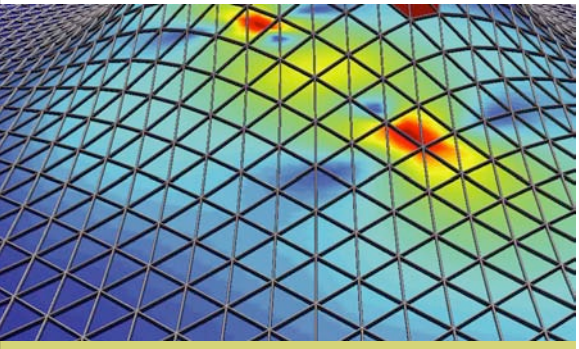
the Hertz FOUNDATION
freedom to innovate

FALL 2006



The Hertz Foundation identifies and empowers America's outstanding graduate students in the applied physical, biological, and engineering sciences.

News and Observations

Dr. John F. Holzrichter, President

You often hear me say that Hertz Fellows are a part of an exceptional group of individuals. As we continue to think about this group we increasingly believe that you represent the top percent or so of the nation's applied science and engineering leadership…an important segment when one considers the long-term impact of your work. People like you create new knowledge and provide the creative leadership that impact us all, well beyond your numbers.

This fall newsletter features comments and observations on related topics from two such distinguished Hertz Fellows: Dr. Nathan Myhrvold, (Princeton, 1984) and Dr. Wendy Cieslak, (Rensselaer, 1983).

As I meet with many of you, I am frequently asked about our interview process—e.g. regarding the "off the wall" and often probing style of questions. Dr. Tom Weaver shares his perspectives regarding the qualities and talents we seek in selecting a Hertz Fellow.

I have enjoyed our meetings during the past year, and like you, I am finding the connections with other Hertz Fellows to be very meaningful. We seek new ways to strengthen these linkages and welcome your thoughts and insights as to how we can best capitalize on the incredible talent pool represented by the Hertz Fellows.

www.hertzfoundation.org

The Magic of Invention: Lessons on creativity from the world of aviation, Teflon, and Velcro

Nathan P. Myhrvold, former CTO at Microsoft, Hertz Fellow, Princeton, 1984

Invention is the origin of all technology: Everything new started as a spark in someone's head. Without the break-through idea—without knowing how something can be done—you are at a fundamental disadvantage. After you know something, it often seems obvious; you say, "God, why didn't I think of that?" After you have the invention, you can apply lots of cleverness to making something work, but up front you need to have that invention. But ironically, the world does not focus much effort on invention. In fact, invention is a sideline or a hobby for virtually everyone who practices it.

Academic research is wonderful, but academics aren't suppose to invent—they're supposed to learn new things about the world; they're supposed to expand mankind's knowledge. You can be a fantastic researcher without ever inventing something. There are great academics who invent, but they do it on the side. The same thing, ironically, is true of engineers. Most engineers are paid to build something. If you said, "Hey, you can build your product without actually doing a new invention," most engineering managers would say, "Great!" There is going to be no risk. I hate when we have to solve a problem no one has solved before!" So while engineers can be great inventors, very few people are motivated to do it full time.

The world doesn't support invention very well. There is a systematic set of constraints: What is the next product version? What suits my research? What can I get my graduate student to do? Most of all: What can I get funded for? The great debate in design is whether form follows function. But in much of life, form follows funding. If you can't get funded to invent, if people won't take a chance, how are you going to get there? As a result, a huge amount of invention is done sub rosa—some of it by academics who really have a grant to do something else. Very few companies support really radical things—because if it is really radical, almost by definition it is not somebody's business to do up front.

The world is focused very much on what you do after you have the idea. If you go to a venture capitalist on Sand Hill Road in Menlo Park, California, and say, "You know, I am sure I am going to have a good idea!" the meeting ends right there. I like to think that if you really focus on invention we could have a whole lot more, and a whole lot better.

But what are the inspirations for invention? Where does invention come from? One of the most powerful ideas is to take inspiration from the natural world—to see something that nature has invented and use that as an inspiration directly for human invention. It is a great idea—but it rarely happens. There is one terrific example: Velcro. In 1948, Swiss biologist George de Mestral got some cockleburs stuck in his sock. Many

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Hertz Fellow Nathan Myhrvold, shares his perspective.

2007 Hertz Symposium

March 16-18, 2007

The Hertz Foundation second national Symposium for Hertz Fellows and Friends will be held March 16-18, 2007 in San Jose, California at the Fairmont Hotel.

Sessions will be structured to allow dialogues with the featured speakers and in-school Fellows will share their work during several poster sessions over two days. The final session on Sunday morning March 18th will include discussion round tables on topics of general interest to all Fellows.

Mark your calendars and schedule your business trips nearby. Plan to attend a fun, stimulating, informative symposium with some of the nation'smost creative and talented leaders in applied science and technology.

Volunteer Opportunities
There are many volunteer opportunities for the 2007 Symposium. If you are interested in assisting please contact **smartinez@hertzfoundation.org.**

of us have had that happen. But George was a little more curious than most of us about how these cockleburs stuck to his socks. He looked at one under a microscope, and saw lots and lots of little hooks. The hooks engage the fibers; originally, they evolved to engage fibers in an animal's hide to catch a ride. So de Mestral said, "I can make hooks!" and came up with the idea of Velcro.

The other classic example is flying. Mankind always has been fascinated with the graceful way birds soar. Early in the history of aviation, birds provided direct, natural inspiration. The primary proponent was the German inventor Otto Lilienthal, who built wonderful, birdlike gliders in Germany. But it turns out that acting like a bird isn't a good way to make a glider, and Otto flew and flew until he crashed. In 1894, a bicycle mechanic, Wilbur Wright, read about this, and he and his brother set out deliberately to invent the airplane. They took a very different approach. They weren't interested in birds at all—they built the first practical wind tunnel. It was by taking an approach that was utterly unlike a bird that they had some success.

The interesting thing is how deliberate the Wrights were. In 1899, they wrote to the Smithsonian Institute—that was back when the Smithsonian took requests—and said, "We would like all of the literature you have on human or artificial flight." Someone at the Smithsonian boxed up all these papers and sent them off. And so Orville and Wilbur Wright said, "Ok, let's roll up our sleeves and learn how to fly." It wasn't based on birds, but on a systematic approach of saying, "Damn it; there has got to be a way to achieve this!" It took them four years. I think that it is really remarkable when you consider that after four years of seriously working at it—on something that people had speculated about since Leonardo da Vinci's time—these guys invented the airplane.

Most great inventions actually come out of something like the Wrights' approach. Someone gets a crazy idea and, of course, up front it is ludicrous. The more important the idea, the more ludicrous it has to be when you set out. I used to say at Microsoft Research that we wanted to hire researchers who were "narrowly insane": insane, because they believed they could solve a problem no one else in the world could solve; narrowly, because you wanted them to be pretty sensible in other ways. This kind of dedicated approach to invention is something I think the world needs to support a lot more.

There is another big theory of invention: the "happy accident" theory, in which someone can come up with an interesting observation through a bit of serendipity. Roy Plunkett, who invented Teflon, had been doing an experiment that involved putting some fluorine gas and other things into a tank. He opened the stop cap to the tank, and nothing came out. The tank was heavy, he shook it, and eventually he took a hacksaw and sawed it apart, and discovered that there was this waxy white substance in it. It is a classic example of serendipity. It is also a classic example of how not to manage invention. Immediately after this, Plunkett was transferred and was never allowed to work on Teflon again at DuPont.

Happy accidents like Teflon do occur. But very few great inventions are accidental—and even in those that are, the great thing isn't the accident itself. A whole lot of people could have made Roy Plunkett's discovery and just thrown the whole thing out. The really great inventions that come from serendipity are the accidents waiting to happen. There is a saying: Luck favors the prepared mind. First you have to notice this thing, and then you have to be prepared to develop it. And you have to have the right support.

From a technological perspective, this is the ideal time to be an inventor. We have greater connectivity than we have ever had before, greater access to information and knowledge. The world is a much smaller place now that the Internet can allow us to connect with each other. That's a terrific stimulus. And the pace of invention has never been faster.

All of these things lead me to believe that the 21st century is going to be an era of incredible and dynamic invention. It's also a time, frankly, when we *have* to do it. At the turn of the last century, about half of our workforce was on the farm. By the 1960s it had dwindled to about 6 percent, and today, it's less than 3 percent. American farms are the most efficient in the world, but agriculture as a major part of the workforce has

come and gone. So has manufacturing: It was just getting going in 1900 and peaked at about a third of the economy in the 1950s; today it is about 10 percent. Most companies in America now do a lot of the design, but a huge amount of what they do is built overseas. If we don't learn to invent, if we don't foster invention and innovation, it is not clear what we are going to do for a living.

Invention is the source of it all, yet it is strangely neglected. Enough of it happens, and happens randomly, that it keeps us busy. But if you focus on fostering it, it can really be done deliberately. There are people who disagree with this. Maybe you can't always set out and succeed like the Wright brothers did. After all, there probably were a lot of guys in 1899 that set out to invent something—be we only celebrate the people who got there.

But you sure can kill invention. Creativity absolutely can be strangled. It can be squelched; it can be underfunded. I think it is incumbent upon us to continue to push, in education and in business, to support it. The economies of the 21st century are going to be driven by the magic of invention.

Princeton Alumni Weekly—April 6, 2005

The American Competitiveness Initiative

Dr. Wendy Cieslak, Sandia National Lab, Hertz Fellow, Rensselaer, 1983

It's being called the Silent Sputnik. But that falls short of defining the unifying and compelling goal that will rally the United States government and citizens around science and engineering education and fundamental research in the physical sciences. It has been several decades since the arms race and the space race pumped up the infrastructure for the physical sciences in this country and motivated students to enter technical careers for the challenge, the career earning potential and the national pride of U.S. technological leadership. The era of great scientific and engineering endeavors was initiated by the Manhattan project, which put an end to World War II in 1945. The race for the atom bomb gave way to the space race when the Soviets launched Sputnik in 1957. A generation of scientists and engineers were motivated by John F. Kennedy's vision to "Put a Man on the Moon," a challenge the United States accomplished in 1969. We have not had a technical grand challenge of such magnitude since that time.

The Hertz Foundation quietly made a difference during the intervening decades by choosing people of the highest quality and providing them opportunities to contribute to national security and competitiveness while doing what they love doing. Today, the country is unfocused and, in some cases, undisciplined. Hertz Fellows are a breed of dedicated and talented individuals who can make a difference. The Foundation has supported over 1000 Fellows since 1963 who currently live and work across the continent (and a few across the globe). We are helping the United States to provide peace and prosperity to the world by advancing technologies that will, for example, provide sustainable and affordable energy and water. But to really make a difference in today's culture, we must be more than lab rats. Students need a broad based education and continued learning in how to communicate the promise of technological advances to Joe-on-the-street. Better yet, we need for Joe to understand why learning math and science is important no matter what field he enters, just like learning grammar and history serve us well in our technical endeavors.

My message to today's Fellows is to interact across departments and disciplines and colleges and countries. Learn the perspective of those who think differently than you do and teach them yours. We need you who understand math and science at the deepest level to make it popular in America, to change the culture to value scientists and engineers alongside the football coaches and movie stars. That will happen only with familiarity and understanding, both of which depend upon communicating our viewpoints, our contributions and our passions across the breadth of society.

Theses 2005-2006

Dr. Edward Boyden
Stanford University
Task-Specific Neural Mechanisms of Memory Encoding

Dr. Elizabeth Lee Foley
Princeton University
Development of the Motional Stark Effect with Laser-Induced Fluorescence Diagnostic

Dr. Edwin Paul Gerber
Princeton University
A Dynamical and Statistical Understanding of the North Atlantic Oscillation and Annular Modes

Dr. Arthur Clayton Goldsipe
Massachusetts Institute of Technology
Molecular-Thermodynamic Theories of Micellization of Multicomponent Surfactant Mixtures and of ph-Sensitive Surfactants

Dr. Jeffrey Chen Gore
University of California, Berkeley
Single-molecule Studies of DNA Twist Mechanics and Gyrase Mechanochemistry

Dr. Karen Huyser
Stanford University
On the Modeling and Classification of Wafer Map Failure Patterns

Dr. Jeremy Kubica
Carnegie Mellon University
Efficient Discovery of Spatial Associations and Structure with Application to Asteroid Tracking

Dr. Christopher Own
Northwestern University
System Design and Verification of the Precession Electron Diffraction Technique

Dr. M. Scott Shell
Princeton University
Advances in the Simulation and Theory of Soft Matter: Novel Perspectives on Liquids, Glasses, and Proteins

Dr. Kartik Srinivasan
California Institute of Technology
Semiconductor Optical Microcavities for Chip-Based Cavity QED

Dr. Christopher Weber
University of California, Berkeley
Optical Transient-Grating Measurements of Spin Diffusion and Relaxation in a Two-Dimensional Electron Gas

So what exactly are we looking for in Hertz interviews?

Thomas A. Weaver, Senior Interviewer, Hertz Fellow, U.C. Berkeley, 1975

One of the first things we emphasize to new Hertz interviewers is we're not trying to find out what's "wrong" with applicants or what they don't know. Instead we're looking for what's special about an applicant—something that would justify investing up to $240,000 to offer them the freedom to give full rein to their creativity. We've found perfect GRE and GPA's aren't very good predictors of future innovation. What counts more is evidence that even as undergraduates they were driven by a deep curiosity to understand how the world works and are bubbling over with creative ideas on how to change it for the better. We've given Hertz Fellowships to students with many B's—and even some with lukewarm recommendations from advisors who couldn't understand why the student didn't want to do the project they were told to do.

Hertz Fellows tend to make their own way as undergraduates, caring more about learning and seeking out real research opportunities rather than "perfection" in meeting formal requirements. A key question we ask the applicant is that they describe a project of theirs which best exemplifies their own personal creativity. This often serves as a jumping off place to an open-ended exploration of what they've learned and whether they've already made the transition from passive learning to active invention and hypothesis. I especially like to ask them about what problems remain unsolved in their fields and then speculate on how these problems might be approached.

What we're looking for here is not whether they can solve a "Grand Challenge" problem in the course of a 60 minute interview, but whether they have the knowledge, physical intuition and vision to enter into and explore questions that don't have pat or memorized answers. We try to tailor each interview to the individual applicant, and ask interviewers to take the risk of exploring with the student. In the end, it comes down to a judgment call (to be confirmed by a second interview): Do they have the creativity, drive, broad physical intuition, research ability, etc. that characterize a successful Hertz Fellow? We've found that it's difficult to answer this question using only the written application, but that personal, technical interviews provide much better and more consistent answers. One year, we made a point of re-interviewing all the applicants that looked truly exceptional on paper but not to the first interviewer. I was convinced they must have made a mistake or had an off day—but in every case the second result was essentially the same.

For me, the interviews are the most interesting and unique part of the Hertz Selection process. The hard part is having to turn down—due to lack of funds—about half of the 30 or so truly exceptional candidates we find each year.

New Fellows for 2006

Dmitriy Aronov
Massachusetts Institute of Technology
Computational Biology

Anna Bershteyn
Massachusetts Institute of Technology
Materials Science and Engineering

Brian Camley
University of California, Santa Barbara
Physics

Elena Fabrikant-Koslover
Stanford University
Quantitative Biology

Eric Hoke
Stanford University
Physics

David Horning
The Scripps Research Institute
Biotechnology

Paul Podsiadlo
University of Michigan, Ann Arbor
Chemical Engineering

Rahul Satija
University of California, Berkeley
Bioinformatics

Michael Schnall-Levin
Massachusetts Institute of Technology
Computer Science

Daniel Slichter
University of California, Berkeley
Physics

Elizabeth Stephens
Rice University
Biotechnology/Materials Science

James Wray
Cornell University
Astronomy

David Zhang
California Institute of Technology
Biotechnology

Images: Matthew A. Meitl, University of Illinois, Urbana-Champaign, *Silicon Microbeams on a Conformable Transfer Element*; Joseph Morrone III, Princeton University, *Snapshot of Water Path Integral Simulation.*

Images (left to right): Hertz Director Dick Miles and Susan Miles, Hertz Director Harold Newman and Ruth Newman, Hertz Fellow Stephanie Susetka, Hertz Director Tom McCann and Carol McCann.




Hertz Fellow Michael Ansour with Hertz Foundation President, John Holzrichter.

Hertz Fellow Kevin Lin.

Hertz Fellow Ray Sidney with Professor Abu-Mustafa of Caltech University.

Hertz Fellow Gatherings

During the last six months Hertz Fellows and Friends gathered in Southern California and the New York area at a variety of venues. All events were stimulating, professionally productive, and fun.

Southern California
Hertz Director, Tom McCann and his wife Carol hosted an evening in their Huntington Beach home followed by a reception the next day at Caltech University. Lively conversations covered a wide range of topics including personal stories of Fellowship interviews and perspectives regarding key problems facing America today. At Caltech, Ray Sidney honored Professor Abu-Mustafa with the establishment of an endowed Fellowship in his name currently held by David Van Valen.

Connecticut, New Jersey and New York
Hertz Fellow, Stephanie Susetka, and her husband Bill hosted an afternoon tea in their Pound Ridge home. Guests roamed through their spectacular garden, shared stories and successes, and strengthened their network with one another.

Hertz Director, Dick Miles, and his wife Susan arranged a Tuesday evening dinner in their Princeton home. Dr. John Hopfield, President of the American Physical Society provided insights into the recent report titled "The Gathering of the Rising Storm".

Hertz Fellow, Michael Ansour hosted an evening at the Union Club in New York City for Fellows and Friends encouraging all to become more engaged in the Foundation's work.

We look forward to seeing **YOU** at one of our future events…and at the Spring Symposium!

Hertz Fellows converse with Dr. John Hopfield in Dick Miles' living room.




Images clockwise: Christopher Loose, Hertz Fellow, Edward Boyden, Hertz Fellow 2004, Alice Gast, Hertz Fellow 1984, and Louis Lerman, Hertz Fellow 1986.

Do you have news to share?

Please contact Susan Overman at **soverman@hertzfoundation.org** or by phone **925.373.1642**.

Front Cover Images (left to right): Julius Lucks, Harvard University, *Curved Space Crystallography*; Edwin Gerber, Princeton University, *Simulation of the North Atlantic Oscillation*.

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Announcements

If you have been looking for a way to recognize and thank a California high school teacher who played an important role in your academic success we have an opportunity for you. The **Carlston Family Foundation** is seeking nominations for their Outstanding Teachers of America Award. The online nomination form can be found at **www.carlstonfamilyfoundation.org/nomination** and takes only minutes to fill out. If you have questions, please contact Carlston Family Foundation's executive director, Michele Samuels at **cff_samuels@pacbell.net** or **415.388.4763**.

In School Fellows

Christopher Loose, Hertz Fellow, MIT, won the MIT $100K Business Venture Robert P. Goldberg Grand Prize (www.mit50k.net). Chris also won the Harvard GSAS biotechnology business plan competition.

Alumni News

Edward Boyden, Hertz Fellow, Stanford University, 2004, has been selected for this year's Technology Review TR35, the top 35 young innovators in the world, for his work in the new field of neurotechnology. Look for the September 8th issue of Technology Review to read about Ed's success.

Alice Gast, Hertz Fellow, Princeton University, 1984, has been named LeHigh University's 13th President.

Development News

Louis Lerman, Hertz Fellow 1986, is sponsoring the in-school Fellow retreats for 2006-2007. These meetings allow in-school Fellows the opportunity to hear scholarly updates and areas of common interest.

Wolfram Research has generously offered, for the 4th consecutive year, Mathematica to our new Fellows while continuing Premier Service for our in school Fellows.

Congratulations Chris, Ed, and Alice and thank you Louis and Wolfram Research for your support.

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