K, MA Nowak (1999). Evolutionary game theory. *Curr Biol* 9: R503-R505. DOI: 10.1016/S0960-9822(99)80321-2
 128. Taylor GP, SE Hall, S Navarette, CA Michie, R Davis, AD Witkover, M Rossor, MA Nowak, P Rudge, E Matutes, CRM Bangham, JN Weber (1999). Effect of lamivudine on human T-cell leukemia virus type 1 (HTLV-1) DNA copy number, T-cell phenotype, and anti-Tax cytotoxic T-cell frequency in patients with HTLV-1 associated myelopathy. *J Virol* 73: 10289-10295.
 129. Wahl LM, MA Nowak (1999). The continuous Prisoner's Dilemma: I. Linear reactive strategies. *J theor Biol* 200: 307-321.
 130. Wahl LM, MA Nowak (1999). The continuous Prisoner's Dilemma: II. Linear reactive strategies with noise. *J theor Biol* 200: 323-338.
 131. Wodarz D, AL Lloyd, VAA Jansen, MA Nowak (1999). Dynamics of macrophage and T cell infection by HIV. *J theor Biol* 196: 101-113. DOI: 10.1006/jtbi.1998.0816
 132. Wodarz D, MA Nowak (1999). Dynamics of HIV pathogenesis and treatment. In *Origin and Evolution of Viruses*, eds. E Domingo, R Webster, J Holland. London: Academic Press, 197-223.
 133. Wodarz D, MA Nowak (1999). Dynamics of immune escape in HIV infection. *Wien Klin Wochenschr* 111: 419-427.
 134. Wodarz D, MA Nowak (1999). Evolutionary dynamics of HIV-1 induced subversion of the immune response. *Immunol Rev* 168: 75-89.
 135. Wodarz D, MA Nowak (1999). Specific therapy regimes could lead to long-term immunological control of HIV. *Proc Natl Acad Sci USA* 96: 14464-14469.
 136. Wodarz D, MA Nowak, CRM Bangham (1999). The dynamics of HTLV-I and the CTL response. *Immunol Today* 20: 220-227. DOI: 10.1016/S0167-5699(99)01446-2

2000

137. Arnaout RA, MA Nowak (2000). Competitive coexistence in antiviral immunity. *J theor Biol* 204: 431-441. DOI: 10.1006/jtbi.2000.2027
138. Arnaout RA, MA Nowak, D Wodarz (2000). HIV-1 dynamics revisited: Biphasic decay by cytotoxic T-lymphocyte killing? *Proc R Soc B* 267: 1347-1354. DOI: 10.1098/rspb.2000.1149
139. Barchet W, S Oehen, P Klenerman, D Wodarz, G Bocharov, AL Lloyd, MA Nowak, H Hengartner, RM Zinkernagel, S Ehl (2000). Direct quantitation of rapid elimination of viral antigen-positive lymphocytes by antiviral CD8+ T cells in vivo. *Eur J Immunol* 30: 1356-1363.
140. Krakauer DC, MA Nowak (2000). Book review of *Fragile Dominion: Complexity and the Commons*, S Levin. *Not Am Math Soc* 147: 564-568.
141. Lifson JD, JL Rossio, R Arnaout, L Li, TL Parks, DK Schneider, RF Kiser, VJ Coalter, G Walsh, RJ Imming, B Fisher, BM Flynn, N Bischofberger, M Piatak, VM Hirsch, MA Nowak, D Wodarz (2000). Containment of simian immunodeficiency virus infection: Cellular immune responses and protection from rechallenge following transient postinoculation antiretroviral treatment. *J Virol* 74: 2584-2593. DOI: 10.1128/JVI.74.6.2584-2593.2000
142. Nowak MA (2000). Evolutionary biology of language. *Phil Trans R Soc B* 355: 1615-1622. DOI: 10.1098/rstb.2000.0723
143. Nowak MA (2000). *Homo grammaticus*. *Nat Hist* 109: 36-44.
144. Nowak MA (2000). The basic reproductive ratio of a word, the maximum size of a lexicon. *J theor Biol* 204: 179-189. DOI: 10.1006/jtbi.2000.1085
145. Nowak MA, RM May (2000). *Virus Dynamics: Mathematical Principles of Immunology and Virology*. Oxford: Oxford University Press. ISBN: 9780198504177
146. Nowak MA, KM Page, K Sigmund (2000). Fairness versus reason in the ultimatum game. *Science* 289: 1773-1775. DOI: 10.1126/science.289.5485.1773
147. Nowak MA, JB Plotkin, VAA Jansen (2000). The evolution of syntactic communication. *Nature* 404: 495-498. DOI: 10.1038/35006635

148. Nowak MA, K Sigmund (2000). Cooperation versus competition. *Financ Anal J* 56: 13-22. DOI: 10.2469/faj.v56.n4.2370
149. Nowak MA, K Sigmund (2000). Games on grids. In *The Geometry of Ecological Interactions*, eds. U Dieckmann, R Law, JAJ Metz. Cambridge: Cambridge University Press, 135-150.
150. Nowak MA, K Sigmund (2000). Shrewd investments. *Science* 288: 819-820. DOI: 10.1126/science.288.5467.819
151. Page KM, MA Nowak (2000). A generalized adaptive dynamics framework can describe the evolutionary ultimatum game. *J theor Biol* 209: 173-179. DOI: 10.1006/jtbi.2000.2251
152. Page KM, MA Nowak, K Sigmund (2000). The spatial ultimatum game. *Proc R Soc B* 267: 2177-2182. DOI: 10.1098/rspb.2000.1266
153. Plotkin JB, MA Nowak (2000). Language evolution and information theory. *J theor Biol* 205: 147-159. DOI: 10.1006/jtbi.2000.2053
154. Plotkin JB, MD Potts, DW Yu, S Bunyavejchewin, R Condit, R Foster, S Hubbell, J LaFrankie, N Manokaran, LH Seng, R Sukumar, MA Nowak, PS Ashton (2000). Predicting species diversity in tropical forests. *Proc Natl Acad Sci USA* 97: 10850-10854. DOI: 10.1073/pnas.97.20.10850
155. Regoes RR, MA Nowak, S Bonhoeffer (2000). Evolution of virulence in a heterogeneous host population. *Evolution* 54: 64-71. DOI: 10.1554/0014-3820(2000)054[0064:EOVIAH]2.0.CO;2
156. Sigmund K, MA Nowak (2000). A tale of two selves. *Science* 290: 949-950. DOI: 10.1126/science.290.5493.949
157. Sigmund K, MA Nowak (2000). Playing for keeps. Book review of *Game Theory Evolving: A Problem-Centered Introduction to Modeling Strategic Interaction*, H Gintis. *Science* 290: 281. DOI: 10.1126/science.290.5490.281
158. Trapa PE, MA Nowak (2000). Nash equilibria for an evolutionary language game. *J Math Biol* 41: 172-188. DOI: 10.1007/s002850070004
159. Wahl LM, B Bittner, MA Nowak (2000). Immunological transitions in response to antigenic mutation during viral infection. *Int Immunol* 12: 1371-1380. DOI: 10.1093/intimm/12.10.1371
160. Wahl LM, MA Nowak (2000). Adherence and drug resistance: Predictions for therapy outcome. *Proc R Soc B* 267: 835-843. DOI: 10.1098/rspb.2000.1079
161. Wodarz D, RA Arnaout, MA Nowak, JD Lifson (2000). Transient antiretroviral treatment during acute simian immunodeficiency virus infection facilitates long-term control of the virus. *Phil Trans R Soc B* 355: 1021-1029. DOI: 10.1098/rstb.2000.0639
162. Wodarz D, RM May, MA Nowak (2000). The role of antigen-independent persistence of memory cytotoxic T lymphocytes. *Int Immunol* 12: 467-477. DOI: 10.1093/intimm/12.4.467
163. Wodarz D, MA Nowak (2000). CD8 memory, immunodominance, and antigenic escape. *Eur J Immunol* 30: 2704-2712. DOI: 10.1002/1521-4141(200009)30:9<2704::AID-MMU2704>3.0.CO;2-0
164. Wodarz D, MA Nowak (2000). Correlates of cytotoxic T-lymphocyte-mediated virus control: Implications for immuno-suppressive infections and their treatment. *Phil Trans R Soc B* 355: 1059-1070. DOI: 10.1098/rstb.2000.0643
165. Wodarz D, MA Nowak (2000). HIV therapy: Managing resistance. *Proc Natl Acad Sci USA* 97: 8193-8195. DOI: 10.1073/pnas.97.15.8193
166. Wodarz D, MA Nowak (2000). Immune responses and viral phenotype: Do replication rate and cytopathogenicity influence virus load? *J Theor Medicine* 2: 113-127. DOI: 10.1080/10273660008833041
167. Wodarz D, KM Page, RA Arnaout, AR Thomsen, JD Lifson, MA Nowak (2000). A new theory of cytotoxic T-lymphocyte memory: Implications for HIV treatment. *Phil Trans R Soc B* 355: 329-343. DOI: 10.1098/rstb.2000.0570

2001

168. Komarova NL, P Niyogi, MA Nowak (2001). The evolutionary dynamics of grammar acquisition. *J theor Biol* 209: 43-59. DOI: 10.1006/jtbi.2000.2240

169. Komarova NL, MA Nowak (2001). Natural selection of the critical period for language acquisition. *Proc R Soc B* 268: 1189-1196. DOI: 10.1098/rspb.2001.1629
170. Komarova NL, MA Nowak (2001). Evolutionary dynamics of the lexical matrix. *B Math Biol* 63: 451-484. DOI: 10.1006/bulm.2000.0222
171. Krakauer DC, MA Nowak (2001). Genetic redundancy. In *Encyclopedia of Genetics*, eds. S Brenner, J Miller. London: Academic Press, 845-846.
172. Lifson JD, JL Rossio, M Piatak, T Parks, L Li, R Kiser, V Coalter, B Fisher, BM Flynn, VM Hirsch, RE Means, S Czajak, KA Reimann, JE Schmitz, J Ghrayeb, N Bischofberger, MA Nowak, RC Desrosiers, D Wodarz (2001). Role of CD8+ lymphocytes in control of simian immunodeficiency virus infection and resistance to rechallenge after transient early antiretroviral treatment. *J Virol* 75: 10187-10199. DOI: 10.1128/JVI.75.21.10187-10199.2001
173. Nowak MA, NL Komarova (2001). Towards an evolutionary theory of language. *Trends Cogn Sci* 5: 288-295. DOI: 10.1016/S1364-6613(00)01683-1
174. Nowak MA, NL Komarova, P Niyogi (2001). Evolution of universal grammar. *Science* 291: 114-118. DOI: 10.1126/science.291.5501.114
175. Plotkin JB, MA Nowak (2001). Major transitions in language evolution. *Entropy* 3: 227-246. DOI: 10.3390/e3040227
176. Sigmund K, C Hauert, MA Nowak (2001). Reward and punishment. *Proc Natl Acad Sci USA* 98: 10757-10762. DOI: 10.1073/pnas.161155698
177. Sigmund K, MA Nowak (2001). Evolution: Tides of tolerance. *Nature* 414: 403-405. DOI: 10.1038/35106672
178. Wodarz D, SE Hall, K Usuku, M Osame, GS Ogg, AJ McMichael, MA Nowak, CRM Bangham (2001). Cytotoxic T-cell abundance and virus load in human immunodeficiency virus type 1 and human T-cell leukaemia virus type 1. *Proc R Soc B* 268: 1215-1221. DOI: 10.1098/rspb.2001.1608

2002

179. Belz GT, D Wodarz, G Diaz, MA Nowak, PC Doherty (2002). Compromised influenza virus-specific CD8+-T-cell memory in CD4+-T-cell-deficient mice. *J Virol* 76: 12388-12393. DOI: 10.1128/JVI.76.23.12388-12393.2002
180. Komarova NL, C Lengauer, B Vogelstein, MA Nowak (2002). Dynamics of genetic instability in sporadic and familial colorectal cancer. *Cancer Biol Ther* 1: 685-692. DOI: 10.4161/cbt.321
181. Komarova NL, MA Nowak (2002). Population dynamics of grammar acquisition. In *Simulating the Evolution of Language*, eds. A Cangelosi, D Parisi. London: Springer Verlag, 149-163.
182. Michor F, MA Nowak (2002). Evolution: The good, the bad and the lonely. *Nature* 419: 677-679. DOI: 10.1038/419677a
183. Michor F, MA Nowak (2003). Immunology tomorrow. Book review of *Immunology and Evolution of Infectious Disease*, SA Frank. *Nature* 420: 741-742. DOI: 10.1038/420741b
184. Nowak MA (2002). From quasispecies to universal grammar. *Z Phys Chem* 16: 5-20. DOI: 10.1524/zpch.2002.216.1.005
185. Nowak MA, NL Komarova, P Niyogi (2002). Computational and evolutionary aspects of language. *Nature* 417: 611-617. DOI: 10.1038/nature00771
186. Nowak MA, NL Komarova, A Sengupta, PF Jallepalli, IM Shih, B Vogelstein, C Lengauer (2002). The role of chromosomal instability in tumor initiation. *Proc Natl Acad Sci USA* 99: 16226-16231. DOI: 10.1073/pnas.202617399
187. Nowak MA, K Sigmund (2002). Biodiversity: Bacterial game dynamics. *Nature* 418: 138-139. DOI: 10.1038/418138a
188. Nowak MA, K Sigmund (2002) Super- and coinfection: The two extremes. In *Adaptive Dynamics of Infectious Diseases: In Pursuit of Virulence Management*, eds. U Dieckmann, JAJ Metz, M Sabelis, K Sigmund. Cambridge: Cambridge University Press, 124-138.
189. Page KM, MA Nowak (2002). Empathy leads to fairness. *B Math Biol* 64: 1101-1116. DOI: 10.1006/bulm.2002.0321

190. Page KM, MA Nowak (2002). Unifying evolutionary dynamics. *J theor Biol* 219: 93-98. DOI: 10.1006/jtbi.2002.3112
191. Plotkin JB, MA Nowak (2002). The different effects of apoptosis and DNA repair on tumorigenesis. *J theor Biol* 214: 453-467. DOI: 10.1006/jtbi.2001.2471
192. Sigmund K, E Fehr, MA Nowak (2002). The economics of fair play. *Sci Am* 286: 82-87. DOI: 10.1038/scientificamerican0102-82
193. Wodarz D, MA Nowak (2002). Mathematical models of HIV pathogenesis and treatment. *Bioessays* 24: 1178-1187. DOI: 10.1002/bies.10196

2003

194. Frank SA, Y Iwasa, MA Nowak (2003). Patterns of cell division and the risk of cancer. *Genetics* 163: 1527-1532.
195. Frank SA, MA Nowak (2003). Cell biology: Developmental predisposition to cancer. *Nature* 422: 494. DOI: 10.1038/422494a
196. Iwasa Y, F Michor, MA Nowak (2003). Evolutionary dynamics of escape from biomedical intervention. *Proc R Soc B* 270: 2573-2578. DOI: 10.1098/rspb.2003.2539
197. Komarova NL, MA Nowak (2003). Language dynamics in finite populations. *J theor Biol* 221: 445-457. DOI: 10.1006/jtbi.2003.3199
198. Komarova NL, MA Nowak (2003). Language, learning and evolution. In *Language Evolution*, eds. MH Christiansen, S Kirby. Oxford University Press, 317-337.
199. Komarova NL, A Sengupta, MA Nowak (2003). Mutation-selection networks of cancer initiation: Tumor suppressor genes and chromosomal instability. *J theor Biol* 223: 433-450. DOI: 10.1016/S0022-5193(03)00120-6
200. Michor F, SA Frank, RM May, Y Iwasa, MA Nowak (2003). Somatic selection for and against cancer. *J theor Biol* 225: 377-382. DOI: 10.1016/S0022-5193(03)00267-4
201. Michor F, Y Iwasa, NL Komarova, MA Nowak (2003). Local regulation of homeostasis favors chromosomal instability. *Curr Biol* 13: 581-584. DOI: 10.1016/S0960-9822(03)00172-6
202. Michor F, MA Nowak, SA Frank, Y Iwasa (2003). Stochastic elimination of cancer cells. *Proc R Soc B* 270: 2017-2024. DOI: 10.1098/rspb.2003.2483
203. Mitchener G, MA Nowak (2003). Competitive exclusion and coexistence of universal grammars. *B Math Biol* 65: 67-93. DOI: 10.1006/bulm.2002.0322
204. Nowak MA, F Michor, Y Iwasa (2003). The linear process of somatic evolution. *Proc Natl Acad Sci USA* 100: 14966-14969. DOI: 10.1073/pnas.2535419100
205. Rajagopalan H, MA Nowak, B Vogelstein, C Lengauer (2003). The significance of unstable chromosomes in colorectal cancer. *Nat Rev Cancer* 3: 695-701. DOI: 10.1038/nrc1165
206. Sasaki A, MA Nowak (2003) Mutation landscapes. *J theor Biol* 224: 241-247. DOI: 10.1016/S0022-5193(03)00161-9
207. Wei X, JM Decker, S Wang, H Hui, JC Kappes, X Wu, JF Salazar-Gonzalez, MG Salazar, JM Kilby, MS Saag, NL Komarova, MA Nowak, BH Hahn, PD Kwong, GM Shaw (2003). Antibody neutralization and escape by HIV-1. *Nature* 422: 307-312. DOI: 10.1038/nature01470

2004

208. Frank S, Nowak MA (2004). Problems of somatic mutation and cancer. *Bioessays* 26: 291-299. DOI: 10.1002/bies.20000
209. Iwasa Y, F Michor, MA Nowak (2004). Evolutionary dynamics of invasion and escape. *J theor Biol* 226: 205-214. DOI: 10.1016/j.jtbi.2003.08.014
210. Iwasa Y, F Michor, MA Nowak (2004). Some basic properties of immune selection. *J theor Biol* 229: 179-188. DOI: 10.1016/j.jtbi.2004.03.013
211. Iwasa Y, F Michor, MA Nowak (2004). Stochastic tunnels in evolutionary dynamics. *Genetics* 166: 1571-1579. DOI: 10.1534/genetics.166.3.1571
212. Jones NA, X Wei, DR Flower, ML Wong, F Michor, MS Saag, BH Hahn, MA Nowak, GM Shaw (2004). Determinants of human immunodeficiency virus type 1 escape from the primary CD8+ cytotoxic T lymphocyte response. *J Exp Med* 200:1243-1256. DOI:10.1084/jem.20040511

213. Matsen FA, MA Nowak, (2004). Win-stay, lose-shift in language learning from peers. *Proc Natl Acad Sci USA* 101: 18053-18057. DOI: 10.1073/pnas.0406608102
214. Michor F, Y Iwasa, MA Nowak (2004). Dynamics of cancer progression. *Nat Rev Cancer* 4: 197-205. DOI: 10.1038/nrc1295
215. Michor, Y Iwasa, H Rajagopalan, C Lengauer, MA Nowak (2004). Linear model of colon cancer initiation. *Cell Cycle* 3: 358-362. DOI: 10.4161/cc.3.3.690
216. Mitchener WG, MA Nowak (2004). Chaos and language. *Proc R Soc B* 271: 701-704. DOI: 10.1098/rspb.2003.2643
217. Nowak MA (2004). Prisoners of the dilemma. *Nature* 427: 491. DOI: 10.1038/427491a
218. Nowak MA (2004). Theory is available light. *Curr Biol* 14: R406-R407. DOI: 10.1016/j.cub.2004.05.027
219. Nowak MA, F Michor, NL Komarova, Y Iwasa (2004). Evolutionary dynamics of tumor suppressor gene inactivation. *Proc Natl Acad Sci USA* 101: 10635-10638. DOI: 10.1073/pnas.0400747101
220. Nowak MA, A Sasaki, C Taylor, D Fudenberg (2004). Emergence of cooperation and evolutionary stability in finite populations. *Nature* 428: 646-650. DOI: 10.1038/nature02414
221. Nowak MA, K Sigmund (2004). Evolutionary dynamics of biological games. *Science* 303: 793-799. DOI: 10.1126/science.1093411
222. Nowak MA, K Sigmund (2004). Population dynamics in evolutionary ecology. In *Life Sciences for the 21st Century*, eds. E Keinan, I Schechter, M Sela. Weinham: Wiley-VCH.
223. Taylor C, D Fudenberg, A Sasaki, MA Nowak (2004). Evolutionary game dynamics in finite populations. *B Math Biol* 66: 1621-1644. DOI: 10.1016/j.bulm.2004.03.004

2005

224. Imhof LA, D Fudenberg, MA Nowak (2005). Evolutionary cycles of cooperation and defection. *Proc Natl Acad Sci USA* 102: 10797-10800. DOI: 10.1073/pnas.0502589102
225. Iwasa Y, F Michor, NL Komarova, MA Nowak (2005). Population genetics of tumor suppressor genes. *J theor Biol* 233: 15-23. DOI: 10.1016/j.jtbi.2004.09.001
226. Iwasa Y, F Michor, MA Nowak (2005). Virus evolution within patients increases pathogenicity. *J theor Biol* 232: 17-26. DOI: 10.1016/j.jtbi.2004.07.016
227. Lieberman E, C Hauert, MA Nowak (2005). Evolutionary dynamics on graphs. *Nature* 433: 312-316. DOI: 10.1038/nature03204
228. Michor F, TP Hughes, Y Iwasa, S Branford, NP Shah, CL Sawyers, MA Nowak (2005). Dynamics of chronic myeloid leukemia. *Nature* 435: 1267-1270. DOI: 10.1038/nature03669
229. Michor F, Y Iwasa, C Lengauer, MA Nowak (2005). Dynamics of colorectal cancer. *Semin Cancer Biol* 15: 484-493. DOI: 10.1016/j.semcancer.2005.06.005
230. Michor F, Y Iwasa, B Vogelstein, C Lengauer, MA Nowak (2005). Can chromosomal instability initiate tumorigenesis? *Semin Cancer Biol* 15: 43-45. DOI: 10.1016/j.semcancer.2004.09.007
231. Nowak MA, NL Komarova (2005). The evolution of altruism: From game theory to human language. In *Spiritual Information*, ed. C Harper. Templeton Foundation Press, 308-314.
232. Nowak MA, K Sigmund (2005). Evolution of indirect reciprocity. *Nature* 437: 1291-1298. DOI: 10.1038/nature04131
233. Traulsen A, A Sengupta, MA Nowak (2005). Stochastic evolutionary dynamics on two levels. *J theor Biol* 235: 393-401. DOI: 10.1016/j.jtbi.2005.01.019
234. Willensdorfer M, MA Nowak (2005). Mutation in evolutionary games can increase average fitness at equilibrium. *J theor Biol* 237: 355-362. DOI: 10.1016/j.jtbi.2005.04.020

2006

235. Bürger R, M Willensdorfer, MA Nowak (2006). Why are phenotypic mutation rates much higher than genotypic mutation rates? *Genetics* 172: 197-206. DOI: 10.1534/genetics.105.046599

236. Dingli D, MA Nowak (2006). Cancer biology: Infectious tumour cells. *Nature* 443: 35-36. DOI: 10.1038/443035a
237. Fudenberg D, MA Nowak, C Taylor, L Imhof (2006). Evolutionary game dynamics in finite populations with strong selection and weak mutation. *Theor Popul Biol* 70: 352-363. DOI: 10.1016/j.tpb.2006.07.006
238. Hauert C, F Michor, MA Nowak, M Doebeli (2006). Synergy and discounting of cooperation in social dilemmas. *J theor Biol* 239: 195-202. DOI: 10.1016/j.jtbi.2005.08.040
239. Imhof LA, MA Nowak (2006). Evolutionary game dynamics in a Wright-Fisher process. *J Math Biol* 52: 667-681. DOI: 10.1007/s00285-005-0369-8
240. Iwasa Y, F Michor, MA Nowak (2006). Evolution of resistance during clonal expansion. *Genetics* 172: 2557-2566. DOI: 10.1534/genetics.105.049791
241. Michor F, Y Iwasa, MA Nowak (2006). The age incidence of chronic myeloid leukemia can be explained by a one-mutation model. *Proc Natl Acad Sci USA* 103: 14931-14934. DOI: 10.1073/pnas.0607006103
242. Michor F, MA Nowak, Y Iwasa (2006). Evolution of resistance to cancer therapy. *Curr Pharm Design* 12: 261-271. DOI: 10.2174/138161206775201956
243. Michor F, MA Nowak, Y Iwasa (2006). Stochastic dynamics of metastasis formation. *J theor Biol* 240: 521-530. DOI: 10.1016/j.jtbi.2005.10.021
244. Nowak, MA (2006). *Evolutionary Dynamics: Exploring the Equations of Life*. Cambridge, MA: Harvard University Press. ISBN: 9780674023383
245. Nowak MA (2006). Five rules for the evolution of cooperation. *Science* 314: 1560-1563. DOI: 10.1126/science.1133755
246. Nowak MA, F Michor, Y Iwasa (2006). Genetic instability and clonal expansion. *J theor Biol* 241: 26-32. DOI: 10.1016/j.jtbi.2005.11.012
247. Ohtsuki H, C Hauert, E Lieberman, MA Nowak (2006). A simple rule for the evolution of cooperation on graphs and social networks. *Nature* 441: 502-505. DOI: 10.1016/j.jtbi.2005.11.012
248. Ohtsuki H, MA Nowak (2006). Evolutionary games on cycles. *Proc R Soc B* 273: 2249-2256. DOI: 10.1098/rspb.2006.3576
249. Ohtsuki H, MA Nowak (2006). The replicator equation on graphs. *J theor Biol* 243: 86-97. DOI: 10.1016/j.jtbi.2006.06.004
250. Pacheco JM, A Traulsen, MA Nowak (2006). Active linking in evolutionary games. *J theor Biol* 243: 437-443. DOI: 10.1016/j.jtbi.2006.06.027
251. Pacheco JM, A Traulsen, MA Nowak (2006). Coevolution of strategy and structure in complex networks with dynamical linking. *Phys Rev Lett* 97: 258103. DOI: 10.1103/PhysRevLett.97.258103
252. Pfeiffer T, MA Nowak (2006). Climate change: All in the game. *Nature* 441: 583-584. DOI: 10.1038/441583a
253. Pfeiffer T, MA Nowak (2006). Digital cows grazing on digital grounds. *Curr Biol* 16: R946-R949. DOI: 10.1016/j.cub.2006.10.011
254. Taylor C, Y Iwasa, MA Nowak (2006). A symmetry of fixation times in evolutionary dynamics. *J theor Biol* 243: 245-251. DOI: 10.1016/j.jtbi.2006.06.016
255. Taylor C, MA Nowak (2006). Evolutionary game dynamics with non-uniform interaction rates. *Theor Popul Biol* 69: 243-252. DOI: 10.1016/j.tpb.2005.06.009
256. Traulsen A, MA Nowak (2006). Evolution of cooperation by multilevel selection. *Proc Natl Acad Sci USA* 103: 10952-10955. DOI: 10.1073/pnas.0602530103
257. Traulsen A, MA Nowak, JM Pacheco (2006). Stochastic dynamics of invasion and fixation. *Phys Rev E* 74: 011909. DOI: 10.1103/PhysRevE.74.011909

2007

258. Beerenwinkel N, T Antal, D Dingli, A Traulsen, KW Kinzler, VE Velculescu, B Vogelstein, MA Nowak (2007). Genetic progression and the waiting time to cancer. *PLoS Comput Biol* 3: e225. DOI: 10.1371/journal.pcbi.0030225

259. Hauert C, A Traulsen, H Brandt, MA Nowak, K Sigmund (2007). Via freedom to coercion: The emergence of costly punishment. *Science* 316: 1905-1907. DOI: 10.1126/science.1141588
260. Imhof LA, D Fudenberg, MA Nowak (2007). Tit-for-tat or win-stay, lose-shift? *J theor Biol* 247: 574-580. DOI: 10.1016/j.jtbi.2007.03.027
261. Iwasa Y, F Michor, MA Nowak (2007). Directional evolution of virus within a host under immune selection. In *Mathematics for Life Science and Medicine, Vol. 2*, eds. Y Takeuchi, K Sato, Y Iwasa. Springer: New York. DOI: 10.1007/978-3-540-34426-1_7
262. Lieberman E, JB Michel, J Jackson, T Tang, MA Nowak (2007). Quantifying the evolutionary dynamics of language. *Nature* 449: 713-716. DOI: 10.1038/nature06137
263. Nowak MA, S Roch (2007). Upstream reciprocity and the evolution of gratitude. *Proc R Soc B* 274: 605-609. DOI: 10.1098/rspb.2006.0125
264. Nowak MA, K Sigmund (2007). How populations cohere: Five rules for cooperation. In *Theoretical Ecology: Principles and Applications*, eds. RM May, A McLean. Oxford: Oxford University Press, 7-16.
265. Ohtsuki H, P Bordalo, MA Nowak (2007). The one third law of evolutionary dynamics. *J theor Biol* 249: 289-295. DOI: 10.1016/j.jtbi.2007.07.005
266. Ohtsuki H, MA Nowak (2007). Direct reciprocity on graphs. *J theor Biol* 247: 462-470. DOI: 10.1016/j.jtbi.2007.03.018
267. Ohtsuki H, MA Nowak, JM Pacheco (2007). Breaking the symmetry between interaction and replacement in evolutionary dynamics on graphs. *Phys Rev Lett* 98: 108106. DOI: 10.1103/PhysRevLett.98.108106
268. Ohtsuki H, JM Pacheco, MA Nowak (2007). Evolutionary graph theory: Breaking the symmetry between interaction and replacement. *J theor Biol* 246: 681-694. DOI: 10.1016/j.jtbi.2007.01.024
269. Taylor C, MA Nowak (2007). Transforming the dilemma. *Evolution* 61: 2281-2292. DOI: 10.1111/j.1558-5646.2007.00196.x
270. Traulsen A, Y Iwasa, MA Nowak (2007). The fastest evolutionary trajectory. *J theor Biol* 249: 617-623. DOI: 10.1016/j.jtbi.2007.08.012
271. Traulsen A, MA Nowak (2007). Chromodynamics of cooperation in finite populations. *PLoS ONE* 2: e270. DOI: 10.1371/journal.pone.0000270
272. Traulsen A, MA Nowak, JM Pacheco (2007). Stochastic payoff evaluation increases the temperature of selection. *J theor Biol* 244: 349-356. DOI: 10.1016/j.jtbi.2006.08.008
273. Traulsen A, JM Pacheco, MA Nowak (2007). Pairwise comparison and selection temperature in evolutionary game dynamics. *J theor Biol* 246: 522-529. DOI: 10.1016/j.jtbi.2007.01.002
274. Willensdorfer M, R Bürger, MA Nowak (2007). Phenotypic mutation rates and the abundance of abnormal proteins in yeast. *PLoS Comput Biol* 3: e203. DOI: 10.1371/journal.pcbi.0030203

2008

275. Dingli D, MA Nowak (2008). Evolutionary dynamics of cancer. Book review of *Dynamics of Cancer: Incidence, Inheritance, and Evolution*, SA Frank. *Trends Ecol Evol* 25: 254-255. DOI: 10.1016/j.tree.2007.12.007
276. Dreber A, MA Nowak (2008). Gambling for global goods. *Proc Natl Acad Sci USA* 105: 2261-2262. DOI: 10.1073/pnas.0800033105
277. Dreber A, DG Rand, D Fudenberg, MA Nowak (2008). Winners don't punish. *Nature* 452: 348-351. DOI: 10.1038/nature06723
278. Fu F, C Hauert, MA Nowak, L Wang (2008). Reputation-based partner choice promotes cooperation in social networks. *Phys Rev E* 78: 026117. Republished in *Virtual Journal of Biological Physics Research* 16(5). DOI: 10.1103/PhysRevE.78.026117
279. Hauert C, A Traulsen, H Brandt, MA Nowak, K Sigmund (2008). Public goods with punishment and abstaining in finite and infinite populations. *Biological Theory* 3(2): 114-122. DOI: 10.1162/biot.2008.3.2.114
280. Jones S, W Chen, G Parmigiani, F Diehl, N Beerenwinkel, T Antal, A Traulsen, MA Nowak, C Siegel, VE Velculescu, KW Kinzler, B Vogelstein, J Willis, SD Markowitz (2008).

- Comparative lesion sequencing provides insights into tumor evolution. *Proc Natl Acad Sci USA* 105: 4283-4288. DOI: 10.1073/pnas.0712345105
281. Langer P, MA Nowak, C Hauert (2008). Spatial invasion of cooperation. *J theor Biol* 250: 634-641. DOI: 10.1016/j.jtbi.2007.11.002
 282. Nowak MA (2008). Generosity: A winner's advice. *Nature*. 456: 579. DOI: 10.1038/456579a
 283. Nowak MA, H Ohtsuki (2008). Prevolutionary dynamics and the origin of evolution. *Proc Natl Acad Sci USA* 105: 14924-14927. DOI: 10.1073/pnas.0806714105
 284. Ohtsuki H, MA Nowak (2008). Evolutionary stability on graphs. *J theor Biol* 251: 698-707. DOI: 10.1016/j.jtbi.2008.01.005
 285. Pacheco JM, A Traulsen, H Ohtsuki, MA Nowak (2008). Repeated games and direct reciprocity under active linking. *J theor Biol* 250: 723-731. DOI: 10.1016/j.jtbi.2007.10.040
 286. Pinker S, MA Nowak, JJ Lee (2008). The logic of indirect speech. *Proc Natl Acad Sci USA* 105: 833-838. DOI: 10.1073/pnas.0707192105
 287. Traulsen A, N Shresh, MA Nowak (2008). Analytical results for individual and group selection of any intensity. *B Math Biol* 70: 1410-1424. DOI: 10.1007/s11538-008-9305-6
- 2009**
288. Antal T, MA Nowak, A Traulsen (2009). Strategy abundance in 2x2 games for arbitrary mutation rates. *J theor Biol* 257: 340-344. DOI: 10.1073/pnas.0902528106
 289. Antal T, H Ohtsuki, J Wakeley, PD Taylor, MA Nowak (2009). Evolution of cooperation by phenotypic similarity. *Proc Natl Acad Sci USA* 106: 8597-8600. DOI: 10.1016/j.jtbi.2008.11.023
 290. Antal T, A Traulsen, H Ohtsuki, CE Tarnita, MA Nowak (2009). Mutation–selection equilibrium in games with multiple strategies. *J theor Biol* 258: 614-622. DOI: 10.1016/j.jtbi.2009.02.010
 291. Fu F, L Wang, MA Nowak, C Hauert (2009). Evolutionary dynamics on graphs: Efficient method for weak selection. *Phys Rev E* 79: 046707. DOI: 10.1103/PhysRevE.79.046707
 292. Gokhale CS, Y Iwasa, MA Nowak, A Traulsen (2009). The pace of evolution across fitness valleys. *J theor Biol* 259: 613-620. DOI: 10.1016/j.jtbi.2009.04.011
 293. Manapat M, H Ohtsuki, R Bürger, MA Nowak (2009). Originator dynamics. *J theor Biol* 256: 586–595. DOI: 10.1016/j.jtbi.2008.10.006
 294. Nathanson CG, CE Tarnita, MA Nowak (2009). Calculating evolutionary dynamics in structured populations. *PLoS Comput Biol* 5: e1000615. DOI: 10.1371/journal.pcbi.1000615
Nathanson CG, Tarnita CE, Nowak MA, (2010) Correction: Calculating Evolutionary Dynamics in Structured Populations. *PLoS Comput Biol* 6 (1). DOI: 10.1371/annotation/064a9048-e6f7-4cf8-b259-f40cfb6696ba
 295. Ohtsuki H, Y Iwasa, MA Nowak (2009). Indirect reciprocity provides only a narrow margin of efficiency for costly punishment. *Nature* 457: 79-82. DOI: 10.1038/nature07601
 296. Ohtsuki H, MA Nowak (2009). Prolife catalysts and replicators. *Proc R Soc B* 276: 3783-3790. DOI: 10.1098/rspb.2009.1136
 297. Rand DG, A Dreber, T Ellingsen, D Fudenberg, MA Nowak (2009). Positive interactions promote public cooperation. *Science* 325: 1272-1275. DOI: 10.1126/science.1177418
 298. Rand DG, MA Nowak (2009). Name and shame: How reputation could save the Earth. *New Scientist* 204 (2734): 28-29. DOI: 10.1016/S0262-4079(09)62991-2
 299. Rand DG, H Ohtsuki, MA Nowak (2009). Direct reciprocity with costly punishment: Generous tit-for-tat prevails. *J theor Biol* 256: 45-57. DOI: 10.1016/j.jtbi.2008.09.015
 300. Tarnita CE, T Antal, MA Nowak (2009). Mutation-selection equilibrium in games with mixed strategies. *J theor Biol* 261: 50-57. DOI: 10.1016/j.jtbi.2009.07.028
 301. Tarnita CE, T Antal, H Ohtsuki, MA Nowak (2009). Evolutionary dynamics in set structured populations. *Proc Natl Acad Sci USA* 106: 8601-8604. DOI: 10.1073/pnas.0903019106
 302. Tarnita CE, H Ohtsuki, T Antal, F Fu, MA Nowak (2009). Strategy selection in structured populations. *J theor Biol* 259: 570-581. DOI: 10.1016/j.jtbi.2009.03.035

303. Taylor C, MA Nowak (2009). How to evolve cooperation. Pages 41-56. In *Games, Groups, and the Global Good*, ed. S Levin. New York: Springer. DOI: 10.1007/978-3-540-85436-4_2
304. Traulsen A, C Hauert, H Brandt De Silva, MA Nowak, K Sigmund (2009). Exploration dynamics in evolutionary games. *Proc Natl Acad Sci USA* 106: 709-712. DOI: 10.1073/pnas.0808450106
305. Wakano JY, MA Nowak, C Hauert (2009). Spatial dynamics of ecological public goods. *Proc Natl Acad Sci USA* 106: 7910-7914. DOI: 10.1073/pnas.0812644106

2010

306. Bozic I, T Antal, H Ohtsuki, H Carter, D Kim, S Chen, R Karchin, KW Kinzler, B Vogelstein, MA Nowak (2010). Accumulation of driver and passenger mutations during tumor progression. *Proc Natl Acad Sci USA* 107 (43): 18545–18550. DOI: 10.1073/pnas.1010978107
307. Fu F, MA Nowak, C Hauert (2010). Invasion and expansion of cooperators in lattice populations: Prisoner's dilemma vs. Snowdrift games. *J theor Biol* 266 (3): 358-366. DOI: 10.1016/j.jtbi.2010.06.042
308. Hill AL, DG Rand, MA Nowak, NA Christakis (2010). Emotions as infectious diseases in a large social network: the SISa model. *Proc R Soc B* 277 (1701): 3827-3835. DOI: 10.1098/rspb.2010.1217
309. Hill AL, DG Rand, MA Nowak, NA Christakis (2010). Infectious disease modeling of social contagion in networks. *PLoS Comput Biol* 6 (11): e1000968. DOI: 10.1371/journal.pcbi.1000968
310. Imhof LA, MA Nowak (2010). Stochastic evolutionary dynamics of direct reciprocity. *Proc R Soc B* 277 (1680): 463-468. DOI: 10.1098/rspb.2009.1171
311. Manapat ML, IA Chen, MA Nowak (2010). The basic reproductive ratio of life. *J theor Biol* 263 (3): 317-327. DOI: 10.1016/j.jtbi.2009.12.020
312. Nowak MA, CE Tarnita, T Antal (2010). Evolutionary dynamics in structured populations. *Phil Trans R Soc B* 365 (1537): 19-30. DOI: 10.1098/rstb.2009.0215
313. Nowak MA, CE Tarnita, EO Wilson (2010). The evolution of eusociality. *Nature* 466 (7310): 1057-1062. DOI: 10.1038/nature09205
314. Ojosnegros S, N Beerenwinkel, T Antal, MA Nowak, C Escarmis, E Domingo (2010). Competition-colonization dynamics in an RNA virus. *Proc Natl Acad Sci USA* 107 (5): 2108-2112. DOI: 10.1073/pnas.0909787107
315. Rajamani S, JK Ichida, T Antal, DA Treco, K Leu, MA Nowak, JW Szostak, IA Chen (2010). Effect of stalling after mismatches on the error catastrophe in nonenzymatic nucleic acid replication. *J Am Chem Soc* 132 (16): 5880–5885. DOI: 10.1021/ja100780p
316. Yachida S, S Jones, I Bozic, T Antal, R Leary, B Fu, M Kamiyama, RH Hruban, JR Eshleman, MA Nowak, VE Velculescu, KW Kinzler, B Vogelstein, CA Iacobuzio-Donahue (2010). Distant metastasis occurs late during the genetic evolution of pancreatic cancer. *Nature* 467 (7319): 1114–1117. DOI: 10.1038/nature09515

2011

317. Beale N, DG Rand, H Battey, K Croxson, RM May, MA Nowak (2011). Individual versus systemic risk and the Regulator's Dilemma. *Proc Natl Acad Sci USA* 108 (31): 12647-12652. DOI: 10.1073/pnas.1105882108
318. Fu F, DI Rosenbloom, L Wang, MA Nowak (2011). Imitation dynamics of vaccination behaviour on social networks. *Proc R Soc B* 278 (1702): 42-49. DOI: 10.1098/rspb.2010.1107
319. Michel JB, YK Shen, A Presser Aiden, A Veres, MK Gray, The Google Books Team, JP Pickett, D Hoiberg, D Clancy, P Norvig, J Orwant, S Pinker, MA Nowak, E Lieberman Aiden (2011). Quantitative analysis of culture using millions of digitized books. *Science* 331 (6014): 176-182. DOI: 10.1126/science.1199644
320. Nowak MA, R Highfield (2011). *SuperCooperators: Why We Need Each Other to Succeed*. Simon & Schuster. ISBN: 9781451626636.

321. Nowak MA, CE Tarnita, EO Wilson (2011). Nowak et al. reply. *Nature* 471 (7339): E9-E10. DOI: 10.1038/nature09836
322. Rand DG, MA Nowak (2011). The evolution of antisocial punishment in optional public goods games. *Nat Commun* 2: 434. DOI: 10.1038/ncomms1442
323. Tarnita CE, N Wage, MA Nowak (2011). Multiple strategies in structured populations. *Proc Natl Acad Sci USA* 108 (6): 2334-2337. DOI: 10.1073/pnas.1016008108
324. van Veelen M, MA Nowak (2011). Evolution: Selection for positive illusions. *Nature* 477 (7364): 282-283. DOI: 10.1038/477282a

2012

325. Allen B, MA Nowak (2012). Evolutionary shift dynamics on a cycle. *J theor Biol* 311: 28-39. DOI: 10.1016/j.jtbi.2012.07.006
326. Allen B, A Traulsen, CE Tarnita, MA Nowak (2012). How mutation affects evolutionary games on graphs. *J theor Biol* 299: 97-105. DOI: 10.1016/j.jtbi.2011.03.034
327. Bozic I, B Allen, MA Nowak (2012). Dynamics of targeted cancer therapy. *Trends Mol Med* 18 (6): 311-316. DOI: 10.1016/j.molmed.2012.04.006
328. Cavaliere M, S Sedwards, CE Tarnita, MA Nowak, A Csikász-Nagy (2012). Prosperity is associated with instability in dynamical networks. *J theor Biol* 299: 126-138. DOI: 10.1016/j.jtbi.2011.09.005
329. Chatterjee K, JG Reiter, MA Nowak (2012). Evolutionary dynamics of biological auctions. *Theor Popul Biol* 81 (1): 69-80. DOI: 10.1016/j.tpb.2011.11.003
330. Chatterjee K, D Zufferey, MA Nowak (2012). Evolutionary game dynamics in populations with different learners. *J theor Biol* 301: 161-173. DOI: 10.1016/j.jtbi.2012.02.021
331. Chen I, MA Nowak (2012). From prelife to life: how chemical kinetics become evolutionary dynamics. *Acc Chem Res* 45 (12): 2088-2096. DOI: 10.1021/ar2002683
332. Derr J, ML Manapat, S Rajamani, K Leu, R Xulvi-Brunet, I Joseph, MA Nowak, IA Chen (2012). Prebiotically plausible mechanisms increase compositional diversity of nucleic acid sequences. *Nucl Acids Res* 40 (10): 4711-4722. DOI: 10.1093/nar/gks065
333. Diaz LA Jr., RT Williams, J Wu, I Kinde, JR Hecht, J Berlin, B Allen, I Bozic, JG Reiter, MA Nowak, KW Kinzler, KS Oliner, B Vogelstein (2012). The molecular evolution of acquired resistance to targeted EGFR blockade in colorectal cancers. *Nature* 486 (7404): 537-540. DOI: 10.1038/nature11219
334. Fu F, MA Nowak, NA Christakis, JH Fowler (2012). The evolution of homophily. *Sci Rep* 2: 845. DOI: 10.1038/srep00845
335. Fu F, CE Tarnita, NA Christakis, L Wang, DG Rand, MA Nowak (2012). Evolution of in-group favoritism. *Sci Rep* 2: 460. DOI: 10.1038/srep00460
336. Hill AL, DIS Rosenbloom, MA Nowak (2012). Evolutionary dynamics of HIV at multiple spatial and temporal scales. *J Mol Med* 90 (5): 543-561. DOI: 10.1007/s00109-012-0892-1
337. Manapat ML, DG Rand, C Pawlowitsch, MA Nowak (2012). Stochastic evolutionary dynamics resolve the Traveler's Dilemma. *J theor Biol* 303: 119-127. DOI: 10.1016/j.jtbi.2012.03.014
338. Nowak MA (2012). Evolving cooperation. *J theor Biol* 299: 1-8. DOI: 10.1016/j.jtbi.2012.01.014
339. Nowak MA (2012). Why we help. *Sci Am* 307 (1): 34-39. DOI: 10.1038/scientificamerican0712-34
340. Rand DG, JD Greene, MA Nowak (2012). Spontaneous giving and calculated greed. *Nature* 489 (7416): 427-430. DOI: 10.1038/nature11467
341. Rand DG, MA Nowak (2012). Evolutionary dynamics in finite populations can explain the full range of cooperative behaviors observed in the centipede game. *J theor Biol* 300: 212-221. DOI: 10.1016/j.jtbi.2012.01.011
342. Rosenbloom DIS, AL Hill, SA Rabi, RF Siliciano, MA Nowak (2012). Antiretroviral dynamics determines HIV evolution and predicts therapy outcome. *Nature Medicine* 18 (9): 1378-1385. DOI: 10.1038/nm.2892

343. van Gestel J, MA Nowak, CE Tarnita (2012). The evolution of cell-to-cell communication in a sporulating bacterium. *PLoS Comput Biol* 8 (12): e1002818. DOI: 10.1371/journal.pcbi.1002818
344. van Veelen M, J García, DG Rand, MA Nowak (2012). Direct reciprocity in structured populations. *Proc Natl Acad Sci USA* 109 (25): 9929-9934. DOI: 10.1073/pnas.1206694109
345. van Veelen M, MA Nowak (2012). Multi-player games on the cycle. *J theor Biol* 292: 116-128. DOI: 10.1016/j.jtbi.2011.08.031

2013

346. Allen B, J Gore, MA Nowak (2013). Spatial dilemmas of diffusible public goods. *eLife* 2: e01169. DOI: 10.7554/eLife.01169
347. Allen B, MA Nowak (2013). Cooperation and the fate of microbial societies. *PLoS Biol* 11 (4): e1001549. DOI: 10.1371/journal.pbio.1001549
348. Allen B, MA Nowak, (2013). O Brave New World with Such Games. *Science* 341 (6148): 844-844. DOI: 10.1126/science.1241750
349. Allen B, MA Nowak, U Dieckmann (2013). Adaptive dynamics with interaction structure. *Am Nat* 181 (6): E139-E163. DOI: 10.1086/670192
350. Allen B, MA Nowak, EO Wilson (2013). Limitations of inclusive fitness. *PNAS* 110(50): 20135-20139. DOI: 10.1073/pnas.1317588110
351. Bianconi G, K Zhao, I Chen, MA Nowak (2013). Selection for replicases in protocells. *PLoS Comput Biol* 9 (5): e1003051. DOI: 10.1371/journal.pcbi.1003051
352. Bozic I, MA Nowak (2013). Unwanted evolution. *Science* 342 (6161): 938-939. DOI: 10.1126/science.1247887
353. Bozic I, JG Reiter, B Allen, T Antal, K Chatterjee, P Shah, YS Moon, A Yaquib, N Kelly, DT Le, EJ Lipson, PB Chapman, LA Diaz Jr., B Vogelstein, MA Nowak (2013). Evolutionary dynamics of cancer in response to targeted combination therapy. *eLife* 2: e00747. DOI: 10.7554/eLife.00747
354. Coakley S, MA Nowak, eds (2013). *Evolution, Games, and God: The Principle of Cooperation*. Harvard University Press. ISBN: 9780674047976.
355. Ellingsen T, B Herrmann, MA Nowak, DG Rand, CE Tarnita (2013). Civic capital in two cultures: The nature of cooperation in Romania and USA. DOI: 10.2139/ssrn.2179575
356. Fu F, MA Nowak (2013). Global migration can lead to stronger spatial selection than local migration. *J Stat Phys* 151 (3-4): 637-653. DOI: 10.1007/s10955-012-0631-6
357. Hilbe C, MA Nowak, K Sigmund (2013). The evolution of extortion in iterated Prisoner's Dilemma games. *Proc Natl Acad Sci USA* 110 (17): 6913-6918. DOI: 10.1073/pnas.1214834110
358. Hilbe C, MA Nowak, A Traulsen (2013). Adaptive dynamics of extortion and compliance. *PLoS One* 8 (11): e77886. DOI: 10.1371/journal.pone.0077886
359. Manapat ML, MA Nowak, DG Rand (2013). Information, irrationality, and the evolution of trust. *J Econ Behav Organ* 90 (Suppl): S57-S75. DOI: 10.1016/j.jebo.2012.10.018
360. Novak S, K Chatterjee, MA Nowak (2013). Density games. *J theor Biol* 334: 26-34. DOI: 10.1016/j.jtbi.2013.05.029
361. Randles AP, DG Rand, C Lee, G Morrisett, J Sircar, MA Nowak, H Pfister (2013). Massively parallel model of extended memory use in evolutionary game dynamics. *IPDPS*: 1217-1228. DOI: 10.1109/IPDPS.2013.102
362. Rand DG, JD Greene, MA Nowak (2013). Rand et al. reply. *Nature* 498 (7452): E2-E3. DOI: 10.1038/nature12195
363. Rand DG, MA Nowak (2013). Human cooperation. *Trends Cogn Sci* 17 (8): 413-425. DOI: 10.1016/j.tics.2013.06.003
364. Rand DG, CE Tarnita, H Ohtsuki, MA Nowak (2013). Evolution of fairness in the one-shot anonymous Ultimatum Game. *Proc Natl Acad Sci USA* 110 (7): 2581-2586. DOI: 10.1073/pnas.1214167110

365. Reiter JG, I Bozic, B Allen, K Chatterjee, MA Nowak (2013). The effect of one additional driver mutation on tumor progression. *Evol Appl* 6 (1): 34-45. DOI: 10.1111/eva.12020
366. Reiter JG, I Bozic, K Chatterjee, MA Nowak (2013). TTP: Tool for Tumor Progression. *Lect Notes Comput Sc* 8044: 101-106. DOI: 10.1007/978-3-642-39799-8_6
367. Suchow JW, B Allen, MA Nowak, GA Alvarez (2013). Evolutionary dynamics of visual memory. *J Vis* 13 (9): 20. DOI: 10.1167/13.9.20
368. Tarnita CE, CH Taubes, MA Nowak (2013). Evolutionary construction by staying together and coming together. *J theor Biol* 320: 10-22. DOI: 10.1016/j.jtbi.2012.11.022
369. Yoeli E, M Hoffman, DG Rand, MA Nowak (2013). Powering up with indirect reciprocity in a large-scale field experiment. *Proc Natl Acad Sci USA* 110 (Suppl 2): 10424-10429. DOI: 10.1073/pnas.1301210110
370. Zagorsky BM, JG Reiter, K Chatterjee, MA Nowak (2013). Forgiver triumphs in alternating Prisoner's Dilemma. *PLoS One* 8 (12): e80814. DOI: 10.1371/journal.pone.0080814

2014

371. Adlam B, MA Nowak (2014). Universality of fixation probabilities in randomly structured populations. *Nature Scientific Reports* 4: 6692. DOI: 10.1038/srep06692
372. Allen B, MA Nowak (2014). Games on graphs. *EMS Surv Math Sci* 1(1): 115-151. DOI: 10.4171/EMSS/3PDF
373. Bozic I, MA Nowak (2014) Timing and heterogeneity of mutations associated with drug-resistance in metastatic cancers. *Proc Natl Acad Sci* 111 (45): 15964-15968. DOI: 10.1073/pnas.1412075111
374. Chatterjee K, A Pavlogiannis, B Adlam, MA Nowak (2014). The time scale of evolutionary trajectories. *PLoS Comput Biol* 10(9): e1003818. DOI: 10.1371/journal.pcbi.1003818
375. Fu F, Kocher SD, Nowak MAN. (2014) The risk-return trade-off between solitary and eusocial reproduction. *Ecology Letters* DOI: 10.1111/ele.12392
376. Ghang W, MA Nowak (2014). Stochastic evolution of staying together. *J theor Biol* 360: 129-136. DOI: 10.1016/j.jtbi.2014.06.026
377. Hauser OP, MA Nowak, DG Rand (2014). Punishment does not promote cooperation under exploration dynamics when anti-social punishment is possible. *J theor Biol* 360: 163-171. DOI: 10.2139/ssrn.2298851
378. Hauser OP, DG Rand, A Peysakhovich, MA Nowak (2014). Cooperating with the future. *Nature* 511: 220-223. DOI: 10.1038/nature13530
379. Hauser OP, A Traulsen, MA Nowak (2014). Heterogeneity in background fitness acts as a suppressor of selection. *J theor Biol* 343(21):178-185. DOI: 10.1016/j.jtbi.2013.10.013
380. Hilbe C, Wu B, Traulsen A, Nowak MA. (2014) Cooperation and control in multiplayer social dilemmas. *Proc Natl Acad Sci*. 111(46): 16425-16430. DOI: 10.1073/pnas.1407887111
381. Hill A, MA Nowak (2014). Mind over matter. *Trends Ecol Evol* 29(2):74-75. DOI: 10.1016/j.tree.2013.10.004
382. Hill A, DLS Rosenbloom, F Fu, MA Nowak, RF Siliciano. (2014). Predicting the outcomes of treatment to eradicate the latent reservoir for HIV-1. *Proc Natl Acad Sci USA* 111: 37:134756-13480. DOI: 10.1073/pnas.1406663111
383. Humplik J, AL Hill, MA Nowak (2014). Evolutionary dynamics of infectious diseases in finite populations. *J theor Biol* 360: 149-162 DOI: 10.1016/j.jtbi.2014.06.039
384. Jeong H-C, S-Y Oh, B Allen, MA Nowak (2014). Optional games on cycles and complete graphs. *J theor Biol* 356(7): 98-112. DOI 10.1016/j.jtbi.2014.04.025
385. Kocher SD, L Pellissier, C Veller, J Purcell, MA Nowak, M Chapuisat, NE Pierce (2014). Transitions in social complexity along elevational gradients reveal a combined impact of season length and development time on social evolution. *Proc. Roy. Soc. B* 281 (1787) DOI: 10.1098/rspb.2014.0627

386. Markvoort AJ, S Sinai, MA Nowak (2014). Computer simulations of cellular group selection reveal mechanism for sustaining cooperation. *J theor Biol* 357: 123-133. DOI: 10.1016/j.jtbi.2014.04.029
387. Olejarz JW, MA Nowak (2014). Evolution of staying together in the context of diffusible public goods. *J theor Biol* 360:1-12. DOI: 10.1016/j.jtbi.2014.06.023
388. Peysakhovich A, MA Nowak, DG Rand (2014). Humans display a 'cooperative phenotype' that is domain general and temporally stable. *Nature Comm* DOI: 10.1038/ncomms5939
389. Rand DG, A Dreber, OS Haque, RJ Kane, MA Nowak, S Coakley (2014). Religious motivations for cooperation: an experimental investigation using explicit primes. *Religion Brain Behav* 4 (1):31-48. DOI: 10.1080/2153599X.2013.77566
390. Rand DG, A Peysakhovich, GT Kraft-Todd, GE Newman, O Wurzbacher, MA Nowak, JD Greene (2014). Social heuristics shape intuitive cooperation. *Nature Comm* 5: 1-12. DOI: 10.1038/ncomms4677
391. Szabó G, KS Bodó, B Allen, MA Nowak (2014). Fourier decomposition of payoff matrix for symmetric three-strategy games. *Physical Review E* 90 (4), 042811 DOI: 10.1103/PhysRevE.90.042811
392. Rand DG, Nowak MA, Fowler JH, Christakis NA. (2014) Static network structure can stabilize human cooperation *Proc Natl Acad Sci.* 111(48):17093-17098. DOI: 10.1073/pnas.1400406111
393. Wilson EO, MA Nowak (2014). Natural selection drives the evolution of ant life cycles. *Proc Natl Acad Sci USA* 111(35): 12585-12590. DOI: 10.1073/pnas.1405550111

2015

394. Adlam B, Chatterjee K, MA Nowak (2015). Amplifiers of Selection. *Proc. Royal. Soc. A.* 471(2181). DOI: 10.1098/rspa.2015.0114
395. Allen B, C Sample, YA Dementieva, RC Medeiros, C Paoletti, MA Nowak. The molecular clock of neutral evolution can be accelerated or slowed by asymmetric spatial structure. *PLoS Comput Biol* 11(2): e1004108. DOI: 10.1371/journal.pcbi.1004108 PDF
396. Allen B, MA Nowak (2015). Games among relatives revisited. *Journal of Theoretical Biology.* 378: 103-116. DOI: 10.1016/j.jtbi.2015.04.031 PDF
397. Antal T, PL Krapivsky, MA Nowak (2015). Spatial evolution of tumors with successive driver mutations. *Phys. Rev. E.* 92(2), 022705. DOI: 10.1103/PhysRevE.92.022705 PDF
398. Fu F, Nowak MA, Bonhoeffer S. (2015) Spatial heterogeneity in drug concentrations can facilitate the emergence of resistance to cancer therapy. *PLoS Comput Biol* 11(3): e1004142. DOI: 10.1371/journal.pcbi.1004142 PDF
399. Ghang W, MA Nowak. (2015) Indirect reciprocity with optional interactions. *J theor Biol.*:365: 1-11. DOI: 10.1016/j.jtbi.2014.09.036 PDF
400. Hilbe C, M Hoffman, MA Nowak (2015). Cooperate without looking in a non-repeated game. *Games* 6(4), 458-472. DOI: 10.3390/g6040458
401. Hilbe C, B Wu, A Traulsen, MA Nowak (2015). Evolutionary performance of zero-determinant strategies in multiplayer games. *J Theor Biol.*: 374: 115-124 DOI: 10.1016/j.jtbi.2015.03.032
402. Hoffman, M, E Yoeli, MA Nowak (2015) Cooperate without looking: Why we care what people think and not just what they do. *Proceedings of the National Academy of Sciences*, 112(6), 1727-1732. DOI: 10.1073/pnas.1417904112 PDF
403. Hoffman, M., Suetens, S., Gneezy, U. & Nowak, M.A. (2015) An experimental investigation of evolutionary dynamics in the Rock-Paper-Scissors game. *Sci. Rep.* 5, 8817. DOI: 10.1038/srep08817
404. Ibsen-Jensen R, K Chatterjee, MA Nowak (2015). Computational complexity of ecological and evolutionary spatial dynamics. *Proc Natl Acad Sci.* ePub 7 Dec 2015. DOI: 10.1073/pnas.1511366112
405. Landau D, E Tausch, A N. Taylor-Weiner, C Stewart, J G. Reiter, J Bahlo, S Kluth, I Bozic, M Lawrence, S Böttcher, S L. Carter, K Cibulskis, D Mertens, C L. Sougnez, M Rosenberg, J M. Hess, J Edelman, S Kless, M Kneba, M Ritgen, A Fink, K Fischer, S Gabriel, E S. Lander, M

- A. Nowak, H Döhner, M Hallek, D Neuberg, G Getz, S Stilgenbauer & C J. Wu (2015) Mutations driving CLL and their evolution in progression and relapse. *Nature* 526: 525-530. DOI: 10.1038/nature15395
406. Leventhal G, A Hill, MA Nowak, S Bonhoeffer. (2015) Evolution and emergence of infectious diseases on theoretical and real-world networks. *Nature Communications* 6(6101) DOI: 10.1038/ncomms7101
407. Misale, S, I Bozic, J Tong, A Peraza-Penton, A Lallo, F Baldi, K Lin, L Trusolino, A Bertotti, F Di Nicolantonio, MA Nowak, L Zhang, K Wood, A Bardelli (2015). Vertical suppression of the EGFR pathway prevents onset of resistance in colorectal cancers. *Nature Communications* 6(8305). DOI: 10.1038/ncomms9305
408. Moreno-Gámez S, Hill AL, Rosenbloom DIR, Petrov D, Nowak MA, Pennings P (2015). Imperfect drug penetration leads to spatial monotherapy and rapid evolution of multi-drug resistance. *Proceedings of the National Academy of Sciences*, 112(22) E2874-E2883. DOI: 10.1073/pnas.1424184112
409. Nowak MA (2015). Obituary: John Forbes Nash (1928 - 2015). *Nature* 522:420. DOI: 10.1038/522420a
410. Nowak MA, Allen B (2015) Inclusive Fitness Theorizing Invokes Phenomena That Are Not Relevant for the Evolution of Eusociality. *PLoS Biol* 13(4): e1002134. DOI: 10.1371/journal.pbio.1002134
411. Ohtsuki H, Y Iwasa, MA Nowak (2015). Reputation effects in public and private interactions. *PLOS Comp Biol*. 11(11): e1004527 DOI: 10.1371/journal.pcbi.1004527
412. Olejarz J, B Allen, C Veller, MA Nowak (2015). The evolution of non-reproductive workers in insect colonies with haplodiploid genetics. *ELife* 4:e08918. DOI: 10.7554/eLife.08918
413. Olejarz J, W Ghang, MA Nowak (2015). Indirect Reciprocity with Optional Interactions and Private Information. *Games* 6(4), 438-457. DOI: 10.3390/g6040438
414. Pavlogiannis A, K Chatterjee, B Adlam, MA Nowak (2015). Cellular cooperation with shift updating and repulsion. *Sci Rep*. 5:17147. DOI: 10.1038/srep17147
415. Rand DG and MA Nowak. "Cooperation among humans." *Global Cooperation and the Human Factor in International Relations*. Ed. Dirk Messner, Ed. Silke Weinlich. New York: Routledge, 2015. 113-138. Print.
416. Reiter JG, Kanodia A, Gupta R, Nowak MA, Chatterjee K. (2015) Biological auctions with multiple rewards. *Proc. R. Soc. B* 282: 20151041. DOI: 10.1098/rspb.2015.1041
417. Szabó G, KS Bodó, B Allen, MA Nowak (2015). Four classes of interactions for evolutionary games. *Phys. Review. E* 92(2). DOI: 10.1103/PhysRevE.92.022820
418. Tomasetti C, L Marchionni, MA Nowak, G Parmigiani, B Vogelstein. (2015) Only three driver gene mutations are required for development of lung and colorectal cancers. *Proc Natl Acad Sci*. 112(1):118-123. DOI: 10.1073/pnas.1421839112 PDF
419. Veller C, Nowak MA, Davis CC (2015). Extended flowering intervals of bamboos evolved by discrete multiplication. *Ecology Letters*.18(7):653-9. DOI: 10.1111/ele.12442 PDF
420. Vukov J, L Varga, B Allen, MA Nowak, G Szabó (2015). Payoff components and their effects in a spatial three-strategy evolutionary social dilemma. *Phys. Rev. E*. 92, 012813 DOI: 10.1103/PhysRevE.92.012813
421. Waclaw B, I Bozic, ME Pittman, RH Rhuban, B Vogelstein, MA Nowak (2015). A spatial model predicts that dispersal and cell turnover limit intratumour heterogeneity. *Nature*. 525(7568):261-4. DOI: 10.1038/nature14971

2016

422. Allen B, MA Nowak (2016). There is no inclusive fitness at the level of the individual. *Current Opinion in Behavioral Sciences* 12: 122-128. DOI: 10.1016/j.cobeha.2016.10.002

423. Baek SK, HC Jeong, C Hilbe, MA Nowak (2016). Comparing reactive and memory-one strategies of direct reciprocity. *Sci Rep.* 6(25676). DOI: 10.1038/srep25676
424. Bozic I, JM Gerold, MA Nowak (2016). Quantifying clonal and subclonal passenger mutations in cancer evolution. *PLoS Comput Biol* 12(2): e1004731. DOI: 10.1371/journal.pcbi.1004731
425. Burger, J.A., Landau, D.A., Taylor-Weiner, A., Bozic, I., Zhang, H., Sarosiek, K., Wang, L., Stewart, C., Fan, J., Hoellenriegel, J., Sivina, M., Dubuc, A.M., Fraser, C., Han, Y., Li, S., Livak K.J., Zou, L., Wan, Y., Konoplev, S., Sougnez, C., Brown, J.R., Abruzzo, L.V., Carter, S.L., Keating, M.J., Davids, M.S., Wierda, W.G., Cibulskis, K., Zenz, T., Werner, L., Dal Cin, P., Kharchenko, P., Neuberg, D., Kantarjian, H., Lander, E., Gabriel, S., O'Brien, S., Letai, A., Weitz, D.A., Nowak, M.A., Getz, G. & Wu, C.J. (2016) Clonal evolution in patients with chronic lymphocytic leukaemia developing resistance to BTK inhibition. *Nature Communications*, 7(11589). DOI: 10.1038/ncomms11589
426. Chen Y, A McAvoy, MA Nowak (2016). Fixation probabilities for any configuration of two strategies on regular graphs. *Sci Rep* 6:39181. DOI: 10.1038/srep39181
427. van Gestel J, MA Nowak (2016). Phenotypic heterogeneity and the evolution of bacterial life cycles. *PLoS Comput Biol* 12(2): e1004764. DOI: 10.1371/journal.pcbi.1004764
428. Hauser O, A Hendriks, DG Rand, MA Nowak (2016). Think global, act local: Preserving the global commons. *Sci Rep.* 6:36079 DOI: 10.1038/srep36079
429. Kaveh K, C Veller, MA Nowak (2016). Games of multicellularity. *J Theor Bio.* 403:143-158. DOI: 10.1016/j.jtbi.2016.04.037
430. Olejarz J, B Allen, C Veller, R Gadagkar, MA Nowak (2016). Evolution of worker policing. *J. Theor. Bio.* 399: 103-116. DOI: 10.1016/j.jtbi.2016.03.001
431. Paterson C, MA Nowak, B Waclaw (2016). An exactly solvable, spatial model of mutation accumulation in cancer. *Sci Rep.* 6:39511 DOI: 10.1038/srep39511
432. Rand DG, J Jordan, M Hoffman, MA Nowak (2016). Uncalculating cooperation is used to signal trustworthiness. *Proc Natl Acad Sci.* epub 21 July 2016. DOI: 10.1073/pnas.1601280113
433. Reiter, J. G., A Makohon-Moore, J Gerold, I Bozic, K Chatterjee, C Iacobuzio-Donahue, B Vogelstein, MA Nowak (2016). Reconstructing the evolutionary history of metastatic cancers. *Cancer Research*, 76(14 Supplement), 2374-2374. DOI: 10.1158/1538-7445.AM2016-2374
434. Veller C, D Haig, MA Nowak (2016). The Trivers-Willard hypothesis: sex ratio or investment? *Proc. R. Soc. B* 283(1830). DOI: 10.1098/rspb.2016.0126
435. Yamamoto Y, CP Offord, G Kimura, S Kuribayashi, H Takeda, S Tsuchiya, H Shimojo, H Kanno, I Bozic, MA Nowak, Ž Bajzer, D Dingli (2016). Tumor and immune cell dynamics explain the PSA bounce after prostate cancer brachytherapy. *British Journal of Cancer* 115: 195–202. DOI: 10.1038/bjc.2016.171
436. Yeates J AM, C Hilbe, M Zwick, MA Nowak, N Lehman (2016). Dynamics of prebiotic RNA reproduction illuminated by chemical game theory. *Proc Natl Acad Sci.* DOI: 10.1073/pnas.1525273113

2017

437. Allen B, G Lippner, Y-T Chen, B Fotouhi, N Momeni, S-T Yau, MA Nowak (2017). Evolutionary dynamics on any population structure. *Nature* 544: 227–230. DOI: 10.1038/nature21723
438. Altrock, P.M., A Traulsen & MA Nowak (2017). Evolutionary games on cycles with strong selection. *Physical Review E*, 95 : 022407. <https://doi.org/10.1103/PhysRevE.95.022407>
439. Bozic I, M Nowak (2017). Resisting Resistance. *Annu. Rev. Cancer Biol.* 2017. 1:10.1–10.19. DOI: 10.1146/annurev-cancerbio-042716-094839
440. Hilbe C, L A Martinez-Vaquero, K Chatterjee, MA Nowak (2017). Memory-n strategies of direct reciprocity. *Proc Natl Acad Sci.* 114(18): 4715-4720. DOI: 10.1073/pnas.1621239114
441. Kinsler G, S Sinai, N K Lee, MA Nowak (2017). Prebiotic selection for motifs in a model of template-free elongation of polymers within compartments. *PLoS ONE* 12(7): e0180208. <https://doi.org/10.1371/journal.pone.0180208>
442. Knoll A, MA Nowak (2017). The Timetable of Evolution. *Science Advances* 3(5): e1603076. DOI: 10.1126/sciadv.1603076
443. Makohon-Moore AP, M Zhang, JG Reiter, I Bozic, B Allen, D Kundu, K Chatterjee, F Wong, Y Jiao, ZA Kohutek, J Hong, M Attiyeh, B Javier, LD Wood, RH Hruban, MA Nowak, N Papadopoulos, KW Kinzler, B Vogelstein, CA Iacobuzio-Donahue (2017). Limited heterogeneity of known driver gene mutations among the metastases of individual pancreatic cancer patients. *Nature Genetics*. DOI: 10.1038/ng.3764
444. Naxerova K, J G Reiter, E Brachtel, J K Lennerz, M van de Wetering, A Rowan, T Cai, H Clevers, C Swanton, MA Nowak, S J Elledge, R K Jain (2017). Origins of lymphatic and distant metastases in human colorectal cancer. *Science* 357(6346): 55-60. DOI: 10.1126/science.aai8515
445. Noble C, J Olejarz, K Esvelt, G Church, MA Nowak (2017). Evolutionary dynamics of CRISPR gene drives. *Science Advances* Vol. 3, no. 4, e1601964. DOI: 10.1126/sciadv.1601964
446. Nowak MA, B Allen, A McAvoy, EO Wilson (2017). The general form of Hamilton's rule makes no predictions and cannot be tested empirically. *Proc Natl Acad Sci* 114(22): 5665-5670. DOI: 10.1073/pnas.1701805114
447. Nowak MA, B Waclaw. Genes, environment, and "bad luck" (2017). *Science* 355 (6331): 1266-1267. DOI: 10.1126/science.aam9746
448. Pavlogiannis A, J Tkadlec, K Chatterjee, MA Nowak (2017). Amplification on Undirected Population Structures: Comets Beat Stars. *Sci Rep* 7(82). DOI: 10.1038/s41598-017-00107-w
449. Reiter J, A Makohon-Moore, J Gerold, I Bozic, K Chatterjee, C Iacobuzio-Donahue, B Vogelstein, MA Nowak (2017). Reconstructing metastatic seeding patterns of human cancers. *N Comms* 8(14114). DOI: 10.1038/ncomms14114
450. Veller, C., Hayward, L. K., Hilbe, C., & Nowak, M. A. (2017). The Red Queen and King in finite populations. *Proc Natl Acad Sci* 114(27): E5396-E5405. DOI: 10.1073/pnas.1702020114