Physics 205 - Introduction to Research in Physics

Physics 205 meets Mondays 4-5:45 pm in ISB 231. All first-year Physics grad students must register for Physics 205.

Requirements: Attend every class (at most one will be excused) and turn in a summary of two research topics that interest you, each summary1 or 2 pages in length, based on Phys 205 lectures and possibly follow-up meetings with the relevant Physics faculty.

Website: http://physics.ucsc.edu/~joel/Phys205/ **Password**: Phys205

Instructor: Joel Primack, joel@ucsc.edu, ISB 318, Office Hours: Wed 2-3 or by appointment

Weekly Schedule

1/9 Joel Primack – Physics as a Profession
Sue Carter – Non-Academic Career Opportunities

1/23 Michael Dine – Anticipating LHC Physics
Tom Banks - Low Energy Supersymmetry Breaking
Jason Nielsen & Bruce Schumm – LHC and ILC

1/30 Sasha Sher – Imaging of Neural Function and Structure
Sriram Shastry – Supercomductors, Magnets, Thermoelectics
Gey-Hong Gweon – Spectroscopy on HTSCs and Graphene

2/6 Robert Johnson/Steve Ritz – Fermi γ-ray Space Telescope
David Williams – VHigh Energy Gamma Ray Astrophysics
David Smith – X-Ray Astronomy and Geophysics

2/13 Howard Haber – Theory/Phenomenology of the Terascale
Anthony Aguirre - Testing Theories of the Super-Early Universe?
Stefano Profumo – Fundamental Physics with GeV Gamma Rays
Joel Primack – Gamma Ray Cosmology

2/27 Joshua Deutsch – Biophysics & Condensed Matter Theory
Peter Young - Frustration and Quantum Computing

3/5 Bud Bridges – Crystal Structure and Macroscopic Properties
Art Ramirez – Strongly Correlated Matter
David Belanger - Nanoparticle Magnetism

3/12 Joel Primack – Physics Ethics

Physics 205 Research Proposals

Each short research proposal should have your name and the title at the top, and then explain

• what physics question you want to answer and why this question is interesting,

• what method(s) you propose to use,

• what information and resources (e.g. experimental apparatus, computational capability, and funding) you expect to need,

• how long you expect this project to take, and

• other relevant information such as which faculty member(s) you discussed this project with, why you are especially interested in this project, and what you might want to do if it succeeds.

Your two research project summaries are due at the last meeting of Physics 205, Monday March 12, 2012. However, if you submit drafts to me in advance, I will try to return them to you quickly with comments that may help you improve them. Please submit your research project summaries by email to joel@physics.ucsc.edu (please also cc a copy to relevant faculty members who would advise you on each project).

Physics 205 - Introduction to Research in Physics

January 9, 2012

PHYSICS AS A PROFESSION

4 pm Joel Primack – **Physics as a Profession**

5:15 pm Sue Carter – **Non-Academic Career Opportunities**

Physics as a Profession

Joel Primack

Demographics of the Physics Profession

Physics occupations including Public Interest Science

How scientific fields grow and stagnate

Working on the frontier vs. developed fields

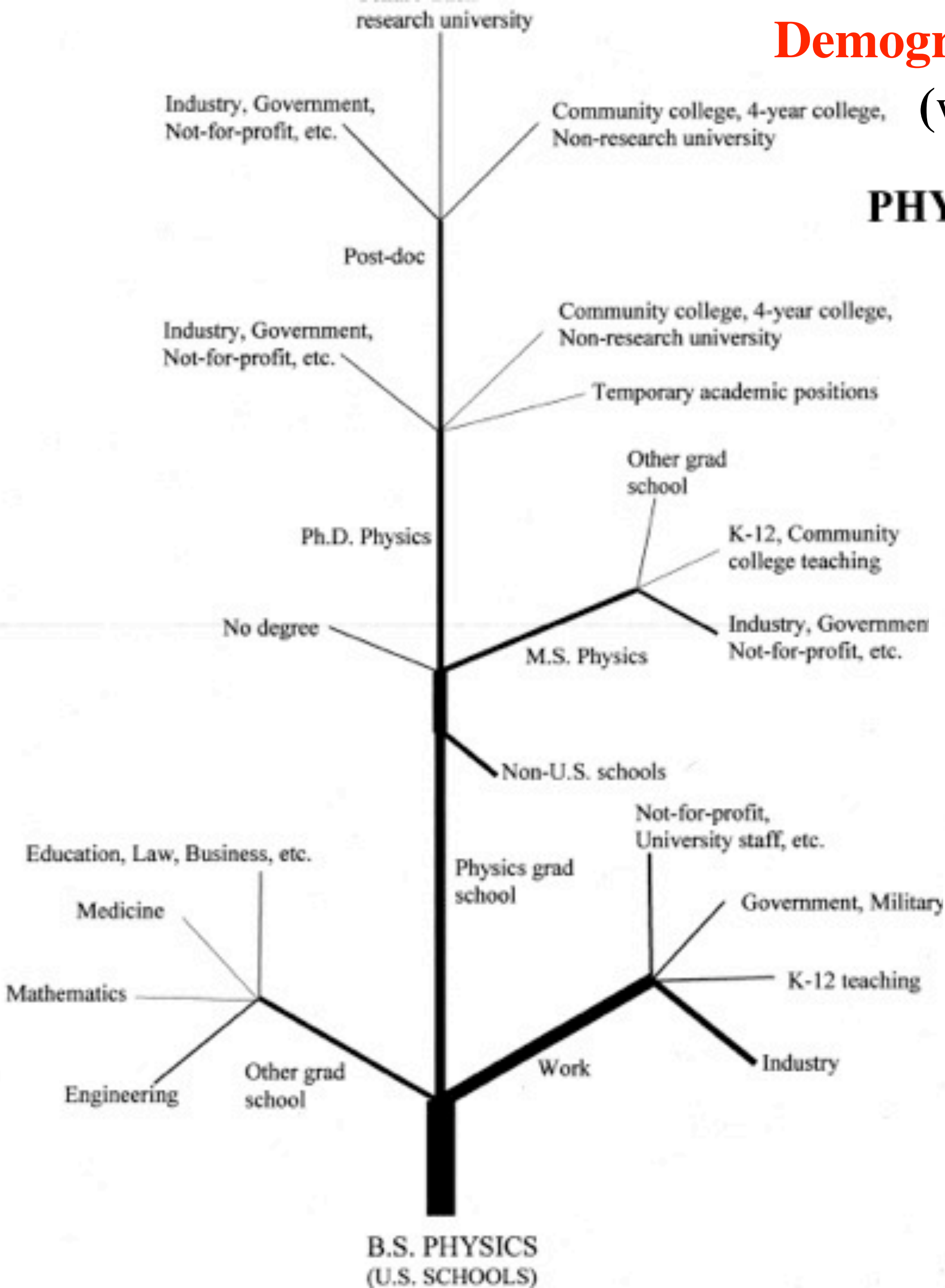
The PhD is a research degree

Patterns of physics careers – importance of ~10 yr post-PhD

U.S. and International Science Budgets and Indicators

Demographics of the Physics Profession

(with thanks to Fred Kuttner)



PHYSICS MAJOR CAREER SUMMARY

Research University Faculty – 2%

Other University Faculty – 2%

Four-Year College Teaching – 3%

Community College Teaching – 3%

K-12 Teaching – 10%

Government, Not-for-Profit, Law, Medicine, etc. – 20%

Private Industry – 60%

Sources:

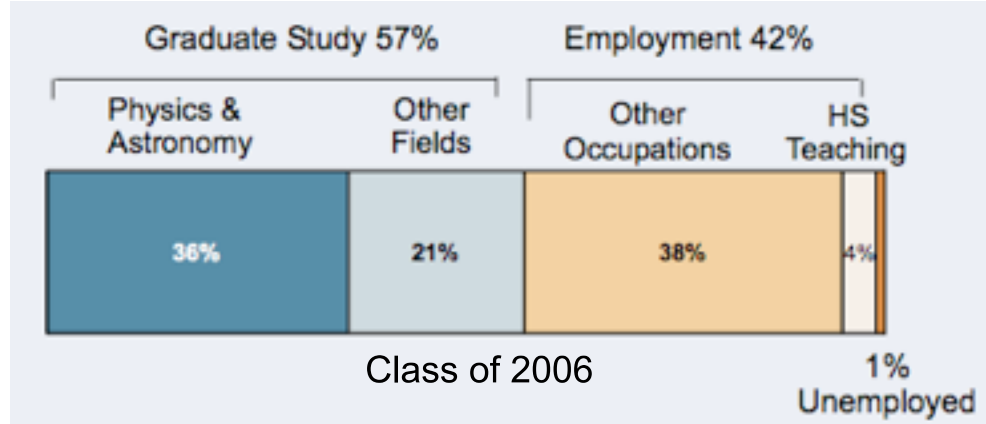
www.aip.org/statistics

2004 Physics & Astronomy Academic Workforce

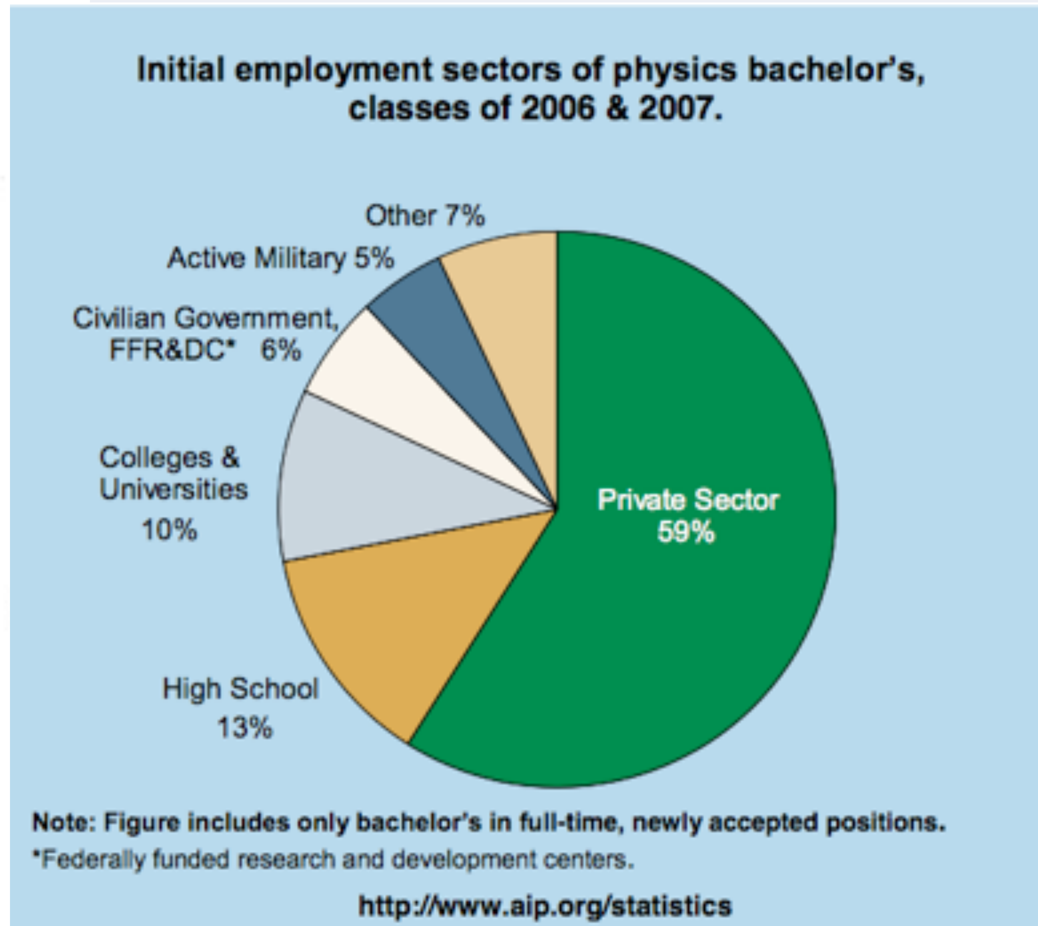
Initial Employment Report: Physics and Astronomy Degree Recipients of 2002 & 2003

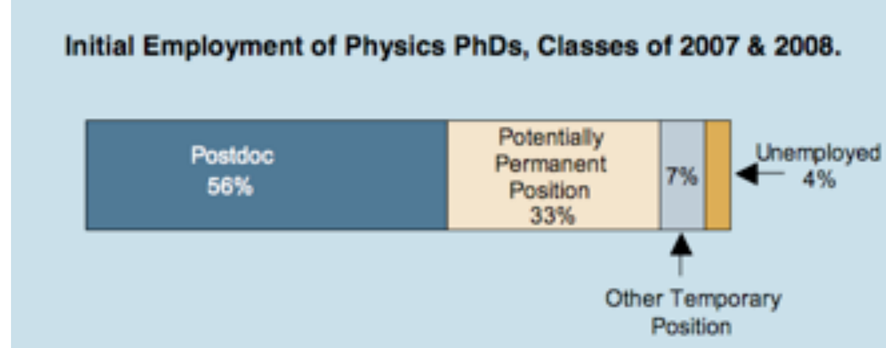
Enrollment and Degrees Report, 2003

Where Do Physics Bachelors Go?

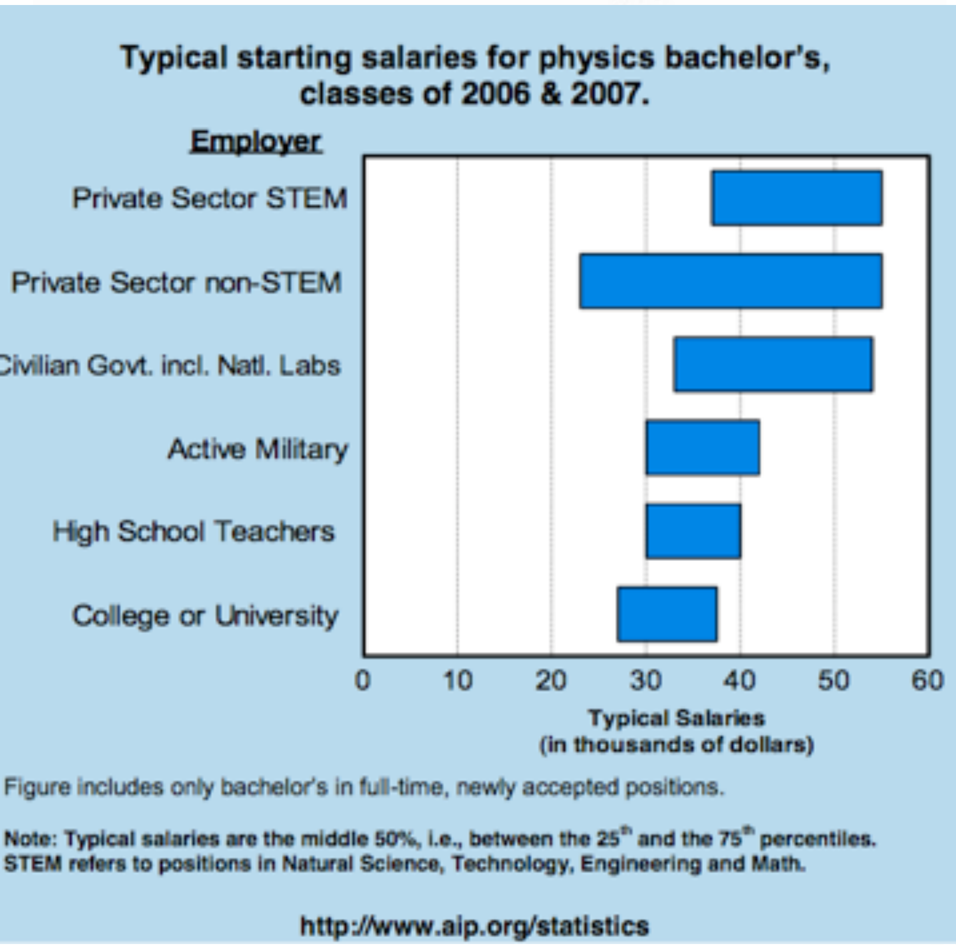


Where Do They Work?

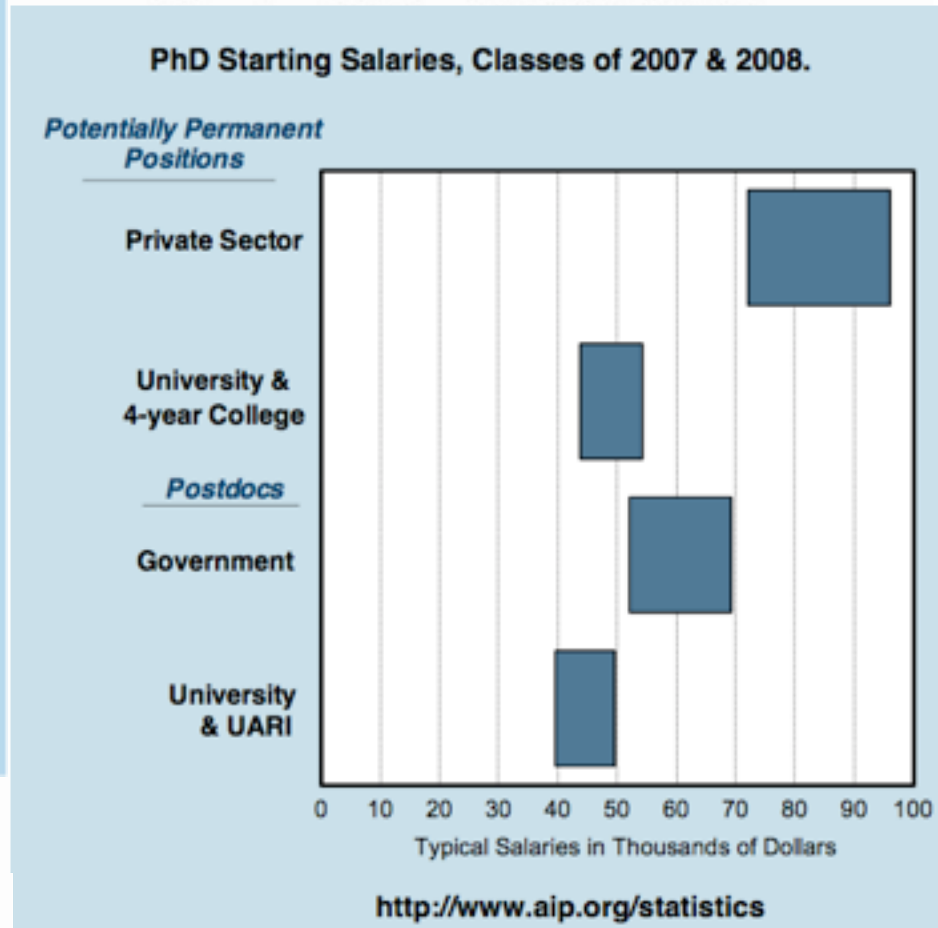


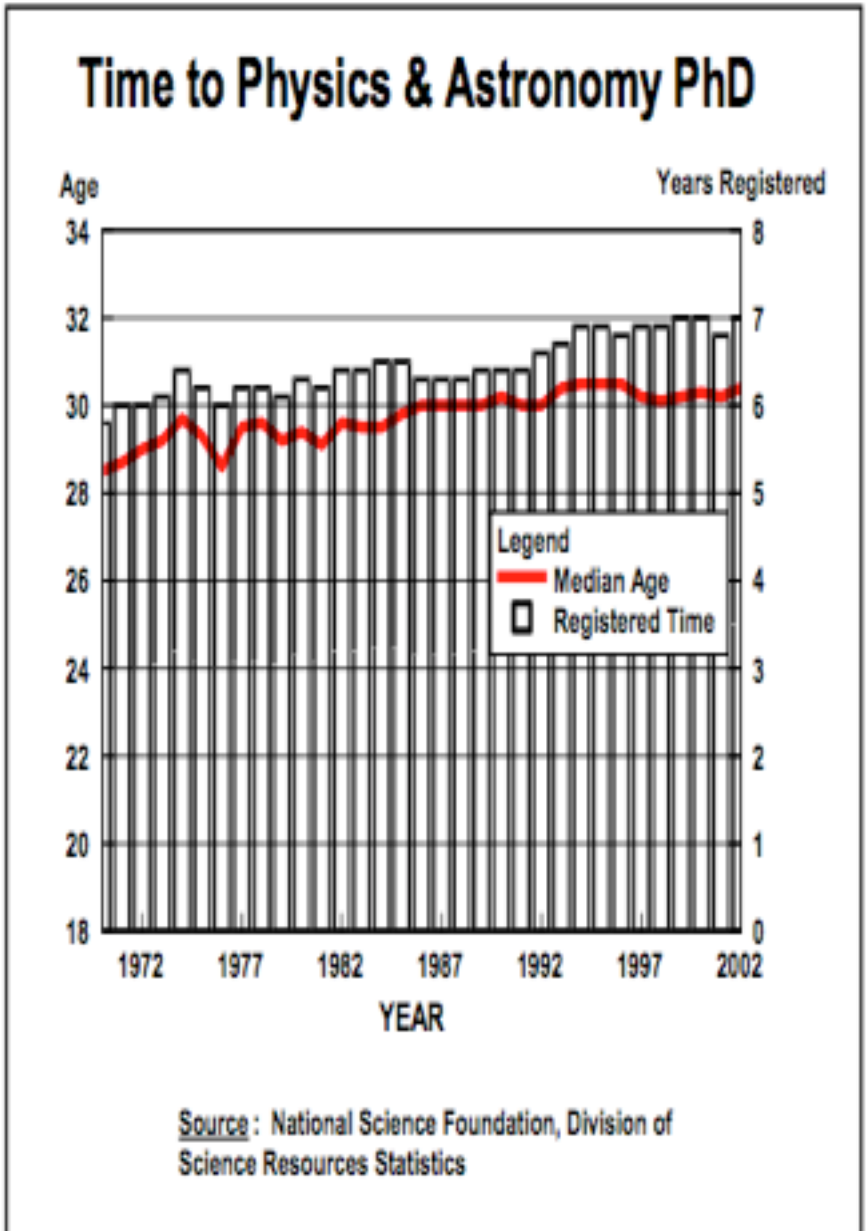


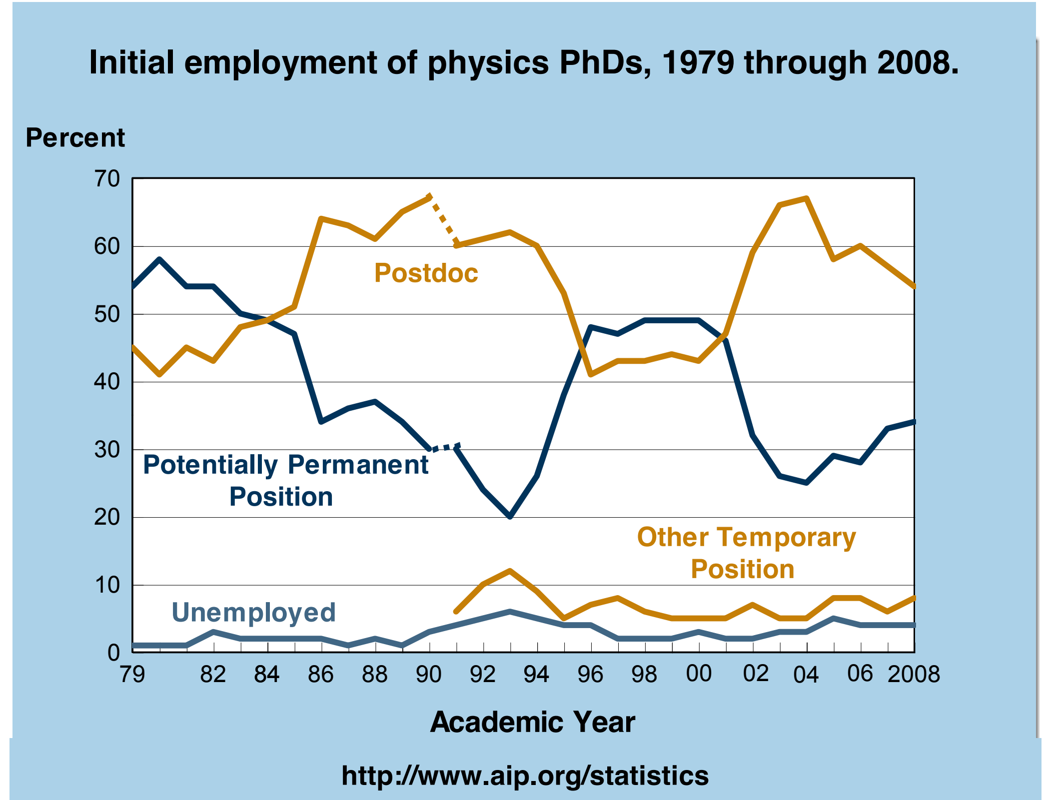
Bachelor's Starting Salaries



PhD Starting Salaries







ATTRITION AND TIME TO DEGREE

What percentage of entering PhD students complete a PhD in physics?

96 physics departments answered this question

# of Departments	% of Students
5	0 to 30
3	30.1 to 40
12	40.1 to 50
8	50.1 to 60
16	60.1 to 70
28	70.1 to 80
9	80.1 to 90
4	>90
11	Don't know

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Statistical Research Center

http://www.aip.org/statistics/

The Statistical Research Center is your source for data on education and employment in physics, astronomy and allied fields. The links below lead to listings of full reports and highlighted tables and graphs for each general topic:

Full Reports by topic	Essential data (click on keywords to jump to detailed tables and graphs on the topic)
High school & two-year college physics	enrollments | teachers | teaching conditions | salaries | initiatives
Undergraduate education	2-year college | degrees | women & minorities | student goals| college choice| undergrad experience
Graduate education	enrollments | degrees| subfields | support | women & minorities | citizenship
Faculty	number | job market | women & minorities | new faculty | 2-yr college
Employment	bachelors | masters | PhDs | faculty | salaries
Women	degrees | faculty | international | high school & 2-year college
Minorities	bachelors | PhDs | faculty | most degrees
International	foreign students in U.S. | women | degrees abroad | international community

http://www.nsf.gov/statistics/

National Science Foundation
WHERE DISCOVERIES BEGIN

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Statistics

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Science and Engineering Indicators

Women, Minorities, and Persons with Disabilities in S&E

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[formerly the Division of Science Resources Statistics (SRS)]

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[collapse -]

Education

Degrees • Disabilities • Elementary and Secondary • Graduate Students • International • Minorities • Postdoctorates • Universities and Colleges • Women

Federal Government

Budget Function • Demographics • Expenditures • Facilities • Funding • Research and Development • Workforce

Business and Industry

Funding • Geographic • Innovation • Research and Development • Trends • Workforce

International

Education • Graduate Students • Research and Development • Workforce

Research and Development (R&D)

Academic • Budget Function • Business and Industry • Cyberinfrastructure • Expenditures • Facilities • Federal Government • Funding • Geographic • International •

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*See also Joel Primack and Frank von Hippel, *Advice and Dissent: Scientists in the Political Arena* (Basic Books, 1974; New American Library, 1976).

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Programs

Science & Policy

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AAAS Science & Technology Policy Fellowships

2010-11 AAAS S&T Policy Fellows

THE LATEST:

AAAS S&T Policy Fellows Make Key Contributions to White House Report on Adapting to Climate Change

Fall Edition of the *Fellowship Focus* e-newsletter

Watch Our Webinar

FELLOWS IN THE NEWS

University of Nebraska Medical Center profiles Renaisa Anthony (2007-08) in their Winter 2010 newsletter. Read it now.

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AAAS Science & Pubic Policy Fellowships

Q: What is the deadline for AAAS Fellowship applications?
The annual deadline is 5 December, without exception. All required information, including three letters of recommendation, must be submitted by 11:59 p.m. U.S. Pacific Standard Time on that date. Applications are being accepted this year from early September to 5 December, for the fellowship class that begins the following September.

Q: Who is the ideal candidate for a AAAS fellowship?
There is no "ideal" candidate for a fellowship. Fellows come from many different disciplines in science and engineering; they arrive from academia, industry and the non-profit sectors; and they represent a broad range of career stages, from recently graduated postdocs to mid-career professionals and faculty on sabbatical, to retired individuals.

Q: Is previous experience in public policy necessary to be a strong candidate?
No, the fellowships are designed to help scientists and engineers learn about the policymaking process by participating in it. However, it is important to convey an understanding of the societal impacts of science in your application materials and during an interview. You should also be prepared to speak about how your specific scientific specialty relates to policy issues and how it can be applied in government decision-making.

>150 Science and Public Policy Fellowships per Year

Q: How many persons apply each year and how many are selected?
The ratio of applicants to fellowships awarded is different in each of the fellowship program areas. We urge you not to consider "the odds," but to apply to the fellowships that fit best with your interests and area of expertise. It is in those areas that you will be most competitive. Overall, AAAS awards more than 150 fellowships each year, including second year renewal fellowships. In addition, approximately 30 congressional and 10 executive branch fellowships are selected and awarded by other science and engineering societies that partner with AAAS to provide the Science & Technology Policy Fellowships.

Q: Does AAAS have any fellowship programs for undergraduate or graduate students?
Yes. AAAS also administers the Mass Media Fellowship Program, which places undergraduate and graduate students at various media sites throughout the U.S. during the summer, to work as science journalists. For more information about this program, contact Stacey Pasco at spasco@aaas.org.

Q: What impact has the fellowship had on the career path of former Fellows?
In the year immediately following their fellowship, approximately 40-50% of the Fellows continue working in the policy realm; 20-25% return to the sector in which they worked previously; and another 20-25% use the experience as a stepping stone to a new opportunity. To read about AAAS Fellows' perspectives on their experiences click here.

I recruited the first class of Congressional Science Fellows in 1973. They were physicists Ben Cooper and Michael Telson and biologist Jessica Tuchman [Mathews]. Ben Cooper, one of the first two APS Fellows, gave up tenure at Iowa State after his Fellowship year to join the staff of the Senate Interior Committee, subsequently renamed Energy and Natural Resources, where he remained for more than twenty years. Michael Telson had received his M.I.T. PhD just before becoming a AAAS Fellow. After his Fellowship year, he had offers from three universities and several Federal agencies, but he instead joined the staff of the newly formed House Budget Committee working on energy and environment, where he stayed for twenty years. He subsequently worked as Chief Financial Officer of the DoE for several years, and now works for the University of California. Jessica Mathews helped lead Mo Udall's Presidential campaign, served on the National Security Council staff in the Carter administration, was an editor at the Washington Post, and is now President of the Carnegie Endowment for International Peace.

The career paths of the 58 APS Congressional Fellows (as of 2004) have been diverse. One, Rush Holt, is now the Representative for the New Jersey district that includes Princeton University, where he had earlier worked at the Forrestal Research Center. Five others are presently on Congressional staffs. Twelve have positions in the Executive Branch, ten are at universities or laboratories, eleven work in industry, five are on professional society staffs, and seven work for public interest groups.

Benjamin Franklin is America's earliest model of the "civic scientist". Science was his passion and expertise, but society was his concern. As scientists in a much more complex world than Franklin's – we face a society and momentum that, in many ways, we as scientists have created. Just as many in our ranks have taken on the task of insuring a better informed public on scientific matters, and many have moved into policy positions in government and academic institutions, it is clearly a moment in history when more of us should actively seek that role and responsibility that was so clear to Franklin – the larger public arena.

Neal Lane (Rice University), "Benjamin Franklin, Civic Scientist," Physics Today (October 2003) 41-46.

• A civic scientist should be a credentialed scientist with sufficient professional standing to have credibility among colleagues, policy-makers, students, and the public.

•
A civic scientist must possess the wisdom and judgment to understand the boundaries of scientific authority and when it is appropriate to apply scientific authority to policy issues.

• A civic scientist should be able to communicate effectively with a variety of audiences in order to convey his or her message most effectively.

• A civic scientist must not expect to persuade solely by virtue of his or her scientific authority; rather, he or she should understand the nature of political discourse and decision-making and realize that progress is made incrementally through a process of compromise and consensus building.

• A civic scientist is committed to applying scientific knowledge and experience to the benefit of the public.

Philip W. Hammer (Franklin Institute), "The Civic Scientist – An Introduction to Scientific Citizenship for the 2008 Quadrennial Congress of Sigma Pi Sigma" http://www.sigmapisigma.org/congress/2008/ethics_primer.pdf

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Growth of Knowledge in One Area

Schematic Picture

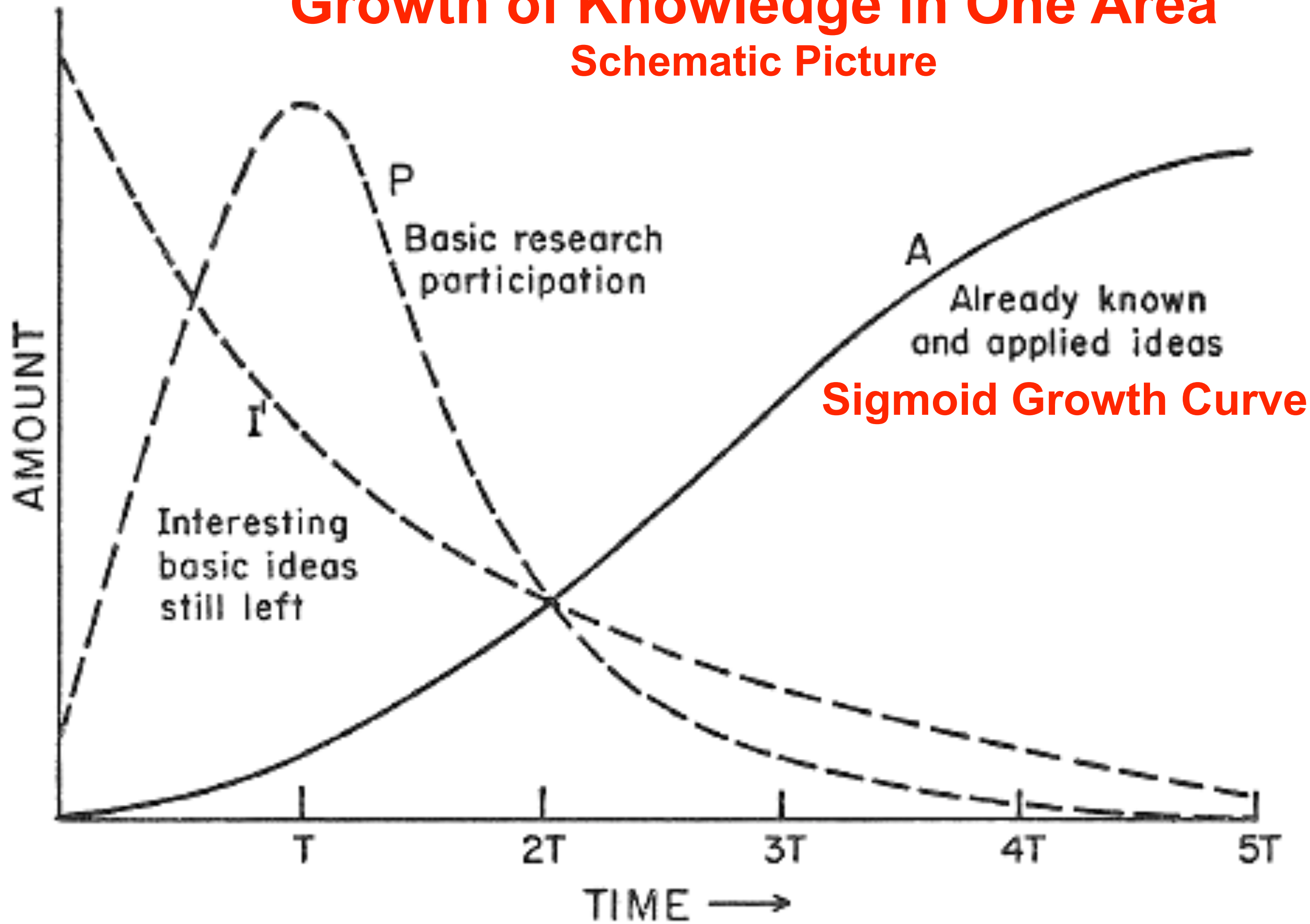


Figure 6. Inverse relationship between the accumulation of application and the interest in a basic-research field.

From Gerald Holton, “Models for Understanding the Growth of Research,” originally published in Doedalus (Spring 1962), reprinted as Chapter 12 of Gerald Holton, *Thematic Origins of Scientific Thought: Kepler to Einstein* (Harvard U Press, 1973).

Linear Sigmoid Growth Curve

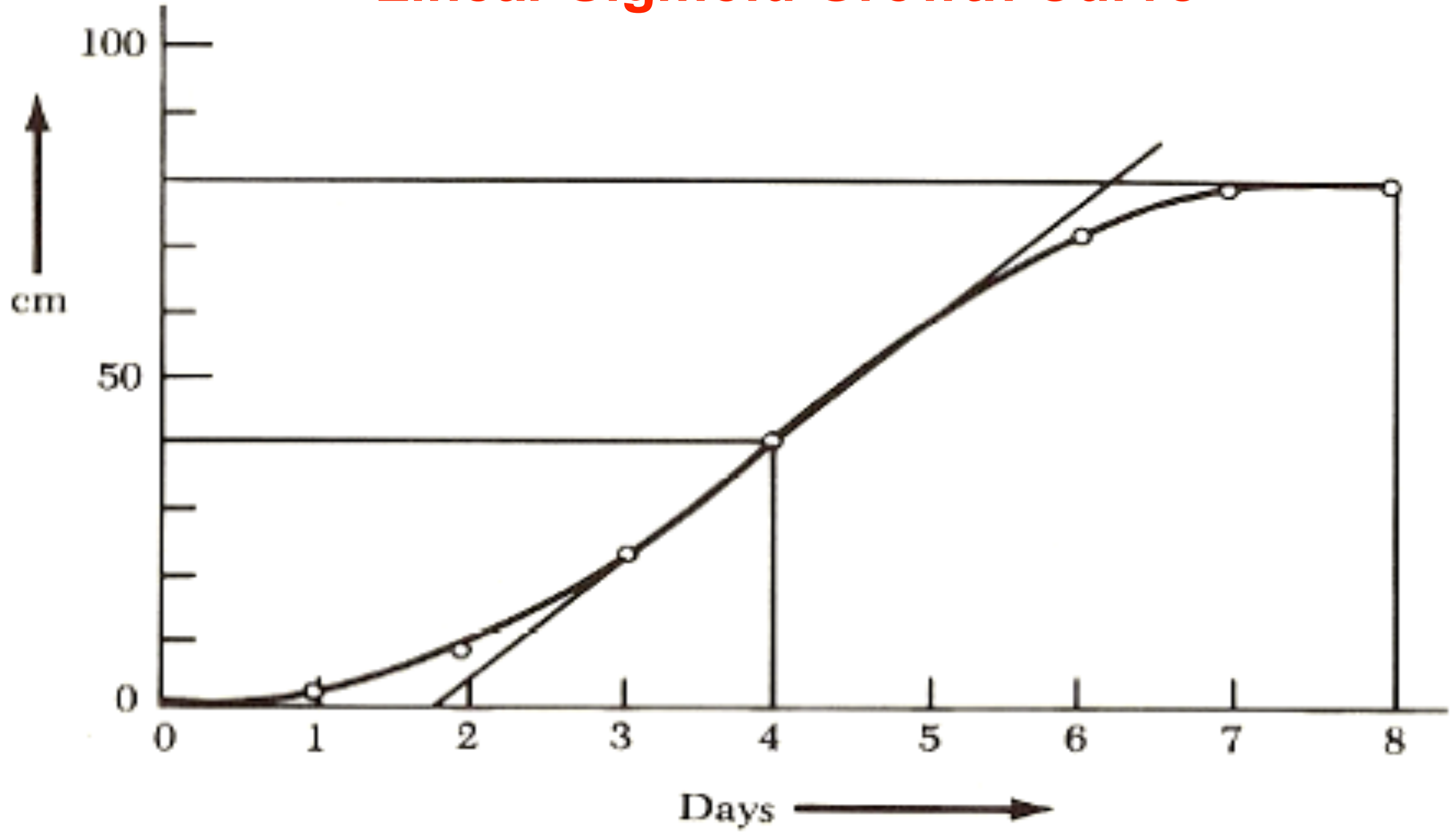


Figure 1.6. Growth in Length of a Beanstalk as a Function of Age

Adapted from D'Arcy W. Thompson, *Growth and Form* (Cambridge: Cambridge University Press, 1948), p. 116, figure 20.

Figure 1.6 in Derek J. de Solla Price, *Little Science, Big Science* (1963).

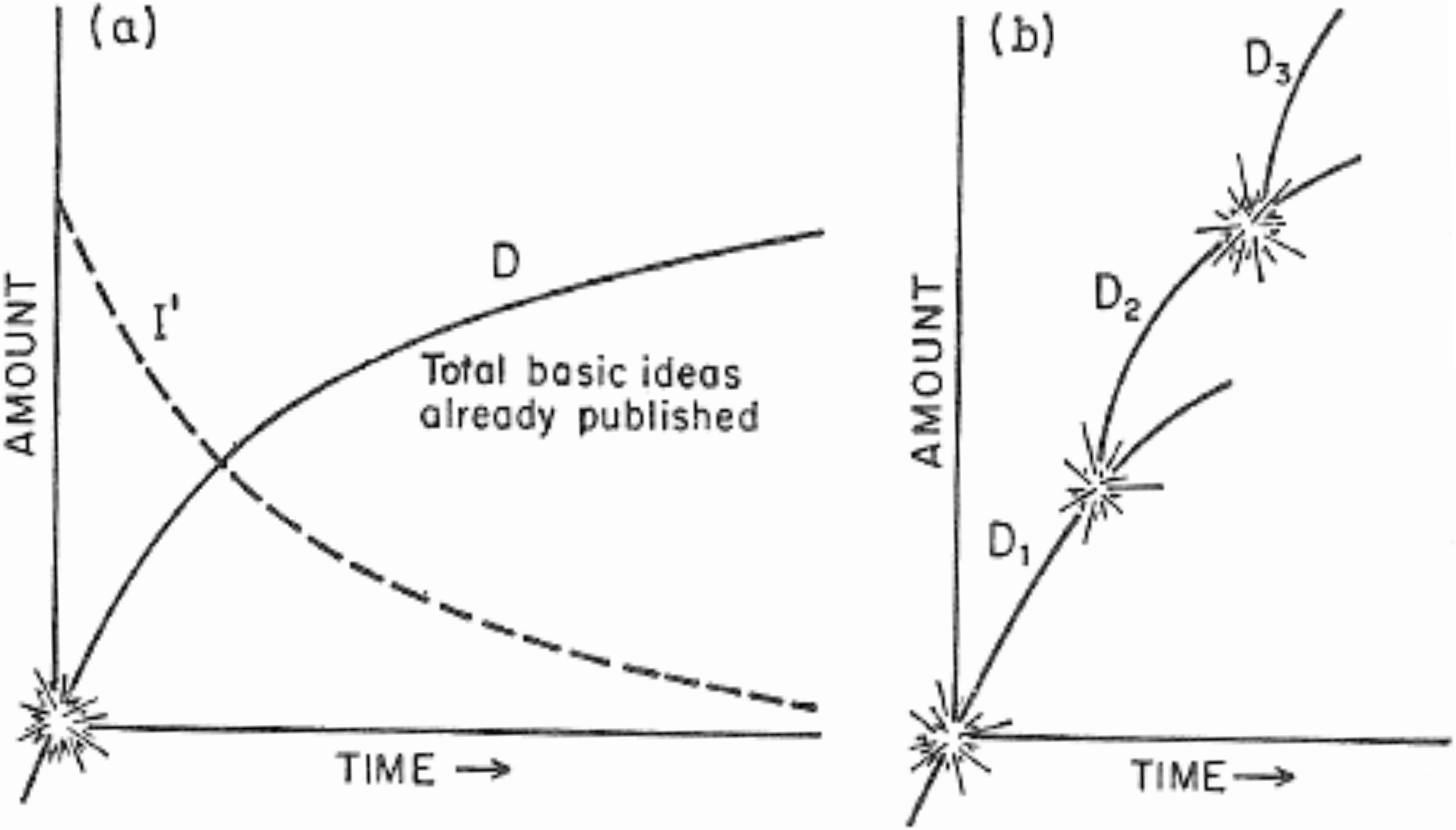


Figure 7. The escalation of discovery lines.

From Gerald Holton, “Models for Understanding the Growth of Research”

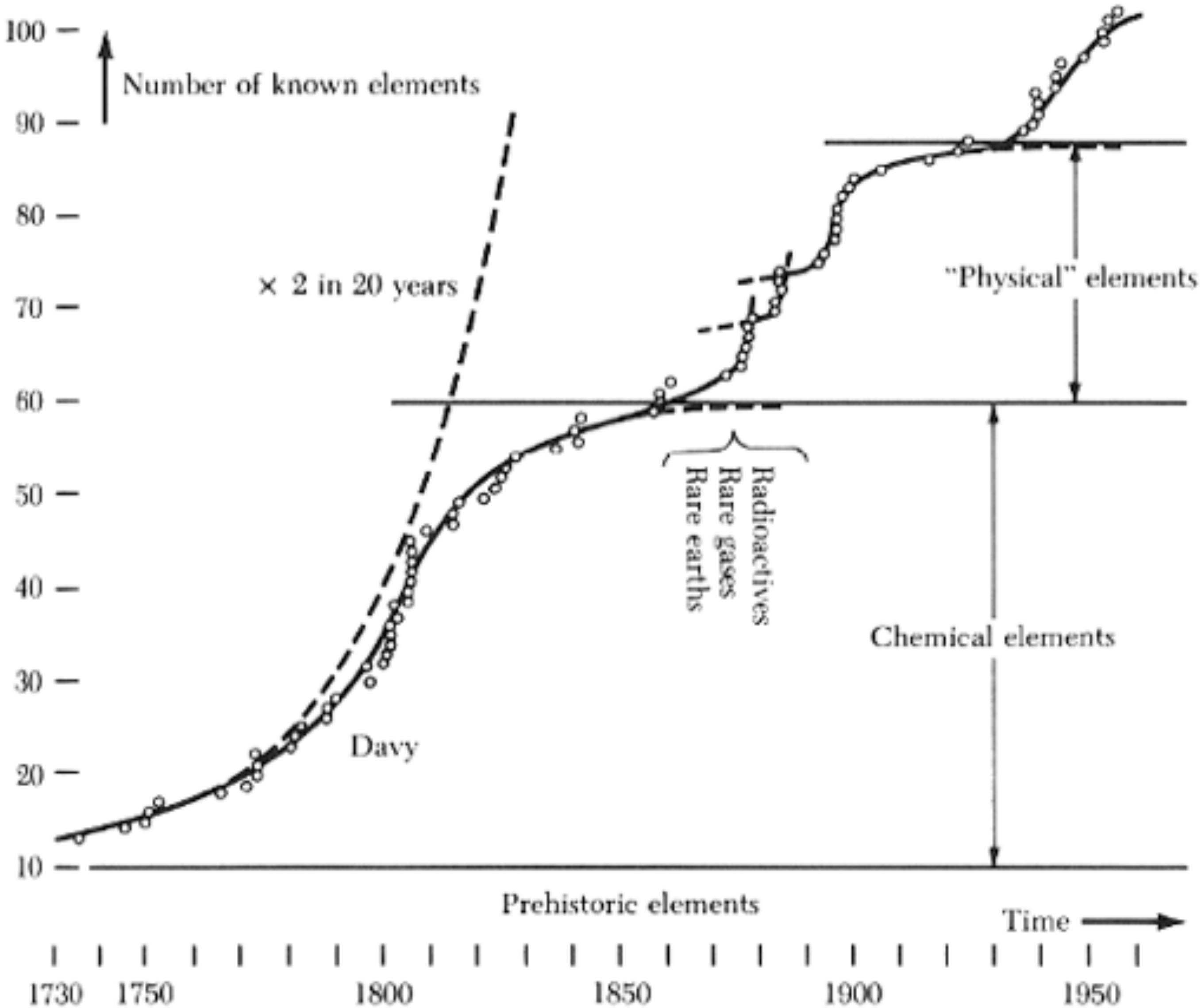


Figure 1.11. Number of Chemical Elements Known as a Function of Date

Figure 1.11 in Derek J. de Solla Price, *Little Science, Big Science* (1963).

How exponential growth can continue via repeating sigmoid growth curves...

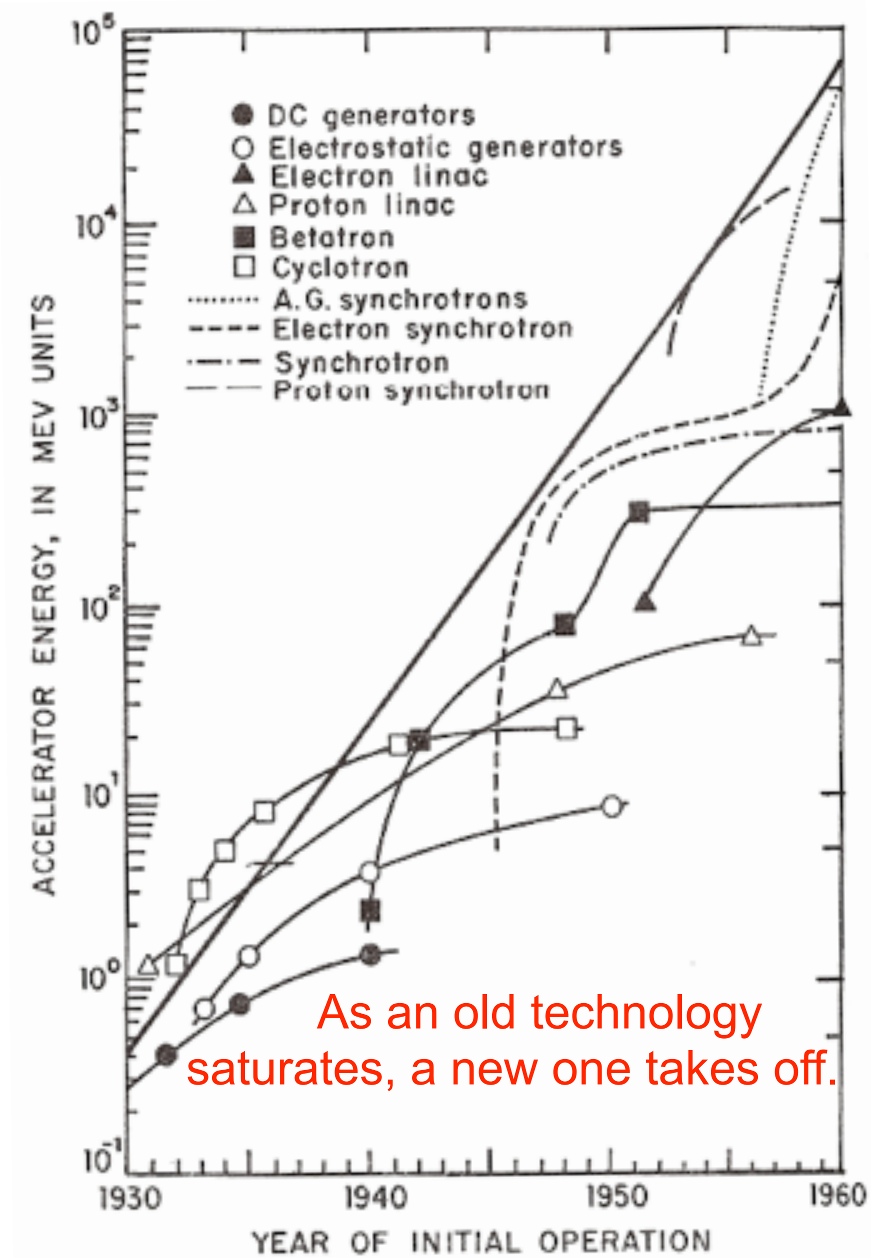
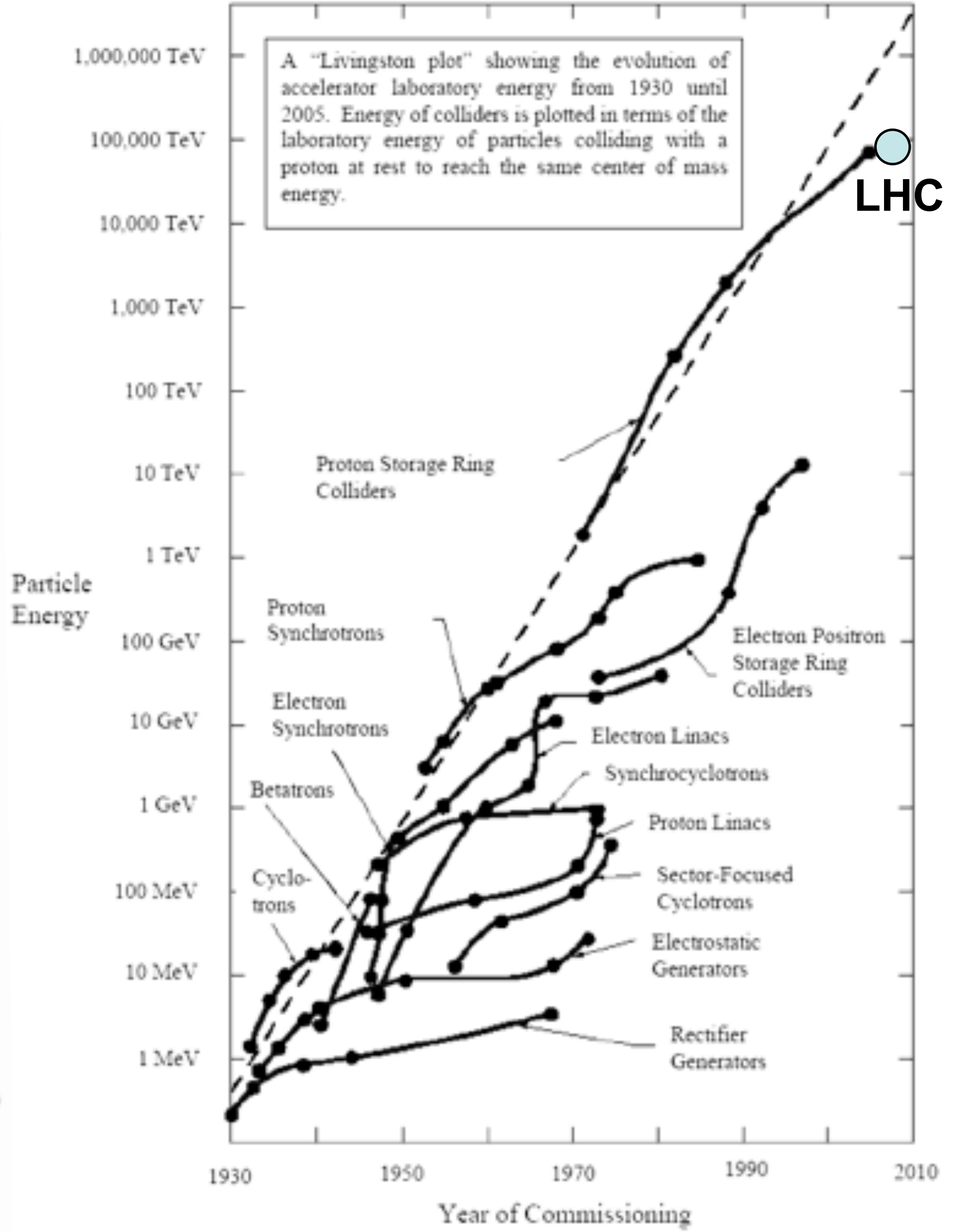
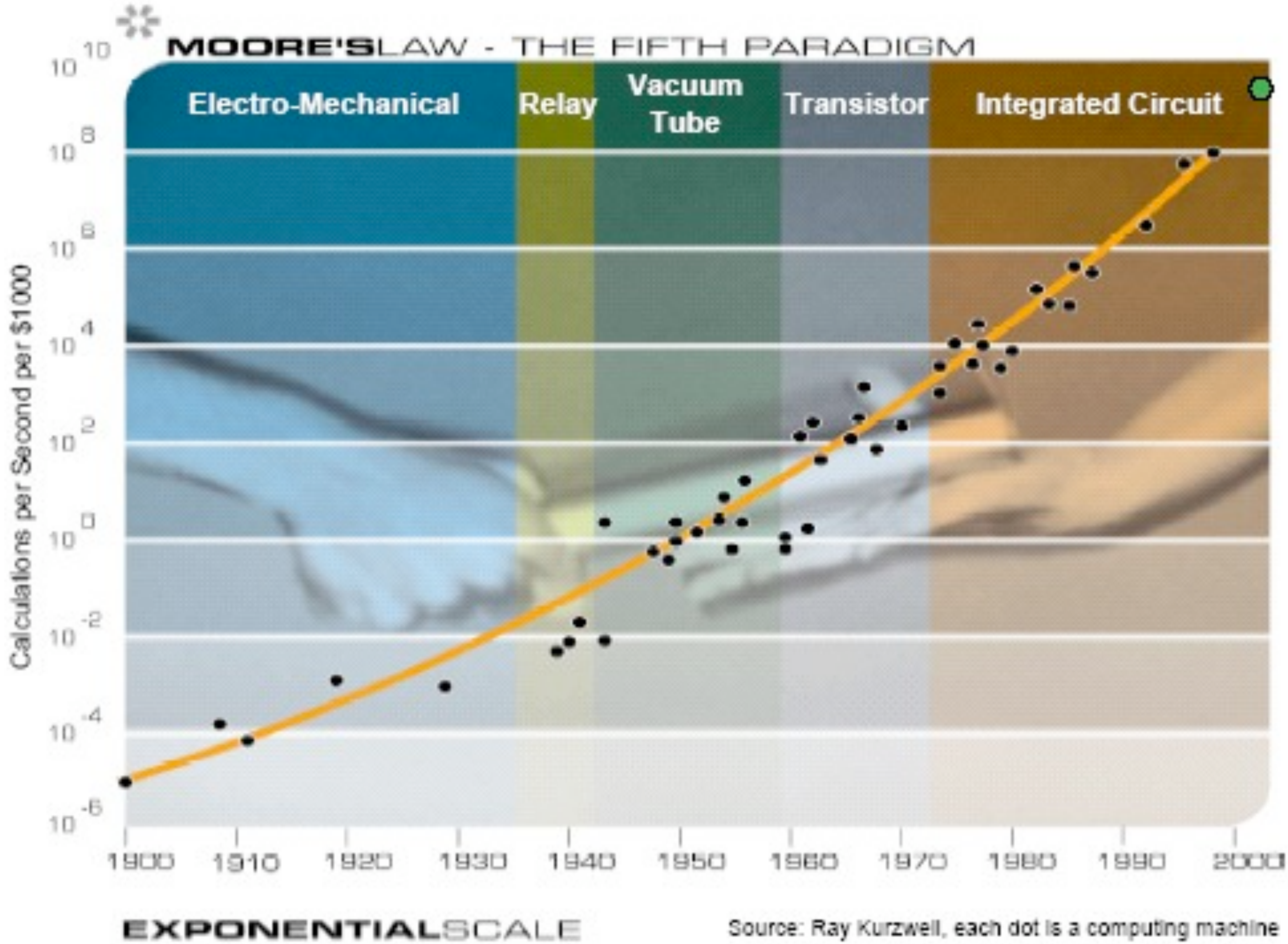
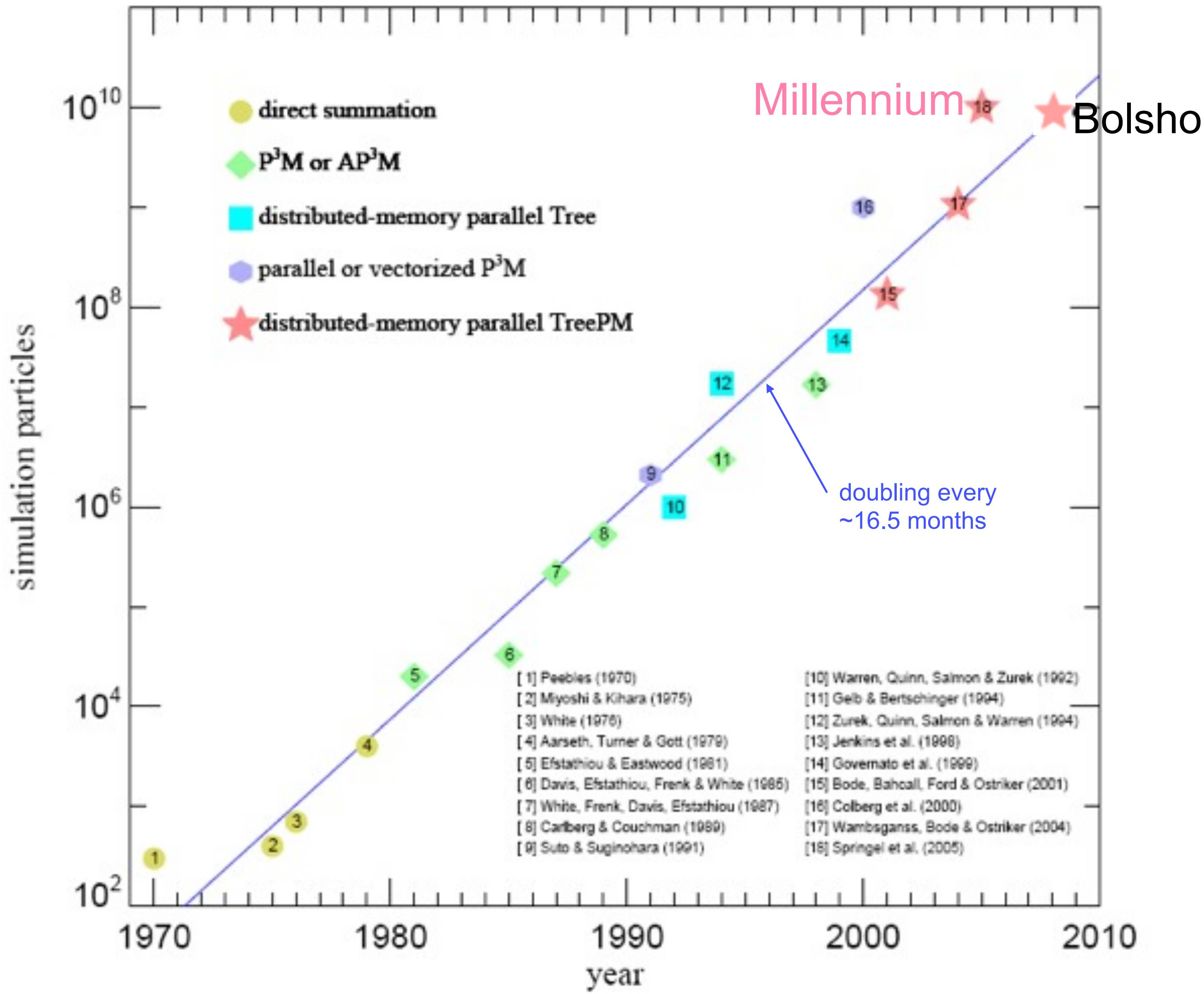


Figure 2. The increase of operating energy in particle accelerators. (Courtesy of M. S. Livingston.)




MOORE'S LAW - THE FIFTH PARADIGM
Electro-Mechanical
Relay
Vacuum Tube
Transistor
Integrated Circuit
Calculations per Second per $1000
10^{10}
10^{8}
10^{6}
10^{4}
10^{2}
10^{0}
10^{-2}
10^{-4}
10^{-6}
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
EXPONENTIAL SCALE
Source: Ray Kurzwell, each dot is a computing machine

Particle number in cosmological N-body simulations vs. pub date



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The element of discontinuity in the general experience of our time merely reinforces the discontinuities in the experiences of contemporary science. The rate at which events happen is again the important variable. For, when a field changes more and more rapidly, it reaches at some point a critical rate of activity beyond which one has to learn by oneself, not merely the important new ideas, but even the basic elements of one's daily work. This is now true of many parts of physics and of some other fields of science, not only for the most productive and ingenious persons, but for anyone who wishes to continue contributing. The recent past, the work of one or two generations ago, is not a guide to the future, but is prehistory.

Thus the representative physicist is far more his own constantly changing creation than ordinary persons have ever been. His sense of balance and direction cannot come from the traditional past. It has to come from a natural sure-footedness of his own—and from the organism of contemporary science of which he strongly feels himself a part. None of the novels or the representations in the mass media which I have seen have portrayed him with success, perhaps because they missed the fact that this is the component that really counts.

From Gerald Holton, "Models for Understanding the Growth of Research," originally published in Doedalus (Spring 1962), reprinted as Chapter 12 of Gerald Holton, *Thematic Origins of Scientific Thought: Kepler to Einstein* (Harvard U Press, 1973).

The Matthew Effect in Science

1968

Robert K. Merton, Science **159**, 56-63 (1968). Reprinted in Robert K. Merton, *The Sociology of Science: Theoretical and Empirical Investigations* (U Chicago Press, 1973). Available on the web at http://garfield.library.upenn.edu/merton/matthew1.pdf

The workings of this process at the expense of the young scientist and to the benefit of the famous one is remarkably summarized in the life history of a laureate in physics, who has experienced both phases at different times in his career. "When you're not recognized," he recalls,

> it's a little bit irritating to have somebody come along and figure out the obvious which you've also figured out, and everybody gives him credit just because he's a famous physicist or a famous man in his field.

Here he is viewing the case he reports from the perspective of one who had this happen to him before he had become famous. The conversation takes a new turn as he notes that his own position has greatly changed. Shifting from the perspective of his earlier days, when he felt victimized by the pattern, to the perspective of his present high status, he goes on to say:

> This often happens, and I'm probably getting credit now, if I don't watch myself, for things other people figured out. Because I'm notorious and when I say it, people say: "Well, he's the one that thought this out." Well, I may just be saying things that other people have thought out before.

In the end, then, a sort of rough-hewn justice has been done by the compounding of two compensating injustices. His earlier accomplishments have been underestimated; his later ones, overestimated.[17]

This complex pattern of the misallocation of credit for scientific work must quite evidently be described as "the Matthew effect," for, as will be remembered, the Gospel According to St. Matthew puts it this way:

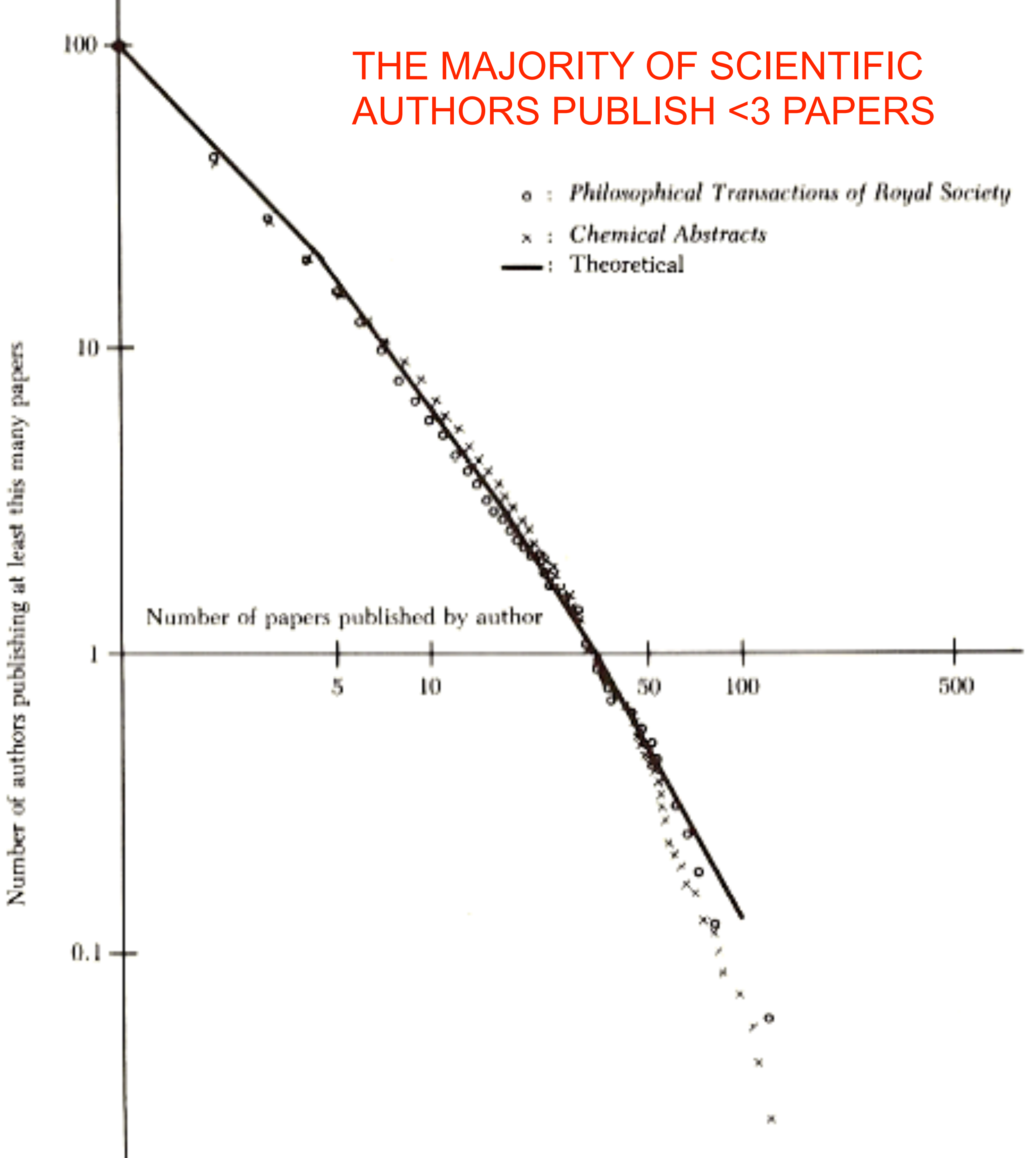
> For unto every one that hath shall be given, and he shall have abundance: but from him that hath not shall be taken away even that which he hath.

Put in less stately language, the Matthew effect consists of the accruing of greater increments of recognition for particular scientific contributions to scientists of considerable repute and the withholding of such recognition from scientists who have not yet made their mark. Nobel laureates provide presumptive evidence of the effect, since they testify to its occurrence, not as victims—which might make their testimony suspect—but as unwitting beneficiaries.

The Parable of the Talents from the Gospel of Matthew 25:14-30

[14]"Again, it will be like a man going on a journey, who called his servants and entrusted his
property to them. [15]To one he gave five talents of money, to another two talents, and to another
one talent, each according to his ability. Then he went on his journey. [16]The man who had
received the five talents went at once and put his money to work and gained five more. [17]So
also, the one with the two talents gained two more. [18]But the man who had received the one
talent went off, dug a hole in the ground and hid his master's money.
[19]"After a long time the master of those servants returned and settled accounts with them.
[20]The man who had received the five talents brought the other five. 'Master,' he said, 'you
entrusted me with five talents. See, I have gained five more.'
[21]"His master replied, 'Well done, good and faithful servant! You have been faithful with a few
things; I will put you in charge of many things. Come and share your master's happiness!'
[22]"The man with the two talents also came. 'Master,' he said, 'you entrusted me with two
talents; see, I have gained two more.'
[23]"His master replied, 'Well done, good and faithful servant! You have been faithful with a few
things; I will put you in charge of many things. Come and share your master's happiness!'
[24]"Then the man who had received the one talent came. 'Master,' he said, 'I knew that you are
a hard man, harvesting where you have not sown and gathering where you have not scattered
seed. [25]So I was afraid and went out and hid your talent in the ground. See, here is what
belongs to you.'
[26]"His master replied, 'You wicked, lazy servant! So you knew that I harvest where I have not
sown and gather where I have not scattered seed? [27]Well then, you should have put my money
on deposit with the bankers, so that when I returned I would have received it back with interest.
[28]" 'Take the talent from him and give it to the one who has the ten talents. [29]**For everyone
who has will be given more, and he will have an abundance. Whoever does not have,
even what he has will be taken from him.** [30]And throw that worthless servant outside, into the
darkness, where there will be weeping and gnashing of teeth.'

[Note: 1 talent ≈ $1000 today.]



Lotka's Law

The number N of authors publishing >n papers is roughly proportional to n^{-2}

Lotka, Alfred J., "The frequency distribution of scientific productivity". Journal of the Washington Academy of Sciences **16** (12): 317–324 (1926).

According to the article in Wikipedia on Lotka's Law, the ~2 power law index slightly differs in different fields. It has been found that Lotka's Law does not apply when papers with >100 authors are included.

Figure 2.2 in Derek J. de Solla Price, *Little Science, Big Science* (1963).

UCSC ranked first in nation for research impact in Physics

In a 2007 analysis of research publications from top U.S. universities, the University of California, Santa Cruz, ranked first for the impact of its faculty in the field of physics and fifth in the field of space sciences. These rankings were reported in *Science Watch*, a newsletter published by Thompson Scientific.

Citation impact is based on the number of times a published paper is cited by other researchers. These rankings are based on the citation impact of research papers published by the top 100 federally funded universities between 2001 and 2005.

UCSC has been highly ranked in similar surveys in the past. Past rankings for the campus, all based on citation impact data, include first among U.S. universities in space sciences (2003), second worldwide in physical sciences (2001), and first among U.S. universities in physics (2000). In 2008, *Science Watch* reported that UC Santa Cruz achieved the highest score for the number of citations per high-impact paper in molecular biology and genetics.

Physics ≥ 500 papers			
Rank	**Institution**	**# of Papers**	**Relative Impact (%)**
1	Univ. Calif., Santa Cruz	630	+225
2	University of Pennsylvania	1,244	+224
3	Univ. Calif., Irvine	1,091	+217
4	Harvard University	2,033	+203
5	University of Washington	1,645	+202
6	Boston University	1,151	+197
7	University of Minnesota	1,552	+184
8	Stanford University	2,807	+181
9	Columbia University	1,267	+173
10	Rice University	667	+169

The Science Impact of Astronomy PhD Granting Departments in the United States

A. L. Kinney, NASA/GSFC

Table 1: Impact Index of US Universities: Based on affiliation with University PhD Granting Departments for Astronomy PhD's.

Rank	University	N	h-index	h(m)	NRC Rank
1	Caltech	347	67	6.46	1
2	UC Santa Cruz	1096	106	6.45	6
3	Princeton University	194	51	6.20	2
4	Harvard University	757	87	6.14	4
5	Colorado	256	55	5.98	12
6	SUNY Stony Brook	209	50	5.90	26
7	JHU (4)	1112	97	5.87	NA
8	Penn State Univ	647	78	5.86	21
9	Univ Michigan	374	62	5.79	25
10	Univ Hawaii	995	89	5.63	11
11	Univ Wisconsin	544	70	5.63	14
12	UC Berkeley	1210	96	5.61	3
13	Michigan State Univ	196	45	5.45	NA
14	U Virginia	474	64	5.44	18
15	New Mexico State U	316	54	5.40	32
16	MIT	409	59	5.32	8
17	Yale University	359	56	5.32	15
18	University of Chicago	617	69	5.28	5
19	Stanford University	131	37	5.26	22
20	U Mass Amherst	297	51	5.22	20

Table 2: Impact Index based on University affiliation (includes Physics, Earth & Planetary Sciences, and Applied Mathematics).

Rank	University	N	h-index
1	Univ Calif Santa Cruz	1096	110
2	Princeton Univ	1220	104
3	Johns Hopkins Univ (1)	1587	107
4	Penn State Univ	828	82
5	SUNY Stony Brook	298	54
6	Univ Michigan	861	79
7	New Mexico State Univ	384	57
8	U Mass, Amherst	297	51
9	University of Virginia	586	67
10	Michigan State Univ	218	45
11	Yale University	470	61
12	Univ Hawaii	1259	90
13	Univ Wisconsin	918	78
14	University of Chicago	1103	83
15	Ohio State Univ	846	74
16	UC Berkeley	2504	114
17	Harvard	3510	126
18	Univ Minnesota	504	58
19	MIT	1248	83
20	Caltech	4113	107

http://arxiv.org/ftp/arxiv/papers/0811/0811.0311.pdf

Physics as a Profession

Joel Primack

Physics occupations include Public Interest Science

How scientific fields grow and stagnate

Working on frontier vs. developed fields

The PhD is a research degree

Patterns of physics careers
– importance of ~10 yr post-PhD

U.S. and International Science Budgets and Indicators

The PhD is a research degree

Graduate students should start research as soon as possible. Ask faculty members about research opportunities both now and starting in summer 2010. Start thinking about affiliating with a research group. Finish a research project and Advance to Candidacy for the PhD by the end of your 3rd year, if possible. Finish your PhD within 3 years after that.

Patterns of physics careers – importance of ~10 yr post-PhD

In science, medicine, law, and even business, during the first decade or so after finishing your advanced degree you are expected to make major progress rapidly. These are also the prime child-bearing years. You can relax somewhat during your graduate studies, but to succeed in a scientific career you must hit the ground running when you get your PhD. You should also finish at least one major paper that's not a continuation of your dissertation during the first year after the PhD.

Nobel Laureates Urge Institutions To Help More Women Reach Top Positions

The AP (12/7/09) reports that Elizabeth H. Blackburn and Carol W. Greider, the two female winners of the 2009 Nobel Prize in medicine urged scientific institutions to change their career structures to help more women reach top positions. Blackburn said, "The career structure is very much a career structure that has worked for men," and "many women, at the stage when they have done their training really want to think about family ... and they just are very daunted by the career structure. Not by the science, in which they are doing really well." Blackburn added that "a more flexible approach to part-time research and career breaks would help women continue to advance their careers during their childbearing years," while Greider said "she especially wants to see measures to get more women onto committees and decision-making positions."

UCSC hosted the 2010 **Undergraduate Women in Physics Conference** on the UCSC campus. About 100 undergraduate women from western states visited.

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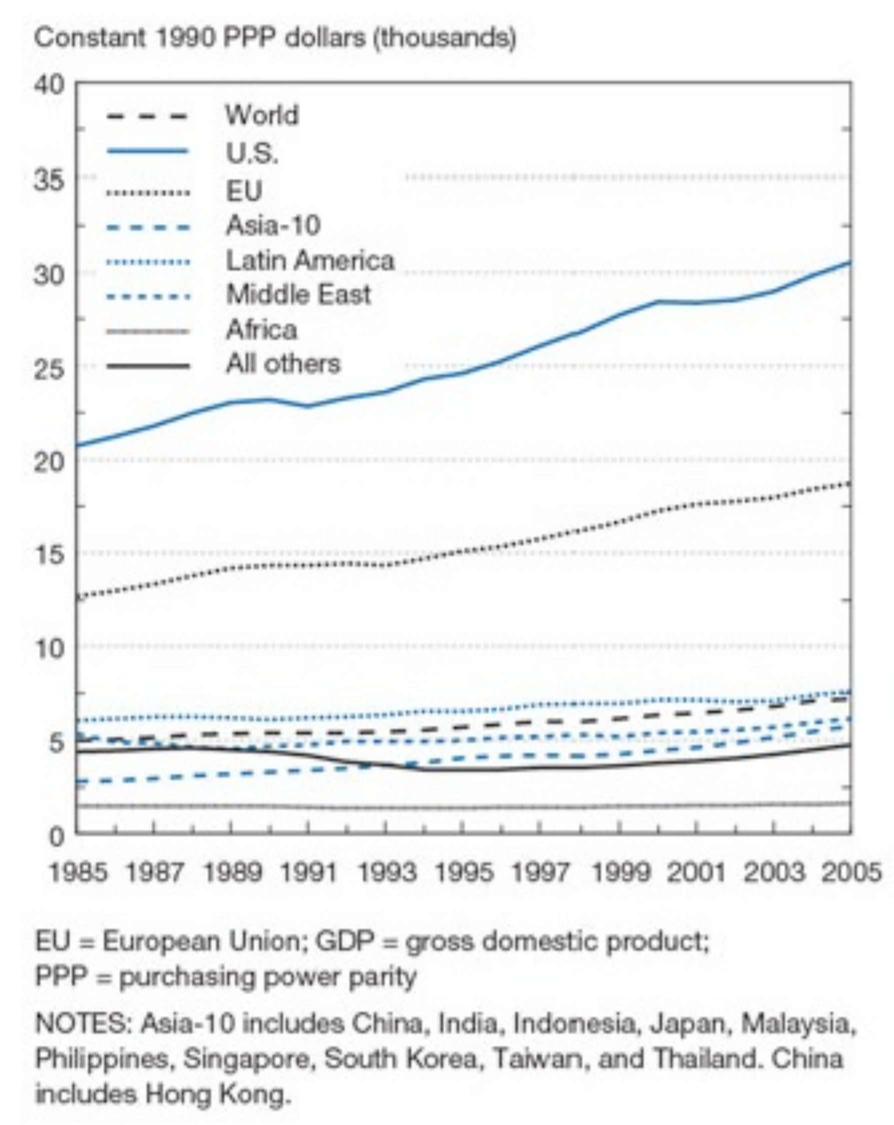
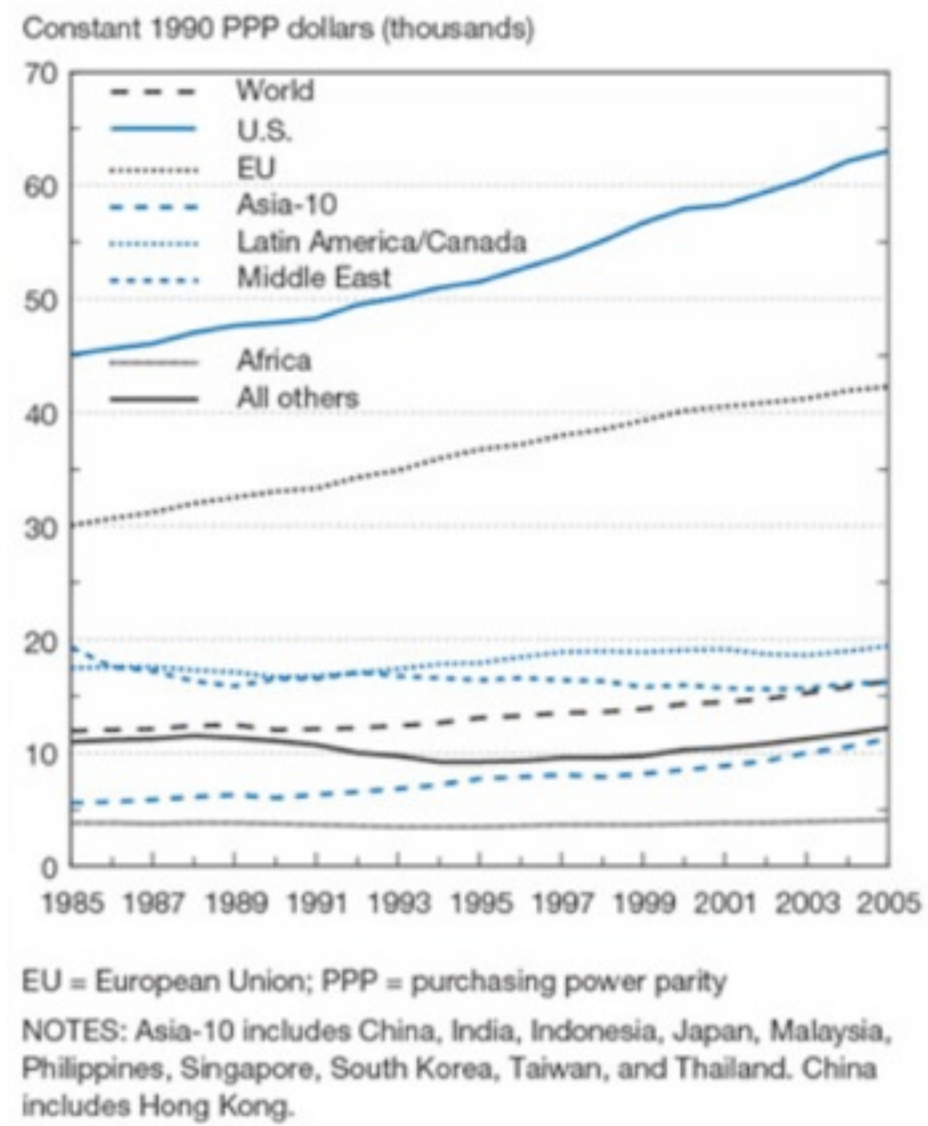
U.S. and International Science Budgets and Indicators

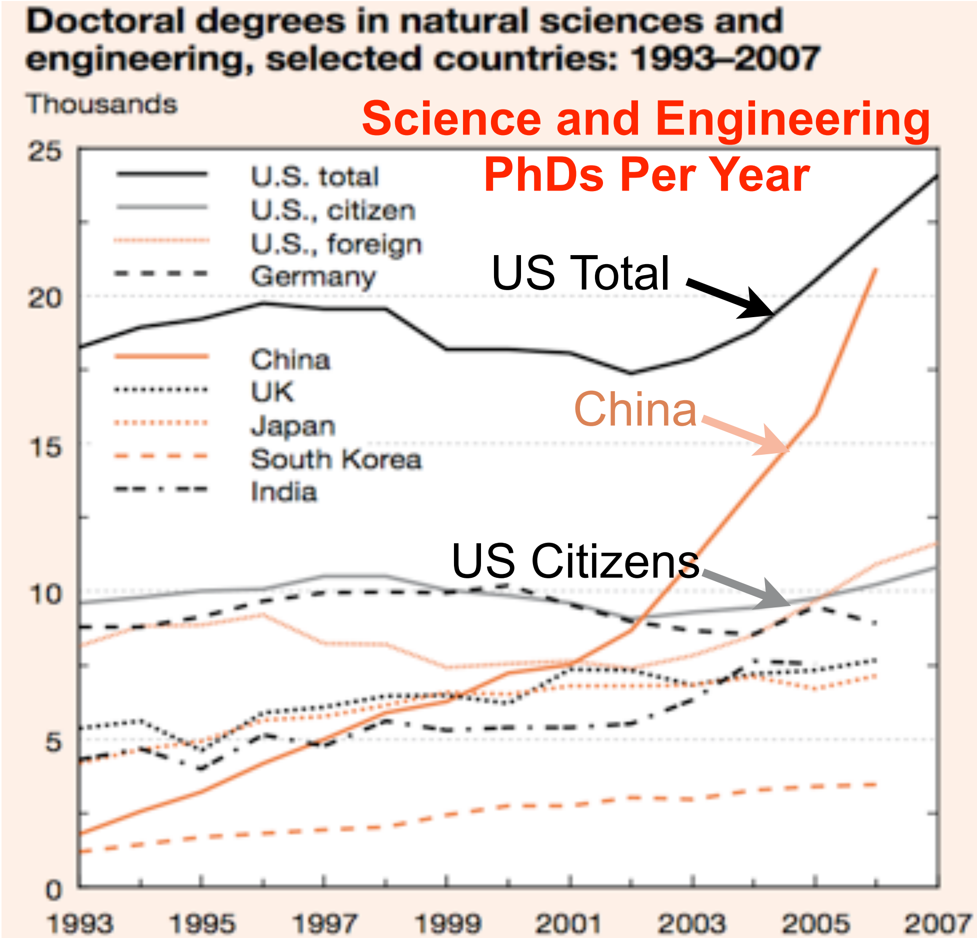
Per Capita GDP by Country/Region

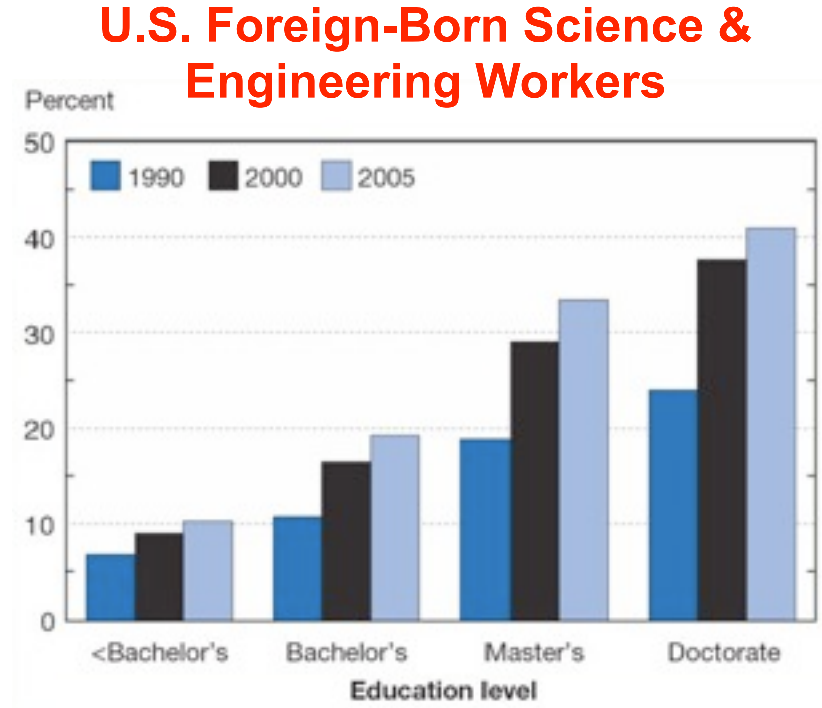


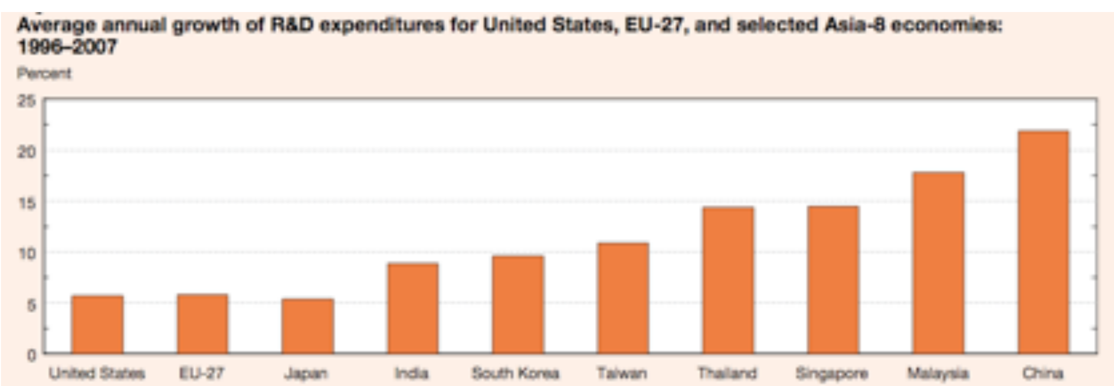
Per Capita Employee Productivity

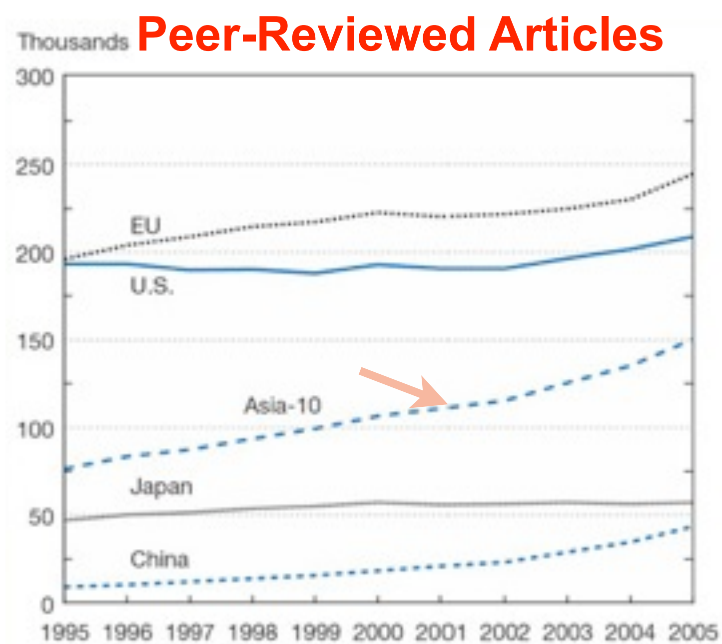


NSB Science and Engineering Indicators 2008 and 2010

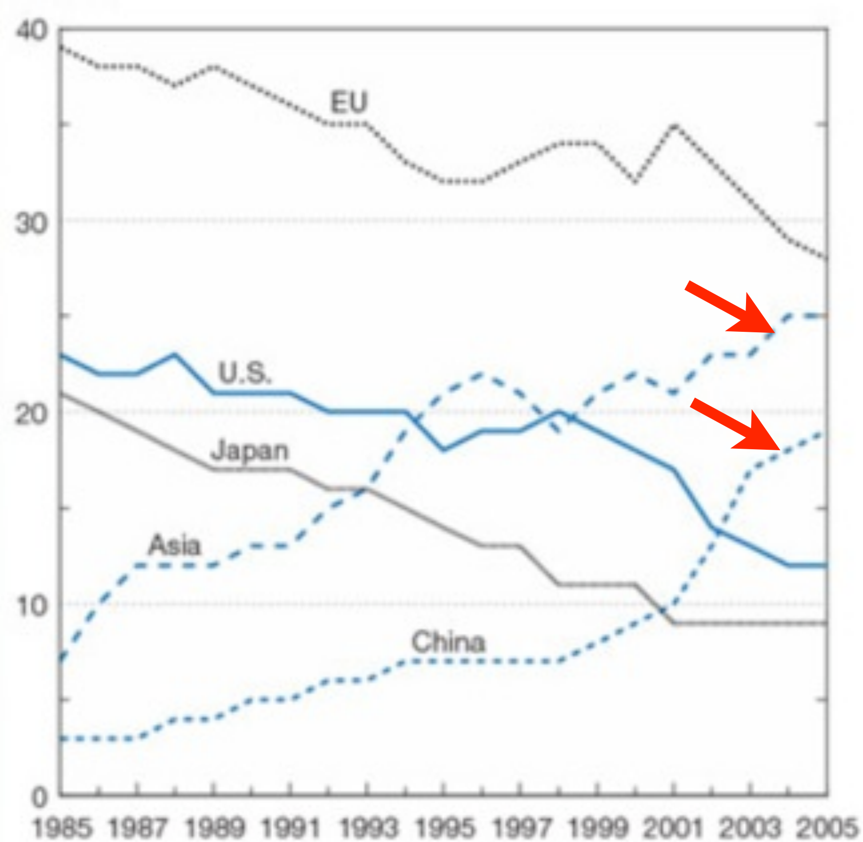

Doctoral degrees in natural sciences and engineering, selected countries: 1993–2007
Thousands
Science and Engineering PhDs Per Year
U.S. total
U.S., citizen
U.S., foreign
Germany
China
UK
Japan
South Korea
India
US Total
China
US Citizens
25
20
15
10
5
0
1993
1995
1997
1999
2001
2003
2005
2007

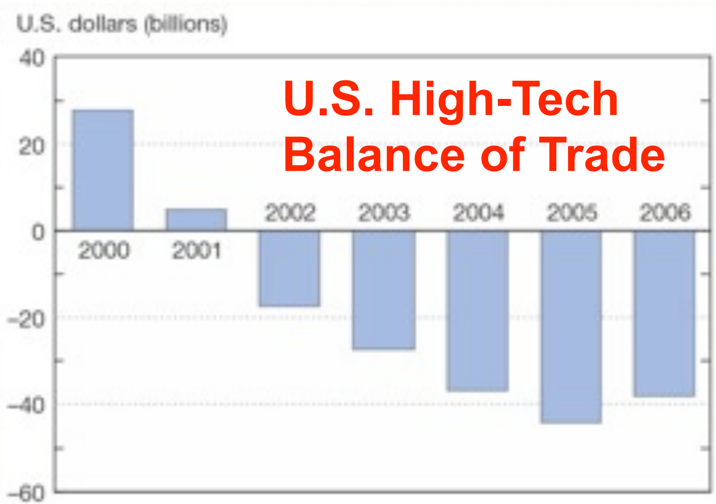

U.S. Foreign-Born Science & Engineering Workers
Percent
1990
2000
2005
50
40
30
20
10
0
<Bachelor's
Bachelor's
Master's
Doctorate
Education level


Average annual growth of R&D expenditures for United States, EU-27, and selected Asia-8 economies: 1996–2007
Percent
25
20
15
10
5
0
United States
EU-27
Japan
India
South Korea
Taiwan
Thailand
Singapore
Malaysia
China

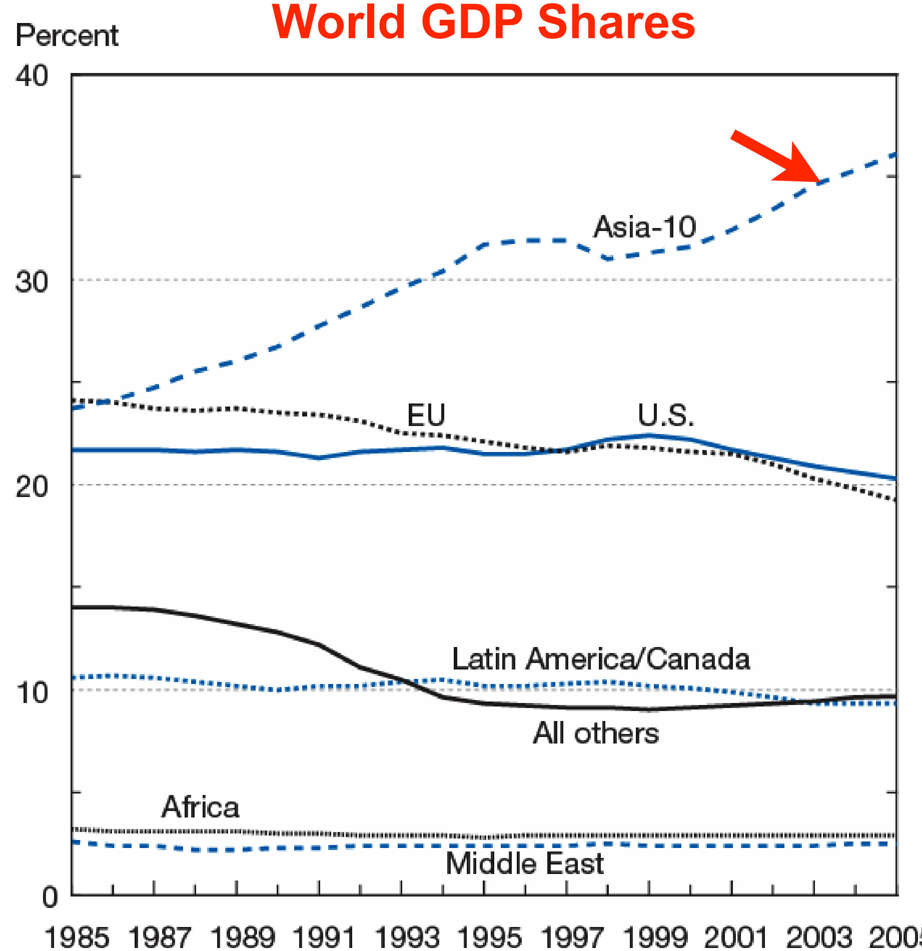

Thousands
Peer-Reviewed Articles
300
250
200
150
100
50
0
EU
U.S.
Asia-10
Japan
China
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005

World High-Tech Exports





World GDP Shares



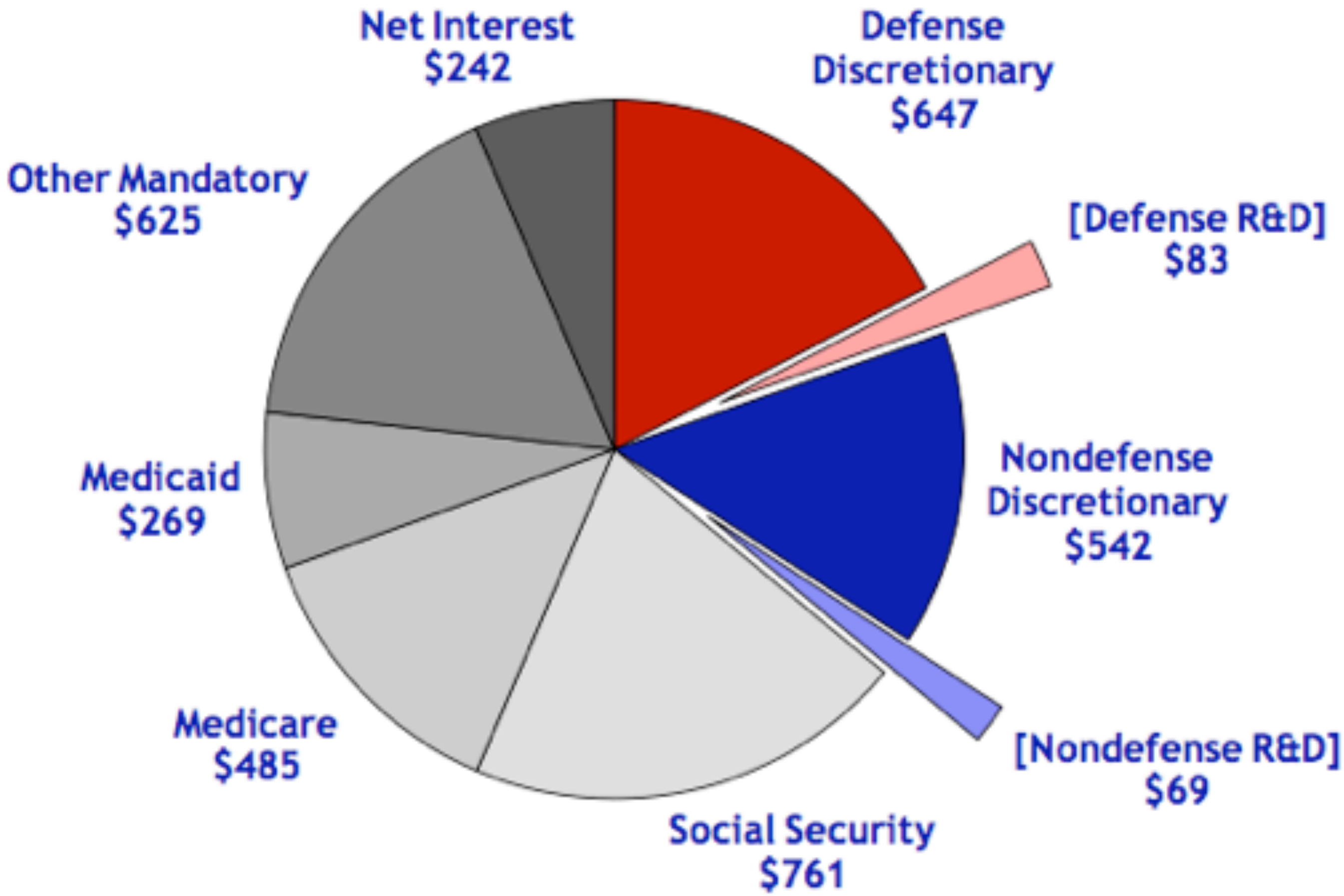
EU = European Union; GDP = gross domestic product

NOTES: Asia-10 includes China, India, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand. China includes Hong Kong.

NSB Science and Engineering Indicators 2008

Composition of the Proposed FY 2012 Budget
Total Outlays = $3.7 trillion

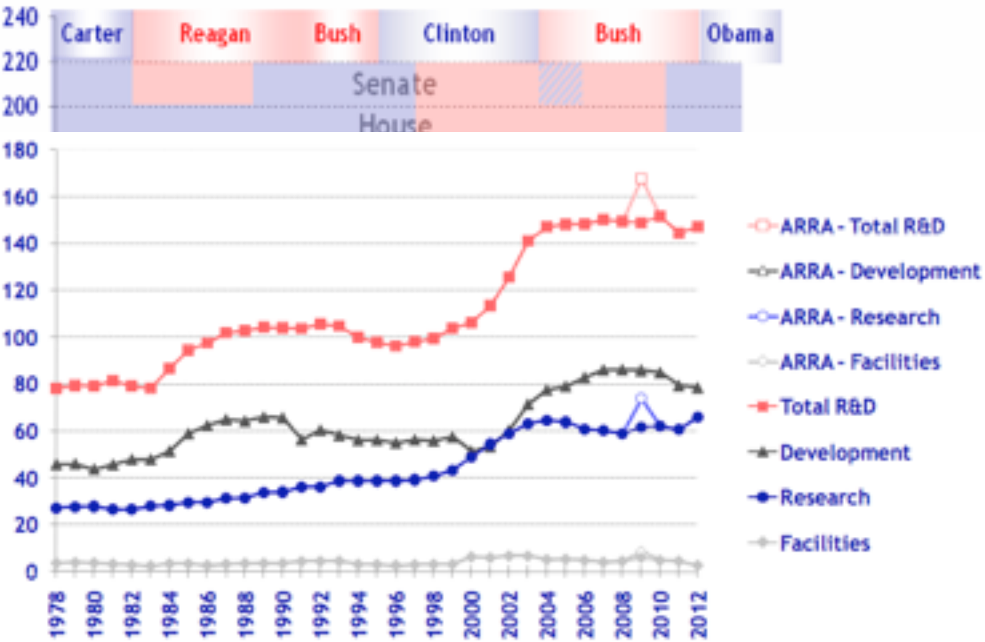
outlays in billions of dollars



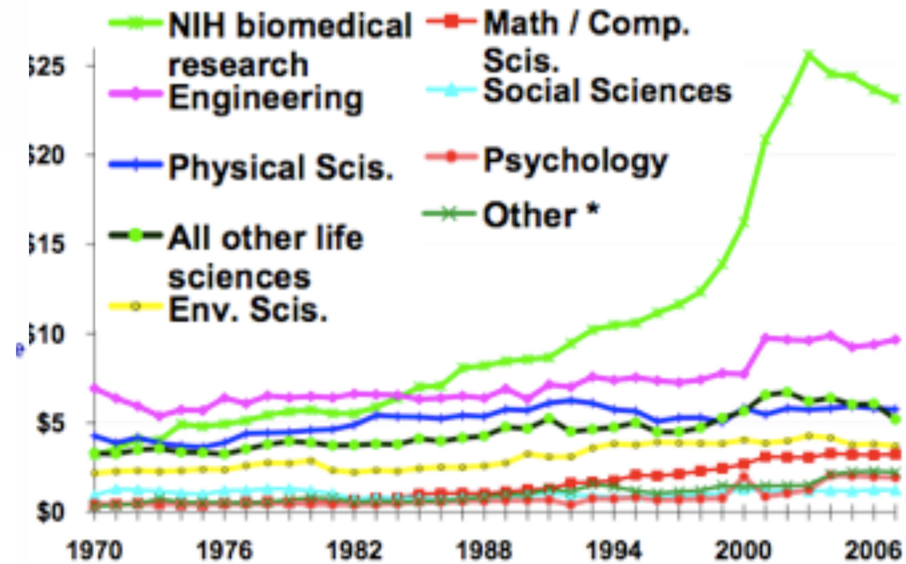
Source: *Budget of the United States Government FY 2012.*
Projected unified deficit is $1.1 trillion.

Trends in Federal R&D

in billions of constant FY 2010 dollars

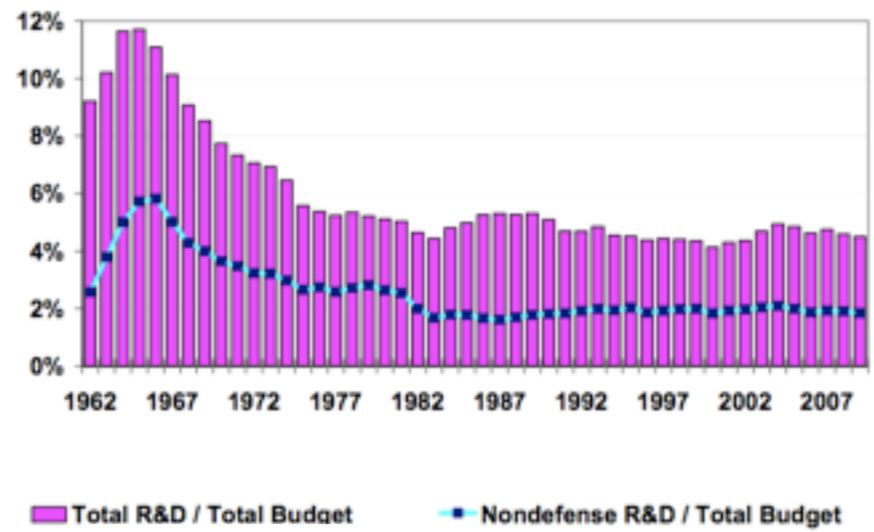


U.S. Budgets for Science & Engineering by Discipline



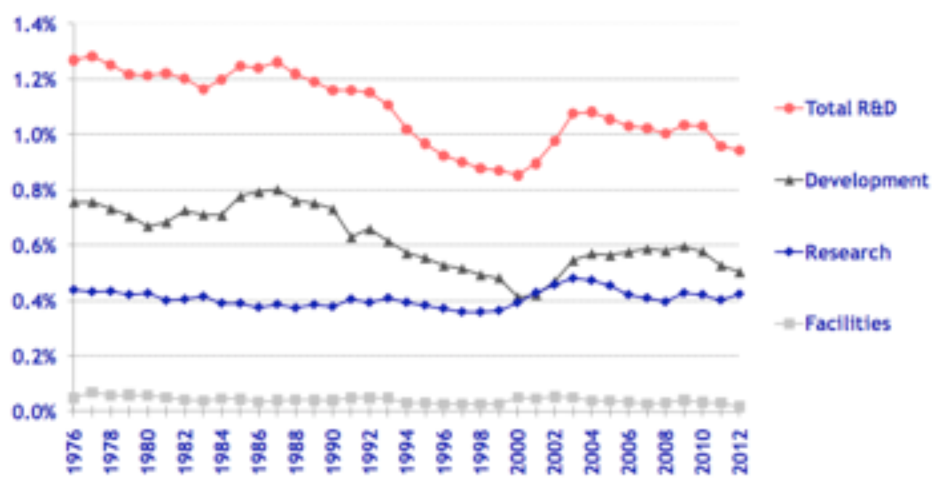
R&D as Percent of the Federal Budget:

FY 1962-2009, in outlays



Trends in Federal R&D

percent of GDP

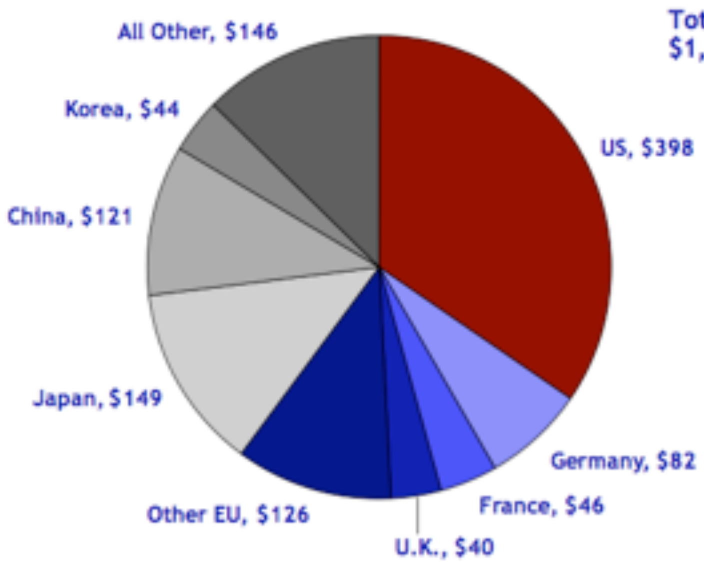


AAAS 2008-2012

Total World R&D, 2008

in billions of PPP $

Total World R&D = $1,151 billion



The United States leads the world in R&D investment

$369b PPP, 35.7% of world R&D investment

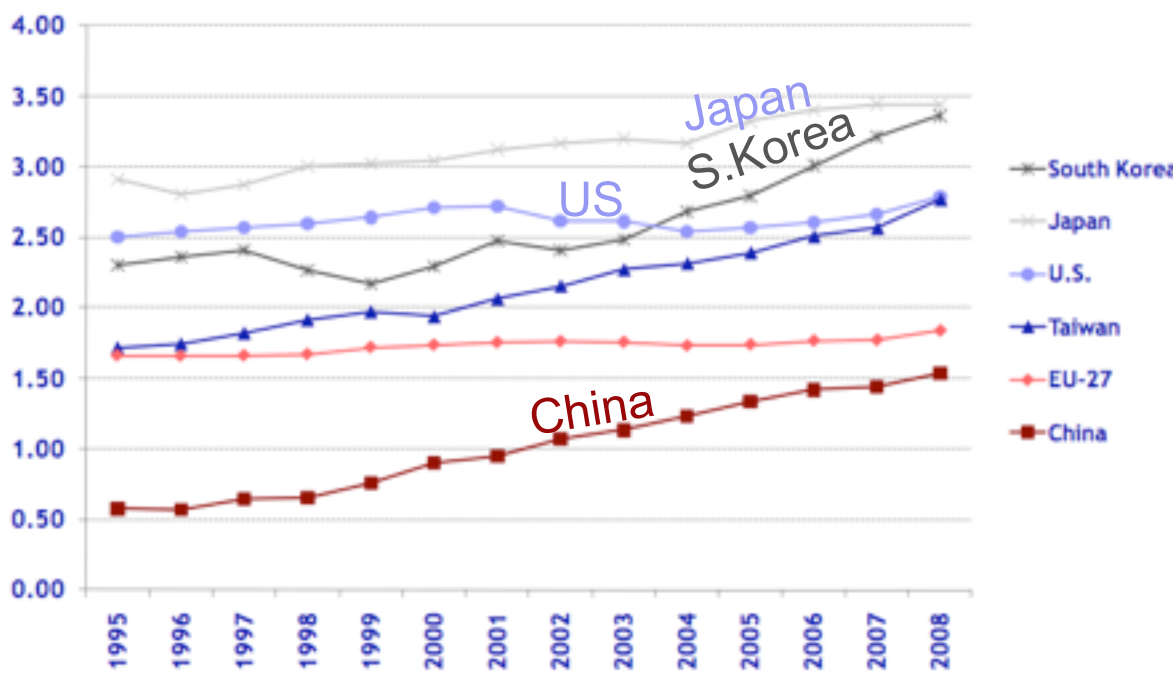
But, others are quickly increasing their investment

- In the decade from 1997 to 2007,
  - South Korea, +0.99% of GDP to 3.47%
  - China, +0.85% of GDP to 1.49%
  - Taiwan, +0.81% of GDP to 2.63%
  - Japan, +0.57% of GDP to 3.44%
  - United States, +0.10% of GDP to 2.68%

President Obama set goal of 3.0% of GDP investment in R&D

National R&D Investment

percent of GDP



http://www.aaas.org/spp/rd/

Physics as a Profession?

It's a great time to be a physicist!

There are now terrific research opportunities in many areas of physics, including astrophysics, particle physics, and condensed matter physics.

Solving many of the world's biggest problems -- energy, climate, environment, defense -- will involve physics.

There will be good employment opportunities as the need for physicists grows and as the current generation of senior physicists retires.

The Obama administration has two superb physicists at Cabinet meetings: Science Advisor John Holdren and Energy Secretary Steve Chu.

On Being a Scientist: Third Edition

Committee on Science, Engineering, and Public Policy, National Academy of Sciences, National Academy of Engineering, and Institute of Medicine

ISBN: 0-309-11971-5, 82 pages, 6 x 9, (2009)

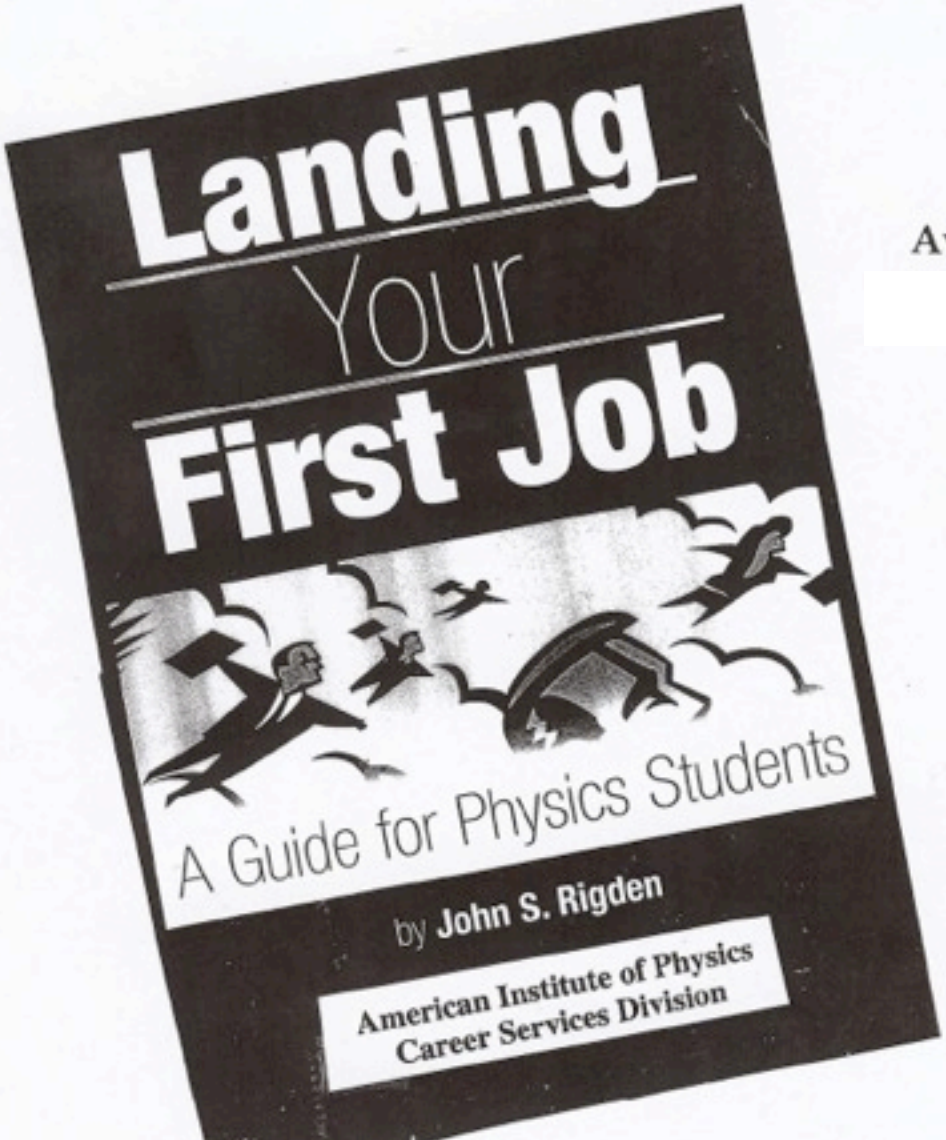
Non-Academic Career Opportunities

Bruce Rosenblum

Preface

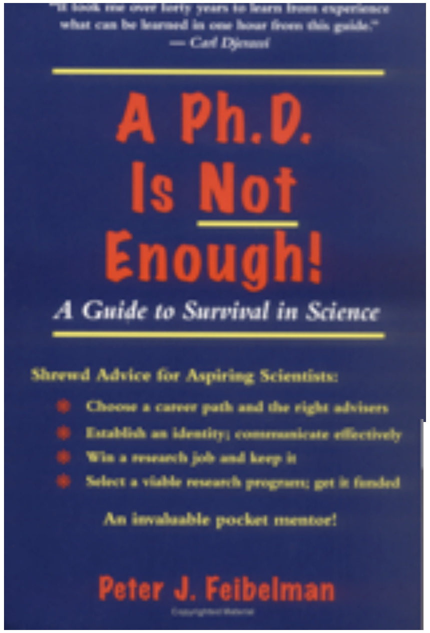
Where do physics students go for help and advice when they anticipate starting a job hunt? Most likely, you would go to your physics professor. However, most academic physicists begin their employment on a campus and they end it on a campus; therefore, they may have little or no experience in industry or government which is where the great majority of physicists work. So your physics professors may be unable to provide the detailed advice and the focused guidance that students need as they plan their job search. You could go to your campus career center. And you should. The career center staff can be very helpful. In addition, read this short book. This book, *Landing Your First Job*, was written to guide students who are looking ahead to seek employment. It is a practical book that identifies the important steps to the first job.

Freshmen, sophomores, and first-year graduate students: start now to plan your job search.

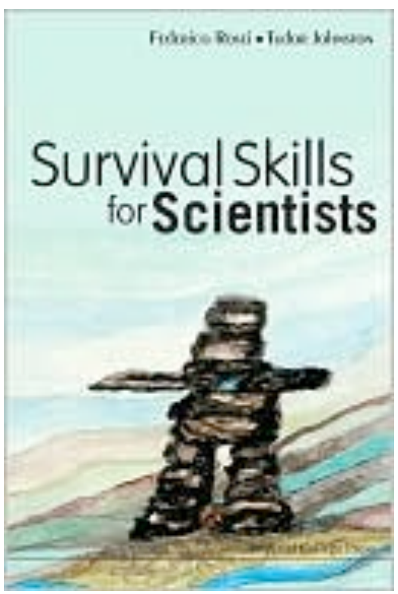


Available for loan.
in Physics Office

Additional highly recommended books for young scientists



Contents



Contents

Basic Choices

In UCSC S&E Library

Sections of this Chapter

1.1 "Know thyself" so you can set realizable goals
1.2 Match your goals to your character and talents
1.3 Work style choices: Lone wolf, collaborator, team player, team leader?
1.4 Choices in work climate
1.5 A basic style choice: Experimentalist or theoretician?

1.1 "Know thyself" so you can set realizable goals

Make the effort to "Know thyself" so that your goals are realistic and will indeed satisfy you when you attain them. What should be your career goals as a scientist? This should include not just what you would like to achieve as a scientist, but how to advance in your career so as to have the means to do what you want. Asking yourself this question openly, critically and realistically at each stage of your career (preferably well before the next stage is to begin) is extremely important. It may save you from a lot of trouble and frustration, later on. Of course you should not forget to ask yourself this basic question from time to time later in your development as a scientist (say every few months at least), and not