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ROCKFORD COLLEGE

ISSUE 21
April 2012

Newsletter of the Center for Ethics and Entrepreneurship at Rockford College
Editor: Stephen Hicks, Ph.D. Designer: Christopher Vaughan

Feature

The Paul Drake Interview:

Entrepreneurial Research Science

R. Paul Drake is the Henry S. Carhart Collegiate Professor of Space Science at the University of Michigan, Ann Arbor. He has worked as a research physicist at the Lawrence Livermore National Laboratory in California and had visiting professorships at universities around the United States. He was featured in the BBC's documentary Hyperspace *(2001) and the Discovery Channel's* How the Universe Works *(2009). Currently, Dr. Drake is also Director of Center for Radiative Shock Hydrodynamics at the University of Michigan.*

INSIDE:

Kaizen: How did you become interested in science as a kid?

Drake: I am not sure. I have been interested in how things worked and in doing things connected with understanding and assembling things as long as I can remember. I remember avidly playing with an Erector set, the mechanical precursor of LEGOs. And I remember doing things with a chemistry set at ages when I don't have a lot of other memories.

Kaizen: Where did you grow up?

Drake: My grade school years were spent in a suburb of Chicago, Illinois where my dad worked as a patent lawyer for Zenith Radio and Television. When I started middle school, he moved the family to Fort Collins, Colorado.

Kaizen: You did your undergraduate degree at Vanderbilt University in Tennessee. What took you from Colorado to Tennessee?

Drake: It was a combination of being a serious student and a naïve young man. I wanted a place that was focused on the two things I wanted to major in, and there were a wide range of those.

Kaizen: At Vanderbilt you ended up majoring in both philosophy and in physics?

Drake: Yes, I did.

Kaizen: What connections between philosophy and physics were interesting to you?

Drake: Well, the philosophy of science and philosophical issues that connect with things scientific were very much a present interest of mine at the time. So some of the coursework I did was connected with philosophy of science. I also very much enjoyed an aesthetics course from a particularly good teacher, so I wasn't limited to that. The undergraduate thesis I did in philosophy was oriented toward causality.

Kaizen: Did you also get a good physics education, in your judgment?

Drake: I did get a good physics education. I particularly treasured the emphasis in the Vanderbilt curriculum on conceptual understanding and not just mathematical manipulation. However, my physics education was not aimed at grad school, because I thought I would probably end up a philosophy professor. Instead I found I greatly enjoyed the physics. It was a lot of fun to do the problem sets and to read and to come to understand

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From the Executive Director

More women than men are now earning Ph.D.s in the biological sciences, according to a Kauffmann entrepreneurship report. And economists estimate that the biological sciences will comprise 15 to 18 percent of GDP over the next two decades. So a question arises: Are we on the verge of an entrepreneurial boom for women in science?

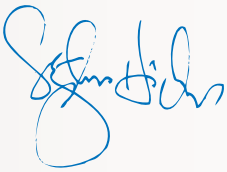
By contrast, a disturbing report is headlined "Science pushed out of California elementary schools":

- 60 percent of districts have no staff dedicated to elementary science.
- 40 percent of elementary teachers spend 60 minutes or less on science instruction each week.
- Only 10 percent of elementary classrooms offer high-quality science learning.

In this issue of *Kaizen*, our feature interview is with entrepreneurial research physicist R. Paul Drake. We spoke with Dr. Drake in Michigan about the realities of professional science—multi-tasking, grant-writing, travel, and learning from failure—the adequacies and inadequacies of American science education, and the likely future of America's pre-eminent position in world science.

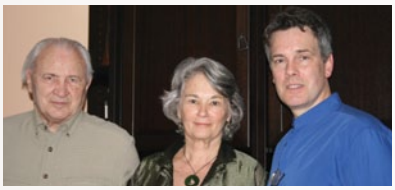
We also report on the excellent work of four students—Melinda Schumacher, Darian George, Amanda Hofmaster, and John Polemikos—as well as visits by Los Angeles artist Michael Newberry and New York City architect John Gillis.

At the Center, our previous issues of *Kaizen* are available featuring our news and extended interviews with entrepreneurs in a wide variety of exciting fields—from architecture to technology to fashion design to venture capital to sports and more. So please feel welcome to visit us on the second floor of Burpee—or online at www.EthicsandEntrepreneurship.org.



Stephen Hicks, Ph.D.

Explaining Postmodernism Seminar



James Fencil, Joan Fencil, and Stephen Hicks

Organized by James Fencil [far left] and including faculty from the University of Chicago and George Mason University, a seminar on Stephen Hicks's book *Explaining Postmodernism* was held in Chicago on March 11. A Portuguese translation of *Explaining Postmodernism* was published in Brazil in 2011, a Persian translation has been published in Iran in 2012, and a Spanish translation will be published in Argentina in 2013.

More information about CEE and Rockford College

Kaizen is published by the Center for Ethics and Entrepreneurship at Rockford College. Founded in 1847, Rockford College is a four-year, independent, coeducational institution offering undergraduate and graduate degrees in traditional liberal arts and professional fields. One of 81 colleges nationwide designated as a "College with a Conscience" by the Princeton Review, Rockford College is also among 76 U.S. colleges and universities selected by the Carnegie Foundation for the Advancement of Teaching for inclusion in a "Community Engagement" college classification. Rockford College is one of 11 colleges in Illinois and 280 in the country with a Phi Beta Kappa chapter, the oldest and most prestigious academic honors society, and in 2007 was named a "College of Distinction." Please visit us online at www.Rockford.edu.

DRAKE, CONTINUED

the different ways of evaluating how things function in the world. Then sometime around junior year I learned that you can get paid to go to grad school in the sciences. That made it an easy decision.

***Kaizen*:** What were you thinking your career path would be?

Drake: I thought I would do both the physics doctorate and a philosophy doctorate in philosophy of science and end up a philosophy professor specializing in philosophy of science. Having said that, however, I've never been one to plan my life more than a few years at a time.

***Kaizen*:** You went to graduate school in physics at Johns Hopkins University in Baltimore. Why there?

Drake: I had a rather unusual background—I was missing several courses that would normally be required by a top physics graduate school, although my test scores were very, very high. Johns Hopkins at the time was ranked about number 20 in physics, and it had a focus on looking for people like me: People who might turn out to succeed very well but who would not be picked up by the Harvards or the Princetons because their background wasn't the standard preparation that one expects and that any top school can demand.

***Kaizen*:** Physics is a broad field. What did you focus on in grad school?

Drake: Right. At Johns Hopkins I went to work for an advisor in the astrophysics group, but he was applying spectrometers to studying machines that were trying to make fusion in magnetic bottles. The reason was that if you are going to put a spectrometer—an inherently fairly delicate instrument—into a very industrial environment, it needs to be quite tough. He and his colleagues had been building and flying spectrometers on rocket ships for quite a while. They knew how to build spectrometers that could survive rocket ships, and that is not so different than what is needed to survive an industrial environment.

***Kaizen*:** After your Ph.D., you went to Lawrence Livermore National Laboratory in California?

Drake: That's correct. I actually made the measurements for my thesis at Lawrence Livermore Lab. Livermore wanted to hire me, and I was having an awful lot of fun doing what I was doing. They were even willing to let me change my focus—I didn't want to go where I had gotten the data and do the exactly the same thing, because it is easy to typecast yourself. They were willing to accommodate that, to let me go there and switch my emphasis.

Kaizen: How long were you at Livermore? Eventually you became a professor in California.

Drake: Right. So I worked in magnetic fusion for three years at Livermore and ended up very angry with a couple of my bosses and decided to move to something else. I had a couple of university offers, but I couldn't talk my wife into leaving at that time, so I ended up going into the laser fusion program.

One of the nice things about big research labs for people thinking about science careers is that it's often easy to move within the big lab from one area of research to another. Lateral movement is comparatively easy.

So I went into laser fusion, started learning that area of physics, and I worked in that for seven years. Then I had an opportunity to get a position that was joint with the University of California, Davis. It was a half-time professorship at Davis and running an institute at the Livermore lab devoted to increasing connections between universities and Livermore. I did that for another six years before my wife and I decided we were both ready to move and ended up landing in Michigan in 1996.

Kaizen: Your position at Michigan combines teaching with research?

Drake: Yes. That is the normal state of affairs at a Research University. The normal professor is expected to teach and do research and do service in some combination.

Kaizen: Was it a difficult transition from a pure research position into significant amounts of teaching as well?

Drake: I always liked to teach and did a variety of self-initiated creation of teaching opportunities as a teenager. I had done quite a bit of classroom teaching in the UC-Davis years, so the teaching was welcome. When you start teaching new courses, there is a lot of work, but other than having to fit in a lot of work, it's interesting and creative work.

Kaizen: You've also published, by the last count I saw, over 140 scholarly papers?

Drake: There are more than a 180 refereed publications and 220 citable publications, increasing rather rapidly in the present phase of my career.

Kaizen: You also directed the Space Physics Research Lab?

Drake: I did that for four years, from 1998 to 2002.

Kaizen: At the same time you transitioned to high-energy-density physics and in 2006 you published the first textbook in that field?

Drake: Yes, in a real sense I began learning parts of high-energy-density physics in 1982 when I moved into laser fusion. Laser fusion is an application of high-energy-density physics, and as I worked on a variety of different problems over the next decade I became more familiar with various areas of it. And once I was at Michigan with an active program in it, the fact that there was no textbook in the field became evident and something very worth fixing.

Dr. Drake teaching

Kaizen: Around the time your book came out, the University of Michigan received a major grant—$17 million over five years—from the National Nuclear Security Administration, and you were chosen to be the director of the new center?

Drake: The funding was initiated in 2008. The award was announced in 2007. In 2006 we were working on the proposal. At the proposal phase you choose the leader of such things. This effort involves more than 20 faculty members and 30 graduate students. It's quite large. At that time, my research team's contribution would not be the dominant focus of the center, and I expected that one of my colleagues would end up running it and I would be supporting them. But when the question came up who should be the director, pretty much all in unison turned and pointed at me.

The secret to leadership is to distribute the credit and take the blame.

Kaizen: What did they see in you that led them to want you as director?

Drake: I'm a natural project manager, I organize things effectively, and people respond well to my leadership.

Kaizen: What is the center's purpose?

Drake: The center has an overall purpose in an area known as predictive science, which is kind of a strange name. Predictive science refers to methods through which one can understand how predictive a model or theory is. In other words, how accurate it will be in predicting some new phenomenon.

Kaizen: The funding agency—the National Nuclear Security Administration—is part of the U.S. Department of Energy. Why is it funding predictive science or uncertainty research?

Drake: The NNSA has a specific challenge, which is that its laboratories must certify to Congress and the President whether or not our nuclear weapons would work if we used them. But they are not allowed to test these devices, since President Clinton signed the Test-Ban Treaty in 1992. So the methods of assessing the accuracy of complex calculations are important and, as a result of that, the NNSA chose to call for and support some fundamental science programs that would develop methods and train people.

Kaizen: As director of the Center, you have a large number of functions: research, writing, managing people, grant writing and reporting, attending conferences, and so on. What is your typical work day or week or month like?

Drake: On the day or week scale, nothing is typical. As part of running such a large research program, I now teach much less than the average professor does, and the research grant supports a large fraction of my time.

Kaizen: If we scale out to a month, then.

Drake: The month will have some time spent in working with the staff or the scientists in the center, to make sure that we are accomplishing the things that we need to accomplish. It will include some time working with the grad students, to steer them and educate them. It will include a significant amount of time writing grants and papers. It will include some kind of national level service work—service on a national panel or some other function that I am asked to perform for the sake of the national evolution of the science that I am involved in. It's likely to include some presence at a conference where I have been asked to speak to share the work we do with colleagues from other places. It's likely to

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Student Essay Contest Winners

Students in the Philosophical Foundations of Education course wrote a critical review essay in response to Dr. Jerry Kirkpatrick's *Montessori, Dewey, and Capitalism*. Maria Montessori and John Dewey were two of the greatest educational theorists of the twentieth century, and Kirkpatrick's book compares their theories and their implications for political economy.

The student's essays were judged on their accuracy and depth of interpretation as well as their independence of thought. Cash prizes were awarded for first place and three honorable mentions.

Congratulations to our winners!

First Prize: Melinda Schumacher

Runner Up: Darian George

Runner Up: Amanda Hofmaster

Runner Up: John Polemikos

Guest Speakers

Michael Newberry

John Gillis

Architect John Gillis and artist Michael Newberry visited Rockford College recently in connection with the course in Philosophy of Art and a CEE video project on art and cultural economics. Previously, Gillis and Newberry were interviewed for our first two issues of *Kaizen*, on the themes of, respectively, *Architecture and Entrepreneurship* and *Art and Entrepreneurship*.

DRAKE, CONTINUED

include a presence at an experiment where my team is obtaining data as well. I am forgetting a lot of stuff too.

***Kaizen*:** My stereotypical view of a scientist is someone holed-up for great stretches of time in the lab—that is not accurate? You also have a lot of travel?

Drake: In order to accomplish those things, there is a great deal of travel. Across science you find that the leaders in a given field end up traveling a lot. There are people who fit the stereotype of the white lab coat holed-up in a room, but they are the minority. That also reflects the fact that much of the science done now is team-oriented and involves the use of large facilities, and that creates a requirement for going to the facility and a requirement for, in various ways, collaborating and that includes the need to physically get together at times.

***Kaizen*:** How do you keep yourself productive when you have to shift focus so many times?

Drake: I am, in that sense, perhaps fortunate that I am not a person who works all that well sitting in an office. And correspondingly, I don't need to be sitting in an office to work well. I work well in coffee shops and that coffee shop can exist anywhere. I work well on airplanes.

***Kaizen*:** How important is the physical contact and the physical travel in this day of the Internet and video conferencing?

Drake: It remains significantly important. It remains the case that communication is much more effective in person than it is even on Skype. In particular, if you don't know someone very well, it becomes a bigger difference, and the difference in quality of communication from email to Skype to in person is much bigger with people you don't know very well. This gets to be an even larger difference if you are not from the same culture. Email, in particular, can be treacherous for people who are not native speakers of the same language or even who just don't know each other very well.

***Kaizen*:** As the director, you're also a manager and leader. Did the managing skill set come naturally to you, or were there things you had to learn and to work at?

Drake: I'd say it came fairly naturally to me. One of the funny things about leading a university center is that this job is not a full-time management job. If you spend all the time on management, you could do the management better; if you spent all the time on teaching, your courses would be better. So, there is an issue of balancing many competing demands and one needs to do everything well and at the level that meets whatever the relevant standards are, but without over-investing.

In terms of working with people, I think the secret to leadership is to distribute the credit and take the blame.

Kaizen: That's a good phrase.

Drake: If things are going well, it's because your people did that somehow; and if they're going badly, it's your fault. The buck stops with you. And if you ever catch yourself blaming one of your people to someone outside, you're probably screwing up.

Kaizen: Good advice. Going back to your education and the way science works now: Top scientists have to get grants and manage people as well as doing the science. Could your science education have better prepared you for the reality of a scientific career? You had a straightforward scientific career, but there were other things you picked up along the way as a matter of necessity.

Drake: That is an accurate statement. One hears this kind of question and a lot of advocacy about various things that would well be added to an education. I am nervous about this, because it's really hard to get educated to the doctoral level in a quantitative science. It takes a very deep commitment to learning fundamentals and working with them and accomplishing something that becomes a thesis. If you add a whole bunch of other things that an individual may or may not turn out to need, are you going to make him spend two more years in school?

Also, many students come right out of undergrad school into grad school. They don't bring any life experience to bear on the lessons in, say, leading people or dealing with money.

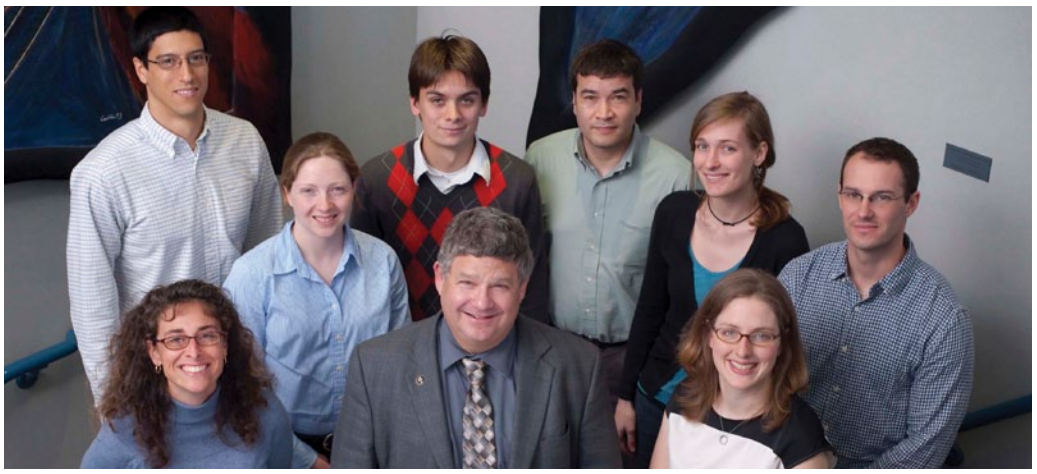
So I am sure there are things that can be done better and things that would be good to add, but I'd start with more emphasis on writing at the undergraduate level.

Kaizen: Do you have advice about how young scientists should learn the grant-writing ropes?

Drake: At times I involve my students in reviewing material for grant applications. Writing grant applications is a very nuanced activity and not simple to teach. One isn't going to do a set of lectures to create learning that's relevant to grant application writing. One could create an experiential course in which people were given calls for proposals, asked to write proposals, and given feedback, and that wouldn't be a bad thing to do.

Kaizen: Your center has its own internal institutional arrangements. Does the broader University of Michigan system affect how you do things at your center?

Drake: It has significant effects on how we put together projects like this. My center actually has eight departments involved—faculty from eight departments from two colleges from



Dr. Drake (center) at the 2011 Omega Laser Facility Users Group workshop, Rochester, NY

Michigan, in addition to people from two other universities. So we have procedures for putting things together, and they're relatively effective at enabling us to put together large interdisciplinary projects quickly and effectively.

This is one of the areas where the top research universities distinguish themselves from many of the others. When I compare what we do and what my colleagues do at many of the lower-ranked universities, they face purely bureaucratic obstacles I don't face. The ability of a top research university to enable its people to go after research opportunities is a key competitive edge. In addition, Michigan specifically has a very interdisciplinary culture.

Kaizen: The University of Michigan is a state institution that relies on state funding. Does that affect your center's work? Or are you independent of that—raising your own outside funds?

Drake: The University of Michigan is often described by analysts as a semi-private university. In terms of the total funding of the institution, the state support is well under ten percent. And that state support is very much focused on providing tuition relief for in-state undergraduate students. So, indeed, issues of state support have essentially no bearing on our work.

Most scientists have a personal commitment to integrity.

Kaizen: You've also worked at non-academic research labs, like Lawrence Livermore. Are there significant differences between those two institution types?

Drake: Enormously significant differences. The large labs can field coordinated efforts to work big problems that a university could not hope to engage in. But in addition to being large, long-term institutions, they grow bureaucracies that significantly reduce their productivity.

Kaizen: But academic institutions often have large bureaucracies.

Drake: Universities have bureaucracies as well. But there is a little closer connection between the fact that at the universities, the money comes in through effective teaching and through effective grant writing, so the need of the faculty to produce in those areas is more widely understood. Inside the big labs, the money comes through much less direct means and the bureaucracy tends to feel much freer to occupy all the time of the people and tends to expect to be the first priority no matter what.

Kaizen: So have the research universities been more successful at generating results than the labs?

Drake: Yes, on a per dollar basis, definitely. But the labs can do some big things that the universities can't. The big labs remain the best places for many scientists to spend some of their careers and for some scientists to spend all of their careers. Despite the bureaucratic burdens, there is a lot of ability to do work one enjoys without, for example, having to personally find the funds to support it.

Kaizen: In science, we're interested in objectivity and the pursuit of truth. But funding sources can exert pressure: government funding can come with political strings attached, and corporate or private funding can come with economic strings attached. Are those real concerns in your experience?

Drake: I think certainly those concerns can be real, depending on the practices of the individuals in government or industry providing the funds, and to some extent depending on what a given university is willing to accept. The University of Michigan, for example, is willing to accept pre-publication reviews, but not the requirement of making changes in the papers reviewed. So there may be a sponsor who wants to review before something is published, and we will accept grants and contracts that require that.

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Dr. Drake in the television program *How the Universe Works* on The Discovery Channel, 2010

DRAKE, CONTINUED

***Kaizen*:** Distortion can also enter science at the individual level. People have goals—for example, wanting fame—or they can have various sources of cognitive bias. Are those regular problems, or do most scientists' commitment to truth and personal integrity keep them focused properly?

Drake: I believe that most scientists have a personal commitment to integrity. You mentioned two types of bias—things driven, let's say, by a desire for fame. It's a small minority of people—and the people in the field know who they are—who exaggerate the importance of their results to try to be famous. The ultimate limit of that is the people who cheat to try to be famous. We see cases of that backfiring every year. This is a tiny fraction of the individuals.

Cognitive bias is a harder thing, because science is really hard. You are trying to put together incomplete information to draw conclusions that help you develop new knowledge. And that kind of process has a significant emotional component, when one asks, "Well, is there something I haven't thought of?" And you don't get at "the thing I haven't thought of" by coming up with a conscious list of all five thousand things that have a bearing on the problem you're working on. You rely on a feeling when your subconscious integrates your knowledge and says, "Oh, there's something that is not quite right. It's not complete." And if you bring some kind of a bias to your work, it interferes with those feelings. That's why I'm never very eager to see a conclusion from someone about a scientific point if I think they know what they want to conclude about that point in advance, because I believe it truly interferes with cognitive functioning to have that bias of desiring a particular outcome.

Science is mostly about failing.

***Kaizen*:** Other checks, aside from one's personal ethics, are engaging in discussions with other scientists, brainstorming and bouncing ideas, where they will put the hard questions to you. I assume a lot of that happens. And then formal peer review for papers.

Drake: Yes. Brainstorming interactions are more useful for developing novel ideas to go in some direction. But in the process of presenting one's results at conferences, one gets a chance to interact with colleagues about issues that may affect the validity of the claims one would like to make about some new result. Beyond that, there is the formal peer review process when one publishes, which gives a limited number of individuals the opportunity to identify weaknesses in the work.

***Kaizen*:** To return to your experience as professor. You work at a highly-regarded university, so you teach some of the best students in the country. Do they arrive at Michigan as scientifically well-educated—whatever you think freshman-level science should be?

Drake: Absolutely not. Our undergraduates are all very, very smart kids—they test very well. And that is how they get in. But many of them have gotten through high school by memorizing, regurgitating, and forgetting, which leaves them unprepared to deal with structured, conceptual knowledge. That is a real knock on high school education.

***Kaizen*:** Do you have a longitudinal sense here? Because it is a common complaint across the generations for professors to say that undergrads are unprepared. Professors in the 1990s, 1980s, 1970s, and so on, were saying the same thing.

Drake: I haven't got thirty years in as a professor. So I don't have that long of a longitudinal baseline. And my involvement is more strongly with grad students and with undergrads who seek out my research program to do research with us. But public education in the U.S. hasn't changed all that much: it was bad forty years ago and it's still bad.

***Kaizen*:** To switch to the graduate students. Do they arrive adequately prepared, by whatever appropriate standard?

Drake: Yes. On the whole, the graduate students are arriving well-prepared. And they've prepared themselves through applying themselves, through effective learning, and through obtaining research experience as an undergrad.

***Kaizen*:** How about the math component?

Drake: I think at Michigan, it depends what they study. The students in engineering and the hard sciences come in with decent math skills. In that area, more is better. And it's tragic that the mathematics education allows so many people to fall off the table in middle school or high school. Because the key to a very wide range of technical careers, increasingly in even things like biology, that were formerly thought to be non-mathematical—the key is math skills as a basis for further work.

***Kaizen*:** In a broader historical context, for the last century or so arguably the United States has been the leading powerhouse scientific nation in the world. But when one goes further back in history, there is an interesting trend. During the early Renaissance, Italy was the dominant scientific nation, but it declined. Then the Dutch came on strong in the 1600s and then declined. The English and the French became the great powers in the 1700s, Germany came on strong in the 1800s, and then the USA in the 1900s. Is the USA going to be strong in the 21st century? Or do you see signs of decline?

Drake: Decline very much would not surprise me. But I don't think it's guaranteed. The argument for decline is that we are not properly focused nationally. The way that we have decided to fund fundamental science nationally is primarily through federal support, but we are not focused nationally on sustaining American leadership in important areas of science. And we do not follow through in many ways that we would need to assure that we will retain the lead in scientific areas.

A second part of the argument is the economic one. All federal discretionary spending is now a third of the budget, and entitlements are two-thirds. It's not clear what the run-out of that is going to be—that is, how poor and dumb the country has to get before we fix that problem.

***Kaizen*:** On the first issue of area focus: What areas of science do you think that we are not focusing on or following through on appropriately?

Drake: This is very spotty, because the process by which funding gets provided nationally is political and involves the interactions of many individuals in both the agencies and Congress. The results that come out of that process are sausage-making. It's random.

Kaizen: So if federal funding is a lion's share of the overall funding, and politics is a sausage-making process, then we get erratic results?

Drake: Exactly. It's not consistent across time and it's not consistent across disciplines. If you survey any given discipline, you'll find holes where we are not sustaining our excellence.

Kaizen: Do you have examples of the sausage-making in areas you are familiar with?

Drake: There is an area of research to develop technologies one needs to do power plants using lasers, and also a variety of other things using lasers, called high-average power lasers. We had a national program aimed at developing high-average power lasers—something that should be part of the overall national scientific effort. But it so happened that that program was funded by earmarks, and in the first Obama budget, the earmarks all got cut, which one would say is a good thing. But since this part of the work we should be doing nationally was funded by earmarks, that program got killed and remains dead to this day. That is an example of the accidental flow of events leading to a result that anyone with a well-rounded overview would conclude as unreasonable.

Kaizen: Are there things on the positive side of the ledger?

Drake: On the positive side is the entrepreneurial structure of our scientific effort. We have a system in which a wide range of people, both in universities and laboratories in industry, are in a position to seek support by whatever method they can invent, and to create new science and new inventions by whatever means they can. That degree of inherent flexibility in the U.S. system is not present in any other country.

Also, the education that supports innovative thinking is present here and in Europe, but not in Asia. These are real advantages that will help the United States overcome its weaknesses.

Kaizen: What are your plans for the next several years?

Drake: For the next several years, I expect to continue leading research projects, continue educating grad students, and, in general, fulfilling a range of activities that a professor fulfills.

Kaizen: The center you are directing will be up for a grant renewal in a few years.

Drake: Another year and a half.

Kaizen: So, depending on how that goes …

Drake: So that center will either continue or not. I lead another center that is much smaller, but which incorporates projects from a number of sponsors, and that center will continue or not, it will grow or shrink. This is the ebb and flow of research, sponsor-funded research.

Kaizen: What do you like to do outside of your work life?

Drake: I'm a life-long athlete, by inclination. And at my age, it's a good thing to keep exercising for my health as well. So I'm very devoted to my various sporting activities. My favorite activity is a kind of cross-country called skate-skiing, in which one propels oneself by motions much like one uses on ice skates. It's very intensely aerobic.

Kaizen: You've been a professional scientist now for many decades. What stands out as having been the most rewarding thing about your career in science?

Drake: I found many rewards, so it is hard to say that one thing is a most rewarding thing. There have been moments in my career when I realized I had discovered something significant, something that would have an impact among my colleagues in my field, and those are high points. In addition, the process of being engaged in a problem and trying to understand it and making progress in figuring it out remains rewarding to me to this day. In another context, watching the graduate students who work with me develop from smart bachelor's degree people into functioning, independent scientists is a deeply rewarding process.

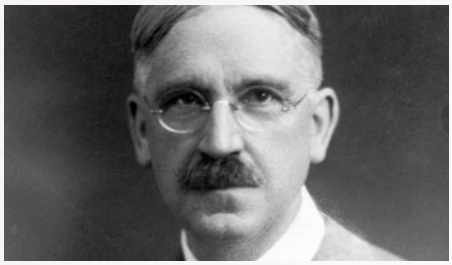
Kaizen: To transition from being a young person interested in science to being a fully independent scientist, many things have to come together. One has to have smarts, and one has to have the courage to ask sometimes-uncomfortable questions. Also perseverance, and being able to fail and to bounce back from that.

Drake: Science is mostly about failing. You fail most of the time. You need to have a lot of ideas that fail to have the good one. There was an excellent article a couple of years ago. In class, students are taught to expect to succeed; there are expected to get all of the homework right, to try to get all the problems on the test right. And then as soon as you start learning research, it's all about failure. You're failing all the time. You feel stupid a lot. And it's only the people who can really embrace that and who find the challenge of failing well enough to eventually succeed—they're the ones who flourish in research.

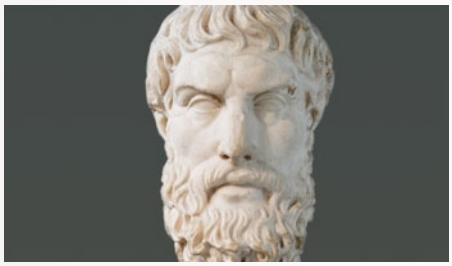
Kaizen: Do you have advice about how to cultivate that "celebration of" failure or "embracing" failure or "coping with" failure? I'm not sure what the right word would be.

CONTINUED ON PAGE 8

On Science



"Every great advance in science has issued from a new audacity of imagination."
—John Dewey



"A man cannot dispel his fear about the most important matters if he does not know what is the nature of the universe but suspects the truth of some mythical story. So that without natural science it is not possible to attain our pleasures unalloyed."
—Epicurus

"A fact is a simple statement that everyone believes. It is innocent, unless found guilty. A hypothesis is a novel suggestion that no one wants to believe. It is guilty, until found effective."
—Edward Teller

"It is a good morning exercise for a research scientist to discard a pet hypothesis every day before breakfast. It keeps him young."
—Konrad Lorenz

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The Center for Ethics and Entrepreneurship
5050 East State Street
Rockford, IL 61108

DRAKE, CONTINUED

Drake: "Coping" is a bad word, because if you're there, you're far from the right place. It's embracing failure, embracing good failure. Any idea you have that doesn't pan out is a success: you've learned something that didn't work. You've narrowed the range of possibilities for what will work. And it's a key thing you see in successful scientists and people who are good leaders of scientists as well.

For young people, the best way to both explore and prepare for a career in science is to get involved in research. At many schools, there are numerous opportunities to get involved in research with professors; and if you're at a school where you don't have those opportunities, there are national programs that will pay you to go for the summer to various kinds of institutions to do research. That is extremely important for your intellectual development and your preparation to be an effective scientist in the long run.

***Kaizen*:** Again looking back to your education, is there anything you think could have been done better to prepare you for the kind of career you've had?

Drake: You know, I'm sure there are, but there is something I don't like about that kind of question. You've asked several of that kind of question. I don't like the premise that the educational environment has to create the full mosaic that is the successful person. And if there is anything the successful person needs, the educational environment has to have it there or somehow that isn't adequate preparation. The person creates the outcome.

So to the students who read this: You are responsible for what happens. It's not whatever idiots designed the educational program you're in. It is you who has to learn what needs to be learned and accomplish what needs to be accomplished and reach the goal you set for yourself. Could people do a better job of supporting you? Sure, but that will always be true and it doesn't matter. You need to be or become the kind of person who will succeed because you pursue your own goals persistently, if you wish—ruthlessly.

Dr. Drake at his home in Michigan

At the undergraduate level, it's finding things you love and working hard. That is key. When you get a little further, it's not being afraid to take chances. I don't think that is so important as an undergrad, but it makes a difference at the graduate level and as your career proceeds after the doctorate: being willing to take chances is a big element.

The people who are strongly successful are the ones who are entrepreneurial with their careers. Whether they are working in an entrepreneurial business or not—they are entrepreneurial in the way that they pursue their careers—they're not afraid to take chances.

This interview was conducted for Kaizen *by Stephen Hicks. For more information about Paul Drake, please see his profile at the University of Michigan's site, http://aoss.engin.umich.edu/people/rpdrake.*

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IN THE NEXT ISSUE:

Jeff Sandefer on Entrepreneurship and MBA Education