

Title: Science as an ethical community

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Abstract: I develop the idea that science works because scientists form communities defined by a set of ethical principles which, even if imperfectly applied, tend to lead to progress in our understanding of nature. While these communities have long been international, the combination of the internet with cheap airfare and easy migration of educated people makes scientists into 'global souls', in Pico Iyer's phrase. This opens up new opportunities and also new challenges for the thriving of scientific communities.

## *Science as an ethical community*

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PI Sept. 08

- 1) Approaches to demarcating science
- 2) Science as an ethical community
- 3) Science as an imaginative, pluralistic community
- 4) Present issues for the health of science
- 5) Does Science 2.0 help or hinder science?

thanks

concerns

dreams



# How does science work?

- Logical positivism: The meaning of a sentence is the instructions to *verify* it.
- Popper: Statements cannot be verified. They can be *falsified*.
- Kuhn: The structure of scientific revolutions
  - Normal science vrs revolutionary science
  - But how does one tell which is which?
- Feyerabend: There is no scientific method.
  - Scientists are opportunists
  - Name any rule. A great scientist broke it (and had to break it to make progress.)

## So how does science *really* work?

- There is no scientific method.
- Both the scientific and the democratic processes require reasoning from shared, but incomplete, evidence to limited, but ever expanding, consensus.
- How can this work?

## **Science works because scientists are members of *ethical communities***

We argue in good faith from shared evidence to shared conclusions.

We honestly report the results of our investigations.

The community teaches mastery over crafts evolved to detect and root out error in arguing from shared evidence.

Membership is open to all who master a relevant craft

## ***Ethical principles underlying science:***

1. If an issue can be decided by people of good faith, applying rational argument to publicly available evidence, then it must be regarded as so decided.
2. If, on the other hand, rational argument from the publicly available evidence does not succeed in bringing people of good faith to agreement on an issue, the community must allow and even encourage people to draw diverse conclusions.

***Entry to the community is based on two criteria:***

1. The mastery at least one of the crafts of a scientific subfield to the point where you can reliably detect the errors in your own work and independently produce work judged by other members to be of high quality and reliability.
2. Allegiance and continued adherence to the shared ethic.



## ***The two principles require us to do certain things***

- We agree to argue rationally, and in good faith, from shared evidence, to whatever degree of shared conclusions are warranted.
- Each individual scientist is free to develop his or her own conclusions from the evidence and to put them forward for the consideration of the whole community. These arguments must be rational and based on evidence available to all members. The evidence, the means by which the evidence was obtained, and the logic of the arguments used to deduce conclusions from the evidence must be shared and open to examination by all members.
- Each scientist is also free to criticize the claims of other scientists, but these likewise must be based on evidence and reflect tolerance for diverse views on undecided questions.

Three key conclusions:

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- **Accreditation** is necessary to the workings of a scientific community. Vast experience has shown that without a Ph.D from a reputable research department or group (or in very rare cases i.e. Freeman Dyson, the equivalent), someone cannot make useful contributions to a scientific community. Scientific communities function well only because discussions among experts are restricted to those with a Ph.D or at least those far along in a Ph.D program. Since these discussions are what defines scientific process this is essential and not incidental.

Three key conclusions:

- **Reputation** is essential to a scientist's participation in their community. Risk to reputation is a major constraint that disciplines members to be careful about their claims, positive and critical.

Like everything else, reputation is governed by the two principles. So we all accord high reputations to those whose claims have become part of the consensus and we agree to disagree about the reputations of those whose claims have not so far.

- Key aspects of reputation include also issues such as fairness, breadth of knowledge, reliability of their reference letters, and ability to pick out and mentor young scientists, etc.

Three key conclusions:

- **Authorship** is hence necessary so that each time a scientist makes a contribution they put their reputation at risk.

***Anonymous contributions and criticisms have no place in a scientific community.***

- Each member must use their own best judgments and do their utmost to argue for their own reading of the evidence.
- Each also recognizes that the ultimate judge of the correctness and interest of their work is what their students learn.
- Authority and status have no role.
- We agree that questions on which consensus has not been achieved are open and competing approaches are encouraged.
- While orthodoxies may become established temporarily in a given subfield, the community recognizes that contrary opinions and research programs are necessary for the community's continued health.

## Conclusions:

Disagreement over issues not forced by experiment is good for science, as is competition between research programs.

Premature consensus, ie before forced by experiment, is bad for the progress of science. Even if a research program has no competitors, if it has not been confirmed by experiment, for its own health as well as the health of the field there should be limits on its growth, and strong incentives for the invention of alternatives.

Where there are competing research programs, resources should be distributed so as to encourage the weaker and increase competition.

Funding and hiring should be done in such a way that young scientists have no incentives to work on existing research programs rather than invent their own. Thus funding should go preferentially directly to those who do the work rather than to senior scientists to hire assistants

Hypothesis: Those countries where the ethical principles are best followed have the largest proportion of leading scientists to investment.

Hypothesis: This explains the success of the UK and Holland in their large number of leading scientists per dollar invested.



***But religious orders and law societies are also ethical societies.***

***What makes science different?***

***First, the ethical principles, but there is more:***

## Scientific communities are also *imaginative* communities

- A community that is oriented to the future and open to novel ideas and practices.
- That incorporates structures and practices that allow members to imagine novel solutions to problems and to experiment with their adoption.
- That can continually evolve, in response both to ever-changing circumstances and the deepening of our ideas about society,
- A community that can evolve without violence or revolution.

# Scientific communities are pluralistic

- We are members of a growing community of “Global Souls” in Pico Iyer’s formulation.
- You are a global soul if you:
  - were educated or are working in a country different from that of your birth
  - have a partner or spouse from a different country.
  - Spend more time on airplanes and in airports than you do with your parents and siblings.

# Concerns for the progress of science

Given the characterization of science as a community that is ethical, imaginative and global, how are decisions to be made?

Are the universities the best places for supporting science?

Universities were constructed on a model of monasteries, which were designed to preserve old knowledge. Are they the best way to organize an institution to incubate new knowledge?

What are the best ways, inside the universities or out, of making the key decisions of who to hire, who to promote and whose work to fund?

Issues for the functioning of scientific communities:

Distributions of resources:

- Promoting competition between approaches

- Young versus old

- Incremental versus high risk/high payoff

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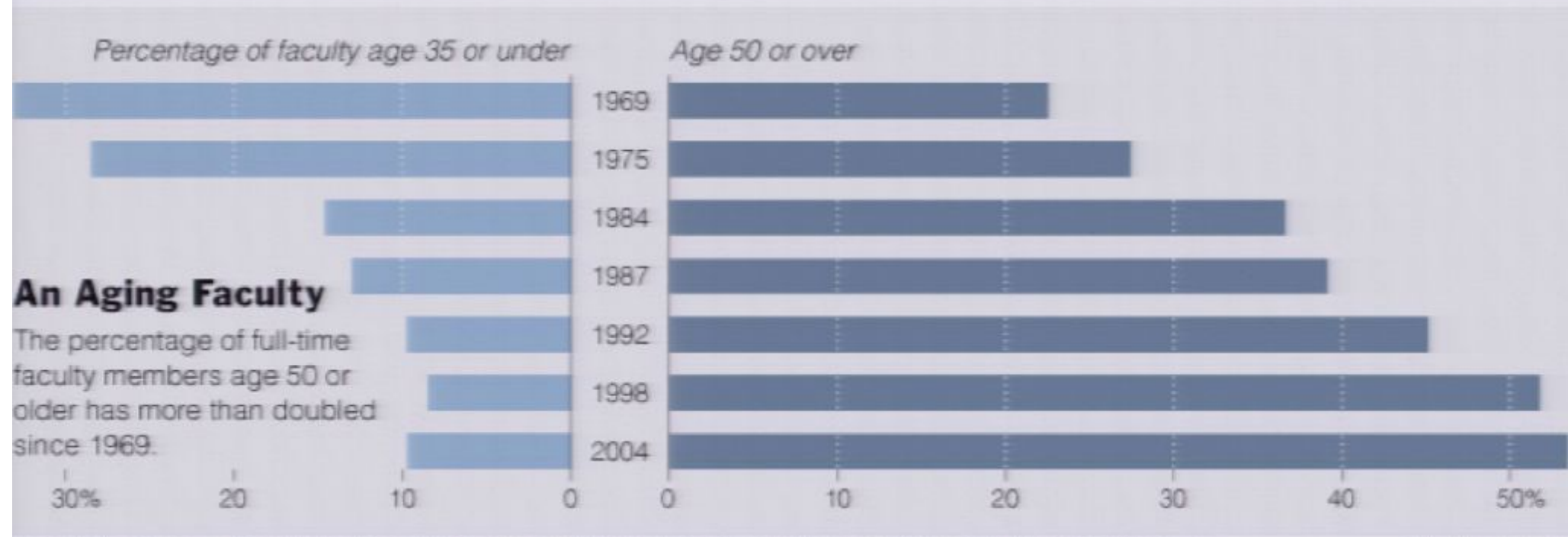
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How does science 2.0 help or impede the functioning of the scientific community?



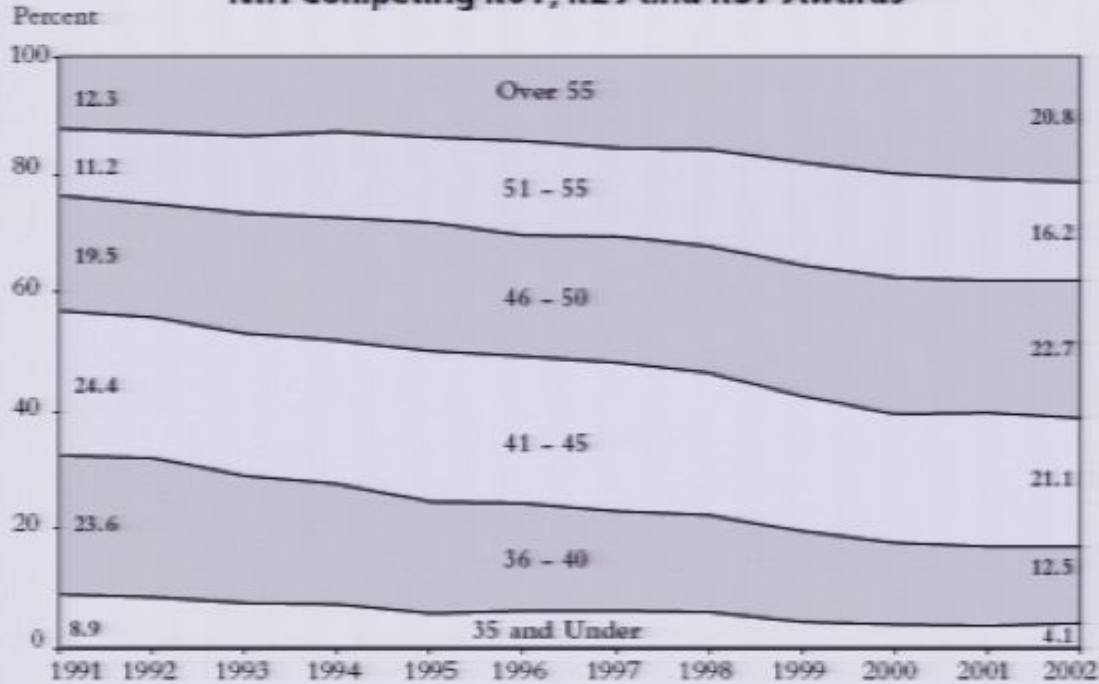
A key issue at present is the domination of resources by older scientists and the squeezing out of the young.



Sources: "The American Faculty" by Jack H. Schuster and Martin J. Finkelstein; National Center for Education Statistics

THE NEW YORK TIMES

**Age Distribution of Principal Investigators  
NIH Competing R01, R29 and R37 Awards**



Data courtesy of National Institutes of Health.

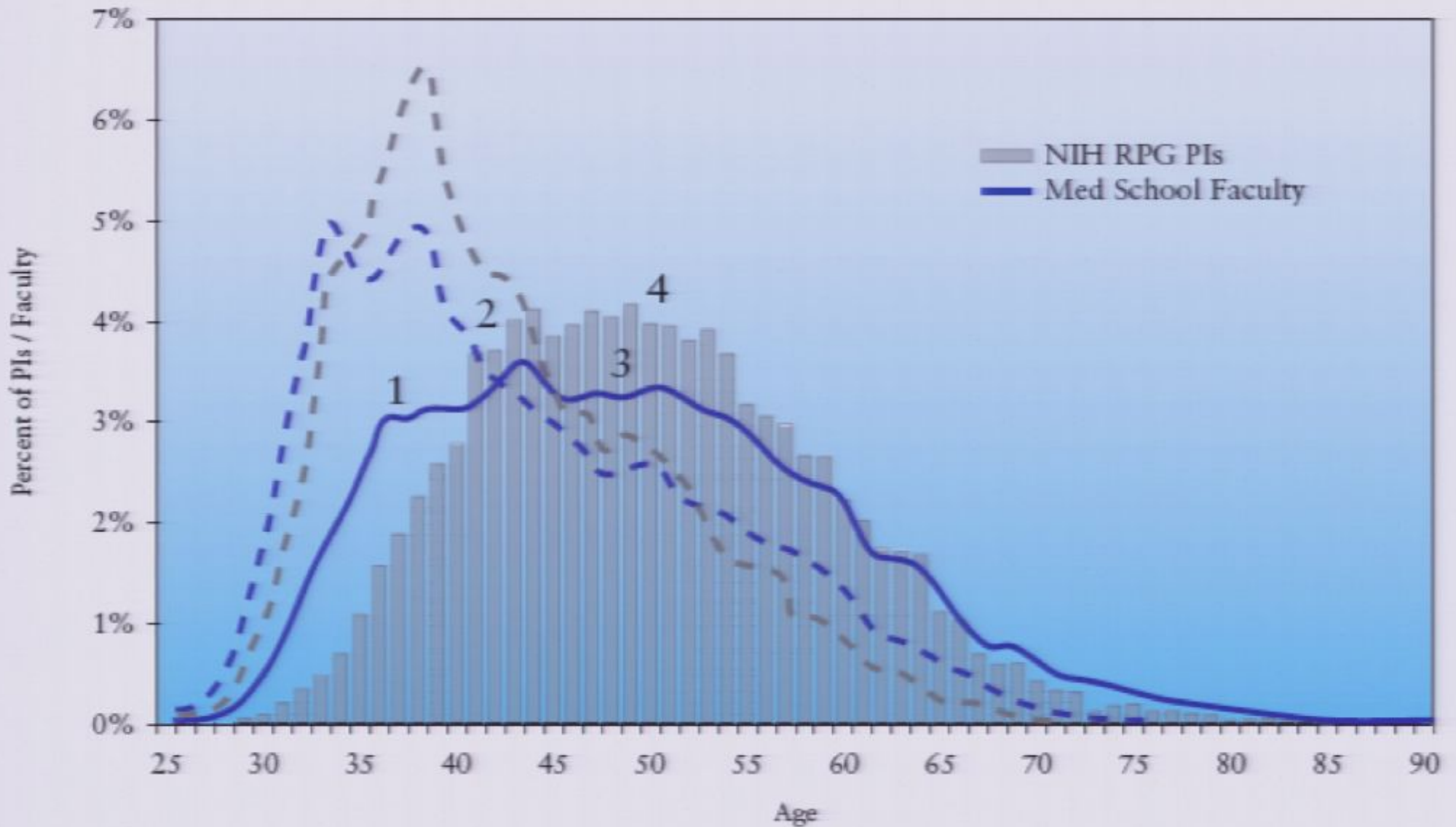
- Fraction of NIH PI's under 40: 1/3 in 1991 down to 1/6 in 2006
- Average age of first grant recipient at NIH: 39 in 1998 up to 42.4 in 2006
- Average years Ph.D to first NSF grant: 8.5 in 1990 up to 9.3 in 2006
- Success rate for first time NSF application: 22% in 2000 down to 15% in 2006
- Success rate for first NIH applications: 86% in 1980 down to 28% in 2007

TABLE 1-1

## Demographic Changes in Medical School Faculty and NIH Principal Investigator Pools from 1980 to 2006

	1980	1998	2006
Number and Average Age of NIH PI	14,887 39.1	17,761 42.7	25,419 50.8
Number and Average Age of NIH New PI	1,843 37.2	1,355 39.0	1,346 42.4
Number of Medical School Faculty Positions	53,552	73,413	121,468
Average Age of Medical School Faculty	43.1	45.2	48.7
Average Age of First-Time Assistant Professors	33.9	35.4	37.7

An aging medical school faculty from 1980 to 2006 is reflected in NIH principal investigators pool. The average age of first assistant professorship is 37.7, and the average age of first NIH award is 42.4. SOURCE: Presentation to the American Academy of Arts and Sciences's Committee by Norka Ruiz Bravo, NIH Deputy Director for Extramural Research, National Institutes of Health, September 21, 2007.



The age distribution of NIH-funded principal investigators (represented by gray bars and line) closely models that of medical school faculty (represented by the dark blue lines). In addition, there has been a dramatic shift to older ages for both the NIH principal investigators and medical school faculty from 1980 (represented by the dashed gray and dark blue lines, respectively) to 2006 (represented by the gray bar graph and solid dark blue line). In 2006 the average of NIH-funded principal investigators was 50.9 (4) years old, similar to the average of medical school faculty, 49.7 (3). For the comparison period, the average age of NIH-funded principal investigators was 38.1 (1) years old, and the average age of medical school faculty was 35.0 (2) years old.

- The average time since degree for first-time principal investigators at NSF also increased between 1990 and 2006. In 1990, it was 8.5 years, and it increased to 9.3 in 2006 (Table 1-3). In 2006, the average age of doctorate recipients in the life sciences, physical sciences, and engineering was 30 to 31 (NSF 2006). Put these two numbers together and the average newly minted doctorate will not receive her or his first NSF award until age 39 to 40, with the median age 37 to 38.
- While funding rates at NSF have decreased for all investigators, the funding rate for new investigators is significantly below that of previously funded investigators. Overall, funding rates decreased from 30 percent in 2000 to 21 percent in 2006. Funding rates for new investigators decreased from 22 percent to 15 percent during that period. The funding rates for established investigators fell from 36 percent in 2000 to 26 percent in 2006 (NSF 2007b).

*Is it possible that some of the interest in science 2.0, in alternative ways of organizing and communicating science, is fueled by the fact that many talented young people, who 20 years ago would have been fast tracked to funding and positions, feel squeezed and frustrated by the difficulties of obtaining funding and positions?*

Briefly, we have developed an incentive system for young scientists that is much too risk averse. In many ways, we are our own worst enemies. The study sections that we establish to review requests for grant funds are composed of peers who claim that they admire scientific risk-taking, but who generally invest in safe science when allocating resources. The damping effect on innovation is enormous, because our research universities look for assistant professors who can be assured of grant funding when they select new faculty appointments. This helps to explain why so many of our best young people are doing “me too” science, working in areas where they compete head-to-head with other scientists who have gone before them — often their mentors or those who have trained in the same laboratory.



***Bruce Alberts, president,  
National Academy of Sciences***

Presented at the Academy's 140th  
Annual Meeting  
April 28, 2003

***What is being done about this?***





## ARISE

### **Advancing Research In Science and Engineering: Investing in Early-Career Scientists and High-Risk, High-Reward Research**

“...many science and technology funding agencies have become overly conservative, shying away from high-risk, high-reward research and thus limiting the prospects of achieving breakthrough results with the potential to transform a field. The authors recommend rebalancing the nation’s research portfolio by investing in targeted grant mechanisms to foster potentially transformative research and adopting policies that nurture riskier research in all award programs.”

#### **Check List for Action**

#### **Recommendations to:**

##### ***Federal Agencies***

- Create Targeted Grant Programs for Early-Career Faculty
- Create Seed Funding Programs for Early-Career Faculty
- Pay Special Attention to Early-Career Faculty in Regular Grant Programs
- Develop Supportive Policies for Primary Caregivers
- Explore Targeted Grant Mechanisms and Policies to Foster Potentially Transformative Research
- Adopt Funding Mechanisms and Policies That Nurture Transformative Research in All Award Programs

Obama: “We will increase research grants for early-career researchers to keep young scientists entering these fields. We will increase support for high-risk, high-payoff research portfolios at our science agencies.”

Answers to ScienceDebate2008

***While science is in many aspects healthy, aspects of the present situation put pressure on the shared ethics and hence threaten the progress of science.***

The balance between incremental investigation of established research programs and the invention of transformative new programs has shifted too far to the former.

The balance between numbers and access to resources between older, experienced researchers and young researchers has shifted too far toward the former.

The professionalization of funding and hiring decisions has too often narrowed the profile of a successful scientist to that of only one kind of scientist, who is an aggressive incrementalist or hill climber.

***How have Science 2.0 initiatives helped the situation?***

***These all act to decrease the support for and tolerance of diversity of approaches and research programs and hence diminish the 2<sup>nd</sup> principle.***

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## ***How have Science 2.0 initiatives helped science?***

- Broaden access to papers and data (Arxiv etc.)
- Broaden opportunities by decreasing the need to work at a few central institutions to have work known and influential.
- Increase diversity for the same reason. The influence of a few people at elite institutions is diminished.
- Allow kids in high school and college direct access to the literature as well as the informal gossip and chatter, so as to allow them to get started sooner as independent thinkers.
- Similarly, broaden diversity by allowing young people growing up outside of the rich countries direct access to the literature, gossip and chatter.
- In experimental sciences, open up lateral communications between low status scientists between laboratories not mediated by senior lab directors or group publishing decisions.
- Reduce the need to travel to be influential as the present era of cheap and easy international travel is likely to end.

## ***How might Science 2.0 initiatives hurt science?***

The notion of a wiki is of concern to the extent that it dilutes the notion of authorship, particularly that an author puts their reputation at risk each time they make a scientific contribution, whether original, review or pedagogical.

Wikipedia has many bright spots, which not surprisingly often have to do with subjects on which there is complete consensus among experts. But it is sometimes misleading and full of errors.

There is a concern that without authorship errors and rumors proliferate, especially as it builds on the weaknesses of the oral culture of science.

*Is there a way to discipline a community to root out error without authorship?*



## *How might Science 2.0 initiatives help science?*

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There should be a measure of influence which scales appropriately with the size of the research community.

Otherwise citations drive growth of the largest research program in an area. ie shouldn't 100 people or even 20 people working on an idea be enough?

What is the right factor?

## *How might Science 2.0 initiatives help science?*

I would love to have a virtual reality representation of the Arxiv, where I could put on goggles and walk around inside of it.

I'd like to have a verbal interface and be able to say,  
"Show me all the papers on positive energy theorems."

"Turn on links showing citations and influence."

"Show me all the papers on bouncing spacelike singularities."

"Show me the founding papers and the most recent."

"Show me a network of the workers in this area, with links"  
I'd like to be able to zoom in and pick up a paper in VR and read its abstract and then open it and read it and, while I'm doing that, dictate an email to its authors.

## *How might Science 2.0 initiatives help science?*

I would love to have a virtual reality representation of my own work, going back to school notebooks, with all my notebooks interlinked and represented visually. I'd love to be able to see not only the work I did but the plans I made for work that dead-ended or I didn't get to yet.

It's too late for me but not for present high school students.

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I'd love to be able to ask, "What is the best appreciated review paper on massive star formation, or the pedagogical introduction to the organization of the visual cortex that people with my training and style best liked?" and get the paper right away.

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I would love to have a virtual reality representation of the whole scientific literature going back to the Babylonians, where I could put on goggles and walk around inside of it.

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Social networks are fine, but many of the people I'd really love to talk with are dead. There is no greater social networking tool than a great library, and I'd like a tool that made the world's literature as accessible to any kid as it was to the young Bertrand Russell.



## *How might Science 2.0 initiatives help science?*

More generally could we use our tools to expand our daily consciousness up to the whole history and future of science?

Rather than shrink our awareness to the arxiv horizon of a few months, or back to 1991, could we have tools that contextualize our work within the time scale of the whole histories of our subjects?

Is there a scientific analogue of the Clock of the Long Now?

## Conclusions:

There are many positive uses of the internet and Science 2.0 tools which can play a very important role in addressing the structural issues in the current organization of science.

But the experience so far shows that there are dangers from irresponsible and disruptive interventions by anonymous posters. Mixing of contexts for discussions among experts and pedagogical discussions with lay people.

Weakening of the roles of accreditation, reputation and authorship in disciplining scientific discourse.

We could make new tools that expand rather than shrink our horizons back and forward in time and across all of science.

***New tools are great to the extent to which they reinforce the two basic ethical principles responsible for the success of science, and harmful to the extent they undermine those principles.***