

ED n° 474 Interdisciplinaire Européenne "Frontières du Vivant" - Liliane Bettencourt

## Workshop: Hands-on Experiments, Scientific Discovery Games and Citizen Science Learning through Research for all

Paris, July 10-13, 2011

*Organizers: François Taddej, Ariel Lindner & Livio Riboli-Sasco*

### THE SPEAKERS

#### Zoran Popovic

*(University of Washington)*

#### Solving Hard Scientific Problems with Game-based Symbiosis of Humans and Computers

As our recent Nature publication, Predicting protein structures with an online multiplayer game shows, games can make a significant impact on traditional science discovery processes and in particular with biochemistry problems. This paper for the first time shows that human problem solving through game-play can outperform all massive scientific computational efforts on specific problems. This new space of games, scientific discovery games, presents a unique set of challenges orthogonal to the usual challenges of game design. This talk will discuss the challenges encountered designing such games and approaches to overcoming them. I will conclude with a wide range of problems that can be similarly addressed with a game driven scientific discovery. I will specifically focus on our current efforts that expand this paradigm towards drug and vaccine discovery, nano-machine design, discovery of new protein based materials, as well as revolutionizing the learning and education process.

#### Bio:

Zoran Popovic is a Professor in computer science at University of Washington and a Director of Center of Game Science. Zoran's research interests lie in computer graphics and interactive games research, focusing on scientific discovery through game play, learning games, high-fidelity human modeling and animation. His laboratory produced Foldit, a biochemistry games whose outcomes are now published in Nature, as well as a award-winning learning games, and real-world games. His contributions to the field of computer graphics have been recently recognized by a number of awards including the NSF CAREER Award, Alfred P. Sloan Fellowship and ACM SIGGRAPH Significant New Researcher Award.



#### Website:

<http://www.cs.washington.edu/homes/zoran/>

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## Harry Swinney

(Center for Nonlinear Dynamics and Department of Physics University of Texas at Austin)

### Bio:

Swinney's research involves small scale hands-on table-top experiments and complementary mathematical modeling. In the 1970s-90s his experiments showed that strange (chaotic) attractors characterize nonperiodic behavior in diverse systems, including fluids and chemical reactions. His group found ordered spatial patterns can emerge at well-defined transitions in chemical reaction-diffusion systems, as predicted by Alan Turing in 1952. Swinney and coworkers developed a laboratory model for the Great Red Spot of Jupiter, found barriers to ocean transport (which can be interpreted as mathematical invariant curves -- KAM tori), and discovered spatial patterns (e.g hexagons, squares, "oscillons") that form spontaneously in oscillating layers of sand. Recent work on oceanic flows revealed resonant boundary currents that shape the continental rise (beyond the continental shelf). A study of growth of neighboring colonies of *Paenebacillus dendritiformis* bacteria (from the same original culture) uncovered a deadly competition that results from a mechanism that likely occurs in many bacterial species. Since 2008, Swinney (together with K. Showalter, R. Roy, and others) have led "Hands-On Research Schools" for young college and university faculty in developing countries. In 1992 Swinney was elected to the US National Academy of Sciences.



### Website:

<http://chaos.utexas.edu/people/faculty/harry-l-swinney>

## François Taddei

(Center for Research and Interdisciplinary - INSERM)

### Bio:



François Taddei heads the Evolutionary Systems Biology team at a unit of the French National Institute of Health & Medical Research (INSERM) in Paris-Descartes University's Medical School. After a generalist scientific education, with majors in physics and biology at the École Polytechnique, he became a tenured higher civil servant at the French Ministry of Agriculture, before earning a PhD in genetics, studying the evolution of the rate of evolution with Miroslav Radman. After postdoctoral training with John Maynard-Smith, for the last 10 years, his research team has been studying innovation and degeneracy in biological systems.

Over the last five years, he has created the CRI (Center for Research and Interdisciplinary) in Paris, which offers a Master's degree (Interdisciplinary Approaches to Life sciences, AIV), a doctoral school (Frontiers of Life, FdV), supported by the Liliane Bettencourt PhD program). CRI's main role is to promote new pedagogies to help creative students take initiatives and develop their research projects, with the help of mentors, research institutions, private companies, and foundations, such as the Bettencourt Foundation, which has supported many student-created activities. These activities range from the first French synthetic biology team (which won the Foundational Research Award at its first participation in the MIT-sponsored iGEM competition) to the "Paris-Montagne" science festival and the "Science Académie," an outreach program that allows high schools students from disfavored neighborhoods to discover the creativity of science while spending their vacations in research labs.

### Website:

<http://www.cri-paris.org>

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## Eva-Maria Schoetz

(HoS, Princeton University)

### Bio:

Eva-Maria Schoetz is currently a Lewis-Sigler Fellow at Princeton University. For her PhD she studied the role of tissue mechanics in vertebrate (zebrafish) development. She continues to work in this area in her group at Princeton, combining tissue rheology and theoretical modeling to describe large-scale tissue movement and patterning during embryogenesis and regeneration. On the other hand, she completely fell in love with planarians and is strongly interested in the dynamics of planarian regeneration & asexual reproduction (on the organismal and population level). Besides playing with these awesome creatures, Eva-Maria is engaged in the development of new teaching methods and actively involved in the newly developed Integrated Science Course at Princeton as well as in outreach activities such as the Hands-on Research School (<http://handsonresearch.org/>).



### Links:

<http://www.genomics.princeton.edu/schoetzlab/publications.html>

<http://www.genomics.princeton.edu/schoetzlab/Outreach.html>

## Mark Shattuck

(HoS, City University of New York)

### Presentation title:

Using MATLAB to Discover the Power of Molecular Simulation.

### Bio:



Mark directs all aspects of the research projects, including meetings with all personnel at least once a week, overall design and selection of components, basic scientific direction, overall design of data analysis software, and development of numerical algorithms. The educational development of the student and post-doctoral participants is a major goal of the projects. He spends a significant fraction of time monitoring and directing the progress of the students and post-doc to facilitate their educational development. During the semester, Mark teaches undergraduate, and graduate courses.

### Website:

<http://gibbs.engr.cuny.cuny.edu>

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## Michael Schatz

(HoS, Georgia Tech)

### Bio:



Michael Schatz is an Associate Professor of Physics at the Georgia Institute of Technology. Schatz's current research interests lie in two distinct areas: (1) Nonlinear Dynamics and (2) Physics Education Research. Schatz's current research in nonlinear dynamics focuses on studies of spatiotemporal complexity and turbulence in fluids experiments with an emphasis on the development of topological techniques to characterize complex spatiotemporal patterns, the use of dynamical systems methods for forecasting and active control of fluid flows, and the experimental characterization of turbulence in two and three dimensions. Schatz's current research in physics education focuses on devising, implementing and assessing new ways to teach introductory physics in both collegiate and high school settings, in particular by implementing and assessing reform curricula

in large lecture classes, introducing and expanding the use of computational thinking methodologies, and characterizing students' motivations for and anxieties about learning computation.

### Links:

<https://www.physics.gatech.edu/user/michael-schatz>

<https://per.gatech.edu/wiki/doku.php?id=start>

## Kenneth Showalter

(HoS, West Virginia University)

### Bio:

Kenneth Showalter holds the C. Eugene Bennett Chair in Chemistry in the Department of Chemistry at West Virginia University. He received his B.S. in Chemistry from Fort Lewis College in 1971 and his Ph.D. in Chemistry from the University of Colorado in 1975. Showalter has broad experience in using chemical model systems to characterize dynamical complexity. In recent years he also has been involved in efforts to promote science in the developing world through the Hands-On Research in Complex Systems Schools.



### Website:

<http://heracles.chem.wvu.edu/>

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## Ingmar Riedel-Kruse

(Stanford University)

### Bio:

Ingmar Riedel-Kruse is interested in understanding and utilizing the emergent dynamics of complex biological systems. His lab focuses on two topics: (1) the biophysics of development and tissue engineering (mainly in zebrafish); and (2) engineering and application of biotic games for education, supporting large-scale science, and simply fun. He has worked experimentally and theoretically in a variety of areas related to biology and biophysics such as collective (synchronous) behavior of molecular motors, sperm cells, genetic oscillators, and neurons. Physics diploma 2000 TU Dresden; PhD in Biophysics 2006 Max Planck Institute for Cell Biology and Genetics with Jonathon Howard; Postdocs with Andrew Oates and Gilles Laurent at the Max Planck and Caltech, respectively. Assistant Professor for Bioengineering at Stanford since 2010.



### website:

<http://www.stanford.edu/group/riedel-kruse/>

### paper:

<http://pubs.rsc.org/en/content/articlelanding/2010/lc/c0LC00399A>

<http://www.stanford.edu/group/riedel-kruse/publications.html>

### movie:

<http://www.youtube.com/watch?v=Pdx7BkYSCq4>

## Scott Barolo

(University of Michigan)

### Presentation title:

Teaching Scientific Reasoning Skills with the Game of Mastermind

### Bio:

I was born in Pittsburgh, Pennsylvania, USA. I received a Ph.D. in developmental genetics from the University of California, San Diego in 1997, and took a faculty position at the University of Michigan Medical School in Ann Arbor, Michigan in 2003. I am currently the course director of a graduate-level developmental biology course at UMMS, but most of my effort goes to research on the control of gene expression in *Drosophila* development. I came to the attention of the organizers of this meeting when a paper I wrote with an undergraduate student in my lab, on using the game of Mastermind to teach scientific reasoning skills, was published in PLoS Biology in January of this year.



### Links:

Lab Website - <http://sitemaker.umich.edu/barolo>

Publications - <http://sitemaker.umich.edu/barolo/publications>

Mastermind teaching paper - <http://sitemaker.umich.edu/barolo/files/MastermindPLOSBIol.pdf>

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## Robert Full

(University of California Berkeley)

### Bio:



Robert Full received his doctoral degree in 1984 from SUNY Buffalo, completed a post doc at The University of Chicago in 1986 and became a Full Professor of Integrative Biology at the University of California at Berkeley in 1995. Professor Full is a Chancellor's and Goldman Professor, Director of the Poly-PEDAL Laboratory, Director of the Center for Bio-inspiration in Education and Research (CIBER), and Principal Investigator on an NSF supported Integrative Graduate Education and Research Traineeship (IGERT). In his 25 years at Berkeley, Professor Full has led a focused international effort to demonstrate the value of integrative biology and biological inspiration. He has been instrumental in the formation of interdisciplinary collaborations and new design teams composed of biologists, engineers, mathematicians and computer scientists from academia and industry.

His fundamental discoveries in animal locomotion have inspired the design of novel neural control circuits, artificial muscles, creations in computer animation, autonomous legged robots and the first self-cleaning dry adhesive. Professor Full's outreach includes contribution to a national education challenge for children (Kids Science Challenge), development of seven museum exhibits, presentation of five Technology, Entertainment and Design (TED) talks, involvement in twenty-five national and international science television programs, and was an invited speaker at the inaugural meeting of The National Academies Science and Entertainment Exchange.

### Links to public talks:

[http://www.ted.com/talks/lang/eng/robert\\_full\\_learning\\_from\\_the\\_gecko\\_s\\_tail.html](http://www.ted.com/talks/lang/eng/robert_full_learning_from_the_gecko_s_tail.html)

[http://www.ted.com/talks/lang/eng/robert\\_full\\_on\\_animal\\_movement.html](http://www.ted.com/talks/lang/eng/robert_full_on_animal_movement.html)

[http://www.ted.com/talks/lang/eng/robert\\_full\\_on\\_engineering\\_and\\_evolution.html](http://www.ted.com/talks/lang/eng/robert_full_on_engineering_and_evolution.html)

## Jeehyung Lee

(Carnegie Mellon)

### Presentation title:

EteRNA &#8208; a multiplayer RNA game with high throughput experimental validation

### Bio:

I'm currently a Ph.D student under Adrien Treuille at Carnegie Mellon University's Computer Science Department. My research focuses on crowdsourcing hard scientific problems through "gamification." I was a developer of Foldit project, a multiplayer protein folding game and I'm currently leading EteRNA project, a multiplayer RNA design game.



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## Jospeh Niemela

(Trieste, International Centre for Theoretical Physics ICTP)

### Presentation title:

Using hands-on activities to develop a culture of science...and vice versa

### Bio:



I am a member of the permanent scientific staff at the Abdus Salam International Center for Theoretical Physics (ICTP) in Trieste, Italy, and head of its Applied Physics group, which conducts research and/or training activities in a variety of fields including synchrotron radiation applications, fluid mechanics, optics, plasmas, medical physics, astro-biology and micro-electronics. My own research interests are centered on fluid dynamics and low-temperature physics. I also direct a UNESCO program in Active Learning in Optics and Photonics (ALOP)—conducting workshops for secondary school teachers and instructors of freshman physics courses in least developed countries around the world-- and am a member of the teaching faculty of the Doctoral School of Environmental and Industrial Fluid Mechanics of the University of Trieste.

### Online tutorial:

<http://physics.aps.org/articles/v1/26>

## Onofrio Gigliotta

(ISTC Roma)

### Presentation title:

In and Out of the Laboratory of Autonomous Robotics and Artificial Life (Laral lab): from basic research to edutainment softwares

### Bio:

Onofrio Gigliotta received his Ph.D in Psychology at the University of Palermo and currently he is a PostDoc at ISTC-CNR (Institute of Cognitive Sciences and Technologies based in Rome) and research assistant at the University of Naples Federico II. He has a special interest in evolutionary robotics, cognitive science and artificial life. He is a member, within the ISTC, of the Laboratory of Autonomous Robotics and Artificial Life (<http://laral.istc.cnr.it/>) and also a member of the Natural and Artificial Cognition Laboratory (<http://www.nac.unina.it/nac/>) at the University of Naples.



### Publications:

<http://laral.istc.cnr.it/gigliotta/pagn/pub.html>

<http://laral.istc.cnr.it/publications.htm>

[http://www.nac.unina.it/nac/index.php?option=com\\_jresearch&view=publicationslist&Itemid=2](http://www.nac.unina.it/nac/index.php?option=com_jresearch&view=publicationslist&Itemid=2)

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## Thomas Schaus

(Harvard)

### Presentation title:

Thoughts on broadening access to DNA nanotechnology and related experiments

### Bio:

Tom joined the lab in September of 2010. Prior to that, he obtained his M.D. and Ph.D. degrees from Northwestern University. For his Ph.D. in cell biology, he worked with Gary Borisy and Ed Taylor, modeling the protrusion of lamellipodia by populations of actin filaments. Before that, Tom obtained a B.S. and M.S. in mechanical engineering from the University of Illinois at Urbana/Champaign. Tom's current research focuses on developing DNA nanotechnology for medical applications such as drug delivery and diagnostics.



### Publications:

<http://yin.hms.harvard.edu/publications.html>

## Thomas Murphy

(University of Maryland)

### Presentation title:

Introducing Students to Engineering Design through Hands-on Projects

### Bio:

Thomas Edward Murphy was born in Falls Church VA, USA. He studied physics and electrical engineering at Rice University, graduating with joint B.A./B.S.E.E. degrees in 1994. In 1994 he joined the NanoStructures Laboratory at MIT, where he pursued research in integrated optics and nanotechnology. He completed his M.S. degree in 1997 and his Ph.D. in 2000. In 1994, he was awarded a National Science Foundation fellowship for graduate research, and in 2000 he and his colleagues received the Lemelson-MIT student team prize for innovation in telecommunications and networking. In 2000, he joined MIT Lincoln Laboratory as a staff member in the Optical Communications Technology Group where he studied and developed ultrafast optical communications systems. In August 2002, he joined the faculty at the University of Maryland, College Park as an Assistant Professor in the Department of Electrical and Computer Engineering. He was promoted to Associated Professor in 2008. Thomas is a member of Tau Beta Pi, Sigma Xi, a senior member of the IEEE, and a recent recipient of the NSF CAREER award. His research interests include optical communications, nonlinear optics, short-pulse phenomena, numerical simulation, optical pulse propagation, nanotechnology and integrated photonics.



### Presentations and publications:

<http://www.photonics.umd.edu/pubs/>

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## Kenneth Stanley

(University of Central Florida)

### Bio:

Kenneth O. Stanley is an associate professor (as of August 2011) in the Department of Electrical Engineering and Computer Science at the University of Central Florida. He received a B.S.E. from the University of Pennsylvania in 1997 and received a Ph.D. in 2004 from the University of Texas at Austin. He is an inventor of the Neuroevolution of Augmenting Topologies (NEAT), HyperNEAT, and novelty search algorithms for evolving complex artificial neural networks. His main research contributions are in neuroevolution (i.e. evolving neural networks), generative and developmental systems, coevolution, machine learning for video games, and interactive evolution. He has won best paper awards for his work on NEAT, NERO, NEAT Drummer, HyperNEAT, novelty search, and Galactic Arms Race. He is an associate editor of IEEE Transactions on Computational Intelligence and AI in Games, on the editorial board of Evolutionary Computation journal, and on the ACM SIGEVO Executive Committee.



### Links:

Picbreeder publication: <http://eplex.cs.ucf.edu/publications/2011/secretan.ecj11.html>

Picbreeder website: <http://picbreeder.org/>

Galactic Arms Race publication: <http://eplex.cs.ucf.edu/publications/2009/hastings.ieeetciaig09.html>

Galactic Arms Race website: <http://gar.eecs.ucf.edu/>

## Eva Guinan

(Harvard)

### Bio:

Eva Guinan is a pediatric hematologist oncologist with subspecialty expertise in marrow failure and stem cell transplantation. She graduated from Harvard College, Harvard Medical School and trained at Children's Hospital Boston and the Dana-Farber Cancer Institute. Dr. Guinan has conducted human proof of concept clinical experiments based upon her own and her collaborators' bench discoveries. She pioneered and pursues the use of costimulatory molecule blockade as a means of inducing alloantigen specific anergy as an application that might facilitate stem cell transplant from haploidentical family donors.. In addition, she developed the preclinical data supporting the exploration of endotoxin neutralization as a strategy to mitigate regimen related toxicity in transplant patients, and potential use of this strategy for toxicity mitigation after unintended radiation exposure. She is also an international expert in management of acquired and congenital marrow failure and has a long history of active clinical investigation in this area. After many years directing bone marrow transplant programs, Dr. Guinan is currently the Director of Translational Research for Radiation Oncology at the Dana-Farber Cancer Institute, and the Medical Director of the Laboratory of Innovative Translational Technology and Director of the Linkages Program within the Harvard Catalyst. In these latter contexts, she helped lead the development of the first HMS-sponsored post-graduate course in translational medicine. Most recently, she has dedicated her efforts to applying and optimizing the use of open innovation strategies in an academic biomedical setting, and in developing a better understanding of the role of current and novel review approaches on the emergence of unconventional ideas.



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## François Grey

(CERN, Citizen Cyberscience Center, Geneva)

### The Citizen Cyberscience Centre: volunteer research for the developing world

The Citizen Cyberscience Centre is a partnership established in 2009 between the European Particle Physics Laboratory, CERN, the UN Institute for Training and Research, UNITAR, and the University of Geneva.

At present most citizen cyberscience projects are organized by scientists in Europe and North America. But thanks to support from the South-African-based Shuttleworth Foundation, a founding sponsor of the Citizen Cyberscience Centre, lectures and hands-on training events have been organized in Beijing, Taipei, Mumbai, Bangalore, Chennai, Mauritius, Brasilia, Rio de Janeiro and Sao Paulo. This is helping to spread know-how about citizen cyberscience more widely in developing regions, and generate new projects there.

Projects that the Citizen Cyberscience Centre has initiated focus primarily on promoting volunteer science for humanitarian purposes, although fundamental science is also supported. For example, in collaboration with IBM's philanthropic World Community Grid and Tsinghua University in Beijing, the Citizen Cyberscience Centre launched the Computing for Clean Water project, which is helping scientists design efficient low-cost water filters for clean water. Volunteers can also help UNOSAT, the operational satellite applications programme of UNITAR, to improve damage assessment data for Libyan cities, by geotagging images of damaged buildings on the Web. This project uses a geotagging experiment from HP Labs called Gloe.

In this talk, I will briefly introduce some of the activities of the Citizen Cyberscience Centre and discuss the broader implications of the rapid growth of Internet connectivity in the developing world on the future of Web-based science.

### Bio:



Francois Grey is a physicist by training, with a background in nanotechnology and a strong interest in science communication. He spent six years at CERN, managing IT communications. In 2004 he initiated and managed the launch of a volunteer computing project called LHC@home. This led to another project called Africa@home, launched in 2005 in collaboration with several academic institutions, NGOs and United Nations agencies. He is currently based in Beijing, where he is a professor at Tsinghua University, where he has helped develop citizen cyberscience in China and more widely in South-East Asia, through an initiative called Asia@home and a project called CAS@home. Francois currently has a Fellowship from the Shuttleworth Foundation for his work in establishing the Citizen Cyberscience Centre.

### Links:

Citizen Cyberscience Centre: [www.citizencyberscience.net](http://www.citizencyberscience.net)

Billion Brain Blog (a personal view of citizen cyberscience): [www.billionbrainblog.com](http://www.billionbrainblog.com)

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## Beau Lotto

(University College London)

### Bio:

Beau is a Reader in neuroscience and head of lottolab at University College London. He received his undergraduate degree from the University of California, Berkeley, in anatomy physiology, a PhD from Edinburgh's Medical School in cellular and molecular developmental neurobiology, and was a research fellow at Duke University. He is co-author of the book entitled *Why We See What We Do*, and his colour illusions have been used by many other scientists, artists, teachers and science museums internationally. The work at lottolab includes computational, behavioural and physiological studies on human, bee, and robot vision.



Public engagement work includes presentations and installations at art galleries (e.g. the Hayward Gallery), science museums, and on the radio and television (most recently BBC Radio 4's *Leading Edge* and BBC 2's *Coast* programme; he is currently making a Channel 4 film on the science and art of emergence). All his work attempts to understand the visual brain as a system defined, not by its essential properties, but by its past ecological interactions with the world. In this view, the brain evolved to see what proved useful to see, to continually redefine normality.

In October 2006 Beau was a panellist at *Randomness and Certainty* at the Dana Centre.

### Website:

<http://www.lottolab.org/>