Putting Your Science to Work: Entrepreneurship (with a little "e")

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March 16, 2011

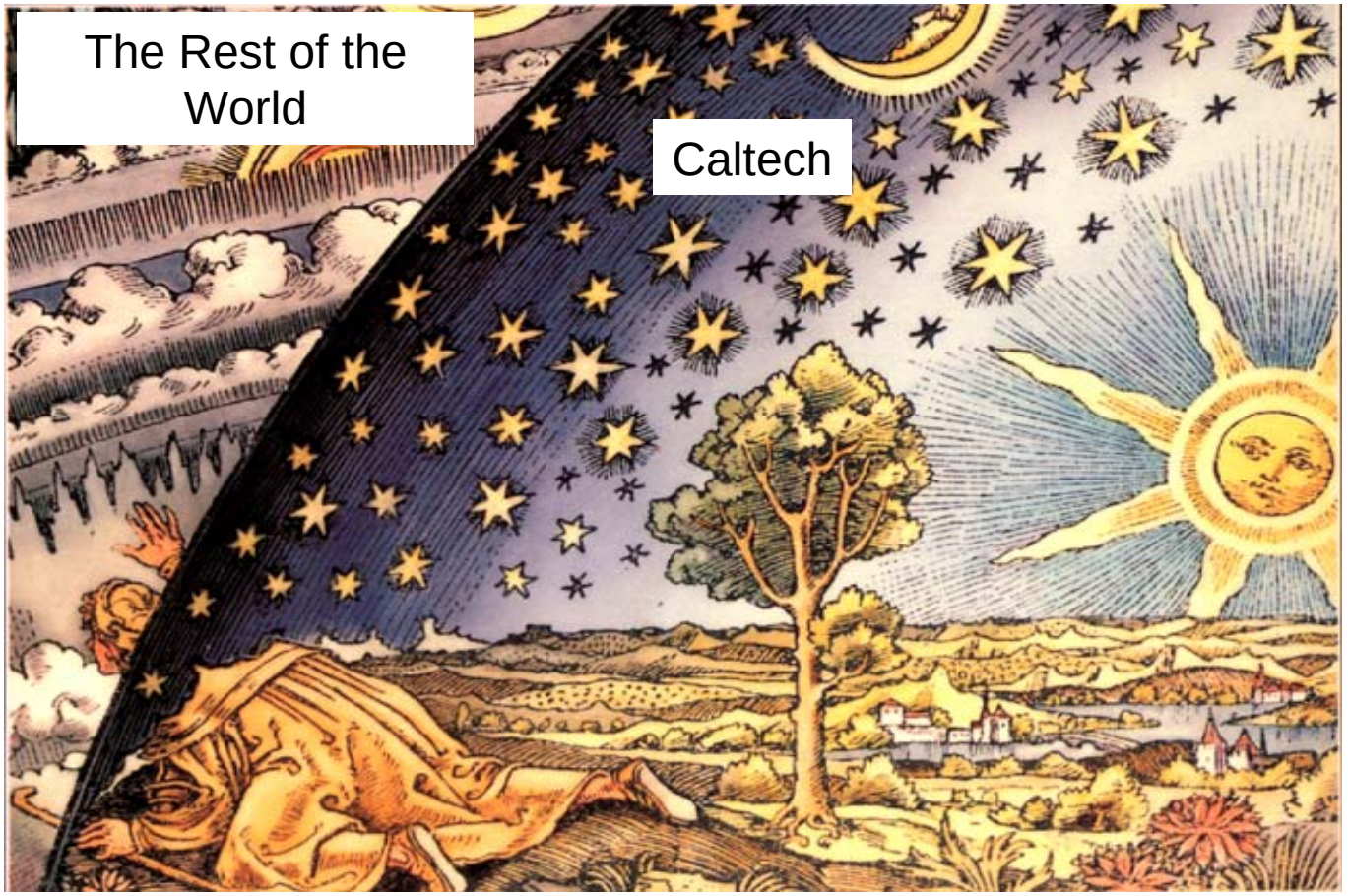
Caltech

Why am I REALLY here?

- **Experience**
  - My career path (so far) has been unusual (for a Ph.D.) but highly stimulating and enormously enjoyable.
  - I benefited from numerous mentors and got lots of good advice
    - Pass some of it along
- **Concern**
  - Young scientists and engineers don't get very good career development advice.
  - Such advice is of greatest value at the START of your career!
- **Prejudice**
  - I believe that technically-trained individuals have enormous potential to improve the world.

Think about MORE than just your next career move

Exploring the world beyond academia…



Transferable skills

1. ability to function in a variety of environments and roles
2. teaching skills: conceptualizing, explaining
3. counseling, interview skills
4. public speaking experience
5. ability to support a position or viewpoint with argumentation and logic
6. ability to conceive and design complex studies and projects
7. ability to implement and manage all phases of complex research projects and to follow them through to completion
8. knowledge of the scientific method to organize and test ideas
9. ability to organize and analyze data, to understand statistics and to generalize from data
10. ability to combine, integrate information from disparate sources
11. ability to evaluate critically
12. ability to investigate, using many different research methodologies
13. ability to problem-solve
14. ability to do advocacy work
15. ability to acknowledge many differing views of reality
16. ability to suspend judgment, to work with ambiguity
17. ability to make the best use of "informed hunches"

Personal qualities

1. intelligence, ability to learn quickly
2. ability to make good decisions quickly
3. analytical, inquiring, logical-mindedness
4. ability to work well under pressure and willingness to work hard
5. competitiveness, enjoyment of challenge
6. ability to apply oneself to a variety of tasks simultaneously
7. thorough, organized and efficient
8. good time management skills
9. resourceful, determined and persistent (and able to live on $2K/month!)
10. imaginative, creative
11. cooperative and helpful
12. objective and flexible
13. good listening skills
14. sensitive to different perspectives
15. ability to make other people "feel interesting"

I asked 20 successful scientists in non-academic careers...

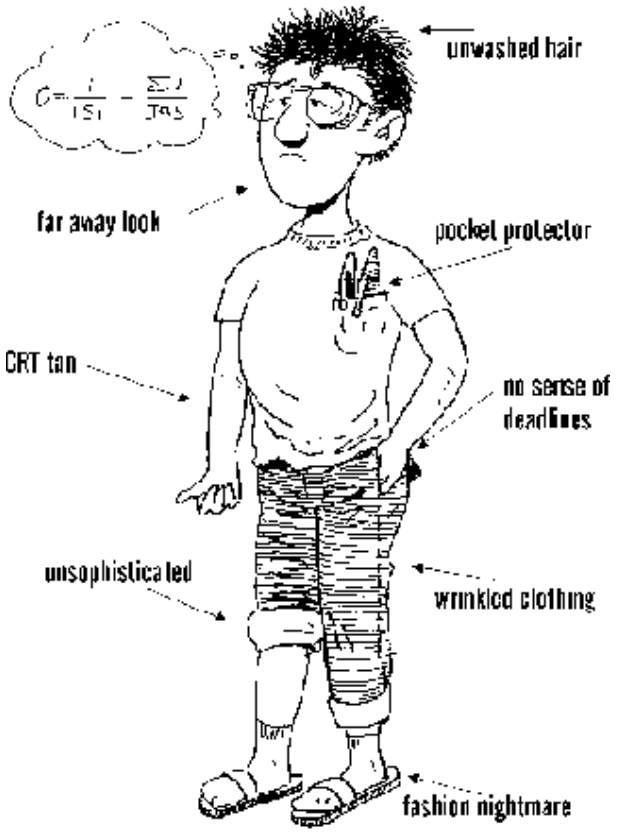
"Of the many skills you developed as a scientist, which ones are the most valuable to you now?"

Finding one's own path and taking initiative with little assistance
Ability to work in a high-stress environment
Independence
Maturity
Computer skills
Circumventing the rules
Learning to seek out problems and solutions
Ability to persuade
Ability to create
Ability to work productively with difficult people

and my favorite:

The ability and courage to start something even if you don't know how yet

What image does the “scientist” conjure?



Entrepreneurship vs. entrepreneurship

Entrepreneur – a career

entrepreneurial – a personal quality

Leading an entrepreneurial life does NOT require you to follow an Entrepreneurial career…

"Entrepreneurship is not about starting a company. Entrepreneurship is an approach to life. It is about leaving footprints."

Ed Zschau, 10/6/00

Techies are not generally natural Entrepreneurs…

- **We focus on, and are stimulated by, technical challenges – we tend to disparage and under-appreciate the non-technical (administration, marketing, human resources, etc…)**

- **We tend to be introverted and like to work alone – we can find the social aspects of leadership unfamiliar or disconcerting…**

- **We have a very poor understanding of risk**

We are deterministic and don't like endeavors that involve a high degree of UNCERTAINTY

The “risks” are over-rated

- **Careers are a LOT more dynamic and unpredictable that you think**
- **Risk of losing your job in a big firm is significant – size is no guarantee of survival**
- **Risk of being frustrated and unhappy are higher the less control you have over your fate**
- **Your career mobility is largely under your control**
- **Your financial stability is largely under your control**

The definition of Mental Health:
Feeling that you have OPTIONS

Important skills for success in entrepreneurship

ability to:

function in a variety of environments and roles
support a position or viewpoint with argumentation and logic
conceive and design complex studies and projects
implement and manage all phases of complex projects
and to follow them through to completion
combine, integrate information from disparate sources
evaluate critically
investigate, using many different research methodologies
problem-solve
do advocacy work
acknowledge many differing views of reality
suspend judgment, to work with ambiguity
make the best use of "informed hunches"

teaching skills: conceptualizing, explaining
counseling, interview skills
public speaking experience
knowledge of the scientific method

Very few of these things are explicitly taught in college…

Important personal qualities

1. intelligence, ability to learn quickly
2. ability to make good decisions quickly
3. analytical, inquiring, logical-mindedness
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Why is it valuable to think like an entrepreneur?

- **Reward systems in academia and the real world are different**
  - Good to keep both scholarship AND practicality in mind while in school
  - Good to think about the larger world
  - Good to THINK SIMPLE
- **Helps focus you on the highest value problems**
  - Ask yourself “What are the most important issues out there?”
- **Helps identify potential employers, sponsors, partners or competition**

Easy to get caught up in the details of what you’re doing and fail to ask:
Is what I am doing important?
Will it make a difference?
To whom?

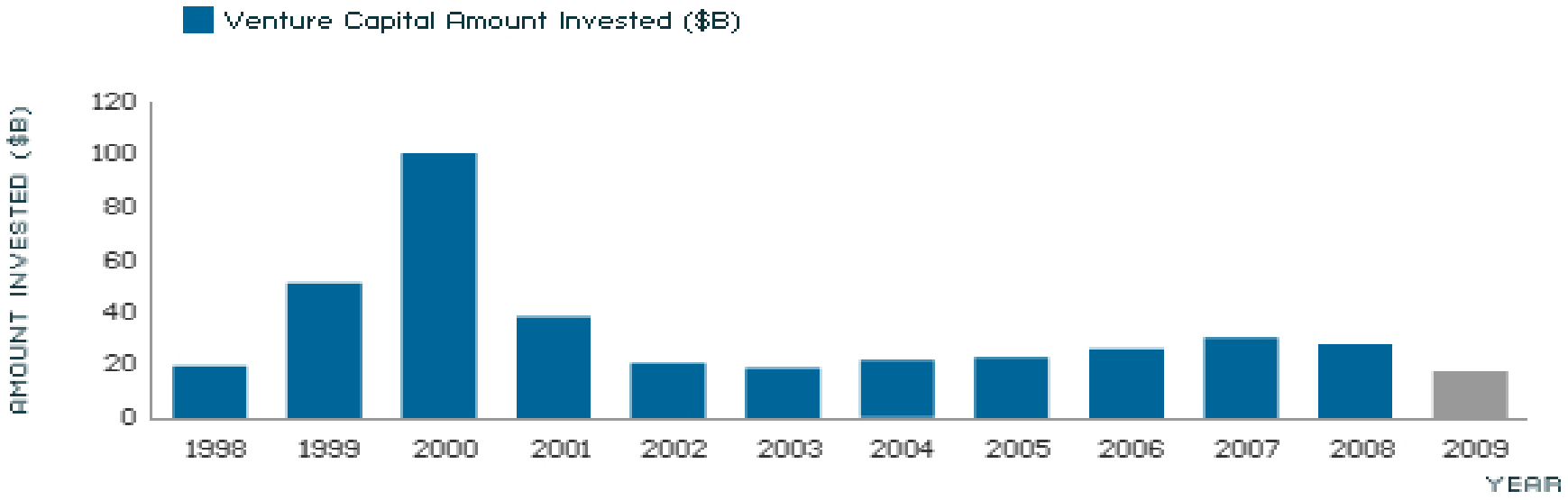
Lots of different ways to be an entrepreneur

- Promulgate your ideas
- Be an active “citizen”
- Consult (great source of second income)
- License your inventions

80:10:10 Rule

Meet the world's most important Venture Capitalist:

Total Venture Capital Dollars Annually



DATA SOURCE: THE MONEYTREE REPORT BY PWC AND NVCA; DATA: THOMSON REUTERS

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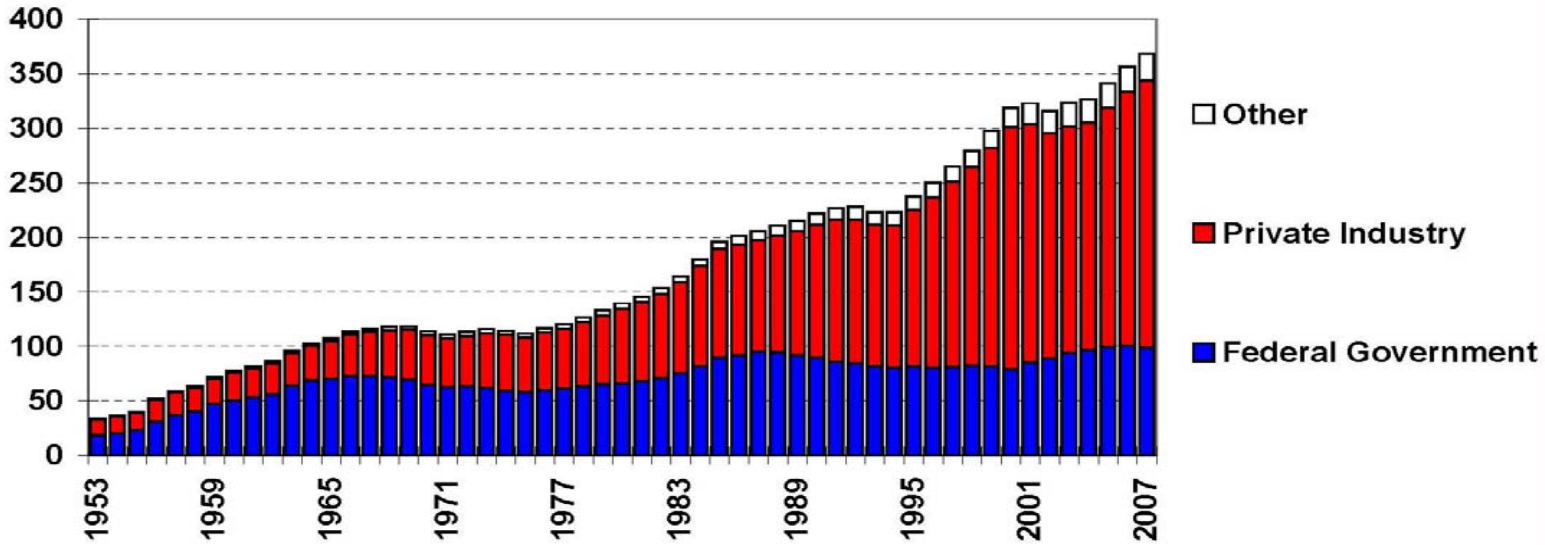
U.S. R&D Funding by Source, 1953-2007

expenditures in billions of constant 2007 dollars



Source: NSF, Division of Science Resources Statistics. (Data for 2007 are preliminary.)

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AAAS

"People forget this: Silicon Valley was actually built on federal funding. People have this notion that SV was built in garages. And it's true, we have some high-profile cases, Jobs – basement, Google in dorm, these things are true – the real fact is that Silicon Valley is the story of federal funding. HP – National Semiconductor, Sherman Fairchild…. People forget that Lockheed was our largest employer. It was these activities that led to the commercial spin-offs – We need to jump "back to the future""

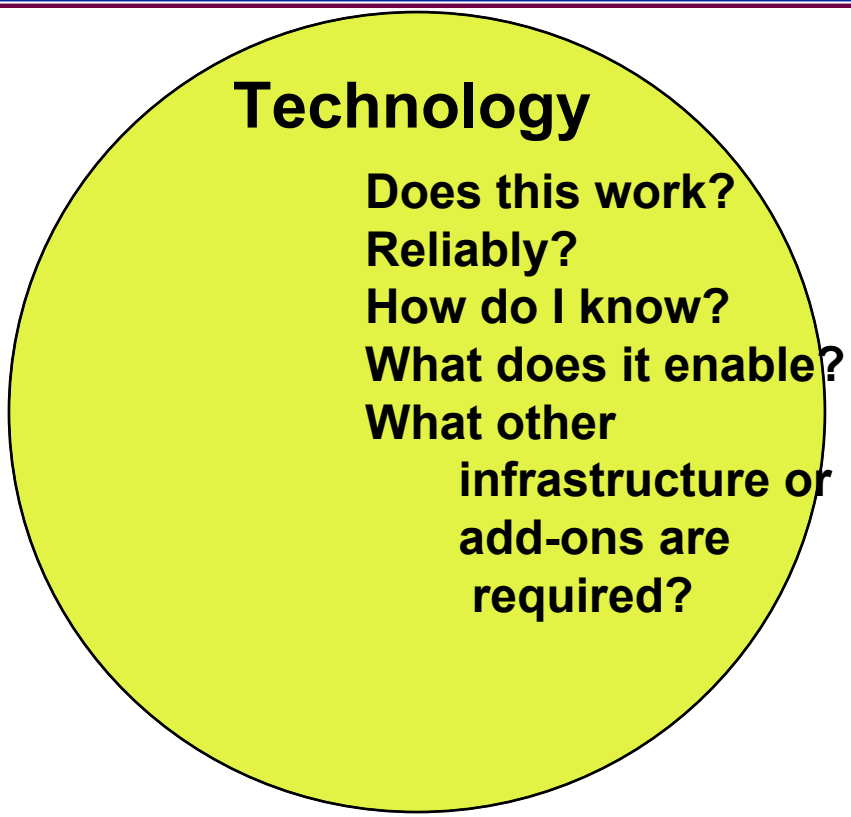
Russell Hancock, Chief Executive, Joint Venture: Silicon Valley Network
KQED Forum: State of the Silicon Valley Economy, 2/17/10

PAX's track record

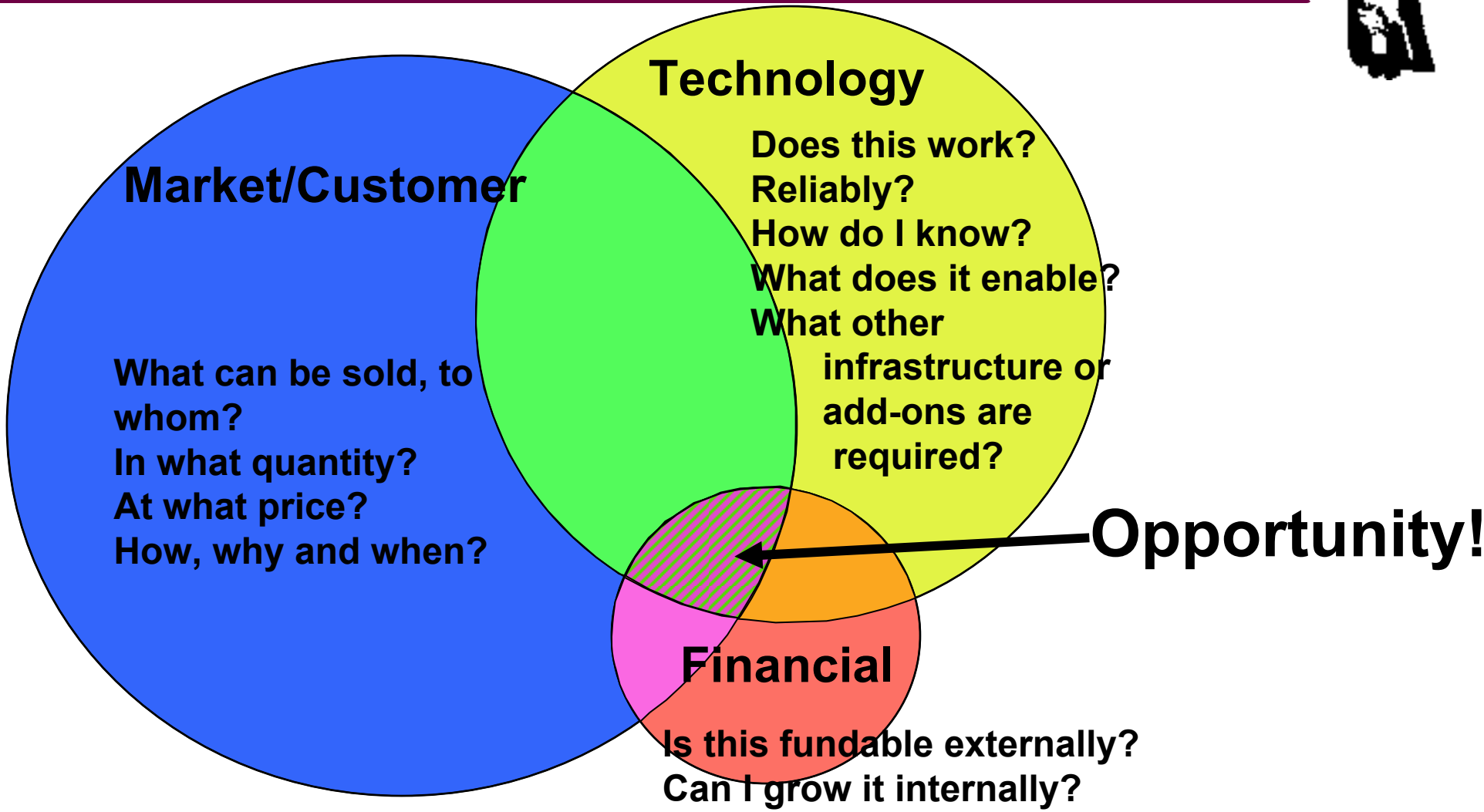
- 2008 – ATP grant ($1.9M)
- 2009 – ARPA-E grant ($3.0M)
- 2010 – CEC-ETDG grants (3 @ $350K)
- 2010 – DOE-SBIR Phase 1 grant ($150K)
- 2010 – DOE-NETL grant ($1.9M)

… others that we're waiting on…

Opportunity Recognition



Opportunity Recognition



Customer Pain: "What pain are you alleviating?"

The RAPT story

- **Unusual Person: Dr. Jeffrey Carr (Ph.D. Chemistry)**
  - Worked at IBM research – CMP, precision engineering
- **Unusual Situation: LLNL's NIF project**
  - World's biggest laser – tremendous optical manufacturing challenge
    - How can you make large, damage-free optics quickly???

Result: Reactive Atom Plasma (RAP) process

- Rapid, precise tool for shaping optical surfaces
- Non-contact, damage-free, ideal for hard-to-shape materials

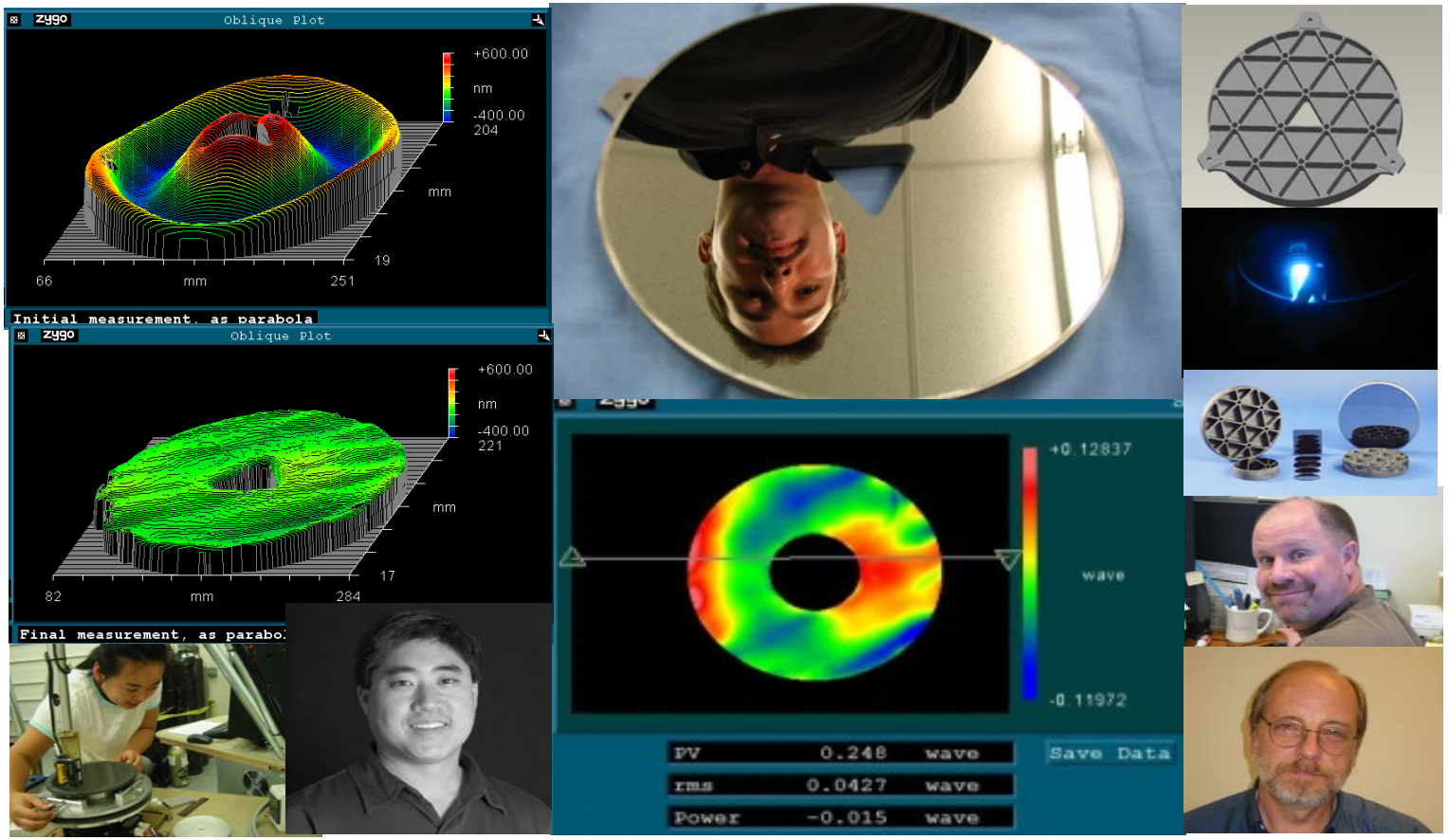
The plot thickens…

- **Prototype works but management wasn't interested**
  - Not-invented-here syndrome
  - Inventor not "politically savvy"

Result: Project funding terminated

Every setback also represents an opportunity…

RAPT INDUSTRIES



www.raptindustries.com

RAPT's timeline

- Oct '00 – Met inventor
- Jan '01 – Founded RAPT Industries, Inc.
- Apr '01 – Won 2001 UC Berkeley B-plan Contest
- Sep '01 – Secured 1st Angel investment
- Oct '01 – Met with first potential customer
- Nov '01 – Set up laboratory (hire employee #1)
- Mar '02 – Met 2nd customer
- Apr '02 – Ran out of money (hire employee #2)
- Oct '02 – 2nd Angel/Friends/Family investment
- Jan '03 – 1st R&D contract (Phase 1 SBIR)
- Apr '03 – 1st BIG R&D contract (ARL)
- Jun '03 – Hire VP Engineering
- Nov '03 – 2nd BIG R&D contract (commercial) (staff up to 7)
- Apr '04 – Hired first external CEO
- Nov '04 – Inventor/co-founder leaves company
- Dec '04 – First commercial product ships (staff up to 9)
- July '05 – 2nd External CEO hired (staff up to 12)
- Dec '05 – 2005 Annual sales $40,000
- Jun '06 – Relocate to larger quarters (staff up to 13)
- Nov '06 – 2006 commercial revenues to date: $400,000

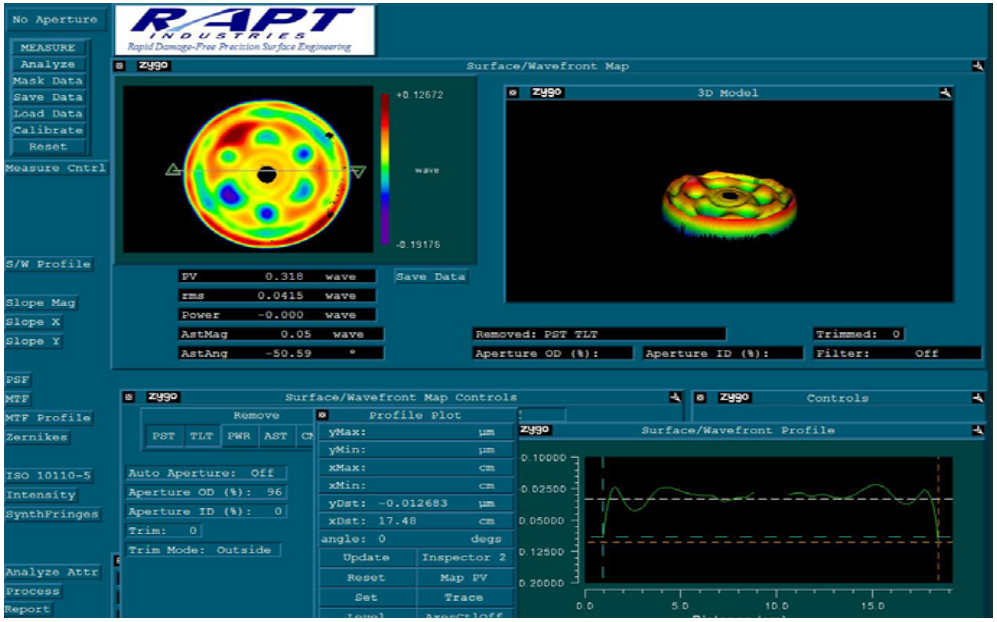
3rd generation RAP process tool

- **Stationary source – moving substrate**
- **350 mm limit for this tool**

On-axis asphere

- On-axis f/2.2 Parabola
- 180 mm Clear aperture
- Vertex ROC = 900 mm

- Finished to 0.0415 λ RMS
- Roughness of 4 Å

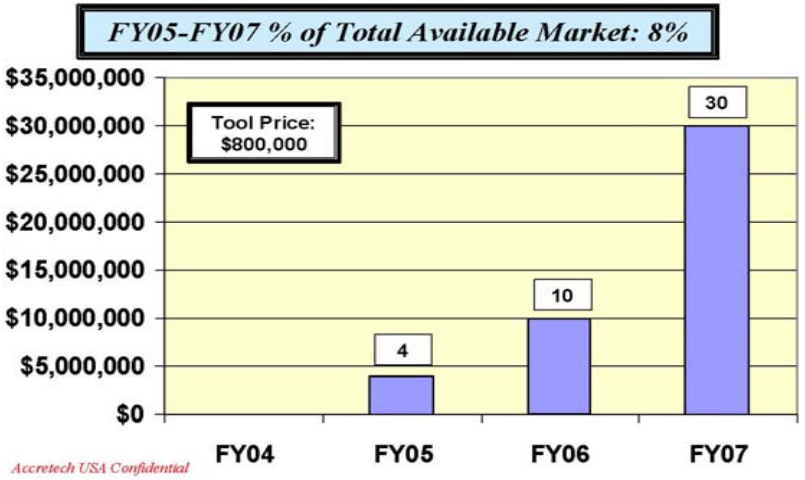


Signed license deal on September 8, 2004

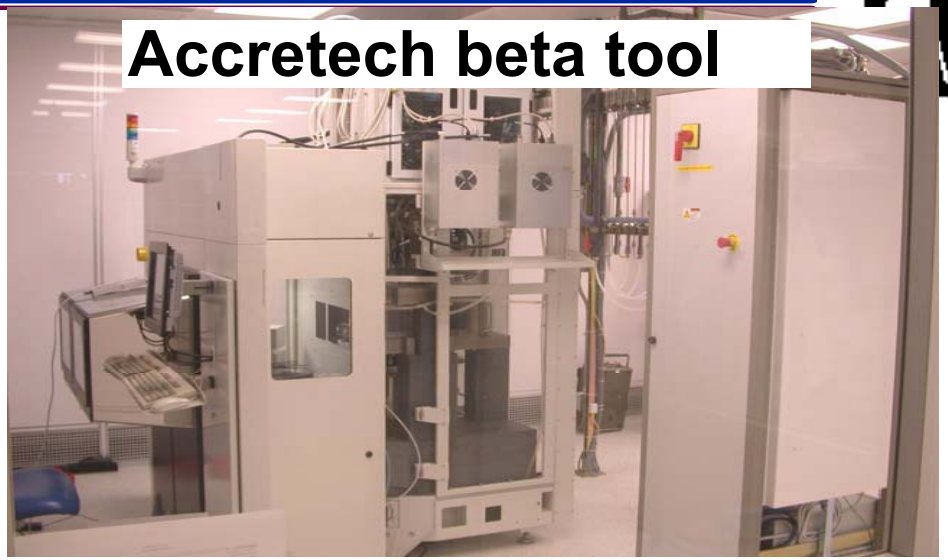
ACCRETECH

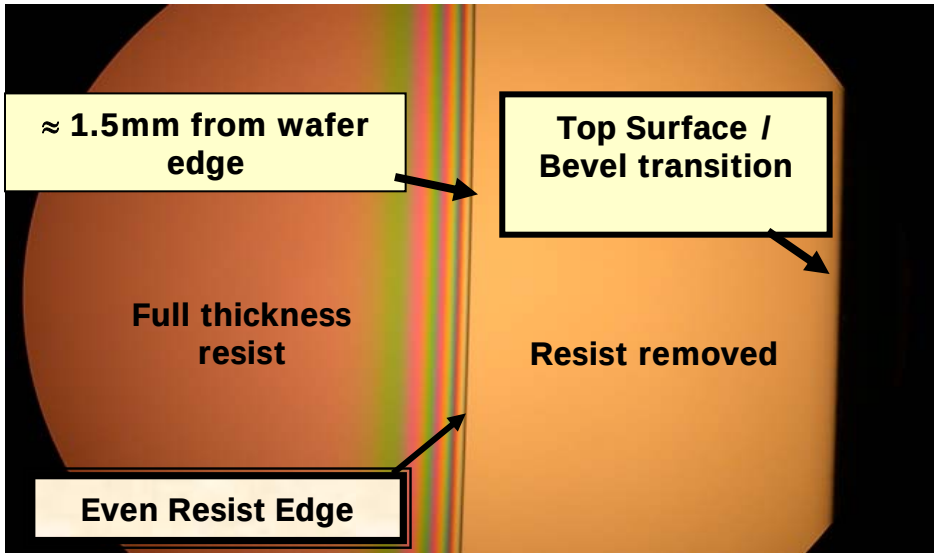
TOKYO SEIMITSU

Initial Sales Projection



Accretech beta tool





Semicon West July 2006

Accretech USA wins SEMI's Technology Innovation Showcase Award with RAP-based tool

Accretech USA, a licensee of RAP technology for wafer edge cleaning, received top awards for its new tool; the Habanero, at this summer's Semicon West. Named after the very hot, very small chili pepper, Habanero utilizes RAPT's proprietary micro-torch plasma technology to rapidly and efficiently clean the edges of in-process semiconductor wafers. Unlike other approaches, the RAP process operates at atmospheric pressure which not only obviates the need for pumps, chambers and seals but also allows for extraordinary wafer throughput. Not only was Habanero included in SEMI's Technology Innovation Showcase but the tool won the popular "Best Solution to a Problem" award at the show as well.

The REST of the story

Dec ’07 – 2007 commercial revenues: $1,636,000

April ’08 – 1.2m RAP tool ships to the UK

Sept ’08 – Bridge Bank pulls $400K line of credit

Oct ’08 – Accretech USA goes belly up

Jan ’09 – RAPT fails to gain Phase 2 program with NASA

Feb ’09 – RAPT fails to meet payroll

April ’09 – RAPT has $700K in liabilities, no employees

March ’10 – RAPT secures NASA Phase 2 SBIR… here we go again!

Eight Things I wish I had Appreciated Better about Technology Commercialization

1. A great team with so-so technology will always win out over a poor team with a great technology.
2. A new technology has no value if it cannot be inserted into a value chain.
3. Making a technology work is easy – solving the marketing challenge is HARD!
4. When it comes to emerging technologies, the government can be the most important investor.
5. Many promising technologies are unfundable by VCs (not because they are bad technologies)

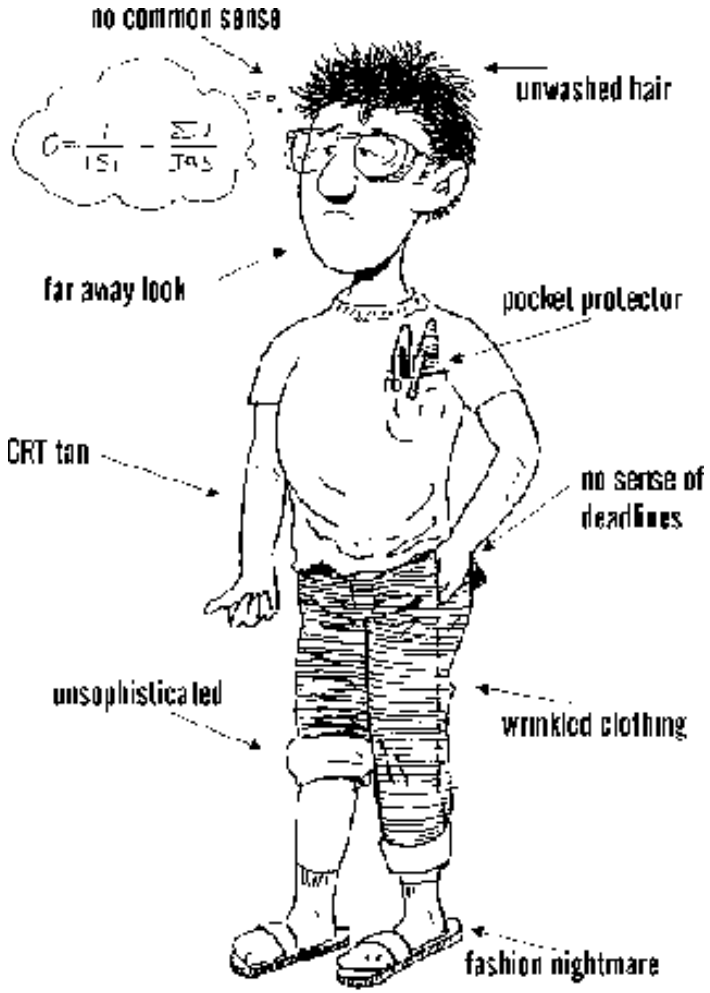
Eight Things I wish I had Appreciated Better about Technology Commercialization

6. **A seemingly minor technological advance can translate into a huge opportunity (don't rank your opportunities by the complexity of the technology)**
7. **Start-ups aren't much riskier than any other job – if you take safeguards:**
   - Don't burn bridges
   - Keep your network alive and intact
   - Aggressively pursue mentors and advisors
8. **Heisenberg's Uncertainty principal as applied to start-ups: You cannot know if you have the chance to be successful until you take the plunge. 'Tis better to have loved and lost than never to have loved at all.**

Perceptions and Realities: Overcoming Stereotypes

According to business people, academics/scientists are:

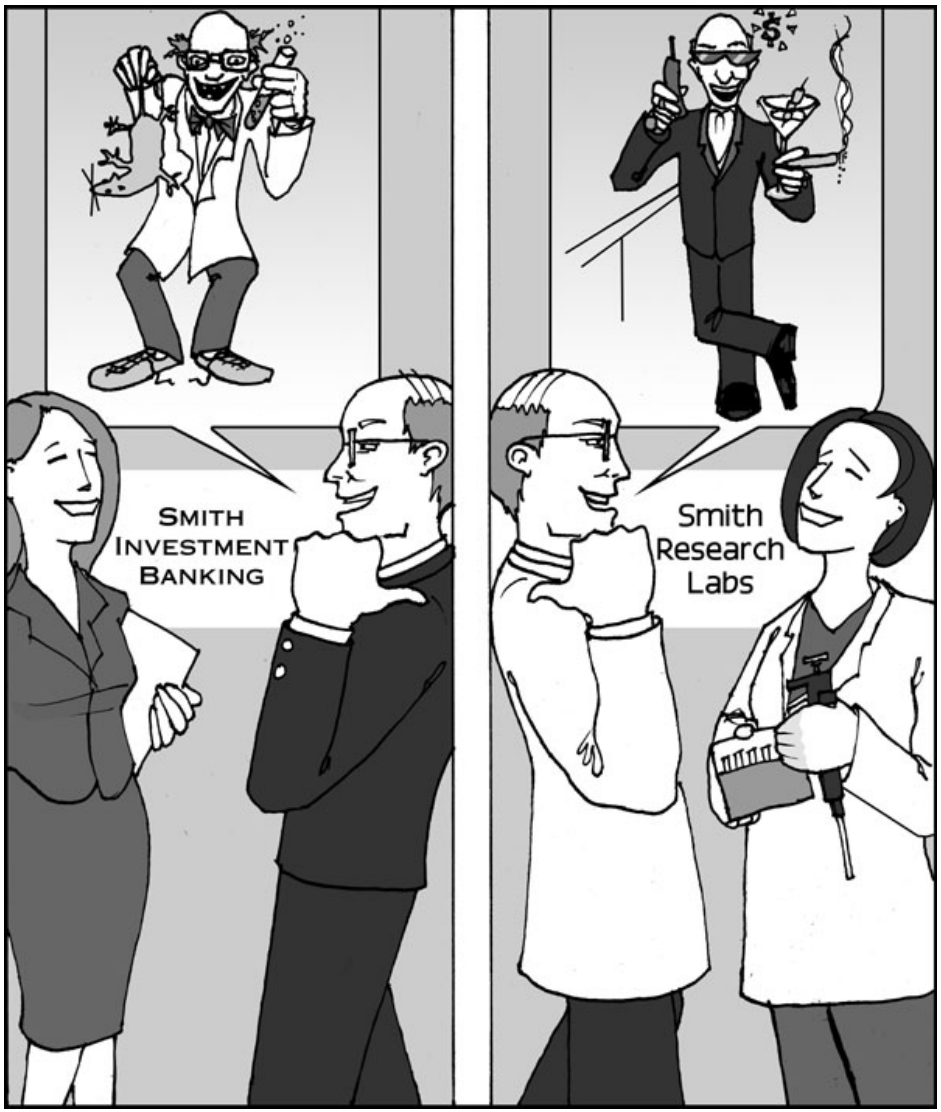
- simple minded about money
- impractical about time
- no sense of deadlines
- socially passive
- value ideals as absolutes



Other potential perceptions to overcome:

- hermit vs. leader
- arrogant vs. team player
- rebel vs. organizer
- problem person vs. solution person

Don’t forget your own misconceptions…

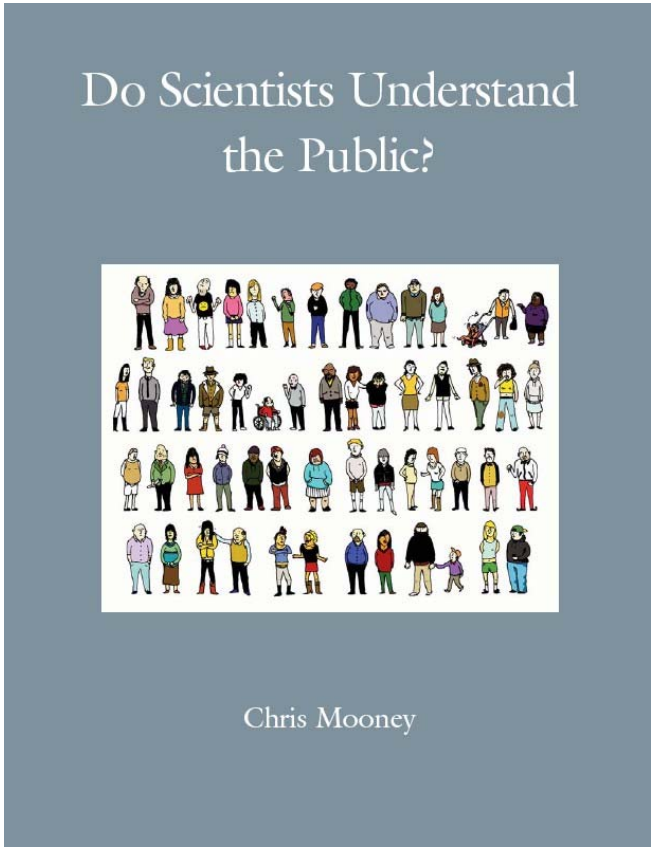


Some final thoughts

1. Don’t do a start-up for the money
2. The more people you know, the greater your “opportunity cross section"
3. A good company ≠ a good VC opportunity
4. Cleantech in particular will require 3 Ps:
    1. Patience (yes, I’m speaking to you, VCs…)
    2. Partnership (China’s advantage?)
    3. Pesos (Does Congress understand this?)

So get out there, and get to WORK!

Required Reading



- **Disbelief in science is not due to poor science education**
  - **Majority of climate change deniers are college educated**
- **Belief in science is not caused by more science education**
  - **Increasing science awareness does not translate to public acceptance of scientific fact**
- **Scientists need to understand and appreciate political and cultural implications to their work**
- **Better connection w/ public comes from scientists (principally younger scientists) presenting their work to the public**

Further information and resources

CAREERS NATURE|Vol 462|5 November 2009

PROSPECTS

Career resilience

It's not enough to be an expert on a specific topic. Today's scientists also need to be able to apply their knowledge, argues Peter Fiske.

Some might assume that cranking out good results is all that is necessary to further a career. But such a 'career protocol' is not safe. That has never been more true than now, as the world tries to climb out of the current recession.

Although the economy has shown signs of improvement, scientists and engineers of all ages will be feeling the effects of the recession for some time. In the past, the scientific community was often insulated from the brunt of economic downturns. Buoyed by the conviction that the future relied on science and technology, many scientists and engineers may have viewed the onset of this current economic storm with some complacency.

Well, no more. Unlike previous recessions, this one has reached into academia directly through budget cuts to higher-education institutions, especially in the United States at, for example, state-funded universities. And the negative effect on research funding may persist longer than normal. Despite efforts in the United States to boost science funding via stimulus spending, federal and state governments will be left with historically large budget deficits to manage: the pressure to cut discretionary government spending will be enormous. And with big losses to retirement portfolios, many senior scientists and engineers will probably remain at their benches for a few years longer to rebuild their nest eggs.

Yes, the news is grim. But I would argue that this is one of the most important events for science in the past 50 years. Scientists and engineers are coming to realize that the traditional models of a 'scientific' career are outdated. Science careers in the future will be marked by adaptability, entrepreneurialism and self-reliance. It's more than a realignment to a different set of jobs; it's a change in approach to a career. The era of 'career resilience' has begun.

From I-shaped to T-shaped

When my father embarked on his scientific career, he was advised to choose one topic and aspire to be the best in the world at it. This made great sense. Science was growing in all directions, so even an infinitesimally narrow area of knowledge was bound to expand. The prevailing wisdom was to be an 'I'-shaped scientist, with deep expertise in a single area.

Today, focusing on a single area of science no longer guarantees safety and security. Like an investment portfolio made up of just one stock, careers that are I-shaped are prone to large swings in value. Career experts often recommend that professionals adopt a 'T'-shaped strategy: deep technical expertise is still needed, but capping that depth should be a broad set of interdisciplinary skills that allow a scientist or engineer to solve problems in a wide range of applications. Despite the growth of interdisciplinary centres on some campuses, university training has yet to adapt to this new reality. Traditional PhD programmes still train students to focus on a single area of scholarly research. 'Broadening' activities, such as participation in interdisciplinary studies or taking business or law courses is, at best, tolerated.

How to cap your 'T'

Broadening your experience base and your network is now widely recognized to be the most effective way to expand your career options and make your career more resilient.

Fortunately, there are several ways to approach this that don't need a major time investment.

Technical consulting, for instance, expands your network and skill base while allowing you to apply your experience and problem-solving skills to real-world problems. Many scientists think that their area of expertise does not have any commercial value or relevance. In a narrow sense, that may be true. But scientists and engineers often fail to appreciate the breadth of expertise that they have developed. Interpreting analytical data, formulating and testing mathematical models, even literature review and analysis, are activities that many private-sector consultants engage in (and are well-compensated for).

Uncertain how to proceed? Seek out someone in your department, school or field who has an active consulting practice and find out how they discover opportunities.

Time away from the lab is often key. Rotational assignments such as sabbaticals provide academics with an opportunity to work in a different institution, build new skills and expand networks. Today, many academics use their sabbatical simply to escape their teaching duties for a year and never leave their department. Even short periods spent at another institution, university or company can be enormously broadening, both for your skills and for your network. Exchange assignments as short as four weeks can allow you to meet and interact with numerous new colleagues.

Scientists and engineers tend to be somewhat reserved in building their networks — focusing mainly on whom they know in the research community. In fact, it is the people outside the world of research who may have greatest effect on your career. If you are interested in an area of technology or commerce outside your area of expertise, consider attending a technical meeting on the subject. Interested in the interface of science and business? Attend lectures at the nearest business school. You'd be surprised who you will meet just by mingling.

Career resilience means investing in a range of activities. It means cultivating and maintaining an active network of colleagues, partners, friends and supporters who can steer you towards new opportunities. It means thinking of yourself as an adaptable and clever problem-solver rather than a technical expert with a narrow sliver of knowledge.

Peter Fiske is chief technology officer of PAX Water Technologies in San Rafael, California, and author of *Put Your Science to WORK*.

Peter Fiske's columns at ScienceCareers.org: "Opportunities"

http://www.nature.com/naturejobs/2009/091105/full/nj7269-122a.html