4. évfolyam · 7. szám · 1994. július

IMPAKT

TÉNYEK A TUDOMÁNYOS ALAPKUTATÁSRÓL

Szilárd: Csak a tényeket írom le – nem azért, hogy bárki is elolvassa,csakis a Jóisten számára.
Bethe: Nem gondolod, hogy a Jóisten ismeri a tényeket?
Szilárd: Lehet, hogy ismeri, de a tényeknek nem ezt a változatát.

[*Leo Szilard, His version of the Facts. S.R. Weart & Gertrud Weiss Szilard* (Eds), MIT Press, Cambridge, MA, 1978, p.149.]

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Megalakult az Akadémia Kutatásértékelési Bizottsága

Ha részben különböző módszerekkel és különböző szervezeti megoldásokkal is, de a világ minden kultúrországában folyik kutatásértékelés. Értékelik a kutatási eredményeket és ennek megfelelően azokat a kutatóhelyeket, amelyekben a kutatási eredmények létrejöttek ("Egyetemek és kutatóintézetek értékelése az OECD országokban", OMFB, Budapest, 1992).

A Magyar Tudományos Akadémia hagyományainál és a magyar tudományos életben betöltött szerepénél fogva nem egedheti meg magának, hogy ezzel a kérdéssel ne foglalkozzon. A most elfogadott akadémiai törvény különben kötelezi is erre, azaz, hogy "rendszeresen értékelje a tudományos kutatás eredményeit..."(3.§.c.)

A feladat természetesen nem új az Akadémia számára. Ha messzebbre nem megyünk is vissza, a közelmúltban csaknem egy évtizedig működött egy Kutatásértékelési Állandó Munkacsoport, mint a főtitkár tanácsadó szerve, legutóbb pedig az Elnökség egy ad hoc bizottságot küldött ki a kérdés tanulmányozására. Ennek eredményeképpen alakult meg, mint állandó elnökségi bizottság (az MTA Elnökségének határozata 1994. február 23-án) az Akadémia Kutatásértékelési Bizottsága.

A bizottság tagjai sorában mindenek előtt helyet kapott a tizenegy tudományos osztály egy-egy képviselője, a Titkárság illetékes munkatársa (számszerűen 3-an), továbbá Solymossy Frigyes és Braun Tibor (az utóbbi, mint a tudománymetria nemzetközileg elismert képviselője). Helyet foglal még a bizottságban a rektori konferencia egy képviselője (a további kettő kiküldetése folyamatban van) és tárgyalások kezdődnek az OTKA és az OAB képviseletét illetően. Az elnöki tisztet Berényi Dénes tölti be, aki a bizottság munkáját két társelnök: Láng István (MTA elnöki tanácsadó) és Abádi Nagy Zoltán, a KLTE rektora (a Rektori Konferencia jelölése alapján) segítségével irányítja. A bizottság titkára Tolnai Márton, aki az MTA Tudományszervezési Intézetével a bizottsági munka hátterét képezi.

A bizottság alakuló ülését március 30-án tartotta, amelynek során mindenek előtt feladatait, munka-és ügyrendjét tisztázta az elnökségi határozat által megadott keretek között. Feladatait röviden négy pontban lehet összefoglalni.

1. Hazánkban már eddig is történtek különböző kutatásértékelési tevékenységek. Ismeretes az akadémiai intézetek nemrégiben befejeződött új rendszerű felülvizsgálata vagy néhány akadémiai kutatóintézet munkájának ICSU értékelése. De megtörtént a mezőgazdasági kutatóintézetek vizsgálata is, az OTKA-ban folyamatos a támogatott témák eredményességének nyomonkövetése, továbbá az OAB ideiglenesen akkreditált doktori programokat. Az OMFB külön ülésszakot szentelt a kutatásértékelés problémáinak ("Konferencia az egyetemek és kutatóintézetek értékeléséről" OMFB, Budapest, 1993).

Szükségesnek látszik mindezek számontartása, a szerzett tapasztalatok összegyűjtése, összegzése és mások számára hozzáférhetővé tétele. Ezt tekinti tehát a bizottság első feladatának.

2. Ha el lehet mondani, hogy hazánkban számos dolog történt a kutatásértékelés vonatkozásában, akkor nyilvánvalóan ezt összehasonlíthatatlanul inkább el lehet mondani nemzetközi vonalon, illetve más országokra vonatkozóan.

(Folytatás a következő oldalon)

A nemzetközi tapasztalatok, a más országokban követett gyakorlat nyomonkövetése, értékelése, és mindezeknek a magyar tudományos közösség számára hozzáférhetővé tétele mint a bizottság második feladata fogalmazódik meg.

3. Az előző két feladat viszonylag passzív jellegűnek tűnik. Az előbbiek alapján azonban — az MTA bizottsági rendszerére támaszkodva — a bizottság feladatának tekinti szempontok, szempontrendszerek (kritériumok) kidolgozását az egyéni kutatási eredményesség, a kutatócsoportok, illetve témák, valamint egész intézmények (kutatóintézetek, egyetemek), sőt egész tudományterületek kutatási eredményességének értékelésére. Igen fontos, hogy a bizottsági rendszeren keresztül és egyéb módon a kutató közösség, az értékelendők véleménye, szempontjaik figyelembe legyenek véve.

Megállapítható különben, hogy a magyar tudományos közösségben határozott igény van arra, hogy a különböző kutatásértékelési tevékenységek meghatározott, előre ismeretes kritériumrendszer alapján történjenek.

Visszatérve a fentebb említett egész tudományterületek (pl. fizika) eredményességének átfogó értékelésére, meg kell említenünk, hogy ez nagyon megszokott eljárás a nemzetközi gyakorlatban. Ezeket általában erre felkért nemzetközi bizottság végzi nemzeti segítséggel. Csak egyet említve példaként: nemrégiben Ausztriában a fizika egészére nézve zajlott le egy ilyen értékelés, amely 53 kutatóhelyet érintett (ezek körül 43 tartozott különböző egyetemekhez) és előkészületekkel, kezdő és végző ülésekkel, intézetlátogatásokkal csaknem két évig tartott.

4. A hazai helyzet, a külföldi tapasztalatok elemzéséből a bizottság bizonyos javaslatokkal élhet, kutatóhelyeket működtető főhatóságok, szervezetek felé bizonyos típusú kutatásértékelési tevékenységek elvégzésére.

A fentiekből nyilvánvaló, de nem árt kifejezetten leszögezni, hogy mit nem akar, mi nem tartozik a bizottság feladatai közé. A bizottság közvetlenül sem egyének, sem kutatóhelyek kutatásait nem fogja értékelni, és tevékenysége semmiféle autonómiát nem sért, senki részére sem fog semmiféle utasítást adni e vonatkozásban. Mint a fentiekből kitűnik, munkája inkább szolgáltató jellegű és javaslatainak orientáló, figyelemfelhívó szerepük van.

Munkarendjére, munkastílusára vonatkozólag a bizottságot nem kötik határidők, de saját magának konkrét célokat és határidőket tűz ki és gondoskodik arról, hogy megállapításai, javaslatai eljussanak az illetékesekhez és megfelelő nyilvánosságot kapjanak.

Így az első ülés határozatai között szerepel, hogy a tagok a bizottság titkárához eljuttatnak minden anyagot, információt az általuk ismert hazai és külföldi kutatásértékelési akciókról, módszerekről és tevékenységről. Mindezeket a következő ülésre (június 2.) a Kutatásszervezési Intézet segítségével a titkár rövid, áttekinthető formában terjeszti a bizottság elé.

A bizottság tagjainak konkrét feladata továbbá, hogy a következő ülést megelőző meghatározott dátumig eljuttassák a titkárhoz azokat az egészen általános, de mégis orientáló szempontokat, amelyeket a bizottság megfelelő vita után eljuttat az MTA egyes bizottságaihoz, amelyek ennek figyelembevételével kidolgozzák a javaslatokat a területükre jellemző specifikus kritériumrendszerre, amely azután ismét visszakerül a bizottsághoz és megfelelő vita, "csiszolás" után nyilvánosságra kerül.

Mind a bizottságnak, mind bármilyen, a kutatások eredményességét bármilyen szinten értékelő szervezetnek tisztában kell lennie azzal, hogy a kutatásértékelési feladatot tökéletesen nem lehet végrehajtani. Ezért van szükség a módszerek állandó tökéletesítésére, a legkülönbözőbb tapasztalatok figyelembevételére és a "kiértékeltek" megjegyzéseinek szem előtt tartására.

Berényi Dénes, (MTA ATOMKI)
Magyar Tudomány, 39 (1994) 720

French insist they have a word for it

The Academy of Sciences in Paris has warned that a draft law on language could spell doom for scientific gatherings in France.

The proposed legislation, which was published last week by the culture minister, Jacques Toubon, would permit meetings in France only if talks in foreign languages were simultaneously translated into French. Conference programmes would have to be written in French, and any other documents written in a foreign language would have to be accompanied by at least a French summary. The only exception to these rules would be gatherings in France that are attended only by foreigners .

"Ridiculous!" says Paul Germain, the secretary of the French Academy of Sciences, which has been lobbying against this type of legislation for more than a year. Germain says the constraints will stop scientists organising meetings in France. Most conference organisers would not have the time or the resources to comply with the law.

"We would need an army of translators expert in very technical language," he says.

The proposed law is aimed at stopping the proliferation of English words that are being used increasingly by advertisers and broadcasters in France. Germain says he is doubling his efforts to persuade French deputies that scientists should be granted the freedom to work in a foreign language when they need to. The deputies are due to debate the draft law in the spring.

Tara Patel,
New Scientists (12 March, 1994) 7

Hot Scientists Have Philosophies In Common

In Dennis Selkoe's lab at Brigham and Women's Hospital, the research focus is on neuroscience, while Stuart Schreiber's team of investigators at Harvard University concentrates on chemical cell biology. Meanwhile, Kenneth Kinzler's group at Johns Hopkins University investigates molecular biology questions. Although the three labs have widely varying research pursuits they also have much in common: They all rely on a broad mix of people and scientific talent in their labs. They all place a great deal of value on the enriching nature of cross-disciplinary research. And they are all notably productive and influential, according to citation records maintained by the Philadelphia-based Institute for Scientific Information (ISI).

Indeed, Selkoe, Schrieber, and Kinzler are among the scientists who have produced the greatest number of highly cited papers over the last three years, as identified by ISI's newsletter *Science Watch* (4[10]:1-2, December 1993), based on a ranking from ISI's Hot Papers Database. Others on the list who have produced five or more of these papers — research articles with a substantially greater number of citations than other papers in similar disciplines during that time — are molecular neurologist Stanley Hamilton, molecular biologist Bert Vogelstein, and neuroscientists Solomon Snyder and David Bredt of Johns Hopkins; molecular biologists Benjamin Margolis and Joseph Schlessinger of New York University Medical Center; molecular biologist Tony Pawson of the University of Toronto and Mount Sinai Hospital, Toronto; and molecular neurologist George, Yancopolous of Regeneron Pharmaceuticals Inc. in Tarrytown, N.Y.

All of the scientists on this list share, in their own ways, the collaborative, integrative, approach of Selkoe, Schreiber, and Kinzler. In fact, many on the list collaborate with each other. For example, Schlessinger sometimes coauthors papers with Margolis and Pawson.

That all of these researchers are life scientists, ISI analysts explain, is largely attributable to the fact that life scientists far outnumber physical scientists; therefore, this larger population produces a far greater number of papers in which their colleagues' work might be cited than other disciplines. Furthermore, they cite a greater average number of references within those papers compared with physical scientists.

These "hot papers" remained heavily cited over several bimonthly periods from November 1990 to November/December 1993. For example, Vogelstein, at Johns Hopkins Oncology Center, had 16 papers on which he was an author stay highly cited during this period. His most cited article (M. Hollstein, et al., "p53 mutations in human cancers," *Science*, 253:49-53, 1991) was cited in 700 papers by the end of 1993.

Kinzler, a coauthor with Vogelstein on nine of these papers, also at the Hopkins Oncology Center, says their main research interest is in understanding the genetic changes that cause cancer, specifically colon and brain cancers. (For a recent example, see N. Papadopoulos, et al., "Mutation of a *mut*L homolog in hereditary colon cancer," *Science*, 263:1625-29, 1994.) Hopkins researchers Snyder and Bredt also wrote, several papers together that put them on this list.

Crossing Boundaries

Taking an integrative approach in answering research questions and participating in interdisciplinary collaborations are keys to their success say these highly cited authors. For example, even though these scientists categorize their work into subdisciplines — such as signal transduction or immunosuppressant biochemistry — they all agree that the strength of their labs' work is in the diversity of their staffs' backgrounds and their ability to cross boundaries in terms of subject matter, methodologies, and communication with colleagues.

For example, Schlessinger, chairman of the New York University Medical Center's pharmacology department, says he collaborates with crystallographers, geneticists, and biophysicists, both within and outside his own institution.

A prime illustration of this integrative approach in the Schreiber lab — a group that takes a chemical approach to cell biology. Schreiber, who holds a joint appointment as a professor in Harvard's chemistry and cellular and molecular biology departments, studies the use of immunosuppressants in understanding signal transduction. "Most of the people who come to my lab are interested in knowing how that field can integrative with neighboring disciplines," he says.

Schreiber explains that the major role that chemistry has played in his interdisciplinary lab is in using synthetic compounds as tools for elucidating the function of important molecules in cell types such as T cells. (For a recent example, see D.M. Spencer, et al., "Controlling signal transduction with synthetic ligands," *Science*, 262:1019-24, 1993.)

The Human Element

Another characteristic to which the research attribute the success of their lab — in their collective words — is their intelligent, energetic, dedicated, and creative staff of doctoral and medical students, postdoctoral fellows, and technicians.

Kinzler explains that the looks not for people who have specific skills, but for people who are bright and enthusiastic, explaining that "they will learn whatever they need to do" once they are on the job. Because of his confidence in his research team's expertise, Vogelstein exercises a relatively free rein in running his lab. "I just let them do their thing," he says.

Schreiber says that attracting highly interactive students to his lab stimulates his own work: "I find it a very exciting way to do science, as opposed to trying to do interesting things in a vacuum."

Timely Research

In addition to the collaborative and talent aspects of research staff, the type and timeliness — with respect to solving current human health problems — of the research itself plays a significant role in the accomplishments of the research programs, say the scientists.

For example, Selkoe, whose lab (along with other colleagues) discovered that abnormal amyloid protein deposits in brain tissue can cause certain types of Alzheimer's disease, says, "The reason there's been so much interest in the biology of Alzheimer's disease is because it's a tremendous public health problem and an enormous of people are affected." Selkoe holds a joint appointment as professor of neurology at Harvard Medical School and as director of the center for neurologic diseases at Brigham and Women's Hospital in Boston.

Specifically, he says, his lab's research has been referenced by colleagues so often because, by using a simple cell-culture system for analyzing soluble amyloid protein, they have found a possible diagnostic tool for testing predisposition to Alzheimer's disease and screening for possible therapeutic drugs. (See C. Haass, et al., "Amyloid beta-peptide is produced by cultured cells during normal metabolism, "*Nature*, 359:322-25, 1993, which is also a hot paper.)

Schlessinger, who studies the role of molecular receptors in the signal transduction pathway of normal and diseased cells, attributes part of his lab's achievements to the fact that he studies the underlying workings of fundamental life processes. "One of the most urgent subjects in biology is understanding basic mechanisms which relate to growth and differentiation, and if you're able to figure out such mechanisms, the rewards will be very high," he explains.

"For the last 15 years we've been trying to understand how receptor tyrosine kinases are activated [in the signal transduction pathway of cells], and by knowing what they do we can also figure out what goes wrong in cancerous cell," he says. [For example, see]. Schlessinger, A. Ullrich, "Growth factor signaling by receptor tyrosine kinases," *Neuron*, 9:383-91, 1992)

Kinzler describes his lab's research as question-driven rather than capability-driven. "We define the question first and worry about how to do it later." As a result, the lab's research "has crossed a lot of borders," Kinzler adds, referring to his lab's practice of learning whatever methods are necessary to fully answer their questions, such as using several types of models — from yeast to mice.

Communication Is Key

Researchers say that another distinguishing feature of their labs is their commitment to open communication. This exchange has many elements, they say, such as discussing research in progress; including all levels of staff — from students to principal investigators — in the dialogue; holding both formal and informal meetings; and, again, adopting an integrative approach.

On the formal side, Kinzler's and Vogelstein's staffs attend weekly joint meetings — whose format is roughly similar to the lab meetings described by the other researchers. "We discuss the literature and get feedback on ideas and interpretation of results. Half of the meeting is devoted to a critical survey of the literature and the other half is devoted to a presentation of new data by one person," says Vogelstein.

Scientists ranked by number of hot papers

Rank	Name	Institution	Field	Number of Papers
1	Bert Vogelstein	Johns Hopkins University	Molecular Biology	16
2	Kenneth W. Kinzler	Johns Hopkins University	Molecular Biology	9
	Joseph Schlessinger	New York University Medical Center	Signal Transduction	9
3	Solomon H. Snyder	Johns Hopkins University	Neuroscience	8
4	Stuart L. Schreiber	Harvard University	Chemical Cell Biology	7
5	David S. Bredt	Johns Hopkins University*	Neuroscience	6
	Dennis J. Selkoe	Harvard University, Brigham & Women's Hospital	Neuroscience	6
6	Stanley R. Hamilton	Johns Hopkins University	Pathology	5
	Benjamin Margolis	New York University Medical Center	Signal Transduction	5
	Tony Pawson	University of Toronto, Mount Sinai Hospital	Signal Transduction	5
	George D. Yancopoulos	Regeneron Pharmaceuticals Inc.	Molecular Neurology	5

* Currently at the University San Francisco, School of Medicine

Source: ISI's Hot Papers Database, November/December 1990-November/December 1993

Schreiber stresses that participants in his joint chemistry-biology lab meetings make a special effort to communicate their work to others outside their area of research.

On the informal side, Bredt, previously a doctoral and medical student in Snyder's lab and since January an assistant professor of physiology at the University of California, San Francisco, Medical School, says of Snyder's lab, "The vast majority of learning happens at the benchside where people just informally discuss their daily progress."

Kinzler also tries to maintain close contact with the people in his lab. "Whatever level you're at — even at the principal investigator level — it's helpful to talk to people about your experiments, so you don't forget something." However, he adds, "As a result, I don't travel very much."

More generally, Schlessinger mentions that all modes of scientific communication — listening to speakers meetings, reading journal articles, talking with colleagues in the lab, for example — "somehow synergizes other thoughts" and inspires him intellectually.

Keeping An Open Mind

Promoting a creative environment that doesn't discourage new interpretations or approaches is also part of a healthy, productive lab, say the researchers. The open climate of Snyder's lab at Johns Hopkins, where Bredt used to work, is one example.

"We [took] on people who aren't so structured in the way they think about science, but are rather more open to new ideas," says Bredt, who studies how the gas nitric oxide functions as a neurotransmitter in the brain. (See D.S. Bredt, et al., "Cloned and expressed nitric oxide synthase structurally resembles cytochrome P-450 reductase," *Nature*, 351:714-8, 1991, also a hot paper.) He traces this practice back to Snyder's Nobel Prize-winning adviser, Julius Axelrod.

Bredt explains that researchers were originally resistant to the idea that nitric oxide could actually be made and used by the body. However, spurred by the fact that nitric oxide had been discovered in the bloodstream as a regulator of blood pressure, his group investigated whether nitric oxide is used as a neurostransmitter in the brain.

Likening the brain to a computer with precisely defined connections between circuits, he says, "nitric oxide is the wrong thing that you'd imagine being used in the computer because it doesn't go between the wires — it affects all the wires in a given area — and there's no computer element like that."

Because nitric oxide is a gas "it doesn't go specifically from one cell to another like all other known neurotransmitters," Bredt says. "Instead, it diffuses out in a sphere in brain tissue so it affects all cells in a defined area." Explaining nitric oxide's possible role in learning, he adds "when [a person's] experience goes through a circuit in the brain, that circuit becomes strengthened and it is thought that nitric oxide mediates this process."

Related to the idea of fostering a creative, uninhibited lab environment is the custom of promoting healthy debate and independent thinking among team members. "I expect people to argue with me when they don't like an idea," Kinzler says. "It's funny, we don't have very much [personal] feuding in the lab, but people will argue about scientific points and it's enjoyable," he says, "once you get used to it."

NYU's Schlessinger encourages new trainees in his lab to find their own related research project by spending their first few weeks talking with their new colleagues: "When a new person comes to the lab, I really do not make this person work on what I think is important. I want them to choose."

Karen Young Kreeger
The Scientists (May 2, 1994)

"Don't forget, this medicine worked better on the rat than it did on the guinea pig, and I think he's more like a guinea pig."

"Think back — were there any musicians in the room when we operated on him?"

Creativity and Science
What Makes a Person Creative?

C.P. Snow's famous distinction between "two cultures" separated science and technology from other highly creative (but less quantitative) pursuits such as art and poetry [1]. But in an article published last year, design engineer Sue Birchmore discussed the imagery that results from believing that scientific creativity is somehow different from artistic creativity [2].

She notes, for example, that scientists are often depicted in popular culture as cold, rational, unemotional (and sometimes demented); that engineers and technologists may be portrayed as practical, prosaic, and often semiliterate; and that science is somehow bereft of human spirit. However, Birchmore believes that "the best scientists are poets,... [that] the real engineer is an artist," and that poetry and art are in the science itself. She points out that terms such as "quarks" (which may possess "charm" and "beauty"), the "solar wind," and the "big bang" were not coined by humorless intellectuals but by "fully developed people possessing the full range of human emotions" — including, presumably, the kind of creativity usually associated with artists [2].

I find this link between science and poetry fruitful: there is an economy of words and beauty of concept in poetry that is always found in the best science [3,4]. Yet it is risky to compare science with poetry — particularly since many scientists buy into the popular image that Birchmore rues. They are thus averse to (or at least unaccustomed to) relying on the emotional experience necessary to create or to respond to such artistic pursuits as poetry.

In fact, far from a climate of intellectual freedom and tolerance that might foster an atmosphere of innovative creativity, contemporary science is subject to pressures greater than any it has ever faced. This is the era of Big Science. More and more, it seems, the emphasis is on management, publications, tenure, and scrambling for funds to support research for which the answer is already known. Even more disturbing, a few scientists seem driven to achieve fame, power, and riches by any means available, including fraud. In recent years we have discussed various types of fraud, intellectual dishonesty, and other forms of deviant behavior in science [5].

What is happening to the love of knowledge and discovery for their own sakes? The exhilaration of being close to an understanding of an important unknown? Is scientific creativity taking a backseat to self promotion, grandstanding, and patent fights? Last year I explored some of these questions in the 12th annual Perey Research Lectureship at McMaster University, Hamilton, Ontario, Canada; this two-part essay on scientific creativity reiterates some of the points I made then and raises some new issues.

What Is Creativity?

"Creativity" is a modern concept. Joanne R. Euster, president, Association of College and Research Libraries, referring to the *Oxford English Dictionary*, notes that the word "created" appeared around 1393. But "creativity" was not coined until 1875, when it was used to refer to the poetic imagination. It is an even more contemporary notion, according to Euster, that creativity be applied to arenas other than the arts — as in such now-common expressions as "creative thinking," "creative problem-solving," and "creative living." She goes on to discuss means of fostering creativity in the library professions [8].

Almost 40 years ago, psychologist J.P. Guilford, University of Southern California, Los Angeles, noted that creativity, in its narrowest sense, comprises "the abilities... characteristic of creative people..., which include such activities as inventing, designing, contriving, composing, and planning. People who exhibit these types of behavior to a marked degree are recognized as being creative [9]."

Others have defined creativity by its results, saying that a person is creative whose work or performance is both original (different or unusual) and significant. However, in spite of the efforts of investigators from a number of fields, according to C. Scott Findlay, Departments of Zoology and Medicine, and Charles J. Lumsden, Department of Medicine, University of Toronto, Ontario, Canada, thorough explanations of creative activity have been elusive [10].

Creativity Research

Hundreds of research studies have been conducted on the subject of creativity and numerous theories of creativity have been proposed. In fact, the "creativity literature" has been growing significantly. In her book *The Social Psychology of Creativity*, Teresa M. Amabile, Department of Psychology, Brandeis University, Waltham, Massachusetts, discusses various aspects of creativity and creativity research. As she notes, *Psychological Abstracts* listed 11 articles under the heading "Creativity" in 1950-0.2 percent of the 5,500 articles abstracted that year. This number grew to 0.4 percent by 1960, 0.8 percent by 1966, and 1 percent by 1970 — even though the total number of articles abstracted also grew [11]. In 1980 approximately 0.7 percent of the database was devoted to creativity.

Research into creativity, as reviewed by Amabile, has taken many forms. Some studies have examined the biographies and autobiographies of well-known creative individuals. Other researchers have investigated individual differences in creativity under "laboratory" conditions (in which investigators five with their subjects and observe them under "typical" conditions). Some studies have offered comparisons of those who score highly in tests designed to assess creativity with those whose scores are low; while others have employed questionnaires that attempt to place respondents on a continuum indicating their level of creativity. Other studies have concentrated on the cognitive skills necessary for creativity and the environmental factors that influence creativity, including social, political, and cultural trends [11]. The direct (or indirect) object of many of these studies has been to "increase the availability" of creativity and "improve its distribution," according to Russell L. Ackoff and Elsa Vergara, formerly of the Wharton School, University of Pennsylvania, Philadelphia [12]; Ackoff is now affiliated with Interact, the Institute of Interactive Management, here in Philadelphia.

Factors Affecting Creativity

It is impossible to do justice to the entire range of creativity research, but a few of the ideas contained in these works can be highlighted. One might make an analogy between creativity and the cultivation of fruit from seed: both need the proper conditions to germinate, grow and develop, and finally bloom, come to full maturity, and bear fruit. Of fundamental importance to creativity are social conditions that favor it and enable it to be expressed productively: And yet, conditions that are beneficial for one creative individual may be detrimental to another.

Amabile considers several examples of the creativity-enhancing effect of work done for its own sake, as well as the creativity-inhibiting effect of work done for the sake of achieving an external goal. The British poet and critic T.S. Eliot, for instance, asserted that his receiving the Nobel Prize would destroy his creativity. Russian novelist Fyodor Dostoyevski was practically paralyzed by a large advance given him for writing a novel he had not yet even begun. And American novelist Thomas Wolfe described suffering from numbing doubt and confusion in attempting to write his second novel after the first had met with critical acclaim: faced with the task of following up his success to prove he wasn't a flash in the pan, he found himself able to concentrate on little else [11].

Yet the promise of rewards and glory can serve as a spur to others, as witness the pursuit of high-temperature superconductors or — the classic example — the description of the double helix structure of DNA. Indeed, the distinguished sociologist of science Robert K. Merton, Columbia University, New York, believes that peer recognition of significant contributions is one of the main driving forces in science [13].

Mentor Relationships

In the scientific community, another important facet of fostering creativity is the so-called master/apprentice relationship. Columbia University sociologist Harriet Zuckerman discusses at length the theme of masters and apprentices in science in chapter 4 of her 1977 book *Scientific Elite* [14]. Science writer Robert Kanigel has also written about the transmission not only of technique and the mechanics of "doing science," but also of a particular style or approach to science from one generation to the next in his book *Apprentice to Genius: The Making of a Scientific Dynasty* [15].

In the book Kanigel 15 explores an interlocking chain of "mentor" relationships between Bernard "Steve" Brodie, often called the father of modern pharmacology for his work on drug metabolism; his young technician Julius Axelrod — who later went on to win the Nobel Prize for his work on the neuronal synapse; Solomon Snyder, the internationally renowned researcher in neuropharmacology who got his start in Axelrod's laboratory; and Candace Pert, who, as a young postdoc, codiscovered opiate receptors in the brain with Snyder [16,17]. Each link in the chain served as the scientific parent of the next, with each first a protégé and then a mentor; in this way lessons learned were passed on and the fabric of science woven. Incidentally, Pert shared her perspective on opiate receptors in a recent Citation Classic [18]; Snyder wrote a Citation Classic commentary on the same subject last year [19].

Mentor relationships have been instrumental in helping young scientists learn to recognize problems that are worthy of attention. In his *Advice to a Young Scientist*, the 1960 Nobel Prize winner Sir Peter B. Medawar writes that "any scientist of any age who wants to make important discoveries must study important problems.... The problem must be such that it *matters* what the answer is — whether to science generally or to mankind [20]."

But most scientists are not formally taught which problems fall into that category; instead, the knack of tackling the right problem in the right way is conveyed by example over years of close working relationships with established scientists. One caveat here: since bad habits can be learned as easily as good ones, perhaps the most important thing a young scientist can do, as Medawar himself notes, is pick the right postdoctoral environment [20].

And according to A.E. Pannenborg, a research administrator for the Philips Company in Eindhoven, The Netherlands, it is incumbent upon those who are in charge of research groups to create the conditions that will allow gifted young scientists to adequately follow their creative instincts. As Pannenborg observes, such conditions should include "room to move": "The more intelligent, the more creative, the more talented the man is, the more you leave him alone..." [21]. This theme is hardly new, having been expounded earlier in this century by, most notably, the German educator Adolf von Harnack (1851-1930), president, Kaiser Wilhelm Institute, Munich (now the Max Planck Society for the Advancement of Science), from 1911 to 1930, and by James Conant (1893-1978), the American chemist and educator who served as president of Harvard University, Cambridge, Massachusetts, from 1933 to 1953.

As Pannenborg and his predecessors clearly imply, an obvious factor in creative productivity that cannot be ignored is a scientist's personality. Table 1 lists some of the personality traits that some studies have indicated scientists share. In a review of the role of personality dispositions in science, J. Philippe Rushton, University of Western Ontario, London, Canada, examines factor analyses of scientists' personalities. Research, as Rushton notes, has suggested that scientists differ from nonscientists by exhibiting a high level of general curiosity, especially at an early age, and in demonstrating a relatively low level of sociability. The implication is that science is conducted by those for whom research is a way of life and social relations are comparatively unimportant [22].

According to such studies, scientists also tend to be shy, lonely, slow in social development, and indifferent to close personal relationships, group activities, and politics. Other attributes include skepticism, preoccupation, reliability, and a facility for precise, critical thinking. Generally, they are

Table 1: Selected list of personality traits exhibited by scientists.

- Assertiveness
- Facility for precise, critical thinking
- High level of general curiosity
- Independence
- Indifference to close personal relationships, group activities, politics
- Loneliness
- Nonconformity
- Reliability
- Shyness
- Skepticism
- Tendency toward preoccupation
- Tendency toward taking risks

cognitively complex, independent, nonconformist, assertive, and unlikely to suppress thoughts and impulses; and, like successful entrepreneurs, eminent scientists are also calculated risk-takers [22].

Permitting Scientific Creativity

Since creativity takes place in the realm of the mind, it is as slippery and difficult to analyze as is the mind itself. Thus, it is difficult to evaluate which of the ideas above come closest to the mark in their various descriptions of creativity — if, indeed, any of them do. Nevertheless, as A. Carl Leopold, Boyce Thompson Institute, Cornell University, Ithaca, New York, noted a decade ago, "The world community recognizes that progress in the arts, in the professions, and in science and technology relies exquisitely on the creativity of the people in these professions" [23].

Leopold likened the "skills with which a person can fit factual assemblages into new ideas" to "a sort of mysterious 'black box' or kaleidoscopic step." While admitting that such a black-box description is relevant to describe innate ability or talent, Leopold also points out the creative process must also be at least partly the consequence of trained or honed skills. Since skills that can be learned can also be taught, he proposes that the art of scientific thinking be taught by allowing students to experience all the thrills — and missteps — of an actual scientific research program or experiment. Quite relevant to this theme was our essay on undergraduate research [24]. Recently, the National Science Foundation began a new, multimillion-dollar program aimed at stimulating interdisciplinary research in the life sciences at the nation's universities — at the undergraduate graduate, and postdoctoral level [25].

I believe that something along the lines of what Leopold suggests is not merely a good idea, but may be essential to the health of science. It may seem absurd to speak of a decline or stifling of creativity at a time when inventions and discoveries — indeed, the flow of new information itself — threatens to become overwhelming. But if scientific creativity is a set of skills that can indeed be taught, then we must not only provide the teachers but the environment in which such skills can be learned, used, and nurtured. If we persist in teaching the facade of science, instead of its realities, then the pressure-cooker, cookie-cutter research programs that seem to be more and more prevalent today will be not just the harbingers of the future of science, but also its death knell.

(My thanks to Stephen A. Bonaduce for his help in the preparation of this essay.)

E. Garfield,
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Asia's Little Dragons May One Day Breathe Scientific Fire

A group of relatively small but rapidly industrializing nations on the western edge of the Pacific Rim have come to be known as "the little dragons," so fiercely do they compete in the business world.

These Asian nations have yet to earn the same reputation in the research world, but in the next century this cluster of countries will likely find its niche in the international scientific sphere, just as Japan and the People's Republic of China are now doing.

Increasing Output...

Science Watch has previously described how Japan and the People's Republic of China have increased their share of the world scientific literature indexed by ISI during the 1980s (for Japan, see *Science Watch*, 1[5]:7, May 1990; 2[1]:1-2, January/February 1991; 2[3]:1-2, April 1991; 2[8]:8, September 1991; 3[7]:8, September 1992; for China, see 3[9]:1-2, November 1992). Japan's share has moved from 5.8% in 1981 to 7.8% in 1992. During the same period, China's share rose from just .3% to 1.2%.

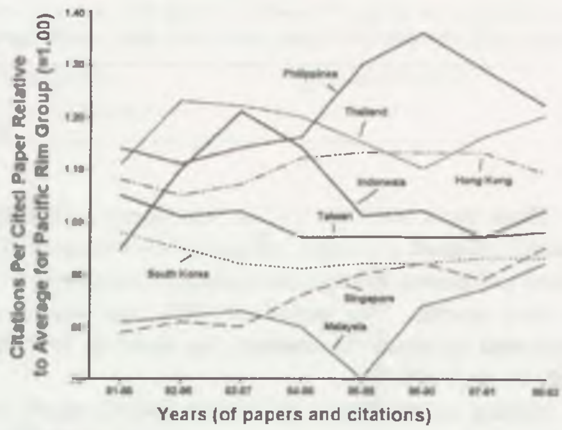
The eight Pacific Rim nations examined here — Hong Kong, Indonesia, Malaysia, the Philippines, Singapore, South Korea, Taiwan, and Thailand — collectively contributed .4% of the ISI-indexed scientific literature in 1981, but 1.4% in 1992, slightly more than that of the People's Republic of China (these statistics were taken from ISI's *Science Citation Index*, CD-ROM version).

In terms of output, then, these Pacific Rim nations can now claim only a modest contribution to the world's elite scientific literature. Like China, however, their share of that literature is rapidly rising and has more than tripled during the last decade.

...But Still Modest Impact

In terms of impact (average citations per paper relative to the world average), the Pacific Rim nations have not yet attained world standing. Their papers generally collect only 30-70% of the world's average citations per paper. It is more interesting, and perhaps more realistic, to compare their citation impact performance against one another.

Citation Impact of Pacific Rim Science Papers



SOURCE: ISI's Science Indicators Database, 1981-92.

The time-series chart above, which was created using moving five-year windows of papers published and citations received, depicts citations per (cited) paper for each nation in all fields of science relative to the average for the group.

Among the smaller paper producers in the group, the Philippines posted the best citation impact record and showed a surge in impact in the middle part of the last decade. Indonesia made a strong move in the early years surveyed, but has since fallen back. The impact of science papers from Malaysia slipped sharply in one or more years in the middle part of the period. Taiwan, South Korea, and Hong Kong, which were the big producers among the group, exhibited a considerably steadier performance.

Pacific Rim Nations Ranked by Citation Impact in Five Fields of Science, 1988-92

Rank	Biology	Medicine	Agriculture	Engineering	Physical Sciences
1	Philippines	Thailand	Philippines	Philippines	Thailand
2	Thailand	Philippines	Taiwan	South Korea	Hong Kong
3	Taiwan	Taiwan	Indonesia	Taiwan	Indonesia
4	Hong Kong	Indonesia	Thailand	Singapore	Philippines
5	South Korea	South Korea	Singapore	Thailand	Singapore
6	Indonesia	Hong Kong	South Korea	Malaysia	Taiwan
7	Malaysia	Malaysia	Hong Kong	Hong Kong	South Korea
8	Singapore	Singapore	Malaysia	Indonesia	Malaysia

Field Strengths

The table above, highlights the field strengths of each nation. All papers surveyed for the period 1988-92 (a total of 38,802) were divided into broad fields of science based upon the journals in which they were published. Then the citations-per-paper average for each country in each field was calculated, and the nations were simply ranked by their citations-per-paper scores. The underlined nations produced 10% or more of the papers in each category.

In biology and clinical medicine, Thailand and Taiwan took top honors among those nations producing a sizable number of papers. In agricultural sciences, the Philippines ranked first. In engineering sciences, South Korea stood out. It appears much more highly ranked in this field than in other fields. Finally, in the physical sciences, Hong Kong showed real strength.

Science Watch 4(3):7, March 1993

Forecast 1993

1993 januárjában a *Nature* rövid előrejelzést közölt a kelet-európai régió tudományos életének kilátásairól. Ahogy megfogalmazták: "*Nature* takes a look into its crystal ball at prospects over the next 12 months in several important areas relating to research and the scientific community." Most, hogy már bizonyos rálátásunk van az időközben eltelt esztendőre, ki-ki maga vetheti össze, hogy az azóta tapasztaltak mennyire igazolták a kristálygömb jövendöléseit.

Eastern Europe

Three years after the fall of the German Democratic Republic triggered a domino collapse of communist states in Central and Eastern Europe, celebrations of the new year have lost their sparkle. The arrival of 1990 was greeted with unsurpassed optimism: by contrast, the mood in 1993 could hardly be more different.

Holding up the best is the former East Germany itself. Universities and research centres, restructured along Western lines with formidable speed and determination, were relaunched on 1 January this year on the same legal basis as those in western Germany. In the past three years, the German Academy of Sciences and its institutes have been dismantled, but two new national research centres and two Max Planck Institutes (plus eight departments) have been founded. Nineteen applied research Fraunhofer Institutes set up in 1991 must meet their goals by the end of this year or face closing.

Although the stage is now set for a bright long-term future, it has not been an easy three years. Academic pay is still only 80 per cent of that in the west, and no-one knows the fate of the tens of thousands of scientists dismissed from overstaffed institutes during the ruthlessly enforced renewal process.

Although the methods have caused pain and resentment, the worst is now over. More intractable problems face other countries struggling to establish a science base in their new democracies.

Money is in short supply everywhere, but science reform and restructuring (usually a euphemism for redundancies) have proceeded very gradually because of social resistance. Most Central and Eastern European countries had followed the communist model, itself based on the French model, of separating research from higher education. Reestablishing links between universities and research and breaking down the political powers in scientific research has been more difficult than first thought.

Furthest along the track are Poland and Hungary, where universities and academies had managed to maintain their distance from the communist party. Furthest behind are Romania and Bulgaria. Romania is the only former communist country that has not tried to evaluate its research activities because of the extensive damage done by the Ceaucescu regime. Bulgaria, in a similar but less severe situation, planned an evaluation last October but failed to reach a consensus on how to proceed.

Between the extremes lies the former Czechoslovakia, whose decision to divide delayed the reform process on both sides. Czech research is relatively strong but academic restructuring has hardly begun. By contrast, Slovak research is weaker but its academic system has always been more liberal. The Czech Republic starts the new year with a new, government-directed research plan; Slovakia hopes to institute a science policy by April.

Science in the former Soviet Union probably faces a prolonged economic crisis. Many fear the disintegration of an infrastructure that once provided pockets of world-class research.

Central and Eastern European countries continue to call for foreign aid as short-term measures to help stem the flow of scientists to the West. The European Commission has recently allocated ECU55 million to fund cooperative projects during 1993. Individual institutes — and some individuals — in the East have offered help of various sorts, and the solidarity within certain close-knit international communities, such as astrophysics, has also meant practical support for some projects.

But these initiatives are dwarfed by an economic depression on a scale not seen for decades in Western Europe. In such circumstances, science and research will remain low on any government's list of priorities in 1993.

A. Abbott,
Nature, 361 (7 January, 1993) 4

Der Forschungs Index

A kutatási index

A német kutatás vezető intézetei
Matematika

A befolyásosak			
	Intézmény	**Idézetek száma** (1990-1993 augusztus)	**Publikációk száma** (1990-1993)
1	Bielefeldi Egyetem	102	127
2	Heidelbergi Egyetem	76	87
3	Bonni Max Planck Matematikai Intézet	71	75
4	Göttingeni Egyetem	71	70
5	Bonni Egyetem	66	106
6	Bochumi Egyetem	65	71
7	Darmstadti Egyetem	59	86
8	Aacheni Egyetem	56	85
9	Würzburgi Egyetem	54	47
10	Esseni Egyetem	51	73

A matematikában a főiskolák egymás között vannak

A Science Citation Index által feldolgozott, világszerte vezető matematikai folyóiratokban évente mintegy 700 dolgozatot német kutatók írnak. Ezek közül több mint 92 százalék egyetemekről származik. A Bielefeldi Egyetem matematikai kara mind a legbefolyásosabb intézmények (legtöbbször idézettek), mind az aktív intézmények (legtöbbet publikálók) rangsorát vezeti. Rajta kívül Bonn és Heidelberg állnak az élen a matematikában. Az egyetemeken kívül az egyetlen intézmény, mely a legjobb tíz között helyet foglal, a bonni Max Planck Matematikai Intézet.

A többi kutatási területhez képest a matematikusok kollégáik munkáit feltűnően kevésszer idézik. Egy matematikai tárgyú munka már akkor is erősen idézettnek tekinthető, ha két éven belül több mint ötször említik más közleményekben. Valószínűleg a problémák túl differenciáltak ahhoz, hogy egy kutatónak közleményében egy másik matematikus eredményeire kelljen hivatkoznia. Az alacsony idézettségi fok másik oka az lehet, hogy a matematikusok gyakrabban használják a "szürke irodalmat" (konferencia beszámolókat és az ülésekről kiadott köteteket) a kommunikálásra, mint a szakfolyóiratokat.

Az aktívak		
	Intézmény	**Publikációk száma (1990-1993)**
1	Bielefeldi Egyetem	127
2	Bonni Egyetem	106
3	Heidelbergi Egyetem	87
4	Darmstadti Egyetem	86
6	Bonni Max Planck Matematikai Intézet	75
7	Esseni Egyetem	73
8	Bochumi Egyetem	71
5	Aacheni Egyetem	85
9	Göttingeni Egyetem	70
10	Erlangen-Nürnbergi Egyetem	69

A matematikai "hot spot"-ok

(az 1990 január és 1993 augusztus között német intézményekből származó legtöbbször idézett matematikai dolgozatok)

Idézetek	Cím	Szerzők	Intézet	Miről szól?
12	Algebraic L2 Decay for Navier-Stokes Flows in Exterior Domains	W. Borches, T. Miyakawa	Gesamthochschule Paderborn	Elméleti áramlásfizika
11	Numerical Solution of Differential-Algebraic Equations for Constrained Mechanical Motions	C. Fuhrer, B.J. Leimkuhler	DLR, Oberpfaffenhofen	Mechanikai rendszerek szimulálása
9	Hopf-Bifurcation with Broken Circular Symmetry	G. Dangelmayr, E. Knobloch	Tübingeni Egyetem	Nem-lineáris dinamikai rendszerek elmélete
9	Analytic Torsion and the Arithmetic Todd Genus	H. Gillet, C. Soule, D. Zagier	Bonni Max Planck Matematikai Intézet	Aritmetikai geometria
9	Two Preconditioners Based on the Multilevel Splitting of Finite-Element Spaces	H. Yserentant	Tübingeni Egyetem	Áramlásmechanika
9	Conjugate Gradient-Type-Methods for Linear Systems with Complex Symmetrical Coefficient Matrices	R.W. Freund	Würzburgi Egyetem	Hullámkiterjedés gőzölgő közegben
8	Global Classical Solutions of the Vlasov-Poisson System in 3-Dimensions for General Initial Data	K. Pfaffelmoser	Müncheni Egyetem	Elméleti matematika
7	Derivation of the Double Porosity Model of Single-Phase Flow via Homogenization Theory	T. Arbogast, J. Douglas, U. Hornung	Universität der Bundeswehr, München	Áramlásfizika, kőolajlelőhelyek szimulálása
7	A Class of Iterativ Methods for Solving Saddle-Point Problems	R.E. Bank, B.D. Welfert, H. Yserentant	Dortmundi Egyetem	Áramlásmechanika
7	On Operators with Bounded Imaginary Powers in Branach-Spaces	J. Prüss, H. Sohr	Gesamthochschule Padeborn	Differenciál-egyenletek elmélete

A "magasabb matamatika" sokszor olyan elit öncélnak tűnik, mely a szakmán kívüliek számára érthetetlen. A "Miről szól?"-oszlop azonban azt mutatja, hogy olyan, felhasználásra alkalmas munkák is vannak, melyekre nagyobb figyelem irányul. Ez fontos lehet abból a szempontból is, hogy a pénzért, állásért és felszerelésért folyó konkurenciaharcban a matematika ne mindig az utolsó helyre kerüljön.

Bild der Wissenschaft, 11 (1993) 6-7
(Forrás: USP Wissenschaftsforschung, Bielfeld, a Science Citation Index alapján.)

Készült az Argumentum Könyv- és Folyóiratkiadó Kft. nyomdájában

Felelős kiadó: az MTAK főigazgatója