Christopher F. Chyba March 2005

Current Position

Associate Professor, Department of Geological and Environmental Sciences, Stanford University, Stanford CA; phone 650 723 0126

Co-Director, Center for International Security and Cooperation (CISAC), Stanford University, Stanford CA; phone 650 723 0126; fax 650 723 0089

Carl Sagan Chair for the Study of Life in the Universe, The SETI Institute, 2035 Landings Drive, Mountain View, CA 94043; phone 650 960 4519; fax 650 962 9419

Education

Microbial Diversity Summer Course (250 laboratory hours) and Workshop on Molecular Evolution, Woods Hole Marine Biological Laboratory, summer 1999.

Ph.D. Astronomy (Planetary Science) 1991, Cornell University, New York, U.S.A.

M.Phil. History and Philosophy of Science 1986, University of Cambridge, Cambridge, England

B.A. Mathematics (Mathematical Physics) 1984, M.A. 1990, University of Cambridge

B.A. Physics (minors in Philosophy and Mathematics) 1982, Swarthmore College

Professional Honors

Fellow, American Association for the Advancement of Science, September 2003

Doctor of Science honorary degree, Swarthmore College June 1 2003

MacArthur Fellow, October 2001

Presidential Early Career Award for Scientists and Engineers, December 1996

Chosen one of "50 for the Future: Time's roster of America's most promising leaders age 40 and under," *Time Magazine*, December 5, 1994.

White House Fellow, 1993-1994

Sage Graduate Fellow (Cornell University 1985-1987)

Marshall Scholar (University of Cambridge 1982-1985)

Phi Beta Kappa, Sigma Xi (Swarthmore College 1982)

Journal Publications

Impact Gardening on Europa. (C.B. Phillips and C.F. Chyba), *Icarus*, in preparation.

Magnetometric Constraints on Salt Concentrations of Europa's Ocean and Biological Implications (K.P. Hand, A. Goldman, C.F. Chyba), *Icarus*, to be submitted.

Policy Forum: Biodefense and Biotechnology—The Fallacy of the Last Move (A.L. Greninger, B.A. Valentino, C.F. Chyba), *Science*, to be submitted.

Biotechnology and Bioterrorism (C.F. Chyba and A.L. Greninger), *Foreign Affairs*, submitted March 2004.

Proliferation Rings: New Challenges to the Nuclear Nonproliferation Regime (C. Braun and C.F. Chyba), *International Security*, submitted October 2003, in revision.

Book Review: The Global Threat of New and Reemerging Infectious Diseases: Reconciling US National Security and Public Health Policy (C.F. Chyba). 2004. *Survival*, Spring 2004, pp. 163-164.

Persistence of Thin Ice Regions in Europa's Ice Crust (L. Buck, C.F. Chyba, M. Goulet, A. Smith and P.J. Thomas). 2002 *Geophysical Research Lett*ers, 29, 12-1-12-4.

Defining 'Life' (C. Cleland and C.F. Chyba). 2002 *Origins of Life and Evolution of the Biosphere* 32, 387-393.

Cometary delivery of biogenic elements to Europa (E. Pierazzo and C.F. Chyba). 2002 *Icarus* 157, 120-127.

Toward Biological Security (C.F. Chyba). May/June 2002 *Foreign Affairs* 81(3), 122-136. Reprinted in R.D. Howard and R.L. Sawyer, eds., *Terrorism and Counterterrorism: Understanding the New Security Environment* (McGraw-Hill/Dushkin, Guilford Connecticut, 2002), pp. 174-184.

Europa as an Abode of Life (C.F. Chyba and C.B. Phillips). 2002. *Origins of Life and Evolution of the Biosphere* 32, 47-68.

Letters: A unified definition of biosecurity (L.A. Meyerson, J.K. Reaser, and C.F. Chyba). 2002. *Science* 295, 44.

Biological Security after September 11th (C.F. Chyba). Fall-Winter 2002 *Stanford Journal of International Relations,* 3(2), 12-15.

Editorial: Biological security in a changed world (C.F. Chyba). 2001. *Science* 293, 2349.

Perspectives/Planetary science: Life without photosynthesis. (C.F. Chyba and K.P. Hand). 2001. *Science* 292, 2026-2027.

Possible ecosystems and the search for life on Europa (C.F. Chyba and C.B. Phillips). 2001. *Proceedings of the National Academy of Sciences USA* 98, 801-804.

Seismic detectability of a subsurface ocean on Europa (R.L. Kovach and C.F. Chyba). 2001. *Icarus* 150, 279-287.

Biological terrorism and public health (C.F. Chyba). 2001. *Survival* 43, 93-106. Reprinted in A. O'Day, ed., *Weapons of Mass Destruction and Terrorism* (Ashgate Publishing, Ltd., London, 2004), to be published.

Letters: Building biodefenses (C.F. Chyba). May/June 2001 *Foreign Affairs* 80(3), 152.

Correction: Energy for microbial life on Europa (C.F. Chyba). 2000. *Nature* 406, 368.

Energy for microbial life on Europa (C.F. Chyba),. 2000. *Nature* 403, 381-382.

Racemization of meteoritic amino acids (B. Cohen and C.F. Chyba). 2000. *Icarus*, 145, 272-281.

Amino acid survival in large cometary impacts (E. Pierazzo and C.F. Chyba). 1999. *Meteoritics and Planetary Science* 32, 909-918.

Book review: An exobiologist's life search. (C.F. Chyba), 1999. *Nature* 401, 857-858.

Radar detectability of a subsurface ocean on Europa (C.F. Chyba, S.J. Ostro, B.C. Edwards). 1998. *Icarus* 134, 292-302.

Monitoring the Comprehensive Test Ban Treaty: Possible ambiguities due to meteorite impacts (C.F. Chyba, G.E. van der Vink and C.B. Hennet). 1998. *Geophysical Research Letters* 25, 191-194.

Organic shielding of greenhouse gases on early Earth (S.L. Miller, J.R. Lyons and C.F. Chyba). 1998. *Science* 278, p.779a.

News and Views/Origins of life: Buried beginnings (C.F. Chyba). 1998. *Nature* 395, 329-330.

The early faint Sun paradox: organic shielding of ultraviolet-labile greenhouse gases (C. Sagan and C. Chyba). 1997. *Science* 276, 1217-1221.

News and Views/Origins of life: A left-handed solar system? (C.F. Chyba). 1997. *Nature* 389, 234-235.

News and Views/Exobiology: Life on other moons (C.F. Chyba). 1997. *Nature* 385, 201.

Carl Sagan (1934-1996) (C.F. Chyba). 1997. *EOS Trans.* 78(16), 167.

William Reid Thompson, 1952-1996 (C.F. Chyba). 1997. *Bull. Am. Astron. Soc.*, 29, 1492-1493.

News and Views/Exobiology: Life beyond Mars (C.F. Chyba). 1996. *Nature* 382, 576-577.

The origin of life in the Solar System: current issues (C.F. Chyba and G.W. McDonald). 1995. *Annual Review of Earth and Planetary Sciences* 24, 215-249. Reprinted in *Origins of Planets and Life* (ed. J. Melosh), pp. 265-299, Annual Reviews Inc., Palo Alto, 1997.

Comets in other planetary systems? (C.F. Chyba). 1995. *Advances in Space Research* 15(3): 45-48.

Book review (C.F. Chyba). 1994. *Environmental Evolution: Effects of the Origin and Evolution of Life on Planet Earth.* (eds. L. Margulis and L. Olendzenski), MIT Press, Cambridge, MA. *Icarus* 109, 219-220.

Explosions of small Spacewatch objects in the Earth's atmosphere (C.F. Chyba). 1993. *Nature* 363, 701-703.

The 1908 Tunguska explosion: atmospheric disruption of a stony asteroid (C.F. Chyba, P.J. Thomas, and K.J. Zahnle). 1993. *Nature* 361, 40-44.

The violent environment of the origins of life: progress and uncertainties (C.F. Chyba). 1993. *Geochimica et Cosmochimica Acta* 57, 3351-3358.

Production and optical constants of ice tholin from charged particle irradiation of (1:6) C_2H_6/H_2O at 77 K (B.N. Khare, W.R. Thompson, L. Cheng, C. Chyba, C. Sagan, E.T. Arakawa, C. Meisse, and P.S. Tuminello.) 1993. *Icarus* 103, 290-300.

Endogenous production, exogenous delivery and impact-shock synthesis of organic molecules: an inventory for the origins of life (C. Chyba and C. Sagan). 1992. *Nature* 355, 125-132. Reprinted in *Origins of Life: The Central Concepts* (eds. D.W. Deamer and G.R. Fleischaker), 123-130, Jones and Bartlett, Boston (1994).

Terrestrial mantle siderophiles and the lunar impact record (C.F. Chyba). 1991. *Icarus* 92, 217-233.

Electrical energy sources for organic synthesis on the early Earth (C. Chyba and C. Sagan). 1991. *Origins of Life and Evolution of the Biosphere* 21, 3-17.

Cometary delivery of organic molecules to the early Earth (C.F. Chyba, P.J. Thomas, L. Brookshaw, and C. Sagan). 1990. *Science* 249, 366-373. Reprinted in *Origins of Life: The Central Concepts* (eds. D.W. Deamer and G.R. Fleischaker), 213-220, Jones and Bartlett, Boston (1994).

Triton's streaks as windblown dust (C. Sagan and C. Chyba). 1990. *Nature* 346, 546-548.

Impact delivery and erosion of planetary oceans in the early solar system (C.F. Chyba). 1990. *Nature* 343, 129-133.

News and Views/Meteoritics: Extraterrestrial amino acids and terrestrial life (C.F. Chyba). 1990. *Nature* 348, 113-114. Reprinted in D.B. Cline, ed., *Physical Origin of Homochirality in Life* (American Institute of Physics, Woodbury, New York, 1996), pp. 3-4.

Voyager 2 at Neptune: Imaging science results (B.A. Smith *et al.*). 1989. *Science* 246, 1422-1449.

Orbital evolution in the Neptune-Triton system (C.F. Chyba, D.G. Jankowski, and P.D. Nicholson). 1989. *Astronomy and Astrophysics* 219, L23-L26.

The heliocentric evolution of infrared cometary spectra: results from an organic grain model (C.F. Chyba, C. Sagan, and M.J. Mumma). 1989. *Icarus* 79, 362-381.

Solid organic residues produced by irradiation of hydrocarbon-containing H_2O and H_2O/NH_3 ices: infrared spectroscopy and astronomical implications (B.N. Khare, W.R. Thompson, B.G.J.P.T. Murray, C.F. Chyba, C. Sagan, and E.T. Arakawa). 1989. *Icarus* 79, 350-361.

On the obliquity and tidal heating of Triton (D.G. Jankowski, C.F. Chyba, and P.D. Nicholson). 1989. *Icarus* 80, 211-219.

Organic cometary matter still a contentious issue (C. Chyba and C. Sagan). 1988. *Nature* 332, 592.

The cometary contribution to the oceans of primitive Earth (C.F. Chyba). 1987. *Nature* 330, 632-635.

Infrared emission by organic grains in the coma of comet Halley (C. Chyba and C. Sagan). 1987. *Nature* 330, 350-353.

Cometary organics but no evidence for bacteria (C. Chyba and C. Sagan). 1987. *Nature* 329, 208.

Kaluza-Klein unified field theory and apparent four-dimensional spacetime (C.F. Chyba). 1985. *American Journal of Physics* 53, 863-872.

Time-dependent embeddings for Schwarzschild-like solutions to the gravitational field equations (C.F. Chyba). 1982. *Journal of Mathematical Physics* 23, 1662-1667.

U.S. military-support equipment sales to the People's Republic of China (C.F. Chyba). 1981. *Asian Survey* 21, 469-484.

The effect of coolant loss on current leads for superconducting magnets (C. Chyba, L.G. Hyman, and L. Roberts). 1981. *Cryogenics* 21, 615-618.

Testimony, Op-Eds

Russia's Poison Gases (C.F. Chyba). 2002. *The New York Times*, October 30, 2002, Op-Ed.

Treating terrorism: The bioweapons threat (C.F. Chyba). 2001. *San Jose Mercury News*, October 21, 2001, pp. 1C, 4C.

Microbe warfare hides the enemy (C.F. Chyba). 2001. *The New York Times*, August 10, 2001, Op-Ed.

Testimony of Christopher F. Chyba for the Hearing before the Subcommittee on Space and Aeronautics, Committee on Science, House of Representatives, 107th Congress, 1st session, July 12, 2001, Serial No. 107-17.

Responding to bioterrorism (C.F. Chyba). 2001. *San Jose Mercury News*, June 24, 2001, p.5C.

Edited books, monographs, theses

The Comprehensive Test Ban Treaty: Next steps. (C.F. Chyba, T. Graham, et al.). Roundtable Discussion, Stanford University July 19, 2000. Lawyers Alliance for World Security, 78pp.

Biological Terrorism, Emerging Diseases, and National Security (C.F. Chyba). 1998. Rockefeller Brothers Fund, Inc., New York, 28pp, http://www.rbf.org/Chyba_Bioterrorism.pdf.

Comets and the Origins and Evolution of Life (eds. P.J. Thomas, C.F. Chyba, and C.P. McKay). Springer-Verlag, New York, 1997, 296pp.

National Security Science and Technology Strategy. (Primary drafter for Chapter 3: "Meeting the Challenge of Global Threats", pp. 42-57.) National Science and Technology Council, The White House, 1995.

Extraterrestrial organic molecules, the heavy bombardment, and the terrestrial origins of life (C.F. Chyba). 1991. *Ph.D. thesis*, Cornell University.

Determining the role of consciousness in quantum measurement: indistinguishability, uncertainty, and the reduced density matrix formalism (C.F. Chyba). 1985. *M.Phil. thesis*, Cambridge University.

The Einstein-Podolsky-Rosen *gedankenexperiment* and schemes for "superluminal" communication (C.F. Chyba). 1983. *Yeats and Rouse Ball Mathematics Prize Essay*, Trinity College, Cambridge.

Book Chapters

Biological terrorism and public health (C.F. Chyba). 2001. *Survival* 43, 93-106. Reprinted in A. O'Day, ed., *Weapons of Mass Destruction and Terrorism* (Ashgate Publishing, Ltd., London, 2004), to be published.

Europa (C.F. Chyba and C.B. Phillips). In *Planets and Life: The Emerging Science of Astrobiology*, eds. W. Sullivan and J. Baross (Cambridge U. Press, Cambridge), to be published.

Does 'Life' Have a Definition? (C.E. Cleland and C.F. Chyba) In *Planets and Life: The Emerging Science of Astrobiology*, eds. W. Sullivan and J. Baross (Cambridge U. Press, Cambridge), to be published.

Geology of Europa (R. Greeley, C.F. Chyba, J.W. Head, T. McCord, W.B. McKinnon, and R.T. Pappalardo). In *Jupiter: Planet, Satellites and Magnetosphere*, ed. F. Bagenal, to be published.

Prospects for Life on Europa (K.P. Hand and C.F. Chyba). Frontiers of Life (The Gioi Publishers, Vietnam, 2003), L.M. Celnikier and J. Tran Thanh Van, eds. pp. 167-171.

Toward Biological Security (C.F. Chyba). May/June 2002 *Foreign Affairs* 81(3), 122-136. Reprinted in R.D. Howard and R.L. Sawyer, eds., *Terrorism and Counterterrorism: Understanding the New Security Environment* (McGraw-Hill/Dushkin, Guilford Connecticut, 2002), pp. 174-184.

The origin of life: Planetary environments (C.F. Chyba and G.D. McDonald). In Baltimore, D., Dulbecco, R., Jacob, F. and Levi-Montalcini, R., eds., *Frontiers of Life, Volume 1: The Origins of Life* (Academic Press, New York, 2002), pp. 139-151.

The search for extraterrestrial life: A core mission for NASA (C.F. Chyba). In *Space Policy in the Twenty-First Century,* ed. W.H. Lambright (Johns Hopkins Univ. Press, 2002), pp. 198-231.

Europa: Prospects for an ocean and life (C.B. Phillips and C.F. Chyba). In *First Steps in the Origin of Life in the Universe*, eds. J. Chela-Flores et al. (Kluwer Acad. Pub., The Netherlands, 2001), pp. 27-34.

Habitable worlds (C.F. Chyba). In *Cosmic Horizons: Astronomy at the Cutting Edge*, eds. S. Soter and N. de Grasse Tyson (The New Press, New York, 2001), pp. 160-165.

Habitability of planets and the origin of life (C.F. Chyba, R.T. Reynolds and D.P. Whitmire). In *Protostars and Planets IV*. (University of Arizona Press, Tucson, 2000), pp. 1367-1395.

Chyba, C. F. and G. D. McDonald 1998. Gli ambienti planetari e l'origine della vita. *Frontiere della Vita*, vol. 1, Instituto della Enciclopedia Italiana, Fondata da Giovanni Treccani.

Comet: Impacts on Earth (C.F. Chyba). In *The Van Nostrand Encyclopedia of Planetary Sciences and Astrogeology* (eds. J.H. Shirley and R.W. Fairbridge), pp. 127—132 (Chapman & Hall, London, 1997).

Comets as a source of prebiotic organic molecules for the early Earth (C.F. Chyba and C. Sagan). In *Comets and the Origin and Evolution of Life* (eds. P.J. Thomas, C.F. Chyba and C.P. McKay), pp. 147-173 (Springer-Verlag, New York, 1997).

Introduction: Comets and the Origin of Life (P.J. Thomas, C.F. Chyba and C.P. McKay). In *Comets and the Origin and Evolution of Life* (eds. P.J. Thomas, C.F. Chyba and C.P. McKay), pp. 1-2 (Springer-Verlag, New York, 1997).

Catastrophic impacts and the Drake equation (C.F. Chyba). In *Astronomical and Biochemical Origins and the Search for Life in the Universe* (eds. C.B. Cosmovici, S. Bowyer and D. Werthimer), pp. 157-164 (Editrice Compositori, Bologna, 1997).

The Origin of Life in a Cosmic Context (C.F. Chyba). In *Carl Sagan's Universe* (eds. Y. Terzian and E. Bilson), pp. 64-74 (Cambridge University Press, Cambridge, 1997).

The origin of life in the Solar System: current issues (C.F. Chyba and G.W. McDonald). 1995. *Annual Review of Earth and Planetary Sciences* 24, 215-249. Reprinted in *Origins of Planets and Life* (ed. J. Melosh), pp. 265-299, Annual Reviews Inc., Palo Alto, 1997.

Are comets necessary for a habitable zone? (C.F. Chyba). In *Circumstellar Habitable Zones-Proceedings of the First International Conference* (ed. L.R. Doyle), pp. 277-281 (Travis House Publications, Menlo Park, CA, 1996).

News and Views/Meteoritics: Extraterrestrial amino acids and terrestrial life (C.F. Chyba). 1990. *Nature* 348, 113-114. Reprinted in D.B. Cline, ed., *Physical Origin of Homochirality in Life* (American Institute of Physics, Woodbury, New York, 1996), pp. 3-4.

Impact delivery of volatiles and organic molecules to Earth. (C.F. Chyba, T.C. Owen, and W.-H. Ip). 1995. In *Hazards Due to Comets and Asteroids* (ed. T. Gehrels) pp. 9-58, University of Arizona, Tucson.

Terrestrial accretion of prebiotic volatiles and organic molecules during the heavy bombardment (C.F. Chyba, C. Sagan, L. Brookshaw, and P.J. Thomas). 1991. In *Bioastronomy: The Search for Extraterrestrial Life--The Exploration Broadens* (eds. J. Heidmann and M.J. Klein), 149-154, Springer-Verlag, Berlin.

The recombinant DNA debate and the precedent of Leo Szilard (C. Chyba). 1980. In *Science and Ethical Responsibility* (ed. S.A. Lakoff), 251-264, Addison-Wesley/Advanced Book Program, New York.

Popular articles

How to win the fight against bioterror (C. Chyba). *Business 2.0,* February 2002, pp. 20-21.

Is there life elsewhere in the Universe? (J.C. Tarter and C.F. Chyba). *Scientific American*, December 1999, pp. 82-87.

Some thoughts on SETI (C. Chyba). *The Planetary Report* 19(3), 6.

Questions and answers: Could there be oil on Mars? (C.F. Chyba). 1998. *The Planetary Report* 18(2), p. 20.

Carl Sagan, teacher. (C. Chyba). 1997. *The Planetary Report* 17(3), 4-7.

The darkened cosmos: A tribute to Carl Sagan (R. Dawkins, A.C. Clarke, M. Gardner, D. Morrison, J. Randi, J. Tarter, P. Kurtz, A. Hale, C. Chyba, L.M. Lederman, C.A. Pickover, J.A. Paulos, C. Denman, S. Carlson, N. Humphrey, D.R. Alonso, J.E. Armentia, B. Williams, P.O. Hulth, S.O. Hansson, M.D. Sofka, M. Boslough, and C. Groves). 1997. *Skeptical Inquirer* 21(2), 5-15.

What happened at Tunguska? (C.F. Chyba). 1997. *The NEO News* 3(2), 1-2.

Charting a collision course (C.F. Chyba). 1994. *Bioastronomy News* 6(2), 1-4.

Questions and answers: How did water arrive, or form, on Earth? And when? (C. Chyba). 1993. *The Planetary Report* 13(3), 20.

Death from the sky (C. Chyba). 1993. *Astronomy* 21(12), 38-45. Errata in: Tunguska corrections (C. Chyba). 1993. *Astronomy* 22(1), 12.

The heavy bombardment and the origins of life (C. Chyba). 1992. *Astronomy* 20(11), 28-35.

Focal point: whence came life? (S.L. Miller and C.F. Chyba). 1992. *Sky and Telescope* 83, 604-605.

Seeding Earth: Comets, oceans, and life (C. Chyba). 1990. *The Planetary Report* 10(1), 20-23, 30.

Selected Invited Lectures

Complementary Approaches to Global Public Health and Biological Security: Recommendations of the Secretary-General's High-level Panel Report. International Peace Academy, March 3, 2005

Are We Alone In The Cosmos? Wonderfest 2004, Hewlett Teaching Center, Stanford, November 6, 2004.

The Search For Life In The Solar System. Agilent Research Labs, Palo Alto, November 3, 2004.

The Search for Life in the Universe. Association of Science - Technology Centers (ASTC) Annual Conference, San Jose, September 18-21, 2004.

Potential for Life on Europa or Other Outer Solar System Satellites. Bioastronomy 2004, Habitable Worlds, Eighth International Conference on Bioastronomy, Reykjavik, Iceland, July 13, 2004.

Biological and nuclear terrorism: What is the threat, and what should be the U.S. response? The Commonwealth Club of California, San Francisco, May 12, 2004.

Biotechnology & Bioterrorism, Princeton. Woodrow Wilson School, New Jersey, April 21, 2004.

The Physics, Chemistry, and Possible Biology of Europa. Princeton University Geoscience Department, Princeton, New Jersey, April 22, 2004.

Terrorism and WMD (panelist), *Weapons of Mass Destruction and the United Nations*, International Peace Academy, New York, March 5, 2004.

Science in the New World Order/Disorder. *National Association of Science Writers*, Seattle, WA, February 12, 2004.

Bioterrorism: Nature of the Threat Internationally and Nationally. CSU San Marcos, Carlsbad, CA, January 27, 2004.

Nuclear Proliferation Rings, *Atoms for Peace after 50 Years: New Challenges and Opportunities*, Lawrence Livermore National Laboratory and Woodrow Wilson International Center for Scholars, Washington DC, December 9, 2003.

Biological security in the 21st century. *Briefing to the UN High-Level Panel on Threats, Challenges, and Change*, December 6, 2003.

Growing dangers posed by non-state actor acquisition and use of chemical, biological, radiological, and nuclear weapons. *WMD Threats and Cross-Cutting Nonproliferation Challenges: Time for Creative Policy*. Monterey Non-Proliferation Strategy Group, Monterey, CA, November 2003

Infectious Diseases: Domestic and International Response Strategies. *US Capitol Hill Briefing*, Washington DC, November 2003

What would be the elements of a more robust regime for containing the risks at the intersection of biotechnology and biological weapons? *Science, Technology, and Security Meeting*, MacArthur Foundation, Chicago, IL, November 2003

Life in a Planetary Context: Habitable Worlds in our Solar System. *ASGSB Meeting*, Huntsville, AL, November 2003

Towards biological security, *Consequences of the War on Terrorism*, Second Pugwash Workshop on Terrorism, Como, Italy, 9-12 October 2003.

Dangerous Knowledge: Science, secrecy and security in the life sciences (moderator of panel). *IEEE Bioinformatics Meeting*. Stanford University, August 12, 2003.

The Twenty-first Century Search for Extraterrestrial Life and Bioterrorism: Not Your Parents' Weapon of Mass Destruction. *Diversa Corporation invited lectures*, San Diego, CA, August 2003.

Biological Security in the 21st Century, *The Future of Arms Control Seminar Series*, Brookings Institution, August 1, 2003.

Prospects for extraterrestrial life: What we know, what we think we know, and what we'd like to know. *Gordon Conference in Applied and Environmental Microbiology*, July-August 2003.

The war on bioterror: What local institutions are doing to help. Keynote address, *World Affairs Council of Northern California*, San Francisco, May 13, 2003.

The physics, chemistry, and possible biology of Europa's ocean. *Department of Geological and Environmental Sciences*, Stanford University, April 23, 2003.

The comet/asteroid impact hazard, *Department of Physics*, Stanford University, April 22, 2003.

The 21st century search for extraterrestrial life. *Bunyan Lecture*, Stanford University, April 21, 2003

Are intelligent beings out there? *Are We Alone in the Universe? Center for the Study of Evolution and the Origin of Life*, UCLA, April 4, 2003.

Biological security and nuclear security. *Biomedical Ethics Grand Rounds*, Stanford University, April 3, 2003.

The search for extraterrestrial life in the 21st century. *Mathematics Department, Cambridge University*, March 14, 2003.

Biological terrorism: New threats for a new century. *The Morning Forum of Los Altos*, March 4, 2003.

Biological terrorism and new proliferation challenges. *Director's Colloquium*, Los Alamos National Laboratory, February 25, 2003.

Prospects for life in our Solar System and intelligent life elsewhere, *Plenary, NASA Astrobiology Institute General Meeting*, Tempe, AZ, February 10, 2003.

Europa: prospects for life and for the origin of life, *American Geophysical Union,* Fall Meeting, San Francisco, December 2002.

Planetary Protection Considerations in Europa Exploration, *34th COSPAR Scientific Assembly - The Second World Space Congress*, Houston, TX, October 16, 2002.

A Vision for the Next 25 Years of Space Science, *34th COSPAR Scientific Assembly - The Second World Space Congress,* Houston, TX, October 16, 2002.

Planetary Protection: Two Relevant Terrestrial Examples, *American Astronomical Society DPS 34th Meeting*, Birmingham, AL, October 7, 2002.

The Comet/Asteroid Impact Hazard, *Lockheed Martin ATC Fall Colloquium*, Palo Alto, CA, October 3, 2002.

The Search for Life in the Solar System*, "Bioastronomy 2002: Life Among the Stars"*, Hamilton Island, Australia, July 2002.

The Search for Life in the Solar System*, Astrophysics of Life, Space Telescope Science Institute*, Baltimore, May 2002.

Astrobiology in the solar system and beyond, *President's Forum, American Society for Microbiology*, Salt Lake City, May 22, 2002

The Search for Life in the Solar System, *Director's Distinguished Lecture Series (DDLS), Lawrence Livermore National Labs*, Livermore, May 2002.

Europa as an Abode of Life. *NASA Ames 2002 Astrobiology Science Conference*, Moffett Field, April 2002.

Europa as an Abode of Life. *NASA Ames 2002 "Contact" Conference: Is the cosmos rife with life?,* Moffett Field, March 2002.

Life in Our Solar System and Beyond: Astrobiology in the 21st Century. *American Astronomical Society, 199th Annual Meeting*, Washington DC, January 2002.

Life in the Universe: Is it Just around the Corner? *Silicon Valley Astronomy Lectures,* Foothill College, October 2001

Biological Terrorism and Infectious Disease Surveillance. *Encino-Tarzana Medical Center*, Los Angeles, CA, July 2001.

Biological Terrorism. *Going Global in the Information Age: The 55th Annual Conference at Asilomar*, World Affairs Council, May 2001.

Extraterrestrial Life: Just Around the Corner? *Maurice and Yetta Glicksman lecture*, Brown University, May 2001.

Europa. *Outer Limits of Life Seminar*, Stanford University, May 2001.

Europa and the Rebirth of Exobiology. *Geophysics Department*, Stanford University, March 2001.

Space Flight in the New Millennium, Then and Now. *AAS/AIAA Space Flight Mechanics Meeting*, Santa Barbara, California, February 2001.

Biological Terrorism, Emerging Diseases, and National Security. *New Century Seminar*, CISAC, Stanford University, November 2000.

Life possibilities on Europa. *Fellows' Science Day 2000*, California Academy of Sciences, San Francisco, October 2000.

Europa and the rebirth of exobiology. *National Academy of Sciences Japanese-American Frontiers of Science Symposium*, Irvine, CA, September 2000.

Implications of the deep subsurface for life on other planets. *The Subsurface Biosphere at Mid-Ocean Ridges,* 5TH RIDGE Theoretical Institute, The National Science Foundation, Big Sky, Montana, July 2000.

Europa and the rebirth of exobiology. *David Schramm Memorial Lecture Series*, Fermilab, May 2000.

Europa as a habitat for life. *Earth and Space Sciences Colloquium*, Jet Propulsion Laboratory, Pasadena, CA, May 2000.

Europa and the rebirth of exobiology. *Distinguished Leaders in the Life and Space Sciences, 1999-2000 Speaker Series*, The National Academy of Sciences, Washington DC, April 2000.

Search for life: The science and policy implications of exploring the Universe for the purpose of finding life. *Space Policy in the 21st Century*, Washington DC, March 2000.

The astrobiology of the origin of life, *American Geophysical Union*, December 1999.

Prospects for life elsewhere in the Solar System, *Frontiers in Astrophysics lecture series*, Hayden Planetarium, American Museum of Natural History, December 1999.

Origin and Development of Life, *Swedish National Science Research Council*, Sigtuna, Sweden, October 1999.

Comet and asteroid delivery of volatiles and organics: An update. *Pardee Keynote Symposium, Geological Society of America Annual Meeting*, Denver, Colorado, October 1999.

Europa and the rebirth of exobiology. *Life in Extreme Environments Lecture Series*, American Museum of Natural History, New York NY, October 1999.

The rebirth of exobiology. *Origins and Evolution of Life in the Universe Seminar Series*, Harvey Mudd College, Claremont, CA, April 1999.

Prospects for life elsewhere in the Solar System. *Life in the Universe: Astrobiology in Action*, Foothill College, Los Altos CA, April 1999.

Looking for an ocean on Europa and thinking about life. *Astrobiology Seminar Series.* University of Washington, Seattle, March 1999.

Planetary perspectives on life in the Solar System. *Capital Science Lectures, Carnegie Institution of Washington*, Washington DC, January 1999.

The astronomy/biology connection: Prospects for life in the Solar System. *American Astronomical Society Annual Meeting*, Austin, Texas, January 1999.

The rebirth of exobiology. *Presidents' Circle, The National Academy of Science*. Houston, Texas, November 1998.

The rebirth of exobiology. *Banquet talk, 3oth Annual Meeting of the American Astronomical Society Division for Planetary Sciences*, Madison, Wisconsin, October 1998.

Habitability of Planets and the Origin of Life. *Protostars and Planets IV,* University of California, Santa Barbara, July 1998

The Origins of Life in the Solar System. *Pfizer/Independent College Fund of New York Science Lectureship*, April 1998.

Europa and Beyond. *Life in the Universe: The Emergence of Astrobiology, George Washington University*, March 1998.

Outer Solar System environments and inner Solar System life. *Department of Astronomy, The University of California, Berkeley, and The Institute for Geophysics and Planetary Physics, Lawrence Livermore National Laboratory*, March 1998.

The 2003 Europa Orbiter Mission. Presentation to the *Committee on Planetary and Lunar Exploration (COMPLEX), Space Studies Board, National Research Council*, February 1998.

Looking for an ocean on Europa and wondering about life. *Carnegie Institution of Washington*, February 1998.

Looking for an ocean on Europa and thinking about life. *Massachusetts Institute of Technology, Department of Earth, Ocean, and Planetary Sciences.* November 1997.

Prospects for life on Europa. *Geological Society of America*, Salt Lake City, October 1997.

Could cometary or asteroidal microorganisms exist? Presentation to the *National Academy Task Group on Sample Return from Small Solar System Bodies,* Washington DC, October 1997.

Interplanetary exchange of organic materials. Presentation to the *National Academy Task Group on Sample Return from Small Solar System Bodies,* Washington DC, October 1997.

Comets and the organic origin of life in the Solar System. *International Astronomical Union, 23rd General Assemby,* Kyoto, Japan, August 1997.

Interplanetary exhange of organic materials: Session Chair. *Gordon Research Conference: Origin of Life,* New England College, Henniker, NH, July 1997.

Origin of life, here and elsewhere. *Gordon Research Conference: Origins of Solar Systems*, New England College, Henniker, NH, June 1997.

Professional Experience

Assistant Professor, Department of Planetary Sciences, The University of Arizona, Tucson, Arizona, 85721 (August 1996 to August 1998).

Contractor, White House Office of Science and Technology Policy (September 1997 to April 1998). Researched and wrote study on improving surveillance for biological terrorism.

Contractor, White House Office of Science and Technology Policy (August 1995 to April 1996). Developed and drafted Presidential directive on U.S. Government response to the threat of emerging infectious diseases.

Visiting Scientist, Department of Geosciences and Center for Energy and Environmental Studies, Princeton University, Princeton, NJ 08544-1003.

Energy Liaison, Division of National Security and International Affairs, White House Office of Science and Technology Policy, the White House (Oct. 1994-July 1995).

Director for International Environmental Affairs, National Security Council staff, The White House (Sept. 1993-Oct. 1994).

National Research Council Associate (NASA Ames Research Center and Goddard Space Flight Center, 1991-1993)

Teaching Assistant (introductory astronomy), Astronomy Department, Cornell University (1987-1988)

Laboratory Assistant to Dr. Neal B. Abraham (chaos in ring laser system), Physics Department, Bryn Mawr College (summer 1982)

Undergraduate Research Participation Program, with Dr. Lloyd G. Hyman (superconducting magnet code; neutrino oscillation monte carlo code), Argonne National Laboratory (autumn 1980)

National Science Foundation Undergraduate Research Project, with Dr. John R. Boccio (black hole evolution), Physics Department, Swarthmore College (summer 1990)

Research Assistant to Dr. Eric Silver (X-ray diagnostic on the PDX fusion tokamak), Princeton University Plasma Physics Laboratory (summer 1979)

Research Assistant to Dr. David Rosen (development of three-dimensional computer graphics package in APL language), Mathematics Department, Swarthmore College (summer 1978)

Teaching Assistant (undergraduate laboratory), Physics Department, Swarthmore College (1978-1980)

Committees and Activities

Member, NRC Committee on Advances in Technology and the Prevention of Their Application to Next Generation Biowarfare Threats, February 2004-present.

Chair, NRC Committee on Preventing the Forward Contamination of Mars, February 2004-present.

Member, National Academy of Sciences Committee on International Security and Arms Control, 2002-present.

Member, NASA Astrobiology Institute Executive Committee, October 2003-present.

Member, NASA Astrobiology Institute Director's Science Council, April 2002-October 2003.

Member, NASA Astrobiology Institute Director's Search Committee, March 2002.

Member, Monterey Nonproliferation Strategy Group, 2001-present.

Member, SETI LITU Humpback Whale Communication Expedition, Glacier Bay, Alaska, August 2000.

Chair, NASA Solar System Exploration Subcommittee (1999 to 2000)

Member, Executive Committee, NASA Space Science Advisory Committee (1999 to 2000)

Member, Defense Threat Reduction Agency Biological Warfare Defense Panel (1998 to present)

Chair, NASA Europa Orbiter Mission Science Definition Team, (September 1997 to 1999)

Chair, Editorial Advisory Board, *The Planetary Report* (January 1997 to 1999)

Chair, Harvard/JPL/SETI Workshop on Searching for Life on Europa (March 1999)

Chair, NASA Campaign Strategy Working Group on Prebiotic Chemistry in the Outer Solar System (February 1998 to January 1999)

Student, *Microbial Diversity* (250 laboratory hours, 110 lecture hours), Woods Hole Marine Biological Laboratory, June 13-July 29, 1999.

Student, *Workshop on Molecular Evolution*, Woods Hole Marine Biological Laboratory, August 1-August 13, 1999.

Member, NASA Solar System Exploration Subcommittee (February 1998 to January 1999).

Member, NASA Astrobiology Institute Director Search Committee (1998).

Member, NASA Exobiology Review Panel (Sept. 1995 to February 1998).

Member, Board of Advisors, Teach for America Math and Science Initiative (1996 to 1998).

Participant, NASA Breckenridge Workshop (May 1997)

Chair, Science Team, *Europa Ocean Discovery* Discovery mission proposal (1996)

Member, NASA Campaign Strategy Working Group on Pre-Biotic Chemistry in the Outer Solar System (November 1996)

Member, NASA Roadmap Development Team (Jan. 1996 to Aug. 1996)

Member, NASA Rosetta Endorsement Review Panel (Sept. 1995)

Member, NASA Discovery Missions Review Panel (Dec. 1994-Jan. 1995)

Member, NASA Mars Science Working Group (1992-1994)

Co-convenor, "Comets and the Origins and Evolution of Life" Conference, University of Wisconsin, Eau Claire (October 1991)

Member, U.S.-Soviet Exobiology Expedition to Northeastern Siberia (June-August 1991)

Graduate Student Associate, Voyager Imaging Team, Voyager spacecraft Uranus and Neptune flybys (1986, 1989)

Delegate, American Center for International Leadership (ACIL) delegation to Chernobyl (June 1989)

Research Grants

Principal Investigator, “Planetary Biology, Evolution, and Intelligence”, NASA Astrobiology Institute, 2003-2008

Principal Investigator, “Strengthening Scientific and Technical Advice in International Security Policy”, John D. and Catherine T. MacArthur Foundation, 2003-2005

Co-Principal Investigator, “International Security in a Changed World: Opportunities and Challenges”, Carnegie Corporation of New York, 2002-2004

Co-Principal Investigator, “International Security in a Changed World”, Carnegie Corporation of New York, 2000-2002

Principal Investigator, Presidential Early Career Award for Scientists and Engineers, 1997-2003. [Note: this grant, and the following exobiology grant, got “stretched out” due to my changes in venue subsequent to 1997; PECASE was to have been a 5-year grant and the exobiology award was to have been a 3-year grant.]

Principal Investigator, "Subsurface liquid water on Mars: Evidence from cratering thermodynamics, and exobiological implications.” NASA Exobiology Program, 1997-2002

Principal Investigator, "Cometary organics and impact effects; martian volatiles and surface chemistry". NASA Graduate Student Researcher's Program NGT-50302, 1988-1991.

University Service

Member, Stanford International Initiative Faculty Committee, March 2004-present

Chair, Stanford Biodefense and International Security faculty search committee

Co-Director, Center for International Security and Cooperation (CISAC), Stanford University

Ph.D. advisor for Mr. Kevin Hand, Stanford Department of Geological and Environmental Sciences

During my two years at the University of Arizona, I served on the Ph.D. defense committees of three graduate students, and served on several admission-to-candidacy examination committees.

Membership in Professional Societies

Division of Planetary Sciences, American Astonomical Society

International Society for the Study of the Origin of Life

American Association for the Advancement of Science

American Geophysical Union

American Society for Microbiology

The Pacific Council

Community Service

Member, Board of Editors, *Science and Global Security* (2002-present)

Member, Editorial Advisory Board, *Astrobiology* (2002-present)

I review manuscripts frequently for *Nature, Science, Icarus, Origins of Life* and *Astrobiology*. I occasionally review manuscripts for *Journal of Geophysical Research, Geophysical Research Letters, Journal of Molecular Evolution, International Security, American Journal of Physics, Geochimica et Cosmochimica Acta,* and other journals.