

**FACULTY BULLETIN
TABLE OF CONTENTS**

JUNE 2007

	PAGE
EDITORIAL INTRODUCTION	2
Peter Wegner and Peter Richardson	
The Annealed Shield: The University of California’s Revised Academic Freedom Policy	3
William Simmons	
The Society of the ElderBears Reaches Middle Age	7
Lewis P. Lipsitt	
Minds on Fire: The University Teacher-Scholar	9
Mark S. Cladis	
How the World Counts and Dates	13
Hendrik J. Gerritsen	
Linking Science, Technology, Math and Engineering at Brown with the K-12 Community	16
Karen Haberstroh	
Connecting the Caduceus: The Chase for Translational Research and Business Creation	19
Gregory D. Jay	
A Short History of Biomedical Engineering at Brown	25
Peter D. Richardson	
Book Review: “The End of Science” by John Horgan	31
Peter Wegner	
INFORMATION FOR CONTRIBUTORS	35

EDITORIAL INTRODUCTION

Peter Wegner and Peter Richardson

This issue's collection of essays covers several time-scales and topics. The time-scales range from kindergarten to post-retirement. The majority of the essays treat aspects of adjustment and adaptation.

Bill Simmons continues to the third part of his series relating to academic freedom, a concept that faculty typically accept and endorse without having followed developments at its cutting edges.

Lewis Lipsitt, famous for his studies of child development from the viewpoint of a psychologist, discusses the development of a brain-child of his together with emeritus colleagues, the ElderBears. While we might not agree they/we have reached middle age, certainly they have matured to a new level, as he describes, helping to expand the role of the emeriti in the reach of the university.

Mark Cladis reflects for us on an adaptation we all make in becoming professors here: being a teacher who is also a scholar, and bringing the continuous reflection, refinement and occasionally revolution that the scholarly life offers, and should illuminate our teaching.

Hendrik Gerritsen reviews for us the arbitrariness in something that might have been a universal practice. The selection of counting and dating systems has a social history, and our social diversity is reflected in the systems used in different places. There are pressures for more uniformity now.

Karen Haberstroh describes a process being applied to achieve outreach in K-12. This engagement of mainly human resources at the university achieves effective partnership with nearby schools and their teachers, an adaptation of the university's reach in the community.

Dr. Gregory Jay argues for such research as is suitable starting from investigations in biology and medicine to be taken to commercialization via business creation, a model where one does not simply obtain results and hope that somehow they will be translated by someone else into beneficial consequences, but one promotes direct and timely translation from clinic and laboratory to products and services.

Peter Richardson, connected with the development of biomedical engineering at Brown from its conception to the present, helps us see its mixed experiences at the hands of its two distinct intellectual parent cultures which applied different expectations to its local evolution. Earlier conflicts were not resolved in ways that kept its initial lead ahead of its institutional competitors. He also outlines its present opportunities. This may have management lessons for so many interdisciplinary fields which strive newly to flourish in the university setting.

Finally, Peter Wegner reviews John Horgan's book "The End of Science". This book suggests that science may be coming to an end because its main ideas have already been discovered and human society is moving in other directions. Though Peter personally denies that science is or should be ending, he feels the book's exploration of the status and contributions of science are useful in evaluating the form of scientific education at Brown and other US universities. We invite articles by readers about science education in response, and on other topics, for the next edition of the *Faculty Bulletin*.

THE ANNEALED SHIELD: THE UNIVERSITY OF CALIFORNIA'S REVISED ACADEMIC FREEDOM POLICY

William Simmons
Professor of Anthropology

In Spring 2002, the Department of English at the University of California at Berkeley posted a course on its website entitled “The Politics and Poetics of Palestinian Resistance” among its offerings for the Fall semester. Little did they know! The original description included the following passages:

Since the inception of the Intifada in September of 2000, Palestinians have been fighting for their right to exist. The brutal Israeli military occupation of Palestine, an occupation that has been ongoing since 1948, has systematically displaced, killed, and maimed millions of Palestinian people. And yet, from under the brutal weight of the occupation, Palestinians have produced their own culture and poetry of resistance....This class takes as its starting point the right of Palestinians to fight for their own self-determination. Conservative thinkers are encouraged to seek other sections.

This course announcement (particularly the last sentence encouraging conservative thinkers to seek other courses) became immediate news of the sort that university presidents and public affairs professionals do not seek. One respondent, Roger Kimball, head of a vigilant organization known as Campus Watch, and author of *Tenured Radicals: How Politics Has Corrupted Our Higher Education*, attacked the announcement in an opinion piece in the *Wall Street Journal* entitled “Are the Regents of the University of California Asleep?” (May 9, 2002). Kimball argued that by its explicit partisanship, abandonment of disinterested inquiry, and warning to conservative thinkers, this course degraded academic freedom and the integrity of the University:

Universities used to be dedicated to the advancement of knowledge. It was understood that if they were to be successful, they had to presuppose what Matthew Arnold called the ideal of ‘disinterestedness’a habit of inquiry that refused to lend itself to any ‘ulterior, political, practical considerations about ideas’....In allowing classes in which conservatives are unwelcome, Berkeley provides further evidence that universities are beholden to leftist ideology.... Finally...Berkeley further erodes the line that once separated academic life from the hurly-burly world of political affairs. The integrity of that line has earned universities a special status as places apart in our society—and tax exempt because their inquiry was not merely partisan.”

Thus awakened, UC chain of command sprang into action. Richard Atkinson, then President of the University of California, asked Professor Robert Post, a leading national authority on academic freedom, to review the “issues of academic freedom and responsibility raised by the controversy surrounding ‘The Politics and Poetics of Palestinian Resistance’.” Post’s response to Atkinson was published in the May/June

2003 issue of *Academe* as “Academic Freedom and the ‘Intifada Curriculum’.” Berkeley Chancellor, Robert Berdahl, Berkeley’s Academic Senate, the Department of English, and the graduate student instructor of the course worked together to resolve the academic freedom issues raised by the course description and in the end, according to Atkinson, “students who took the course gave outstanding ratings to both the course content and the instructor” (Atkinson 2004).

This intense process of review and resolution also revealed what Atkinson described as “a fundamental weakness” in the policies that protect academic freedom in the contemporary university. Referring to the existing University of California policy on academic freedom that was first articulated by President Robert Gordon Sproul in 1934 and formally adopted in 1944, and the policies of other comparison institutions, Atkinson determined that “the principles upon which academic freedom is founded must be elaborated and modified in ways that are relevant to the responsibilities and circumstances of today’s universities” (Atkinson 2004).

The existing policy, known as “APM 010—Academic Freedom”, read in part:

The function of the university is to seek and transmit knowledge and to train students in the processes whereby truth is to be made known. To convert, or make converts, is alien and hostile to this dispassionate duty. Where it becomes necessary, in performing this function of a university, to consider political, social or sectarian movements, they are dissected and examined—not taught, and the conclusion left, with no tipping of the scales, to the logic of the facts.

The University is founded upon faith in intelligence and knowledge and it must defend their free operation. It must rely upon truth to combat error. Its obligation is to see that the conditions upon which questions are examined are those which give play to intellect rather than to passion. Essentially the freedom of a university is the freedom of competent persons in the classroom.

This policy, Atkinson observed, provided unsatisfactory guidance for resolving issues raised by the Palestinian poetry class:

“Neutrality,” the principle that undergirds the Sproul policy, does not constitute a sufficient criterion on which to decide cases of academic freedom. “The logic of the facts” can and does lead different people to dramatically different conclusions. Who decides what is partisan and what is not? Without criteria to make such distinctions, judgment must be made on other grounds. History has shown that those judgments are often based on whether or not the content of a faculty member’s writings or remarks offend specific groups (Atkinson 2004).

Atkinson concluded that the UC policy and other existing policies “did not provide an adequate basis for defining academic freedom” because they focused on the “rights and privileges of a faculty member” but did not provide “clarity about the standard for defining responsibilities [of a faculty member] nor a procedure for judging

whether or not a faculty member met that standard.” A new standard of judgment was needed before a new “crisis or controversy arises.” He therefore charged Professor Post (assisted by colleagues on the faculty and administration), to “formulate a new policy for the University.” This process resulted in the Senate approval and issuance by the President in 2003, of the “Revised Academic Personnel Policy 010, Academic Freedom.” In his letter to Chancellors and Laboratory Directors, Atkinson noted that this new policy “establishes that faculty have primary responsibility for articulating the professional standards by which academic freedom may be sustained” (Atkinson 2003). The distinctive character of the new policy is best expressed in a footnote to the Revised APM-010:

The original language of APM-010...associated academic freedom with scholarship that gave “play to intellect rather than to passion.” It conceived scholarship as “dispassionate” and as concerned only with “the logic of the facts.” The revised version...holds that academic freedom depends upon the quality of scholarship, which is to be assessed by the content of scholarship, not by the motivations that led to its production. The revision...therefore does not distinguish between “interested” and “disinterested” scholarship; it differentiates instead between competent and incompetent scholarship. Although competent scholarship requires an open mind, this does not mean that faculty are unprofessional if they reach definite conclusions. It means rather that faculty must always stand ready to revise their conclusions in the light of new evidence or further discussion. Although competent scholarship requires the exercise of reason, this does not mean that faculty are unprofessional if they are committed to a definite point of view. It means rather that faculty must form their point of view by applying professional standards of inquiry rather than by succumbing to external and illegitimate incentives such as monetary gain or political coercion. Competent scholarship can and frequently does communicate salient viewpoints about important and controversial questions. (<http://www.ucop.edu/acadadv/acadpers/apm/apm-010.pdf>)

By contrast with the AAUP 1915 Declaration of Principles and with the University of California’s original policy on academic freedom, the fulcrum for measuring scholarship and competence has shifted from disinterest and neutrality of the scholar to the quality of work as judged by the academic profession. This revised policy is not without critics—one of whom argued for example that these changes give a free pass to the questionable truth claims of some (mainly humanities) disciplines and that they ignore the quantitative evidence that humanities and social science disciplines are dominated by left-leaning thinkers who in the long run will undermine the “kind of treaty” American universities have with society to “train students in the processes whereby truth is to be made known” (Trow 2005). The new University of California policy nevertheless provides a unique operational innovation in the definition of academic freedom that entrusts academic judgment to the faculty in shared governance while reinforcing the shield of academic freedom against the growing volume of constituencies that would seek to influence that judgment.

Sources

Richard Atkinson

2003 General University Policy Regarding Academic Appointees: Academic Freedom.

<http://www.ucop.edu/acadadv/acadpers/apm/apm-010.pdf>

2004 “Academic Freedom and the Research University.” CSHE Research & Occasional Paper Series: CSHE.2.04 <http://ishi.lib.berkeley.edu/cshe>

Roger Kimball

2002 “The Intifada Curriculum” Campus Watch: Monitoring Middle East Studies on Campus. <http://www.campus-watch.org/article/id/6>

Robert Post

2003 “Academic Freedom and the ‘Intifada Curriculum’.”

<http://www.aaup.org/publications/Academe/2003/03mj/03mjpost.htm>

Martin Trow

2005 “Californians Redefine Academic Freedom.” CSHE Research & Occasional Paper Series: CSHE.3.05 <http://cshe.berkeley.edu/>

THE SOCIETY OF THE ELDERBEARS REACHES MIDDLE AGE

Lewis P. Lipsitt

Professor Emeritus of Psychology, Medical Science, and Human Development

In past issues of the *Faculty Bulletin*, I have spoken of the birth of the Society of the Elderbears, the coming of age of the Elderbears and the achievement of the Elderbears' maturity. It is only fitting, therefore, that we should now recognize that the Elderbears, Brown's only retiree advocacy group, has reached middle age! As a life-span psychologist, I regard this as a critical developmental juncture.

I have to accept myself as a parent figure among the Elderbears, for I was there at the conception. However, none of us wishes to preside over the senescence of this fine organization, so I hope we can regard our current status as that of a watchful parent.

We have given birth to our natural heir. The Faculty Executive Committee (FEC) presented a motion at the February 6, 2007 Faculty Meeting, to establish a new standing faculty committee called **Committee on Faculty Retirement**. Initially drafted with skill by the late Mervin Sibulkin, this motion from the FEC on behalf of the Elderbears was the culmination of an effort to secure recognition of faculty emeriti as continuing faculty members with distinguishing characteristics and distinctive privileges. Hopeful that the launching of this committee will assure friendly and reciprocating relationships of the emeriti with the University, we express our indebtedness to the most recent chairs of FEC, Professors Robert Pelcovits and Ann Dill, for bringing our draft to special clarity and, eventually, approval by the Faculty.

Why would either the Elderbears or a new committee have been necessary to work toward improved conditions at the University for retired faculty? In the past, some retired faculty members who wished to be helpful considered themselves ignored. Some wanted to be "on call" for committee work, or to be available for lecturing to alumni, or to be available for mentoring in their areas of expertise, and perhaps useful to occasional classes or other teaching situations when some pinch-hitting was needed.

Sadly, we learned that some retirees felt excluded by their departments and the University once they had retired. One faculty member reported that he had been "walked to the door" on the day of his retirement, losing his office suddenly and giving up all secretarial or other support services of his department. Some emeriti reported their retirement as marking the onset of psychological depression -- not uncommon in other occupations as well, particularly in business enterprises where individuals have worked for many years and regarded themselves as vital for the company's success.

Other reasons for faculty retirees coming together in a common mission include their expressed need for continuing association with each other, and the creating of opportunities for an enduring camaraderie with colleagues, both in and out of their respective departments. Most retirees are eager for intellectual stimulation and social interaction of the sort that university campuses have provided for them during their work life, and now they want to be free to experience those pleasures without fear of even seeming rejection by the institution with which they have been so closely associated.

Another area of great concern to faculty retirees is that of health care and medical benefits. Most retirees claim they have been quite pleased, during their active teaching years, with the University's contributions to their health policies and medical coverage plans, even as they complained, as does the rest of the population, about the volatility of the health coverage programs. But then, upon retirement, they were chagrined to realize that their health benefits had dropped – on the day of their retirement – to zero. They were now completely responsible for their own health plan coverage.

While most emeriti can take advantage of their Medicare benefits, the supplemental payments became suddenly and entirely their own responsibility. The Elderbears discovered that some retirees did not even realize they would lose all University-subsidized medical benefits upon retirement. Our conversations with young faculty members revealed that most assume that continuing coverage after retirement “comes with the job.”

The Elderbears have explored other institutions' policies for retired faculty. Most institutions, particularly those with which Brown likes to compare itself, have medical benefits for faculty extended into retirement. The size of the benefit varies greatly, but some are very liberal. The California system, as an example of a public university, and Amherst College, as a private institution, provide full – i.e., complete, with no cost to the retired faculty member – medical policy coverage. Yale is perhaps a special case, providing free care to all retirees through its own medical school and associated hospitals.

Yale is a special case in another regard. A building on campus is devoted almost entirely to the retirement organization. In these quarters there are offices available with comfortable furniture and various amenities, including technical assistance, and retirees may request space for specific lengths of time, to work on special projects. This removes the burden on some academic departments which, as soon as a professor retires, must use the office space for a new faculty member.

It is perhaps too much to hope to replicate the Yale situation, made possible by a substantial alumnus gift to Yale to renovate its oldest campus building, transforming part of it into an elegant faculty retirees' center. But the Society of the Elderbears, until now an independent and essentially informal cohort of retirees with a constitution and a mission, is pleased with its development thus far. Many of our concerns, we hope, will be carried forward by the newly born Faculty Committee on Retirement. We now look toward the future with optimism that goes with this stage of development – rather like middle-aged parents. This is a condition many of us recognize as involving a multi-faceted presence. On the one hand, we stand ready to provide advice and guidance, and sometimes notes of caution. On the other hand, we hope that our offspring, the new **Committee on Faculty Retirement**, will be noticing the needs we have, and help the University to treat our presence with kindness and at least a modicum of pleasure.

Professor Lipsitt, a founder of the Society of the Elderbears, retired as an “active professor” in 1996, and now celebrating his 50th year as a Brown University faculty member, maintains an office in the Department of Psychology and continues as a researcher in a long-term study of 4,000 children begun at Brown in 1959. In April 2007 he delivered a keynote address at the Middle East and North Africa Conference of Psychology, in Amman, Jordan on “lessons from babies on the importance of pleasure and annoyance in development, and implications for learning over the lifespan.”

MINDS ON FIRE: THE UNIVERSITY TEACHER-SCHOLAR

Mark S. Cladis
Professor of Religious Studies

On occasion I have come to the conclusion that I have little idea what I am doing as an educator. I am not being modest here. My teaching evaluations are high; I am well prepared for my courses; I am comfortable with students and they with me; I adore teaching, and I am good at it by most standards. It's the standards, perhaps, that give me pause. What are my standards, what are my goals, and who are my models?

I want to reflect briefly on the educational mission of the University. I want to consider what we do—or attempt to do—as University teacher-scholars. More specifically, I want to think about the place of what I will call "the practical" in the University. Given that this is a brief reflection, I will cheat a bit and allow myself to violate our practice of making nuanced qualifications. I will make grand generalizations. I will write of the University with a capital "U," and I will not be referring to Brown in particular but to the University as an ideal type (in a Weberian sense). Although my reflections pertain to undergraduate, liberal arts education, I still choose to write of the University, and not the College, because the ethos of graduate schools profoundly influences undergraduate education.

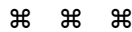
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As the disciplines in the University become increasingly specialized, they produce valuable information, theories, and methodologies, but they often lose sight of the overarching goals and aims of the liberal arts. What are those goals and aims? We can think of a University education as a commitment to developing skills and habits of thought that enable students to interpret and engage a complex world, past and present, near and far, familiar and unfamiliar, natural and social. These goals require such capacities and skills as close reading—of texts and of the natural world; excellence in writing and verbal expression; interpretation of the past from written and physical evidence; close observation in all kinds of field and laboratory work; interpretation of past and contemporary societies, not only by studying them directly, but by acquiring comparative knowledge of other times and other places.

University education, moreover, entails having students become both more and less at home in the world. *More at home*, insofar as students gain confidence in their role in society and become committed to common projects that connect them to others; *less at home*, insofar as students' presuppositions are challenged and students become open to discovery, change, and wonder.

And there's more. University education fosters such virtues as commitment to justice, the cultivation of courage, and the development of practical reasoning (skill in utilizing the best means to achieve one's wisely chosen ends). If we are to tackle such problems as racism, economic injustice, or environmental degradation—problems that have both a personal and an institutional face—then we need to assist students in gaining not only specialized information but also nurtured dispositions that exhibit a practical concern for such democratic values as respecting difference, honoring human dignity,

and engaging in worthy, shared projects. Such dispositions cannot be achieved alone in private. Nor can they be gained in a public culture that neglects the cultivation of character and the interior life. Here I am merely reaffirming a classical understanding of pedagogy: the education of the whole person for the sake of personal and societal flourishing.



The University is often uncomfortable with the practical or with what is sometimes called the applied. With the exception of the natural sciences, in the University “the applied” is often understood as what students may choose to do on their own time. If they want, students may attempt to apply knowledge gained in the classroom to other realms in life. For example, students may opt to apply research in social psychology to their friends or romantic partners; research on group behavior to the University’s admission policies; research on plant ecology to local toxic waste sites; and research on micro- and macro-economics to regional poverty and business.

Below I will briefly allude to one category of the practical that University does often embrace, namely, pre-professional training—preparing students to join the work force. However, first I want to mention a form of the practical that the University seems to be uncomfortable with—moral inquiry and practice.

A few months ago I was talking to a colleague whom I greatly respect about the possibility of hiring someone in biomedical ethics. I suggested such a hire would be a wonderful addition to the Department, expanding the curriculum and connecting us in interesting ways to the Medical School. In an age of rapid biomedical breakthroughs, including, for example, stem cell research and cloning, societies and nations will increasingly need to make important decisions about the funding, application, and consequences of such promising research. My colleague surprised me with the reply, “We shouldn’t have anything to do with that [biomedical ethics].” When I asked “why,” I was told “biomedical ethics has to do with values, and we shouldn’t have anything to do with values.”

This comment is representative of a common view in the University. In this view, professors should not be in the business of asking our students, “How shall we live?” This contemporary view on pedagogy, a recent development to be sure, is at odds with much of our history of educational practices, including classical ones. Take Aristotle, for example. He was a master teacher. His *Nicomachean Ethics*, written for his students, is surely one of the most important works on ethics. Early on in that work he made it clear that the goal of the inquiry is “not in order to know what virtue is, but in order to become good.”¹ Narrow academic knowledge—that is, knowledge disconnected from vital personal and public matters—is not the fundamental aim, but rather the aim is practical skill—skill in becoming good. This is not anti-intellectualism on the part of Aristotle. Careful, critical, analytic, circumspect moral inquiry marks his approach and style (sometimes to the dismay of undergraduates who find his precision and nuance daunting). The point is that the aim of Aristotle’s careful, analytic, sometimes theoretical, other times descriptive, work is practical: that humans become skillful in wisely navigating the complex and multiple worlds in which they find themselves. And such skillfulness, I am arguing, should be part of the mission of the University. Some may even argue that it should be the chief aim of the University and all other aims should be subordinate to it.

I am not putting forward such a strong claim. I merely want to argue for some space in the University for asking in a variety of fitting ways: "Who are we and who should we become?" and pursuing such questions both in the classroom and outside the University gates—outside, for example, in the public schools, in the prisons, in the local woods and farms. Often by asking the second question, "Who should we become?" we begin to make some progress on the first question, "Who are we—what places, people, and events have shaped our diverse identities, backgrounds, membership in separate and overlapping communities, our various hopes, loves, and fears?"

The practical, as I am using the term here, should not be construed as the utilitarian, if by utilitarian we mean the pursuit of narrow, "pragmatic" (think, "hardheaded") goals that do not include such pursuits as beauty or justice. That which is the least utilitarian can turn out in fact to be the most practical. This isn't a paradox. I'm just trading on different meanings of the practical and the utilitarian. The utilitarian often refers to that which most effectively advances one's pragmatic, no-nonsense self-interests. So, we hear people referring to reading, writing, and arithmetic as components of a utilitarian education, because these components, it is held, will someday get you a job. The arts and physical education, in contrast, are not deemed utilitarian and are perhaps even considered frivolous—at least we often hear this argument around the season of school budget cuts. But what if beauty in art or teamwork in sports can save a life? It can, you know. Less dramatically, art and athletics contribute in a variety of ways to human flourishing. In coaching and in the production and appreciation of art, you initiate students to a discipline, to a pursuit of excellence. Work, commitment, love, good results, and the beauty of sheer effort—these ingredients mingle naturally and inform and sustain character, educating hearts and minds. This is practical. Yet the practical is suspect in University education.



There are, then, many pursuits in education which may not have direct utilitarian results, but which are nonetheless deeply practical, if for no other reason than that they contribute to lives worth living. If our classrooms truly became those of "the M'Choakumchild school" in Dickens's *Hard Times*, our students would become as T. S. Eliot's Hollow Men:

Shape without form, shade without colour,
Paralysed force, gesture without motion...ⁱⁱ

The life our students need to prepare for is too complicated, too wonderful, too difficult for the paltry, narrow education of the M'Choakumchild school.

For present purposes, then, I have made a distinction between the practical and the utilitarian in education. I have also suggested that the University culture is nervous about the practical. But what of the utilitarian? What is the University's relation to the utilitarian? This is a complicated question. Here I can only allude to one facet of it. Increasingly, students see a University education as a ticket to a job or to a graduate degree that will bring future success in the professions, especially law, business, and medicine. A well-rounded University education *does* provide excellent training for the professions. Future success in a profession, however, should be seen as a secondary or

indirect consequence of excellence in undergraduate education. When it becomes the chief aim of education, then the University and its professors become mere instruments for the preparation of workers for the marketplace. There is much social pressure on students—and increasingly on the University—to see education as the cultivation of credentials and skills for the market. Education, in this view, is the accommodation of the pre-established demands of the market. To argue against this view is to risk sounding naïve or impractical. I, however, have been suggesting that the older view of education as self-transformation in the context of various common goods forged jointly in community and society is, in fact, practical. It is, moreover, worthy of what we call *higher* education.

Knowledge, beauty, ethics, theory, and the practical—pursue these in our colleges and universities. Different professors and students will give different weight to these domains, attenuating some, emphasizing others. This is as it should be. But permit and celebrate all these avenues of inquiry and human growth. Let the liberal arts be liberal, that is, generous in its offerings. Human flourishing requires diverse nourishment. Practical and theoretical tools for pursuing justice, art, science, wonder, and self-knowledge—admit all of these. Our students deserve no less.

In "The American Scholar," Emerson argued that American colleges do best when they surpass convention and "gather from far every ray of various genius to their hospitable halls, and, by the concentrated fires, set the hearts of their youth on fire." As an American scholar, I want to gather from afar. As an American teacher, I want to set hearts on fire.

¹ Aristotle, The Basic Works of Aristotle, ed. Richard McKeon (New York: Random House, 1941), p. 953 (1103b27-28).

¹ T. S. Eliot, The Complete Poems and Plays (New York: Harcourt, Brace, and World, 1952), p. 56.

HOW THE WORLD COUNTS AND DATES

Hendrik J. Gerritsen
Professor Emeritus of Physics

A while ago an article in the Providence Phoenix drew my attention. It described a movement, called the “Zwanzigein” movement, initiated by a professor from Aachen, Germany, called Gerritzen(!). He tries to change the way Germans count as demonstrated by the number 21, presently pronounced and written out as einundzwanzig. The professor prefers to say zwanzig(und)ein, comparable in structure to the way it sounds in English, twenty- one, and do that also for the other numbers up to 100. This stimulated me to investigate the structures of counting used in a number of –mainly– modern languages. I will restrict myself largely to statements, but have numerous data to back them up

First of all, is English counting actually so logical that it deserves to be used as model for change of the German language? I would argue that it is not quite that perfect. Look at the numbers between 10 and 20 where in English we have thirteen up to nineteen which sound, as I will from now on call this, “inverted”. We do not say t(e)en-three and t(e)en-nine as would be more logical. The numbers eleven and twelve were originally probably also inverted, but got so melted together, that they are almost like special numbers. From 20 on up to 100, the counting in English is rational, not inverted. Another, logical, point in English and German alike, is the pronunciation of the multiples of ten for example: sixty is like 6×10 etc. I now will set up a structure for placing the number: Category I. Contains the numbers from 11 to 20. Category II the numbers from 21 to 100 with the exclusion of Category III: The multiple of 10 numbers. These three categories can have values such as: straight(s) as in twenty-one or inverted(inv) as in nineteen for categories I and II and regular(r) or irregular(irr) for Category III.

An ideal counting language, which would be easy to learn for immigrants and children, particularly for those with some learning disability, would have I and II straight and III regular. I know of at least four such languages: They are Chinese, Japanese, Korean and Samoan –as representative of Polynesian languages-. Judge for yourself as I will give examples of Samoan and Chinese: In Samoan the numbers I selected are 1 = tasi, 2 = lua, 5 = lima, 10 = sefulu. From it we derive words for 11, 12, 20, 21, 50, as follows: sefulutasi, sefululua, luasefulu, luasefulutasi, limasefulu etc. In Chinese, Japanese and Korean it goes in a similar way: In Chinese 2 is er and 10 is shi so 12 is shier and 22 is ershier; the number 5 is wu, so 50 is wushi.

I will now concentrate on less ideal languages, certainly evolved in their particular way due to historical circumstances and older counting systems, and chose languages I am somewhat familiar with namely various examples of the Indogermanic family. Let me begin with English, where we have seen that it is I(inv), II(s), III(r). Of the Germanic languages German and Dutch, we have I(inv),II(inv),III(r).In the Scandinavian family we find that Swedish, Norwegian and Icelandic are similar in structure to English except that in Norwegian 21 is now tjuen (20 = tjue) but in old Norwegian it was enogtyve (en=1 and then 20 was tyve), so it changed from inverted to straight, there is hope for Professor Gerritzen’s movement! Danish is the odd fellow out, irregular in all categories. In particular I believe that multiples of ten show signs of an earlier base 20. I will give now some numbers in Danish with the Swedish in brackets behind them.

1 = en(en), 2=to(tva), 3=tre(tre), 4=fire(fyra), 5=fem(fem), 6=seks(sex), 7=syv(sju), 8=otte(atta), 9= ni(nio), 10=ti(tio) 20=tyve(tjugo), 21=enogtyve(tjugoen), 30=tredive(trettio), 50=halvtreds(femtio), 60=tres(sextio), 70=halvfjerds(sjuttio), 80=firs(attro), 90=halvfems(nittio), 100=hundrede(hundra). One sees here the inversion in Danish for 21, but not in Swedish and the very strange Danish words for multiples of ten. I speculate that Danish shows an earlier base of 20, so that 60 is three times 20 (tre s), 80 is four times 20 (fire s). Now the funny words with halv, which I speculate means half of 20 = 10. Placing it before the larger number may do the same as in Latin, where XL means $50 - 10 = 40$, but LX means $50 + 10 = 60$. So this explains halvtreds as $-\frac{1}{2} \times 20 + 3 \times 20 = 50$ and halvfjerds would then be $-\frac{1}{2} \times 20 + 4 \times 20 = 70$ (fjerds would then equal firs) while halvfems stands for $-\frac{1}{2} \times 20 + 5 \times 20$, where fems would be the no longer used form for 100. I looked at Frisian, a language in between Danish and Dutch. It is inverted in Cat. I and II as those two, but Cat. III is regular, no trace of 20 as base is evident. Among the Latin derived Romance languages, the counting is in general similar to the Latin with exceptions. First, 20 in Latin is viginti, which indicates to me that it is not derived from 2 and 10 but is a separate word. In French it is vingt and similar words in Spanish, Italian, Portuguese, except in Rumanian, where it is douazeci, from doi=2 and zece =10. Category I (11-19) in Latin is inverted, 17 is septem decim, French etc are not inverted but reads dix sept Category II (above 20) is in all languages straight as in 22 = viginti duo in Latin, vingt deux in French, veintidos in Spanish. Category III is regular in all except in French. Consider 80, in Latin octoginta, Spanish ochenta, Rumanian optzeci but in French quatre vingts = 4×20 , in a similar way as in Danish 80 is firs. Then for 90 French uses quatre vingts dix, $4 \times 20 + 10$, the + sign because the ten is placed behind 80. In Latin and the other Romance languages it is nonaginta, Spanish noventa etc.

Now look at a Slavic language, Serbocroatian. Category I is inverted as in 17 = sedamnaest (sedam=7, deset=10) but Cat. I is straight as in 31 = trideset I jedan (jedan = 1). Cat. III is regular so 20 = dvadeset. Finally we look at two ancient languages, old and modern Greek and Lithuanian. I shall transcribe the Greek in the Latin alphabet.

Modern Greek comes close to ideal from the logical perspective. Cat. I and II are almost all straight except for numbers 11 and 12 which are (h)enteka and dodeka, but 13 is already straight dekatria. That was not so in old Greek where Cat. I was inverted. 13 was treiskaideka and 19 (h)enneakaideka which in modern Greek is dekaennia. .

20 has a peculiar word, eikosi, not something like twotens, but otherwise no trace of irregularities. Thirty is trianta and 80 ogdont regular. Lithuanian inverts Cat. I but Cat II and III are straight and regular, as in English. 20 is normal, dvidesjimt (desjimt=10)

In conclusion: Many Indogermanic languages have inversions in Cat I, fewer have it in Cat II Cat. III is mostly regular with few exceptions. There are traces of earlier systems with base 20 and the number 20 itself is not always of the form like two tens, but has a separate word. There appears to be a trend to evolve in a logical direction.

Last week- end I mentioned to my brother in the Netherlands what I was working on and he told me that when he was 7 years old the teacher spent an afternoon to help him deal with the confusion the inverted Dutch counting was giving him. It runs in the family.

The second issue I began to wonder about is how people decide to define a precise date. Here I used present day newspapers from the Rockefeller library as my guide. As European immigrant I have been- and still am occasionally - confused about

the American system of dating and find it illogical. The most logical system is (again) used in the far East, in China, Japan, Korea, where one starts with the year, narrows down further to the month and then finally to the day. The opposite is what I will call the European system, where one starts out with the day, then the month, then the year. This system is used in France, Germany, Greece, Italy, Russia, Sweden, and the Netherlands to mention some countries. I find that system somewhat less logical than the oriental system for the following reason: If one wants to know when an event took place, the most important is the year, which tells you immediately where you have to place it roughly and then define it further. The American system starts with the month, narrows down to the day and then opens up enormously to the year. To cope with the confusion, particularly when in doubt what system was used, I have sometimes benefited from the fact that numbers larger than 12 must refer to the day of the month, but of course it does not always work. Fortunately, administrators at the interface between systems such as border control people instituted a system wherein it is indicated where to put month, day and year on the paper. I also found other interesting things: The European date system is also used in Brazil, Mexico, Puerto Rico, Israel and Samoa, but in England one can find both the European system (in the Guardian) and the American system (in the London Times), but the more widely read Guardian Weekly uses the American system as do Irish papers and English Canadian papers. I am curious about French Canadian papers, anyone knows? When and why did America decide to use such an illogical system?

Should the Americans change their system? I think so and preferably to the Oriental rather than the European system. Does America have the energy to do it? We still suffer from inches, feet, degrees Fahrenheit etc. and have made no progress. May be with the unavoidable further globalization and the growth of the technical influence of the Orient we may be forced to rationalize our archaic systems including that of dating.

As I laid the last hand on this article, a peculiar coincidence happened. I picked up the *Brown Daily Herald* of the 8th of March 2007 and inside was an insert POST-2007,3,08 Volume 8 issue 5. Here we have the best system used, the Oriental one! Of course we can use any system we want and in novels one often uses the European system as I just did.

LINKING SCIENCE, TECHNOLOGY, MATH, AND ENGINEERING AT BROWN UNIVERSITY WITH THE K-12 COMMUNITY

Karen Haberstroh

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Technology, Engineering, and Math (STEM) Outreach**

Brown University is a recognized leader in teaching and research, located in an urban setting with a stressed public school system. The Providence Public School (PPS) system has faced major cutbacks in the past decade, necessitating the elimination of science and computer specialist positions from the elementary schools. In addition and despite the fact that most schools in the PPS system lie within a few miles of Brown University, a large number of Providence Public School children have never stepped on a college or university campus and most will not go on to college. Fewer still will consider careers in science, technology, engineering, and math (STEM).

Undoubtedly, the knowledge and dedication of Brown University's STEM faculty and students, coupled with the many resources that we are fortunate to take advantage of at Brown, can help implement long-term change in the community. These commitments have been most recently highlighted at the university level through large scale efforts like the establishment of a formal partnership between the university and the Providence Public Schools (most notably through the hiring of Lamont Gordon, Brown's Director of Education Outreach), the response to the Slavery and Justice report (including the multimillion-dollar commitment on 2/4/07 by President Ruth J. Simmons aimed at improving public education in the Providence area), and Brown's Plan for Academic Enrichment. Here it was appropriately stated that, "It is impossible for Brown to move forward without interacting with our neighbors on the east side and in the city and state, and our ability to take advantage of possible synergies and work out conflicts in a cooperative and forward-thinking way will have a significant impact on our success with these initiatives." (<http://www.brown.edu/web/pae/community.html>)

In addition, several collaborative programs across campus have marked current and future success with federally funded science education and outreach initiatives. As one example, Brown University recently received a five-year, \$3m Graduate Teaching Fellows in K-12 Education grant from the National Science Foundation ("GK-12: Physical Processes in the Environment") to support nine Brown graduate fellows per year to collaborate directly with the Providence Public School System, and a series of training and enrichment programs for teachers and students. This program is a collaborative effort between the Division of Engineering (co-PIs Gregory Crawford and Karen Haberstroh), the Geological Sciences Department (PI Timothy Herbert), the Physics Department (co-PIs Ian Dell'Antonio and Gregory Tucker), and the Dean of the College's Office (co-PI David Targan).

This exciting program was based on successful pilot initiatives involving Brown graduate students, which taught the GK-12 team that Providence Public School students and their teachers can be caught up in the excitement of science. These efforts have included graduate student delivery of hands-on, application-based teaching "modules" in the K-12 classroom – an approach in line with research suggesting that hands-on learning

tools, teachers meeting parents, and mentoring by peers and faculty are critical to increasing the interest and retention of students in the sciences.

Specifically at the elementary level, nearly 20 graduate students per year from Geological Sciences (one-half of the department's graduate enrolment) have volunteered their time to teach in two fourth-grade classes at the nearby Vartan Gregorian Elementary School. These students visited both fourth grade classes every week in pairs, and brought hands-on activities to the classrooms that promoted both science content knowledge and a deeper understanding of the nature of science. An example lesson on Energy and Natural Resources explored the difference between potential and kinetic energy and emphasized the idea that all energy ultimately derives from stars. Demonstrations included a windmill powered by heat from a candle as an example of the conversion of potential energy to kinetic energy. In another activity, students "mined" the chocolate chips out of cookies to see how resource extraction can damage the environment. The lesson ended with a discussion on how students can decrease their demand of non-renewable resources. High school pilots to date have occurred with Central, Cooley Health Science, and Hope High, where Engineering and Physics graduate students have worked with the high school students on hands-on, inquiry based science. Many of the activities have been designed to complement the science curriculum and included such things as optics (lenses, light scattering, polarization, and laser experiments); experiments with liquid nitrogen and balloons to learn about gas pressure; and building a solar system to scale to learn about the scale of the universe and telescopes. Students have also turned their attention towards preparation for the state Science Olympiad in which these schools had never before competed.

In each case, the graduate students and their developed modules have been very well received by K-12 teachers and students. At the same time we have witnessed an increase in the morale and motivation of the graduate students who participated in public school outreach. It was for these reasons that the co-PIs applied for and obtained NSF GK-12 funding, which allowed for an expanded graduate fellow program that builds on prior strengths and activities. Specifically, the newly funded GK-12 program will provide pedagogical training for K-12 teachers and graduate fellows (provided by the East Bay Education Collaborative in Warren, RI); paid summer research experiences for K-12 teachers and high school students; academic year design and implementation of hands-on science teaching modules in elementary and high schools; professional development for K-12 teachers, graduate fellows and faculty (in the form of an academic year seminar series designed and delivered by Dr. Larry Wakeford of the Science Education Department at Brown); and "Science Days" at Brown University. Critical to the success of this program will be Brown faculty and graduate student understanding of the state and district science standards and benchmarks, as well as the upcoming science testing, so that any modules developed and implemented are in line with the science curriculum.

We expect many long-lasting impacts of this program on the Providence Public schools, its teachers, and its students. It is also our hope that the GK-12 initiative (and others like it on campus) will effect lasting change within Brown students, individual faculty members, science departments, and the larger university culture. The gap in science between universities and public schools is well-recognized. We believe that faculty will grow to further embrace continuing K-12 outreach as they see an improvement in their students' morale and purpose, with tangible benefits to student

retention and long-term productivity. Faculty advisors will see that the experience of learning (through K-12 teachers) to present science in a non-technical and hands-on way makes their graduate students more effective in presenting their research in group meetings and at scientific conferences. Faculty and departments will see that outreach and K-12 educational involvement will be a plus in recruiting new graduate students, as these efforts become part of the distinctive “signature” of their programs. Finally, faculty contact with the PPS will inevitably bring them closer to a very diverse student and teacher population, and therefore enhance their appreciation for teaching to an increasingly diverse student body.

CONNECTING THE CADUCEUS*: THE CASE FOR TRANSLATIONAL RESEARCH AND BUSINESS CREATION

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Translational research is fundamental to the contemporary roadmap of the National Institutes of Health (NIH) and other governmental health agencies, enabling researchers to redirect grantsmanship and add visibility to the institutional research enterprise. Academic medical institutions engaging in translational research can accrue great benefits in a number of different ways. First and foremost, translational research defines a pathway to improved clinical care, bringing great visibility to the institutions that do it well, ultimately defining an academic medical center as cutting-edge and providing an advantage in competitive clinical markets.

Translational research is a new, all encompassing discipline that must successfully integrate elements of basic science, engineering, industrial design and clinical research, and therefore requires skills and resources never attainable in a single academic or clinical department. Translational research is hindered by the traditional structure of the medical and academic institutions, which favor departmental organizations over interdisciplinary consortiums. This hurdle is also raised by promotion requirements favoring grant mechanisms, which do not normally support translation.

Despite the overwhelming investment in biomedical research and the potential benefits institutions accrue by engaging in translational research, translational outcomes have not been fully exploited to improve medical therapies or diagnostic procedures. The lack of success of translation is attributed to many factors. Well meaning translational leaders admit that the proverbial “bench to bedside” process is rarely straightforward and requires continuing research in both the clinic and the laboratory, as well as business vehicles. Synergistic partnership between engineers and physicians is essential for future generations of medical device technologies, which will likely fundamentally alter the definition of modern health care. Indeed, the parallel educational mission of translational research, in close coordination with the relevant academic departments, will be to develop models of interdisciplinary education that can forge curricular pathways for a “new breed” of scientifically multilingual scientist-engineers and physicians with a translational leaning. Cross-trained scientists could also fuel the translation engine by recognizing solutions to stagnant clinical practices and employ a “bedside to bench” approach to solve our most vexing gaps in clinical practice.

Historically, the need for translational researchers has been the niche of Medical Scientist Training (MD-PhD) Programs, but this paradigm should be extended to both undergraduate and graduate education as well. The creation of high technology incubators near academic medical centers has also addressed this need by providing a

place of transition for commerce -oriented biomedical research. Biomedical engineering curriculums have introduced minor concentrations in idea management. However, the true needs remain unmet to prepare academic medicine for redirected NIH priorities and the opportunities which globalized economies will create. One example of this redirection is the Clinical and Translational Science Award (CTSA) grant mechanism, which is a new form of program project grant.

The Warren Alpert Brown Medical School was awarded a Phase I CTSA planning grant in 2006 in the effort to grow translational research in several different ways. Four co-laboratory focus areas were identified, of which one is Emerging Technologies. The Faculty interested in this area at both Brown University, University of Rhode Island (URI) and Rhode Island Hospital (RIH) span multiple disciplines for the reasons described above. By virtue of their achievements there are recognizable translational efforts in neuro rehabilitation, orthopaedic bioengineering, and medical device design and clinical trial. However, these faculty also note the urgent need for support in small business creation as a way to disseminate the translational value of their studies. Figure 1 shows the status quo in Rhode Island as it pertains to these latter efforts.

In between a great idea or laboratory finding which has clinical hope, and the ‘incubator’ is a phase where that idea is nurtured and tested within the confines of our university or hospital. Following the submission of a patent, the investigator can pursue either a licensing or business creation strategy to create an opportunity for meritorious technology that self-fulfills itself through traditional free standing economic enterprise. However, moving from the bench to that stage is fraught with difficulties and challenges which dissuade many scientists and clinicians from company formation. The licensing strategy alternative can be equally frustrating since guarantees do not exist that new technologies will make a clinical impact; serving instead to exclude competitors from a marketplace. A need exists to help faculty make informed decisions about which direction is best for their work.

Figure 2 identifies how to fill a critical gap between institution-based activities and seed funding which can be obtained from local sources such as the Slater Center. This gap is dubbed the “idea accelerator” and can be supported by federal mechanisms such as the Small Business Technology Transfer (STTR) Award. The “idea accelerator” provides that period of idea nurturing and early company formation. This period should be supported by four different institution-based disciplines, which work together to inform faculty and help manage both small company and institutional needs.

Start-up germination begins with a faculty educated about conflict of interest (COI) management, intellectual property creation, and patent law. These are among the first concerns faculty must digest in working with technology transfer officers to determine whether intellectual property exists and how it is best protected. However, administrative and educational assets, which would serve to guide faculty in identifying

COI's and their remediation do not readily exist. This constitutes an early barrier to company formation, particularly since faculty are cognizant of their primary responsibilities in education or patient care. In fact, the identification and documentation of COI's, whether real or perceived, is a necessary exercise, which upon review by the appropriate ethics authority, frequently results in clarified inter-institutional and inter-personal relationships, allowing translational efforts to proceed. The important point however is that a well meaning faculty and student body versed in self identifying COI's is an important asset in overcoming this early barrier. Educational programs are needed to help our faculty and students progress to this level.

The remaining two assets of the idea accelerator Venn diagram are: regulatory issues and business support. Educational and well orchestrated administrative efforts are needed here as well. FDA permits the utility of early data in the regulatory approval process under a strict set of criteria. Appreciation of this process and why it exists is an important aspect of company formation, and one which faculty would best know earlier than later as it may impact the licensing versus company formation decision.

Finally, the idea accelerator should have ready accessibility to business leaders at both the state and local levels. These individuals provide access to a regional network of business leadership talent, angel and venture capital investors who may get an early look at promising nascent technology. This serves to spur translation along by aligning the talent pools helping to ensure technology development in the right vehicles. In addition, leaders from the RI Economic Development Corporation could play a much needed role by allocating matching state funding for certain business creations that are particularly synergistic with the RI economy. As suggested in Figure 2, Slater Center support could be sought after this critical step in the idea accelerator.

In summary, a growing number of well-regarded institutions have addressed the NIH call for translational research with innovative idea management and business creation systems. These institutions recognize that "spun-out" translational research business enterprises will generate a greater and concomitant economic impact than a simple licensing strategy. Faculty from Brown, URI, Miriam Hospital, RIH and Pawtucket Memorial Hospital participating in the CTSA Phase I planning grant recognize this and the need for an idea accelerator. These same faculty also acknowledge the role that these systems play in attracting new high caliber faculty.

A Translational Sciences Center would be unlike any center currently at Brown, an all encompassing effort bringing together scientists, engineers, clinicians, physicians, and technologists from multiple institutions under a truly interdisciplinary 'umbrella', to solve and translate some of the worlds most challenging biomedical problems.

Figure 1: Status Quo in Rhode Island

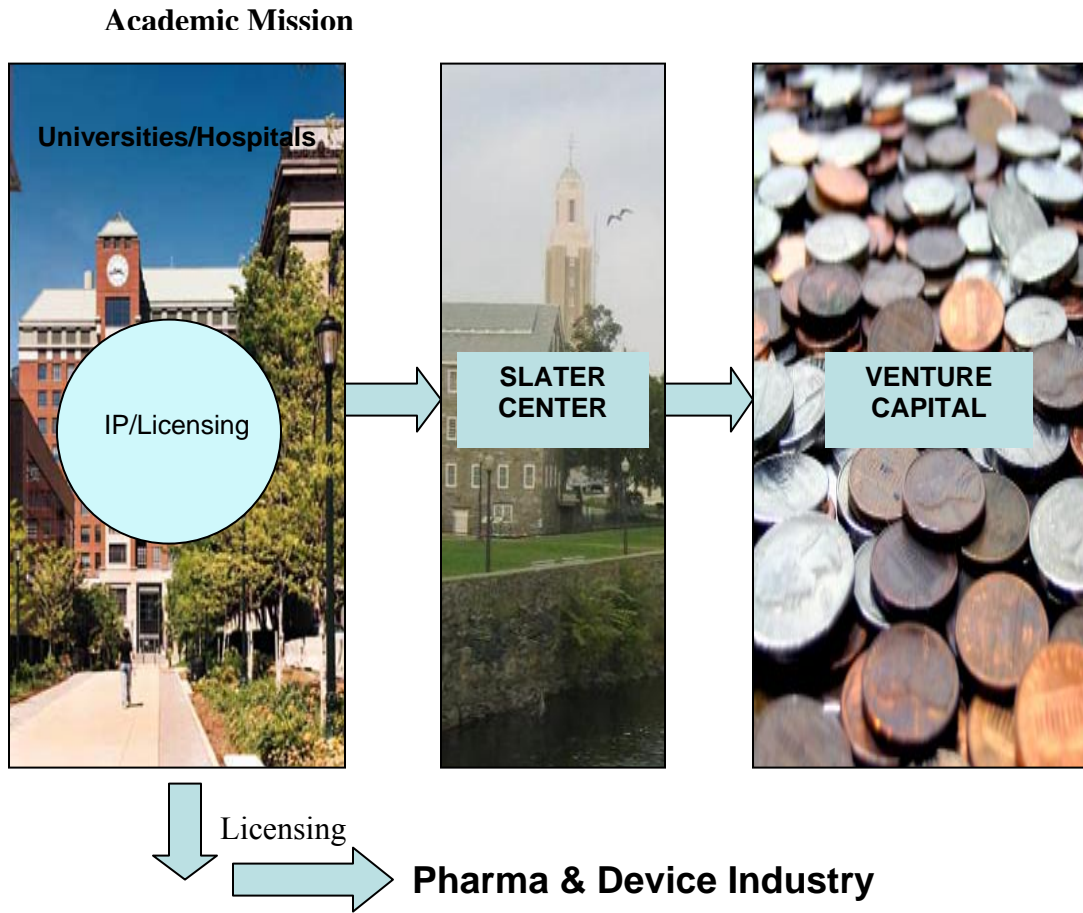
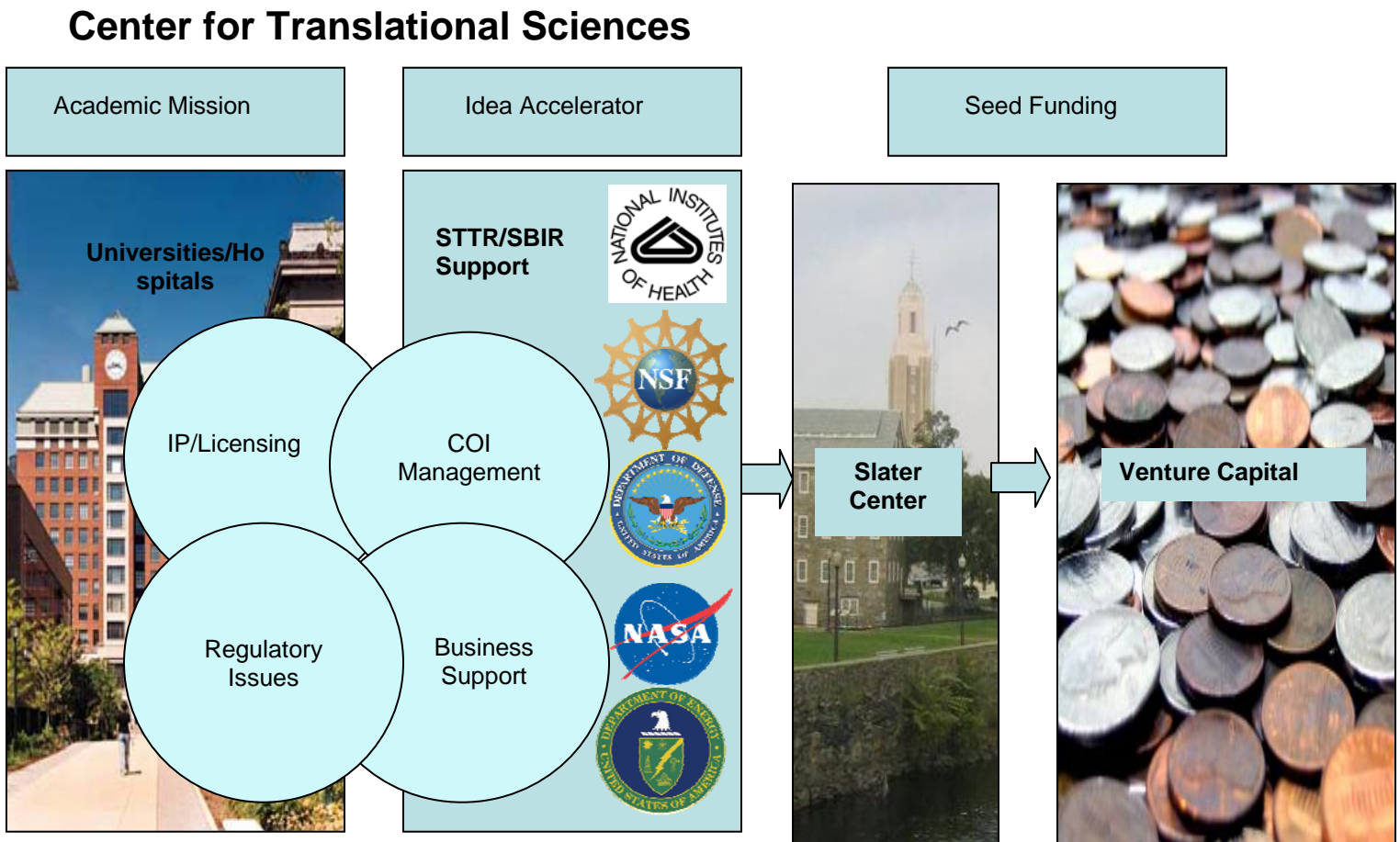


Figure 2: Implementation of the Idea Accelerator towards a Translational Sciences Center



Legend:

Schemas of models of business development in translational research. 1) Status quo as it relates to translational roles and boundaries of departmental effects in “spinning-off” translational research business opportunities and 2) Additional elements in the *idea accelerator* include educating faculty in COI management, regulatory affairs, business development/support and managing an intellectual property portfolio with a new emphasis on clinically translational research enterprise creation.

Answers.com & Columbia University Press* - **caduceus (*kədyū'sēəs*), wing-topped staff, with two snakes winding about it, carried by Hermes, given to him (according to one legend) by Apollo. This staff of Hermes was carried by Greek heralds and ambassadors and became a Roman symbol for truce, neutrality, and noncombatant status. By regulation, it has since 1902 been the insignia of the medical branch of the U.S. army. The caduceus is much used as a symbol of commerce, postal service, and ambassadorial positions and since the 16th century has largely replaced the one-snake symbol of Asclepius as a symbol of medicine.

A SHORT HISTORY OF BIOMEDICAL ENGINEERING AT BROWN

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Within the past fifty years a structure for promoting Biomedical Engineering was developed at the University. This is a short history covering the time from 1960.

The history of biomedical engineering itself goes back much further. Some are willing to consider the ancient Egyptian physician I-em-hetep as inspiration. Others point to selected studies by Euler. Others again consider D'Arcy Wentworth Thompson, 1860-1948, author of "On Growth and Form" (who was a professor in Scotland for 64 years and a classical scholar and naturalist as well as a mathematician) as promoting ways of thinking that continue in bioengineering today.

In the past 50 years, events in medicine applied pressure to keep the concept and scope of biomedical engineering moving forward. Artificial pacemakers for hearts advanced with battery developments in the 1960s. The artificial kidney became usable for treating end-stage kidney disease from 1961, with Belding Scribner's development of implanted blood shunts. Charnley's artificial hip improvements from the late 1960s were critical in achieving a higher success rate and greater durability. Denton Cooley MD implanted a total artificial heart in Haskell Karp on 5th April, 1969, which required the patient being hooked up to an external power supply. There was a blaze of publicity. There was already an Artificial Heart Program at NIH, proceeding more systematically towards durable performance. Many devices were being developed or improved, and universities were in the thick of this. Soon, Federal legislation was created to put regulation of medical devices including artificial organs under the Food and Drug Administration.

PIONEERS AT AND FROM BROWN

At Brown, biomedical engineering was entered first through research, and before the Program in Medicine was established. In the 1960s there were no "start-up" funds for newly-appointed faculty. Typically, young faculty of those times established themselves in some on-going area of research at the University before branching into new fields. This occurred with Paul Paslay and Jacques Duffy, both solid-mechanicians and professors of engineering. Paul published in the area of spine biomechanics in particular, while Jacques (already a noted solid mechanics experimentalist) investigated the dynamic response of human muscles, including dynamic electro-myography. Salvatore Sutura, another engineering faculty member here in the 1960s, was an established fluid dynamicist before he developed a thesis project on modeling the motion of red cells in capillaries, checking how well lubrication theory might explain flow resistance. In this Robert M. Hochmuth was the PhD student - who then took a faculty position at Duke, where he remained associated with biomedical and mechanical engineering until his retirement - probably the first PhD from Brown in biomedical engineering to complete an academic career, during which he contributed much more to knowledge of red cell

mechanics. In 1968 Sal Sutera left Brown and moved to Washington University in St Louis, where he continued biomedical engineering teaching and research.

My entry to biomedical engineering went somewhat similarly. After nearly 10 years following my PhD, working on thermophysical and fluid dynamics research in Engineering, my first paper in the biomedical field (with the late Prof J.H. Whitelaw, FRS, formerly Research Associate at Brown and later Prof at Imperial College) was "Transient heat transfer in human skin". It was based on multi-national studies (experiments and mathematical analysis), made before I went on leave and spent time with the Physiological Flow Studies Unit at Imperial. When I returned from a year's leave in 1968, the former Chair of Engineering at Brown, Paul Maeder, was quick to introduce me to a fellow Swiss, Pierre M. Galletti. Pierre and I quickly identified each other as potential collaborators, and this was fulfilled for more than a dozen years sharing a laboratory suite and writing fifty joint papers, also in jointly teaching a graduate course in Biomed on the Theory and Technology of Artificial Organs, and being co-PIs on NIH-funded research. Our research was mainly on blood-handling artificial organs in which transport processes occurred, such as artificial lungs used as components of heart-lung machines, and the hybrid artificial pancreas. We were keen on the concept of membrane artificial lungs, in which a membrane is placed between the flowing blood and flowing ventilatory gases, because we expected this to lead to much-reduced blood damage compared with the then-popular direct contact oxygenators, especially if we could find ways to reduce thrombosis in the blood passages and avoid condensation in the gas passages. In this we enjoyed much success. One of our papers became the basis for defining standards for blood oxygenators, and for some years I served on the corresponding AAMI national standards committee. We generated a thicket of studies, many of which are listed in:

Richardson PD. The Artificial Lung Facility at Brown: More Than a Dozen Years with Pierre Galletti. *ASAIO JI* 51(2): 165-172, 2005

Some of our regular PhD students of the 1960s-early 1970s period performed post-docs in bioengineering. One of these, Michel Y. Jaffrin, became professor of bioengineering at the Universite de Technologie de Compiègne, where he continues productive research and teaching to the present time. The late George Zahalak, who had strong interests in muscle mechanics was an Assistant Professor at Brown until 1976, when he moved to Washington University in St Louis; later, a fundamental equation in muscle mechanics, the Huxley-Zahalak equation, was named in part after him. The Division of Engineering hired Jerry Daniels, a bioengineer from UC Berkeley with experimental research interests in the visual cortex, in 1977. Prof Marc Richman supported many studies with his microscopy skills, including scanning electron microscopy. The (then) Physiology Section of Biomed at Brown hired Paul Palatt, who had a PhD in biomedical engineering from Case Western Reserve, as an Assistant Professor, and it was a shock when he disappeared one summer in the 1970s from a group climbing in India with Prof Tim Mutch, never to be found. The Physiology Section also hired Alan Perelson (PhD in Biophysics) as an Asst Prof in 1978, but he stayed for only two academic years (I recall one of the neurobiologists at the time complaining how could we have a biologist who did not have a wet lab!) and returned to

Los Alamos National Laboratory to a distinguished career in theoretical biology. Reginald Mason MD PhD joined the Memorial Hospital in Pawtucket, with an established interest in thrombosis and artificial organs, and with him and members of his team including S. Fazal Mohammad PhD (now at the University of Utah) I began sponsored research on effects of flow on platelet adhesion and thrombosis. Ares Pasipoularides MD PhD was interested in mechanics of cardiac function, and after some time at Brown, in which he participated in teaching biomechanics, he moved to Duke University. Reg Mason moved on, first as department chair to Florida and then to Utah, with us continuing our collaboration, but he died suddenly in Utah. Meanwhile Manfred Steiner MD PhD joined Memorial Hospital, and he and I collaborated on platelet research and a book on cell adhesion.

In my commitment to the field, I had completed requirements for a DSc in Physiology from London University in 1983.

CURRICULUM AND PROGRAMS

Organizationally, Brown felt its way forward. As of September 1971, I was appointed first Chairman of the Executive Committee of the Center for Biomedical Engineering. The introduction of the New Curriculum shortly beforehand provided an opportunity to devise an undergraduate ScB curriculum in biomedical engineering, and which was accredited by the Accreditation Board for Engineering and Technology. I believe we were about the third such program accredited. Now there are close to forty. Our program was based on the philosophy that engineering was the noun, biomedical was the adjective, so it was rich in engineering core courses and some existing senior courses as well, with sub-concentrations in bio-electrical, bio-mechanical and bio-materials options. Each was rich enough in the corresponding electrical, mechanical and materials courses such that students could go forward well-prepared in existing regular fields of engineering as well as biomedical aspects. It was a time when some employers were not sure what biomedical engineering covered, so our graduates could be comfortable their strength in a more established field would help them be acceptable in industry. Even around 1975 some of my faculty colleagues in Engineering were themselves unsure whether biomedical engineering was a "real" engineering field. The incoming students had less hesitation; my colleagues acknowledged that some of the best and brightest undergraduate students came to study biomedical engineering. (This persisted into the 1990s and later beyond.) I was conscious that very roughly 50 per cent of engineering graduates end up in a field different from their undergraduate major. Whatever sub-field of biomedical engineering a student chose, we were keen to provide them with the mathematical, biological and engineering knowledge and practice in reading research journal articles in the field. We also incorporated enough design practice - including laboratory testing opportunities in our artificial organs course - to give students confidence in going into applications, and to satisfy engineering accreditation. Some of our students were taking the biomedical engineering option as a route to medical school; and Pierre told me that around that time the seventh most-popular baccalaureate concentration for medical school applicants nationally was engineering.

I looked up the careers taken by a couple of high-scoring biomedical engineering graduates of a graduating class of 8 seniors of that time - Ronald P. Grelsamer took his

MD at Columbia and became Chief of Knee and Hip reconstruction at Maimonides Hospital in New York City; another, Paul H. Steen, took a more traditional route in engineering and after completing his PhD has become a Professor of Chemical Engineering at Cornell, with emphasis on fluid dynamic stability. These two are examples of the success of the approach of the program. Some students continued from the undergraduate concentration into a Master's degree in Biomedical Engineering. A good example of this - and of the attractiveness and success of the program with women students - was Melissa Prince, whose thesis involved studies of etching microfibrillar teflon to remove some of the fluorine and investigate if this made it more attractive to tissue infiltration. She went on to work for a Johnson & Johnson company, later did the design work and FDA approval process for a cardiomy reservoir, and progressed through further parts of the Industry until she obtained some patents and launched her own company. Our women graduates have also gone into academia, such as Sangeeta N. Bhatia, who followed her ScB with honors in biomedical engineering from Brown (1990) with a Harvard MD, an MIT PhD and is a faculty member at MIT.

We were into the spin-off company process quite early. We set up MicroPure Inc, with a patented technology based on an ultrasound device developed for detecting from reflection analysis what bubbles and particulates were in the bloodstream being pumped back into patients on heart-lung bypass. With Leigh Abts (my biomedical engineering PhD student) initially as President, and Karl Karlson MD as thoracic surgeon and collaborator, we partially bankrolled the start-up and looked for commercially-attractive applications, finding them especially in industrial process-control (photofilm development, etching photoresists in semiconductor device manufacture, and secondary oil recovery) and sold out profitably after an exciting six years, over which the payroll had topped 30. Several years later CytoTherapeutics (later to become StemCells Inc) was formed as Rhode Island's first biotechnology company. MultiCell Associates was another tissue engineering start-up.

Our internationalization had always been strong. We had many collaborators from France, Germany, Italy, Japan and the UK. The famous UK pharmacologist Gustav Born collaborated from the early 1970s. Another biomedical engineering PhD (1975) was Kazuo Tanishita, now Professor at Keio University and leader of a large research group there. In the early 1980s we began research with a group in Pisa on biomedical applications for piezoelectric polymers. The two principals there, Danilo DeRossi and Paolo Dario, have senior academic positions in Pisa. A French post-doc, J.J. Altman, carried on our hybrid artificial pancreas approach in Paris and was the first to test it in man. With another French post-doc, R. Barthelemy, we demonstrated 24-hour pumpless partial bypass with complete carbon-dioxide removal via an artificial lung, a technique adapted more than a dozen years later for selected clinical applications. In 1980 I met the late Michael J. Davies, cardiac pathologist at St George's Hospital Medical School, and we collaborated for more than a dozen years after that on biomechanics in atherosclerosis, a period in which Pierre focused more on tissue engineering, including with Patrick Aebischer (since 2000, President of the Swiss Federal Institute of Technology in Lausanne). There were many others.

MIS-STEPS AND CALAMITIES

The early 1970s were not the easiest years in the University administration. In July 1976 Donald Hornig stepped down as President, after his 1975 proposal to pare down the size of the faculty was unfavorably received by faculty and students alike. For many years the University administration took the position that if the Division of Engineering needed more faculty for teaching biomedical engineering, it should do so with a fixed roster. This would have required at least two established groups in the Division to give up one faculty slot each, and in the tightness of the times for the established groups that was unlikely. Under Richard Dobbins' chairmanship one group took this step, and while an outstanding young faculty member, Jason Harry, was hired he left for industry after a few years. We kept teetering on the edge of the minimum number of dedicated faculty required for accreditation, sometimes rescuing the situation at the eleventh hour.

We did not develop a joint PhD program in biomedical engineering. The main sticking point was that engineers generally study and use mathematics to a more advanced level than biologists, and to take many graduate courses in engineering requires more mathematics than biologists have learned. This level of mathematics is also needed for reading much of the research literature in biomedical engineering. At one point the Biomed Division threw down the gauntlet on this by publishing in the Fall of 1986 a flyer advertising a PhD program in biomedical engineering with a view to recruiting students to enter in the following September. However, the program had not been approved by the Graduate Council, nor had it been discussed with the Division of Engineering. Discussions were then held at top level between the Divisions, without coming to a resolution acceptable to both. The plan for this graduate program had been linked to the announcement of the plan to add to an existing Biomed building and include a floor in it for biomedical engineering research, faculty, and graduate students. This neglected that much biomedical engineering research, including that of most of the 1960s and some in the 1970s and 1980s, had not been done in buildings controlled by the Biomed Division, and the space and facilities being proposed would not be adequate to continue that scope. The gauntlet turned to dust. It was left that the PhD in any field in engineering, including biomedical, would be under the administration of the Division of Engineering, as it had been previously.

On March 3rd, 1996, the faculty of the Division of Engineering was led by its Dean into abandoning the ScB in biomedical engineering, which had been sustained with engineering accreditation for more than 20 years, in favor of putting biomedical engineering into sub-options of other established engineering concentration areas. I did not believe that putting Biomedical Engineering into sub-options only would prove as attractive to freshmen as having a bona fide concentration in the subject, to compete with a growing number of other institutions. It would be seen as a reduction in commitment to the subject, when other institutions were demonstrably increasing their commitment. We were falling into a situation where we did not have enough faculty for accreditation, and that was a marker of Brown not committing enough resources to a program popular with students. I heard a report in October 1996 that the Chair of the coming Site Visit Committee for the Accreditation Board in Engineering and Technology (ABET) had

asked, "Why are they planning to give up such a popular program?" Not surprisingly there was a subsequent drop-off in freshmen matriculating to study engineering at Brown.

A decision was made to re-instate an undergraduate ScB program, although differently constructed from the original. At long last the number of roster slots for faculty primarily in this field was to be increased in both Divisions. By this time Biomedical Engineering had become far better understood in industry. However, in (for example) the aerospace industry there are many opportunities for mechanical and electrical engineers by training, and enough overlap with more-traditional engineering subjects is still important for biomedical engineering, as it is in aerospace engineering. Moreover, the principles and practice in application associated with the traditional engineering subjects are more durable, more lasting, than biological knowledge of the more topical forms, except for biomaterials. In nearly 40 years of dealing with both concurrently, this has been progressively more clear to me. In choosing subject matter for undergraduate programs in biomedical engineering, adequate emphasis on durable knowledge and practice in its use seems important to me, as does appropriate guided practice in design. This is also felt important to achieve for all students in the breadth in engineering fields here to allow them to go readily into other engineering fields if they so wish, as had Paul Steen and others, in furthering their careers. Tissue engineering, which is a subject favored by some newer faculty here, presents a problem in that the current foci in that subject as a part of bioengineering mechanics and as part of experimental biology are far from each other intellectually and practically. This may lead to problems for some students trying to integrate their engineering core program with junior and senior-level courses, and fulfill design requirements. The next accreditation site visit should be in 2008.

A calamity for the University, and biomedical engineering within it, occurred with the accidental death of Pierre Galletti on March 8, 1997, following a fall. He had been a persistent and energetic supporting voice in the senior administration here for close to thirty years. His support for the field was well known outside Brown too, and outside there was quicker commitment, development and involvement at some leading research universities. While we made a vigorous start in the field, missteps and calamities here have allowed other educational institutions to advance faster especially in the most recent decade. Fortunately we have been adding highly capable faculty during the recent Academic Enrichment phase, and more distinguished faculty here previously not active in the field have entered biophysics, so the opportunity is strong for Brown to move ahead again in biomedical engineering as this century progresses.

BOOK REVIEW: THE END OF SCIENCE BY JOHN HORGAN

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In his book "The End of Science" (1997), journalist John Horgan explores a variety of scientific disciplines, and suggests that scientific research may be coming to an end because its main ideas have been discovered and the pursuit of new scientific knowledge is therefore no longer necessary. Horgan reviews physics, cosmology, biology, mathematics, computer science, and examines philosophical assertions about scientific ideas. He interviews scientists Roger Penrose, Thomas Kuhn, Karl Popper, Richard Dawkins, Stephen Hawking, Frances Crick, Edward Witten, Noam Chomsky, and Marvin Minsky, providing both a historical and critical perspective on their scientific viewpoint. These interviews comprise a worthwhile review of scientific practice, though readers may question some postulated ideas and I personally disagree with the view that science is nearing its end (science is in fact thriving and contributes importantly to social and economic welfare). This article reviews Horgan's analysis and adds personal observations about scientific beliefs raised by Horgan and the researchers whom he interviews.

Chapter 1, "The End of Progress", suggests that both cultural and scientific ideas may begin, progress, and eventually end. Gibbon's widely accepted "Decline and Fall of the Roman Empire" (1780) and Oswald Spengler's questionable but prescient "Decline of the West" (1918) (*Untergang des Abendlandes*) show that Western culture, including scientific thought, may change or disappear after centuries of progressive contributions to society. However, Spengler asserted that progress was cyclical and science might recover after ending, while Horgan believes Spengler was too narrow and science could never recover because the discovery of the periodic table, and DNA, can occur only once.

Chapter 2, "The End of Philosophy", shows that philosophy has progressed from Greek mathematical principles through Christian religious values to the modern philosophy of Descartes, Kant, and the Vienna Circle, each of which greatly changed the philosophical impact of scientific reasoning. Thomas Kuhn's "Structure of Scientific Revolutions" (1962) argued that new scientific paradigms are often questioned by scientists more concerned with the status and integrity of their own assumptions than with the truth of a new paradigm that may overturn the correctness of their broadly accepted beliefs. Kuhn suggests that, in spite of the belief that science focuses exclusively on "true" arguments, scientists can be just as biased as politicians and other specialists in perverting truth, reason, and honesty in order to justify their personal status, desires, or monetary compensation.

Mathematics became a dominant mode of thought in the Greek culture of Pythagoras, Plato, Aristotle, and Euclid, and was accepted by Newton and later scientists as a foundation for scientific thought. But the dominant role of mathematics has declined, in part because Kurt Godel showed in 1930 that humans could not prove all mathematical theorems. Hilbert proposed in 1900 that mathematical theorems could be completely proved by formalist logical arguments, supporting the widely accepted belief that humans could completely express mathematical ideas about physics and science in general. But in 1930 Godel showed that Hilbert was wrong by proving the

incompleteness of theorem proving, while Turing showed in 1936 the incompleteness of computers in theorem proving and problem solving, and quantum theorists showed that incompleteness (undecidability) was an expected empirical event. The idea that humans could not completely express science mathematically in physics, computing, and logic, indicated that humans were substantively weak (incomplete) in their scientific thinking. Because Godel's incompleteness paradigm contributed to the rejection of mathematical and scientific completeness, it is still discredited by some scientific thinkers in spite of the validity (correctness) of Godel's arguments and proof. For example, Princeton's 100th anniversary celebration of Godel's birth, which I attended in late 2006, included several talks by leading scientists questioning the accuracy and/or importance of Godel's result. The idea that incompleteness should be rejected because it threatens the human scientific and mathematical reasoning relates to Einstein's disapproval of quantum uncertainty because it is incompatible with the mind of God. Einstein's view may be due to his interaction with Godel at the Princeton Institute. I personally feel that both incompleteness and nondeterminism are broadly prevalent in science, politics, and religion, and that rejection of these ideas has led to disastrous political actions and scientifically inappropriate paradigms based on false reasoning.

Physics was the central scientific discipline in the 20th century, fueled by Einstein's relativity theory and Bohr's quantum theory. However, Einstein's failure to develop a complete theory of physics in later life and the failure of a quantum theory of everything in the late 1900s, prompted string theorists like Witten to propose an alternative complete theory in 1980-1990 that failed because its assertions were empirically unverifiable. String theorists continue to claim to be a complete theory of everything despite the absence of empirical evidence to corroborate their radical 10 dimensional model of physics. These failures have contributed to the decline of physics as the central model of scientific inquiry. The government's cancellation of the supercollider in 1993 dealt a further serious blow to physics by radically restricting government financial support of physics.

Physicists interviewed by Horgan included Oxford's Roger Penrose and Stephen Hawking who is a successor of Newton as Lucasian Professor at Cambridge. Penrose's book "The Emperor's New Mind" (1987) and his later "Shadows of the Mind" (1995) suggest that the physical world cannot be completely described by models of physics, mathematics, or computer science, and that there are substantive reasons why the search for a theory of everything by Einstein or Witten is unlikely to succeed. Hawking's "Theory of Time" (1980) and his later "Cambridge Lectures" (1996) examine limitations of theories of time and of physics generally. He explains why we can observe the past but not the future because the thermodynamic arrow of time moves from an ordered state at the beginning to an increasingly unordered state that cannot be reversed to an ordered state. A theory of everything cannot be established because, according to Hawking, humans can determine only what and how but not why the world was created (we cannot know the mind of God). This argument seems religious rather than scientific, and is a surprising ending to Hawking's view that science can determine only what and how.

Biology has replaced physics as the central scientific discipline in the 21st century, in part by facilitating the control of diseases and other human frailties. The emphasis on evolution in Darwin's "Origin of Species" (1859) followed by Mendel's hereditary model and by the "double-helix" model of DNA by Crick and Watson (1953),

led to a growth of departments of biology and to books by Richard Dawkins, Ernst Meir, and many others. However, Darwinian evolution is still strongly questioned by religious fundamentalists who accept biblical creationism and believe God supersedes science as a foundation for human knowledge. The secular inability to explain the origin of life on earth or the existence of the universe contributed to the ascendancy of religious over scientific thought. Though biology has become a primary scientific discipline, a comprehensive theory of everything is still biologically absent, just as it is physically and mathematically absent. Though the incompleteness of science restricts the scope of scientific theories, it does not imply the end of science suggested by Horgan's title.

Neuroscience, the biological study of neurons and the brain, is not as scientifically advanced as evolutionary biology, in spite of substantive studies by Francis Crick, Gerald Edelman, Marvin Minsky, and other scientists. Crick followed his double helix work at Cambridge with work on neuroscience at the Scripps Institute in La Jolla, where his book "The Astonishing Hypothesis" (1994) aimed unsuccessfully to model the Brain and human consciousness. Edelman's "Neural Darwinism" (1987) explores neural behavior as an adaptation of Darwinian evolution. Marvin Minsky's "Society of Mind" (1980) examines the mind in terms of artificial intelligence and computers. Unfortunately, researchers are still unsuccessful in developing a good model of the brain in spite of great progress in biology, indicating that our desire to develop a complete theory fails in mental as well as physical scientific research. We cannot develop a theory of mind or a relation between mind and matter and must accept that the human mind is both weak and indescribable.

Horgan suggests that the social sciences are coming to an end along with the physical and biological sciences by interviews with Edward Wilson, Noam Chomsky, and Clifford Geertz. Ant specialist Edward Wilson's "Sociology: The New Synthesis" (1975) proposes that human sociology was an immoral adaptation of animal to human evolution, since Darwinian immorality is a necessary form of evolutionary growth. His late book "The Creation" (2006) includes a letter to a southern Baptist priest urging religious thinkers to accept the secular scientific model of creation in order to prevent pollution and global warming to save life on earth. Linguist Noam Chomsky's "Language and Problem Solving" (1988) proposes that verbal creativity contributes more to social and political behavior than scientific creativity. Chomsky's later writings and lectures strongly criticized western political principles because they contribute to the weakening of western society. Anthropologist Geertz's "Towards an Interpretive Theory of Culture" (1973) focuses on interpretation as opposed to facts as a method of explaining the meaning of phenomena. Social sciences have not contributed to making the world a socially better place or to a sociological theory of everything, in spite of the increasing role of sociology as a scientific discipline.

Horgan reviews a conference on "The Limits of Scientific Knowledge" (1994) at the Santa Fe Institute, which examined "Limitology" (scientific limits) as a contribution to scientific understanding. Ralph Gomory, former IBM vice president and head of the Sloan Foundation, claimed he funded the workshop because he felt that research on the limits of science is as important for scientific advancement as substantive research. Godel incompleteness expresses an important limitation of mathematics as a form of human knowledge. Chaitin spoke about his work on extending Godel's result to show that a mathematical theory of complexity is not possible. Francis Fukuyama reviewed his

book "The End of History", which shows that history expresses the views of the victors, and suggests that the victory of capitalism over communism may bring history to an end, at least until Islam and China overtake Western culture or machines overtake man in controlling the quest for knowledge. Horgan in fact repeatedly relates the decline of the West to the end of science as a discipline.

The chapter "The End of Machine Science" examines the impact of Hans Moravec on robotics, of Freeman Dyson on computational diversity, and of Frank Tipler on "Omega Point" models. Hans Moravec of Carnegie Mellon University suggests that robots will replace humans as the controllers of social evolution and that their control of cyberspace will require extended scientific work beyond that of human scientific research. Freeman Dyson of Princeton believes that scientific growth in artificial intelligence will expand the diversity of actions by people and computers beyond their current status. Frank Tipler's "Omega Point" theory proposes enhancing human power by an all powerful all knowing cosmic computer that is God-like in its behavior.

It is surprising that religion remains a substantive motive for scientific assertions both among religious thinkers and scientific researchers like Tipler, Hawking, and Einstein. Paul Davies "The Mind of God" 1993 suggests that why questions about science are often answered by religious God-related answers. Fred Hoyle has asserted that scientists are sometimes more religious than clergy in their claims about the nature of the world. In Davies discussion of "Did God Create the Big Bang?" he suggests that the scientific inability to find an empirical answer encourages the religious answer that the universe was creation by God.

Horgan's last chapter "Scientific Theology" and the epilogue "The Terror of God" review the interaction between science and theology. Though some scientists believe that science is compatible with theology, theologians have traditionally discarded incompatible scientific models like that of Galileo in the early 17th century and Darwin in the late 19th century because of their incompatibility with strongly held religious principles. Horgan explores books like William James "Variety of Religious Experience" which connects science with religion and Richard Dawkins "The Blind Watchmaker" (1986) which disparages religious arguments against science. He avoids concluding that science is incompatible with religion, but his writing implies that religion does in fact contribute to the end of science, which in turn diminishes human life on Earth.

Personally, I disagree with Horgan's focus on the end of science, though I believe that his overall exploration of science includes many interesting ideas. I accept that scientists have overemphasized the search for a theory of everything over incompleteness of scientific arguments, but disagree that the unfortunate human anomaly about imposition of substantive truth and honesty implies termination of thought-provoking positive forms of scientific investigation. Scientists should understand that some currently accepted principles of science may be false or incomplete but accept that even so there are still many worthwhile directions in which scientific studies can contribute to the quality of human life and society. Reading the book will encourage better understanding of scientific diversity by both non-scientists and scientists focused on restricted disciplines, promoting the better understanding of relations among accelerating scientific and non-scientific disciplines.

FACULTY BULLETIN
INFORMATION FOR CONTRIBUTORS

GUIDELINES FOR SUBMITTING ARTICLES:

We hope to receive articles for the Fall 2006 issue of the *Faculty Bulletin*
by the middle of September.

Text should be submitted electronically via e-mail attachment to:

Cheryl_Moreau@Brown.edu

Essays should be approximately 1,000 words (two to three pages). If space
permits, longer papers will be considered.

Articles and/or questions should be directed to:

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ⁱ Aristotle, The Basic Works of Aristotle, ed. Richard McKeon (New York: Random House, 1941), p. 953 (*1103b27-28*).

ⁱⁱ T. S. Eliot, The Complete Poems and Plays (New York: Harcourt, Brace, and World, 1952), p. 56.