

James H. Kaufman

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Experience

Research Manager, Healthcare Research	Jan 2003 to Present
Team Lead, OptimalGrid Project	Jan 2000 to Jan 2003
Senior Manager and Strategist, Science and Technology	Dec. 1994 to Jan 2000
Research Manager	June 1990 to Dec. 1994
Science Advisor to IBM Vice President and Director of Research	June 1989 to 1990
Research Staff Member	Feb. 1985 to 1989
Post Doctoral Scientist	Feb. 1984 to 1985

Computer Science:

- Healthcare Information Innovation
- OptimalGrid
- The Social Contract Core
- The Moon Illusion (experiments done with my father to explain this famous illusion. The work was published in the proceedings of the National Academy of Science and recognized world wide).
- Tempus Fugit (Active Calendar project)
- Locus – indexing dynamic spatial data.
- City Simulator (built for Locus Project)

Science and Technology:

- Managed the development of IBMs new non-volatile memory (MRAM). This magneto-electronic device offers the advantages of DRAM, SRAM, and Flash in one technology.
- Materials research for magnetic recording and thin film displays.
- Led computer modeling and theory team to predict limits of magnetic recording.
- Critical Biodiversity
- Modeling the Magnetic Field of the Human Brain. Approaches to solving the inverse problem in MEG

Skills

Healthcare Information Infrastructure:

As manager of the IBM Interoperable Health Information Infrastructure (IHII) Research Joint program in partnership with S&D (Healthcare/Life Sciences), BCS and SWG, created and demonstrated a standards based technology for a future national health information infrastructure. Such an infrastructure will someday transform the healthcare industry and create new models for the handling of medical information. It will improve the quality of

healthcare nationally and help advance medicine as a science. In addition to support for electronic documents and messaging (using IBM's Healthcare Collaborative Network technology), IHII includes support for simulation and analysis tools. We also created the Spatio-Temporal Epidemiological Modeler (STEM), to enable modeling of emerging infectious diseases. STEM provides scientists and public health officials with a powerful tool for understanding and planning more efficient responses to the spread of infectious diseases. STEM facilitates the creation of advanced mathematical models involving multiple populations and interactions between diseases to promote better understanding of epidemiology and to provide new tools for protecting population health. In collaboration with Dr. Donald Burke, Johns Hopkins Bloomberg School of Public Health, we are using STEM to model important emerging infectious diseases.

The IHII project received very widespread press coverage in major media outlets including The New York Times, Associated Press, Dow Jones, Bloomberg, USA Today, Forbes.com, BusinessWeek.com, The San Jose Mercury News, The Los Angeles Times and many more. It was also the basis for IBM's response to the RFP from DHS for prototypes or a national health information infrastructure. IBM won this contract (\$10M).

Distributed Computing:

OptimalGrid is middleware that aims to simplify creating and managing large-scale, connected, parallel grid applications. It optimizes performance and includes autonomic grid functionality. You don't need to be a grid infrastructure expert to use it. You supply the code that represents your basic problem algorithm, and OptimalGrid manages everything else -- problem partitioning, problem piece deployment, runtime management, dynamic level of parallelism, dynamic load balancing, and even system fault tolerance and recovery. The OptimalGrid system is designed to bring the immense potential of Grid computing easily within reach of developers who aren't grid infrastructure experts.

Technology Transfer:

I have taken several research projects from the lab to development and manufacturing. For example, I invented nitrogenated diamond like carbon disk overcoats, designed and built HV deposition tools with thin film disk development people, and transferred the hardware and processes to manufacturing. I also invented Giant Magnetoresistive devices for nonvolatile memory and magnetic recording applications.

General Technical:

Grid Computing, Distributed Systems, Micromagnetics, large scale computer programming and simulation (C, JAVA on windows and unix), optics, OLED devices, thin film materials and deposition (by HV and UHV techniques), basic electronics, conducting polymers, condensed matter physics, electrochemistry, standard machine shop skills, vacuum mechanical, plumbing, electrical, glass blowing, etc. I am enthusiastic, energetic, and love to create.

Education

IBM "Presidents Class", Two week intensive business and finance class taught by the Harvard Business School.	Dec. 1994
Ph.D. in Physics <i>U.C.S.B.</i> , Santa Barbara, CA	May 1984
M.A. in Physics <i>University of Pennsylvania</i> , Philadelphia, PA	January 1982
B.A. (with honors in Physics) <i>Cornell University</i> , Ithaca, NY	May 1980

Honors and Professional Activities

- ◆ Fellow of the American Physical Society
- ◆ IBM "Master Inventor"
- ◆ Chair of the American Physical Society (APS) Forum on Industrial and Applied Physics (This 3 year position is determined by popular vote of APS/FIAP members. I was elected Vice Chair in 1998, served as chair elect in 1999, Chair in 2000).
- ◆ I served as a program chair and organizer for the 1999 centennial meeting of the APS.
- ◆ I served as chair of the APS Fellows selection committee and nominating committee.
- ◆ Organized a new symposium "Physicists at Startups" for the 1998 and the 1999 American Physical Society meetings.
- ◆ I served on the APS Kiethley prize committee (1999, 2000, 2001).
- ◆ IBM "Blue Chip" award for management accomplishments. Award is shares of IBM Stock (1995).
- ◆ I have received several IBM internal awards for inventions and technical accomplishments.
- ◆ Invited to attend IBM "President's Class". Two weeks of intensive business and financial training taught by the Harvard Business School. Dec., 1994.
- ◆ Invited Fellow, University of New South Wales, Sidney, Australia. Jan-Feb., 1993.
- ◆ Co-chair for symposium on Fractals at the 1992 Electrochemical Society Meeting in St. Louis.
- ◆ Co-chairman of the 1989 Fractal Symposium at the Fall MRS Meeting in Boston.
- ◆ Invited to chair a session on fractals at the 1989 APS March Meeting.
- ◆ Graduated Cornell University with Honors in Physics.

Selected Patents Issued

- ◆ "Basic Architecture for Magnetic RAM." Issued 1998 with broad claims approved.
- ◆ "Method and Means for Limiting Adverse use of Counterfeit Credit Cards, Access Badges, Electronic Accounts or the like." *Rated among top IBM Patents, 1996 . Significant licensing value to IBM.*
- ◆ "Transient Liquid Metal Interlayer (TLMI) for Textured Overcoats", by J. Kaufman, S. Metin, M. Mirzamani and T. Wu, April, 1993.
- ◆ "Improved Overcoats by Nitrogen Doping of Amorphous Carbon", by J. H. Kaufman, S. Metin, D. D. Palmer, D. D. Saperstein and A. W. Wu, *The carbon overcoat we invented is now a standard throughout the disk industry. Significant licensing value to IBM.*
- ◆ "Improved Hard Low Stressed Carbon as a Gap Material in Tape Head Structures", by W. C. Cain, J. H. Kaufman, S. Metin, D. D. Saperstein and A. W. Wu. Filed in Tucson, May, 1991.

Recent Patent Activity 6th IBM patent plateau, (past 2 years: 8 Filed, 3 in search, 6 published).

- ARC8-2005-0129 A system, method, and means, to detect and prevent fraudulent medical insurance claims (Search)
- ARC8-2005-0042 Method for the automatic filtering of medical data in limited resource scenarios (Search)
- IL8-2005-0063 Distributed Patient Locator Service (Search)
- ARC8-2004-0182 A Virtual Memory Technique for Efficiently Solving Connected Problems in a Distributed Environment (File)
- ARC8-2004-0174 An Efficient Super Cluster Implementation for Solving Connected Problems in a Distributed Environment (File)
- ARC8-2004-0129 Dynamic Message Pathway Optimization (File)
- USPN6774811 "Designation and Opportunistic Tracking of Valuables"
- AUS8-2003-1319 Improved handling of players and objects in massive multi-player on-line games.
- AUS8-2003-1200 Method for distributing and load geographically balancing telephone client-proxy applications

- Select Patents Issued:

Credit Card patent chosen in **top 5%** of all IBM Patents (2000)

“Improved Overcoats by Nitrogen Doping of Amorphous Carbon”, by J. H. Kaufman, S. Metin, D. D. Palmer, D. D. Saperstein and A. W. Wu, This material is now a standard throughout the disk industry. Issued in Europe in 2003.

Fundamental MagRAM patent key to IBM, Motorola, and Infineon strategy

USPN6515857 "Visual Heat Sink for Computers and Method of Use"

USPN5767624 "Light Emitting Device" (IBM Organic LEDs)

DE69723776T2 German counterpart

EP0817539B1 EPO counterpart

Selected Publications

Computer Science

- Submitted, Panel Proposal to MedInfo 2007 “*Title: Infectious Disease Surveillance: How International Cooperation Is Working*”
- Submitted Tutorial Proposal to MedInfo 2007, “*Title: Two Models for Public Health Interoperability: The Middle East Consortium for Infectious Disease Surveillance (MECIDS) and the French Center for Electronic Disease Surveillance*”
- Submitted Session Proposal to AsiaPac2007, “*Session Title: The Middle East Consortium for Infectious Disease Surveillance (MECIDS)*”
- Invited (Key Note), J. H. Kaufman et al. “*Towards a National Healthcare Information Infrastructure*” DILS 2006, <http://www2.informatik.hu-berlin.de/dils2006/> (*Sarah Knoop presented on my behalf*)
- Ford, D.A., Kaufman, J.H., Eiron, I., "An extensible spatial and temporal epidemiological modeling system", International Journal of Health Geographics (2006)
<http://www.ij-healthgeographics.com/content/5/1/4/>
- Invited J. H. Kaufman, The SpatioTemporal Epidemiological Modeling. A collaborative framework for modeling infectious disease., ENAR Spring Tampa, FL (2006) Sponsor: International Biometric Society
- E. Smith and J. H. Kaufman, “Lowering the Barrier to a Decentralized NHIN Using the Open Healthcare Framework”, ICMCC (International Council on Medical & Care Compunetics), The Hague, (2006)
- J. Lessler, D. Burke, and J. H. Kaufman “A Computational Model of Vaccine Derived Poliovirus Epidemics”, Ninth Annual Conference on Vaccine Research, Baltimore, Maryland (2006). Sponsor: National Federation For Infectious Disease
- J. Lessler, D. Burke, N. Haimenen, and J. H. Kaufman “A Computational Simulation of Evolvable Viruses in Populations: Application to Poliovirus Eradication”, DIMACS Workshop on Facing the Challenge of Infectious Diseases in Africa: The Role of Mathematical Modeling, Johannesburg, South Africa (2006) Sponsor: NSF
- D.A. Ford and J. H. Kaufman, “SpatioTemporal Epidemiological Modeler”, IEEE ISI, Public Health and Biosecurity session, San Diego, CA (2006)
- J. H. Kaufman and D. A. Ford, “Protecting Public Health through Advanced SpatioTemporal Epidemiological Modeling”, Biosurveillance Workshop Tucson, AZ 2006 (sponsor NSF)
- B. Eckman et al., “Varieties of Interoperability in the Transformation of the Healthcare Information Infrastructure”, IBM System Journal (Accepted)

- (Invited) J. H. Kaufman, "Opening up Healthcare Markets with Open Source", Healthcare Day Panelist, LinuxWorld 2006, San Francisco, CA
- Invited, Ganta R. et al., and J.H. Kaufman "The Eclipse Open Health Framework" HCTM 2006; 5th International Conference on the Management of Healthcare & Medical Technology
- N. Perez et al., and J.H. Kaufman "Testing in the Open Healthcare Framework (OHF)" QSE 2006 - Quality Software Engineering Second Latin American Symposium, Mexico (2006)
- N. Perez et al., and J.H. Kaufman "SpatioTemporal Epidemiological Modeler" Technology and Society Committee (TASC) San Jose, CA (2006)
- Deen, G. et al., and J.H. Kaufman "Running Quake II on a Grid IBM Journal of Computing Vol: 45 No: 121-44
- S. Knoop et. al and J.H. Kaufman, "From Regional Healthcare Information Organizations to a National Healthcare Information Infrastructure" Accepted JAHIMA 2005
- J.H. Kaufman et al., "From Regional towards National Healthcare Information Infrastructure, an IBM Research Perspective" Keynote Speaker at State of Oregon: Digitization of Healthcare Summit held in conjunction with "InnoTech" 3/9/05 Place: Portland, Oregon. Sponsor: Governor, State of Oregon
- J.H. Kaufman et al., "Collaborative Health Sentinel" presented at Johns Hopkins 1/21/05
- J.H. Kaufman et al., "On Size and Distance Perception" submitted to Spatial Vision (2005)
- J.H. Kaufman et al., (Invited) "IHII" Critical Issues in eHealth Research Conference, 11/05, Place: Bethesda, MD, Sponsor: NIH. *Presented by Sarah Knoop.*
- Eiron, I. et al., and J.H. Kaufman "A System for Intelligent Data Mining of Clinical Records", Critical Issues in eHealth Research, Bethesda, MD (Sponsor: U.S. National Library of Medicine)
- J.H. Kaufman, Tracking Disease "Storms" from on "I-High", HealthNex (<http://healthnex.typepad.com/>) 2005.
- Running Quake II on a Grid IBM Journal of Computing, in press 2005.
- OptimalGrid: Bringing the Power of Grid to Games, Keynote at 34th International Conference on Parallel Processing (ICPP) 2005 *presented by Glenn Deen*
- (accepted) G. Deen et al. An Autonomic Operating Environment for Large-Scale Distributed Applications, Advanced Engineering Informated Journal by Elsevier, special Autonomic Issue
- (invited) J.H. Kaufman et al., The Social Contract Core, Electronic Commerce Research 5:139-163 (2005)
- (submitted) J. Bethencourt and J.H. Kaufman, Computation and Communication in Parallel Computing with Whiteboards, IPDPS, Denver Co (2005)
- (invited) J.H. Kaufman et al., "Collaborative Health Sentinel" presented at The Fourth IEEE International Conference on Data Mining (ICDM) 2004 Nov 1, 2004.
- (invited) J.H. Kaufman "Is Life Science Data Mining Different or Special?", *Panel Discussion* held at The Fourth IEEE International Conference on Data Mining (ICDM) 2004 Nov 1, 2004.
- (invited) L. Kaufman & J. Kaufman, "On the relation between perceived and physical distance and the perception of size.", *Centennial Meeting of the Society of Experimental Psychologists*, March, 2004 (held at Cornell University).
- (invited) J.H. Kaufman et al. "Grid Computing Made Simple" reprinted in GRID Today 2004, <http://www.aip.org/tip/INPHFA/vol-9/iss-4/p31.html>
- J.H. Kaufman (Invited), The Global Computing Grid, SDForum sponsored by Technology Review, <http://www.sdforum.org/p/calEvent.asp?CID=1092&mo=6&yr=2003>, June 5, 2003.
- J. H. Kaufman (Invited), T. Lehman, G. Deen, Autonomous Optimization of Distributed Computing on the Grid, PPAM 2003, FIFTH INTERNATIONAL CONFERENCE ON PARALLEL PROCESSING AND APPLIED MATHEMATICS Czestochowa, Poland, Sept. 2003
- J.H. Kaufman, et al., A practical introduction to OptimalGrid
- <http://www-106.ibm.com/developerworks/edu/gr-dw-gr-opgrd-i.html> , June 2003.
- James Kaufman, Toby Lehman, OptimalGrid, Autonomic Computing on the Grid. <http://www.aip.org/tip/INPHFA/vol-9/iss-4/p31.html>

- Toby Lehman, James Kaufman, OptimalGrid, The Almaden SmartGrid Project. IEEE Task Force on Cluster Computing Newsletter
- J.H. Kaufman, S. Edlund, D.A. Ford, Electronic Commerce and The Social Contract Core, invited to a special issue of Electronic Commerce Research
- Jussi Myllymaki, James Kaufman, High-Performance Spatial Indexing for Location-Based Services (in preparation)
- J.H. Kaufman, S. Edlund, D.A. Ford, and C. Powers, The Social Contract Core (Invited by Mary Ellen Zurko, Lotus Dev. Corp) to write longer paper to a special issue of Electronic Commerce Research.
- J.H. Kaufman, S. Edlund, D.A. Ford, and C. Powers, The Social Contract Core, Eleventh International World Wide Web Conf., ACM 1-58113-449-5/05/0005. WWW2002 Honolulu, Hawaii, <http://www2002.org/CDROM/refereed/107/>
- (Invited)Jussi Myllymaki, James Kaufman, LOCUS: A Testbed for Dynamic Spatial Indexing, IEEE Data Engineering Bulletin Special Issue on Indexing of Moving Objects. Vol - 25 No - 2
- Jussi Myllymaki, James Kaufman, DynaMark - A Benchmark for Dynamic Spatial Indexing, Sigmod Mobile Data Management (MDM) 2003 Melbourne, Australia accepted.
- Kaufman & Kaufman, The Size-Distance Relation and the Moon-Illusion, NSF Grant Proposal 2002 (funded)
- Tempus Fugit and the e-Social Contract (invited book chapter), Book "Agent Supported Collaborative Work" Accepted 2002.
- Daniel Ford, Joann Ruvolo, Stefan Edlund, Jussi Myllymaki, James Kaufman, Jared Jackson, *Tempus Fugit: A system for making semantic connections*, CIKM'2001
- M. Slaney, D. Ponceleon, and J. H. Kaufman, *Multimedia Edges: Finding Hierarchy in all Dimensions*, Proceedings of the 9th ACM International Conference on Multimedia, Ottawa, Ontario, Sept. 30 -Oct 5, 2001.
- Kaufman & Kaufman, "ILLUSION IN REALITY: Visual Perception in Displays", Human Vision and Electronic Imaging VI, Proceedings of SPIE Vol. 4299, pg 19, June 2001
- J. Kaufman, J. Ruvolo, and D. Ford, *Tempus Fugit and the Need for an e-Social Contract*, 5th International Conference on Autonomous Agents, Montreal Canada Proceedings **W. 11, pg 77**, May, 2001 (**Invited**) and, *Tempus Fugit and the Need for an e-Social Contract*, J. Kaufman, J. Ruvolo, and D. Ford, 5th International Conference on Autonomous Agents, Montreal Canada, Proceedings, **pg174**, May, 2001 (contributed)
- M. Slaney, D. Ponceleon, and J. H. Kaufman, *Temporal Events in all Dimensions and Scales*, IEEE International Workshop on Detection and Recognition of Events in Video, May 2001.
- WhitePaper J.H. Kaufman, J. Myllymaki, and D.A. Ford, *Management Of Dynamic Spatial Data For Transportation Service and Infrastructure Assurance*, A white paper submitted to the Dept. of Transportation in response to BAA DTRS56-01-BAA-0002.
- "Critical Biodiversity", by J. H. Kaufman, and O. R. Melroy. HMS Beagle (Invited comment, internet journal) (April 2000). *I wrote a numerical simulation of the evolution of life which demonstrated the existence of a critical level of biodiversity which determines the stability of an ecosystem. The work done in 1992 and was recently sighted at http://www.biomednet.com/hmsbeagle/76/viewpts/op_ed.*
- "Explaining the Moon Illusion", Kaufman & Kaufman, Proceedings of the National Academy of Science, January 2000. *This paper, which was featured on the cover of pnas, reports the results of an experiment done with my father. We received world wide press coverage for this work which solves a famous > 2000 year old problem. <http://www.pnas.org/content/vol97/issue1/cover.shtml> and http://www.research.ibm.com/resources/news/20000103_moon_illusion.html.*
- "Critical Biodiversity" by Kaufman, Brodbeck, and Melroy. Conservation Biology August, 1998. This work was also be featured in "Research Magazine".
- On Cortical Folds and Neuromagnetic Fields, by L. Kaufman, J. H. Kaufman, and Jia-Zhu Wang. Electroencephalography and Clinical Neurophysiology 79, 211-226 (1991).

Storage Technology

- “Micromagnetic modeling of thermal decay in interacting systems”. O.A.Chubykalo, B.Lengsfeld, B.Jones, J.Kaufman, J.M.Gonzalez, R.W.Chantrell and R. Smirnov-Rueda, J. Magn Magn Mat (accepted)
- O.A.Chubykalo, J.Kaufman, B.Lengsfeld and R. Smirnov-Rueda, *Long-time calculation of the thermal magnetization reversal using Metropolis Monte Carlo*, JEMS Conference (Grenoble, France, August, 2001) and Journal of Magnetism and Magnetic Materials (In Press)
- “Long-time dynamics study of thermal decay in granular media”, B. Lengsfeld, O.A.Chubykalo, B.Jones, J.Kaufman, B., (submitted to Journ Appl Phys.)
- “Calibration of time dependence in a Metropolis Monte Carlo model of thermal decay of magnetization”, J.Kaufman, B.Lengsfeld, B.Jones, O.A.Chubykalo, (in preparation)
- “Modeling thermal decay in magnetic media with Monte Carlo”, B.Lengsfeld, J.Kaufman, B.Jones and O.A.Chubykalo, (in preparation)
- “The influence of exchange parameter to signal-to-noise ratio in longitudinal recording media”, J.Kaufman, O.A.Chubykalo, B.Lengsfeld, and B.Jones, (in preparation).
- “Anisotropy Design in Magnetic Media, A Micromagnetics Study”, J. H. Kaufman, T. Koehler, A. Moser, D. Weller, and B. Jones, J. Vac. Sci. Tech. 1998.
- Anisotropy Design in Magnetic Media, A Micromagnetics Study, J.H. Kaufman, T. Koehler, A. Moser, D. Weller and B. A. Jones, J. Appl. Phys. and IEEE Transactions on Magnetics, (1997).
- Microwave CVD of Diamond Using Methanol Rare Gas Mixtures, by M. Buck, T. J. Chuang, J. H. Kaufman, and H. Seki. MRS Proc. 162, 97 (1990).
- Symmetry Breaking in Nitrogen Doped Amorphous Carbon: IR Observation of the Raman G and D Bands, by J. H. Kaufman, S. Metin, and D. D. Saperstein. Physical Review B 39, 13053 (1989). *We couldn't publish our technical work on nitrogenated carbon but we realized that the IR active modes in nitrogen doped carbon could explain a mysterious interstellar emission band. I was invited to Kitt Peak National Observatory to test the prediction we made in this paper.*
- Nitrogenated Amorphous Carbons: A Potential Source of Diffuse Interstellar Infrared Emission, by D. D. Saperstein, S. Metin, and J. H. Kaufman. The Astrophysical J. Letters L47, (1989).

Display Materials

- "Degradation and failure of MEH-PPV light-emitting diodes," J.C. Scott, J.H. Kaufman, P.J. Brock, R. DiPietro, J. Salem and J.A. Goitia, J. Appl. Phys. 79, 2745 (1996).

Electrochemistry, Pattern Formation, and conducting polymers

- Mechanism of a Morphology Transition in Ramified Electrochemical Growth, by J. H. Kaufman, V. Fleury and Brynn Hibbert. Nature 367, 435-438-03 (1994).
- Evolution of the Space-Charge Layer During Electrochemical Deposition with Convection, by Vincent Fluery, J. H. Kaufman and Brynn Hibbert. Physical Review E 48, 3831-3840 (1993).
- Spinless Charge Carriers in Divalent Cation Doped Polyacetylene, by J. H. Kaufman, S.-M. Huang, R. K. Shiba, and R. B. Kaner. Solid State Communications 74, (1990).
- Physical Description of a Viscoelastically Loaded at Cut Quartz Resonator, by C. E. Reed, K. K. Kanazawa, and J. H. Kaufman. J. Appl. Phys. 68, 1993 (1990).
- An Information Theoretic Study of Pattern Formation: The Rate of Entropy Production of Random Fractals, by J. H. Kaufman, O. R. Melroy, and G. M. Dimino. Phys. Rev. A. 39, 1420 (1989).
- The Onset of Fractal Growth: Statics and Dynamics of Diffusion Controlled Polymerization, by J. H. Kaufman, A. I. Nazzal, A. Kapitulnik, M. Flickner, and O. R. Melroy. Phys. Rev. B, 35, 1991 (1987).
- Statics and Dynamics of Diffusion Limited Polymerization, by J. H. Kaufman, C. K. Baker, A. I. Nazzal, O. R. Melroy, and A. Kapitulnik. Phys. Rev. Lett. 56, 1932 (1986).
- Evolution of Polaron States into Bipolarons in Polypyrrole, by J. H. Kaufman, N. Colaneri, J. C. Scott, and G. B. Street. Phys. Rev. Lett. 53, 1005 (1984) and Mol. Cryst. Liq. Cryst., in press.
- Gravimetric Electrochemical Voltage Spectroscopy: In Situ Mass Measurements During Electrochemical Doping of the Conducting Polymer Polypyrrole, by J. H. Kaufman, K. K. Kanazawa, and G. B. Street. Phys. Rev. Lett. 53, 2461 (1984).

Hobbies

Martial Arts (www.kokarate.com). In the past I did water color painting [breeding tropical fish](#) (and photographing them),(<http://home.earthlink.net/~photofish/>) and studied them with close-up photography.