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Science at a Crossroads[1]

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Abstract

Science is entering an alliance with the economy that will speed the effect of innovation through society. Despite the slowdown of the 'new economy', a cascade paradigm of innovation appears key to increasing the rate of economic growth. Yet for science to continue to thrive and make this contribution to innovation, it must traverse at least three key crossroads. First, while life sciences have built a strong advocacy model to secure growing federal research funding, the physical sciences (including mathematics and engineering) have not and must now do so to thrive. Second, the drop in the numbers of physical scientists and engineers must be reversed if we are to have the talent to maintain a strong trend of scientific advance. Third, although science advances are increasingly interdisciplinary and occurring in the space between the historic science stovepipes, the organization of federal science support is largely unchanged since the beginning of the cold war. While a decentralized model

has value, we must also consider new approaches that encourage deeper cooperation across science sectors and agencies.—Bonvillian, W. B. Science at a crossroads.

Topic: R&D physical sciences research funding

PROFESSOR EINSTEIN WAS selected ‘Person of the Century’ in 2000 by a leading news magazine. He competed with personages as crucial to the century as Winston Churchill and Franklin Roosevelt, but in the end there wasn’t really another choice. Science has been the transforming force in our civilization for a century. Einstein, with his soft smile and the wild twinkle in his eye, best personifies it.

One Einstein story portrays him sitting with another senior professor, reviewing a graduate student’s thesis proposal. They bat questions back and forth, then the other professor concludes, “You know, this is the craziest idea I’ve ever heard of.” Einstein responds, “You know, this idea is not crazy enough.” The story is apocryphal but it does capture Einstein. His response reminds us of the spirit of adventure at the heart of scientific inquiry. Because science is inquiry, we have to question and continually push at its boundaries. Vannevar Bush, science advisor to presidents Roosevelt and Truman, in a book he wrote late in life, Science is Not Enough, adds to this perspective on scientific inquiry. He said, “Science … does two things. It renders us humble. And it paints a universe in which the mysteries become highlighted, in which constraints on imagination and speculation have been removed, and which becomes ever more awe-inspiring as we gaze … It continually reminds us that we are still ignorant and there is much to learn” (1)⇓.

Of course, science has learned about many mysteries since 1967, the year Bush wrote his book. We live at a time when scientific information is increasing geometrically, and it may even be accurate to say scientific knowledge is as well. Let me also be clear at the outset: in using the word ‘science’ I intend to include engineering, an applied science, but as Ronald Kline argued in the Fall 1999 issue of Technology and Society Magazine, certainly a science, and also full of fundamental science features (2)⇓.

Many who spend careers in science do so because they make a kind of religion out of science’s spirit of inquiry. But it is important to remember that science is grounded in a material world. Despite its century of accomplishment, too often science in this country assumes it is on ‘automatic pilot, ’ that its future is assured. It is not. Science is married to society; its well-being depends on that society. Ours is an intensely democratic community caught up in competing interests, and science is only one voice in that loud democratic chorus. Major structural changes are ongoing in science and we need to pay new attention to their meaning. The spirit of inquiry behind science is not self-sustaining, it is increasingly dependent on societal support.

SCIENCE AND THE ECONOMY

The relationship between science and society is growing ever more intimate. The connection increasingly is in the economy. This study explores some of the ongoing changes in the economy and tries to draw lessons and challenges for science, and the spirit of inquiry behind it.

Robert Solow of MIT won the Nobel prize in 1987, and the president’s Medal of Science in 2000, for establishing that technology and related innovation are responsible for at least half of U.S. economic growth. Obviously this has profound ramifications for science. For 10 straight years, lasting until 2001, the U.S. enjoyed the longest economic boom in its history. In the last quarter of 1999 we experienced the hottest economy in nearly two decades:

- gross domestic product (GDP) grew at a 7.3% annual rate;
  unemployment and inflation were at historically low levels; and
- most important, productivity growth was hovering around a sizzling 7%.

What went on? Despite recent economic upheavals we have to look at the Internet as a cause, and place it in the context of other innovation transformations.

The Internet Parable

Dr. Thomas Siems, senior economist at the Federal Reserve Bank in Dallas reported in March 2000 that the Internet, the newest application from the ongoing computer revolution that scientific advances have thrust on us, was playing a central role in those growth numbers. He argued that the Internet gave U.S. business three new core capabilities:

-the ability, through the global network, to leverage ever-increasing computer power to increase operational efficiency;
-the ability to operate more prudently by the ability to generate and monitor information far more quickly; and
-the ability to deploy entirely new business models, created through the world wide web (3)⇓.

He argued that with it manufacturers can personalize production, electronic transactions can slash transaction costs, and a rapid, new balance between supply and demand can build efficiency and competence. New companies were being created where ideas and information systems dwarfed the value of physical assets. Siems was telling us that a science-derived application was now transforming the business landscape.

Of course, the Internet parable was not complete when Siems told his story in 2000. Since then, the ‘new economy’ has halted. For a decade the new economy blended strong growth, low unemployment, and low inflation fueled by relentless productivity gains from technology advances. This was a remarkable mix. The long period from 1973 to 1990 of economic confinement to slow growth and low productivity gains and corresponding declining American competitiveness contrasted sharply with the past decade and highlighted just how special the economy of the past decade was to most Americans. It had much of the thrill of a prison break.

By 1999, the U.S. unemployment rate was among the lowest in the industrialized world; its productivity growth surged ahead of other industrial economies, and its GDP per capita reached a quarter-century high, enabling the U.S. to widen its lead in this area over the rest of the world (4)⇓. But in 2001, rising costs of capital due to Federal Reserve interest rate increases, which coincided with a sharp rise in energy prices, accelerated a steep decline in technology stock values, a near-collapse of Internet stocks, and a major falloff in information technology equipment orders. The September 11th terrorist attacks brought on a broad and deeper economic decline.

The new economy of this past decade was fundamentally a technology-driven economy, arguably a ‘science economy.’ Is the science economy over?

Let us first look for a parable in the residual potential of the Internet. The Internet promised to transform everything. Michael Mandel and Robert Hof argue that it won’t (5)⇓. Instead, it will be adopted into different economic sectors at varying speeds. It faces institutional, regulatory, and competitive barriers at every corner; these barriers limit consumer demand and access and therefore profitability. The Internet has begun to penetrate intra-company, company-supplier, and company-consumer communications and transactions in financial services, manufacturing, retailing, and travel. But, Mandel and Hof note, it has barely touched such promising sectors as health care, government, education, and entertainment. The next big boost to the capability of the Net, broadband, is stalled by anticompetitive and governmental barriers. It appears that although the Internet may be a revolutionary technology, it will be adopted, like all other revolutionary technologies, incrementally.

The Internet, of course, is not unique. We have seen this pattern before. New technologies, with scientific advances behind them, have transformed the American economy many times:

railroads,
electricity,
the automobile,
the telephone,
aerospace,
radio and television.

But all of these technologies acted incrementally on the economy.
What seems different is the speed. Economists Michael Cox and Richard Alm point out that it took 35 years from development of the automobile for a quarter of the U.S. population to own one, 39 years to have a telephone, 23 years to own a radio. In contrast, it took a quarter of the population 18 years to buy a PC, 13 years to buy a cell phone, and just 7 years to get on the Net (6)⇓. As of 2000, 44% of our population was online (7)⇓.

Cox argues that the microchip—a crucial scientific advance—is not operating in a linear way; it is generating a cascade, spilling from one innovation to another, from computers, to cell phone, to biotechnology, to the Internet. This cascade effect is a different innovation paradigm (8)⇓. We no longer have a river, we have a waterfall. If Cox is right, this is as different from what went before as Niagara Falls is from the Hudson River.

Enter Growth Economics

A new economic school, called growth economics, has evolved to explain this innovation phenomenon (9)⇓. The last generation of economists focused on the classic factors of capital and labor supply. These were the factors behind the Keynesian economics practiced by FDR and the Supply Side economics practiced by Ronald Reagan. The factors of labor and capital remain important, but a new generation of economists tells us they are much less significant than innovation. Economics is arguably not anti-historical but profoundly historical, and economic growth is not fixed but dramatically subject to the efficiencies introduced by innovation waves. The story of the American economy is the story of the innovations listed above, which spawned huge new industries and promoted great economic efficiencies. Our ability to promote technological innovation leads to productivity gains, a primary basis for growth. Growth economics says that innovation can change the whole curve of growth. A new goal of public policy becomes promoting innovation as well as encouraging the capital, talent, and business environment to turn it into an ongoing cascade of growth.

The Internet parable remains instructive, however. We need revolutionary technology that can transform productivity, but it will still be adopted incrementally. A science economy depends not only on a scientific breakthrough; a host of other factors have to be operating in concert to ease the passage of the breakthrough.

Science doesn’t operate in isolation.

What other innovation cascades are waiting in the wings as we struggle past the Internet parable? The promise of science remains intense. The biotech revolution has become the genomic revolution. Although laden with ethical questions, genetic engineering promises progress against hereditary disease tendencies. Mapping human proteins using supercomputing could generate many disease treatments. Nanotechnology has been heralded as the next big thing after genomics, leading to ultra-efficient devices operating at the atomic scale. Photonics could lead to computing at light speed instead of silicon speed, and holographic storage to barely imaginable data storage capability. Fractal modeling in mathematics could lead to simulation and modeling capabilities that unlock large-scale systems such as climatic and molecular patterns. This list only scratches the surface of the innovations taking aim at established economic assumptions like a fleet of buccaneers. Even an Internet recession probably cannot head off the evolution toward a cascade paradigm.

Where did this cascade paradigm derive from? Fundamental science 25 or 30 years ago provided the building blocks over which this cascade has flowed.

THE PATTERN OF RESEARCH FUNDING

Fundamental science, starting with the Second World War, has been overwhelmingly funded by the federal government (10)⇓. If the economy and therefore the society are becoming dependent on cascades of innovation, we need to examine the health of its fundamental research root system.

What was the federal contribution to American research and development (R&D) 35 years ago? It was at a high-water mark, just shy of 2% of our GDP. By contrast, federal research is now funded at less than half that percentage (11)⇓. The private sector has traded places with the federal government as the major source of funds for R&D. In the mid- to late 1960s, the federal government provided two-thirds of the nation's R&D funds; now industry provides two-thirds, which in 1999 amounted to almost 2% of total GDP. But this compares apples and oranges. Since the federal government predominantly funds fundamental research and the private sector predominantly funds development, the rise in the private sector R&D role does not offset the decline in U.S. fundamental research funding.

Is percentage of GDP the right measure? Because it provides a snapshot of our level of effort for science discovery against a backdrop of our total economic effort, I believe it is. Of course, the picture of reduced science funding isn't much prettier in inflation-adjusted dollars.

Our ability to launch an ongoing series of innovation cascades, which has become a central factor in our ability to create an opportunity society, depends on the initial flow from fundamental research. The cascade that created the booming economy of the past decade comes from a period of maximum investment in fundamental science approximately three decades ago. How do we expect to keep the innovation cascades flowing for the next generation if we limit the flow of science investment?

THE TWO SIDES OF SCIENCE

The Life Sciences

In sharp contrast to this picture of declining overall federal science investment levels is the startling success story of the life sciences.

According to the National Science Foundation (NSF) and the American Association for the Advancement of Science (AAAS) data, federal funding for the life sciences tripled in constant dollars between 1970 and 1999, to $15 billion (12)⇓. Proponents of life sciences 4 years ago embarked on a campaign to double federal research funding for the National Institutes of Health (NIH), again within 5 years, to approximately $30 billion. In fiscal years 1999, 2000, 2001, and 2002, the life sciences were on track to meet that goal with proportionate funding increases. These are startling increases.

They have not been easy to obtain. The life sciences compete in an appropriations subcommittee dominated by health-care entitlement programs that receive large automatic annual increases, placing pressure on discretionary programs like health research. They also compete against other clear national priorities such as education. These are tough competitors for scarce appropriation dollars.

How have these increases been achieved? The life sciences have a compelling story to tell of remarkable advances and progress. But so does much of the rest of science. The answer, I believe, is in a powerful and effective advocacy effort.

The life sciences have developed close cooperation and collaboration with the biotech and pharmaceutical industries that depend on them. That R&D collaboration has also led to collaboration in political advocacy, and every year this industry makes lobbying for NIH funding a top priority. The next rung of the advocacy ladder is taken by academic medical institutions, which are not afraid to make an emphatic case for health research to Congress. The third rung is taken by patient groups organized around particular diseases that afflict them and their loved ones. They have seen or experienced the power of medical research and send oceans of correspondence to Congress and generally make their numerous voices heard in every congressional district. These efforts at all three levels are carefully organized by several key coordinating institutions.

Life science advocates have worked hard at the political process, a necessity in a vibrant democracy, and have organized to make it work for them to the benefit not simply of themselves, but of public health in general. It has been an impressive performance to witness.

The Physical Sciences

The funding performance of the physical sciences is a painful contrast. While life science research funding has been soaring with the trajectory of a skyrocket, funding for the physical sciences, engineering, and mathematics has been stagnant or declining in the same period life sciences have been growing (13)⇓. Much of the explanation lies with the end of the cold war and the resulting cutbacks in defense R&D spending. Defense science and technology investment was reduced 25% between 1993 and 1999 (14)⇓. The Defense Department's share of federal R&D funding fell in 2001 to its lowest level in 22 years (15)⇓. Although this reduction has been ongoing for more than a decade, no advocacy effort comparable to that of the life sciences, which enlists support from industry and other potential supporters, has yet been organized in the physical sciences.

THE FIRST CROSSROADS: ADVOCACY

In a science economy, dependent on realizing new paradigms of cascading innovation, we need as a society to be increasing our investment in science, from research in the public sector through product development in the private sector. Is there a magic benchmark we should be seeking to establish as a new science threshold? No. Science is far too speculative to fit a neat macroeconomic recipe that says two parts science will yield five parts economic growth. But in a society ever more reliant on technology and innovation for its economic well-being, there is a substantial argument we should not be spending less of our GDP on fundamental science than we invested in the mid-1960s and early 1970s, the high-water mark period that resulted in so many of the advances powering our economy today.

This is ambitious, but the stakes are significant. Science is now more closely connected to economic opportunity than ever before in its history. Although economic opportunity alone does not lead to that elusive goal of an opportunity society, it helps. It is a necessary foundation on which to build a series of other societal goals. For example, the decade of growth during the 1990s led to the lowest rates of minority unemployment and the highest rates of minority home ownership in the nation's history. Minority unemployment between 1985 and 2000 fell by almost 50% (16)⇓.

Apart from society's needs, science has its own stake in its level of support: the imbalance in funding between life and physical sciences is dangerous to science. Increasingly, science is interdependent among its disciplines. Future scientific gains will come in the spaces between disciplines, as advances in one field are applied to another field's problems. There is a yin-yang relationship between physical and life sciences, and underfunding one will, even over a comparatively short period, dramatically affect the other. The dependence of the next stages of human genome research on major strides in supercomputing is a case in point. We require holistic science progress or we will damage the enterprise.

Science is at a crossroads. Whether it continues to thrive in our fiercely contesting democracy depends on whether it builds an advocacy system to explain its needs. The life sciences, to the nation's benefit, have already built a model for the physical sciences to follow. Only a long-term advocacy effort by the physical sciences will sustain the science economy we glimpsed in the 1990s.

THE SECOND CROSSROADS: TALENT

Although jobs requiring technical skills are projected to grow in the U.S. by 51% by 2008 from 1998 levels (17)⇓, which is four times faster than overall job growth, we are not producing the numbers of technically trained students in the physical sciences to meet industry demand. Although the life sciences are sharply increasing their enrollees, undergraduate and graduate degrees in physical science and engineering are flat or declining (18)⇓.

We have been bringing in technically trained foreign workers in massive numbers to solve this problem in the short run. At the behest of industries dependent on the physical sciences, Congress has increased the number of H1-B visas to allow these technically trained workers U.S. entry. In 1998, Congress raised the cap on these visas from 65,000 to 115,000; since then Congress authorized 195,000 visas annually through 2002 (19)⇓. These visa applicant numbers, while falling off somewhat in the current economic slowdown, tell us that the demand for more scientists and technologists in the U.S. is very real. Whereas awards of physical science and engineering degrees are stagnant or declining in the U.S. (20)⇓, they are rising in many other parts of the world (21)⇓. Foreign students received more than 40% of all PhDs in natural science and engineering awarded in 1997 in the U.S. (22)⇓.

So, whether trained in the U.S. or abroad, there is a ready source of supply of foreign talent to fill in the technology gap in the U.S. workforce. While historically, the U.S. has long made use of foreignborn talent to fuel its economy and should continue to do so, the problem we face is that, increasingly, foreign workers are returning to work in the growing economies of their own countries and increasingly training their own scientists and engineers at home. Foreign talent represents a short-term solution but not necessarily a long-term one, to say nothing of opportunities lost for U.S. citizens.

Because the federal R&D system supports much of science graduate education, the problems physical science is having in obtaining research funding means that most of the talent shortfall is occurring in physical science. It may also be affecting the ability of physical science to attract top students. Even though enrollment by top students (those scoring more than 700 on Graduate Record examinations) in the life sciences was up more than 60% between 1988 and 1998, enrollment by top students in math, physical sciences, computer sciences, and engineering was down significantly in the same period (23)⇓. This is a serious warning signal.

The message from these data is that the physical science talent problem will get better if federal R&D funding in the physical sciences is restored. Better R&D advocacy can help solve it. But there is another policy issue at this crossroads. The declining rates of undergraduate degrees awarded in physical sciences and engineering mean that the talent base available to move into physical science and engineering, at either the graduate level or directly into industry, needs particular focus. This cannot be solved only at the graduate level.

Professor Paul Romer, the Stanford growth economist, argues that a crucial input in the process of innovation is a steady flow of significant numbers of well-trained science talent. “Any proposal for achieving an even higher trend rate of growth in the U.S. should take full account of the detailed structure of our current system of higher education for natural scientists and engineers.” (24)⇓ He argues that it needs to be reoriented and has proposed competitive grants to colleges and universities in return for increases in the number of undergraduate physical science and engineering degrees they award. His proposal is not to create a fellowship subsidy that rewards primarily existing behavior but instead to award grants directly to the ‘middlemen’ (college and university authorities) that control the levels of undergraduate science entry, effectively using these grants to negotiate new levels with them.

Undergraduate degree problems are exacerbated by problems in teaching science and math in grades K through 12. Shortages of math and science teachers are reaching critical levels in middle and high schools, particularly in urban schools (25)⇓, and a substantial portion of these math and science teachers lack adequate preparation (26)⇓. Congress recently passed major educational reform proposals to improve K through 12 accountability and performance and to improve teacher quality. Science and engineering would be major beneficiaries of these reforms (27)⇓.
Talent is another important crossroads for physical science and engineering. Though improved federal R&D funding would help solve it at the graduate level, new efforts must be made at the undergraduate and K through 12 levels, as well.

Professor Romer’s point is that although federal science policy has focused on support for the elements of the innovation system, education—the underlying input to that system—deserves comparable focus.

THE THIRD CROSSROADS: THE ORGANIZATION OF SCIENCE

If the first crossroads for physical science and engineering is over its ability to adapt to a new advocacy model for its well-being, and the second is over its ability to renew its talent base, a third is just coming into view. It concerns the ability to adopt new ways of organizing the science enterprise. This argument builds on the points made earlier about the increasing need for interdisciplinary work.

Let's start with an economic analogy. Some economists argue that we are entering a new phase of capitalism. The old economy was characterized by economists like Keynes and built on assumptions of stable market share and incremental growth. The new economy is characterized by economists like Schumpeter and envisions a capitalism of creative destruction, responsive to disruptive technologies that rapidly displace predecessor technologies. Market share is no longer assured and growth can be chaotic as the pace of innovation multiplies.

Science may be developing in a similar pattern. While science learning has been based on incremental steps, we are seeing increasing patterns of breakthroughs that force us to expand and recast significant parts of our science knowledge. Inevitably, breakthrough science is both creative and disruptive. Our ability to absorb and adapt to the new frequency of breakthroughs in disparate fields calls for a new look at the way science is organized.
Professors Robert Rycroft and Donald Kash have argued that technologically complex products now dominate 80% of world trade, twice the level of 1970 (28)⇓. They argue that innovation in complex technologies is not the work of solo inventors but of complex organizational networks combining industry, university,

and government researchers. They argue that complex technologies require self-organizing collaboration networks that behave as learning organizations for economic success.

We may now be in an era of not only complex technologies but of complex science. The third crossroads for science is an organizational one. Will science be able to design the kind of networks for knowledge diffusion, for knowledge application, and for collective learning that will create collaborative science, that will optimize the opportunities science research is now unfolding? (29)⇓. We should remember that business, compelled by information technology and the Internet, is now systematically reorganizing itself for similar reasons.

Our science mission agencies are organized around classic linear 'pipeline' and 'spinoff' models. Science at NSF and the National Institutes traditionally is largely organized around funding individuals or small groups of researchers. We will still need these basic tools. But science advances may demand new tools. We may need to make room for a much higher degree of connection and collaboration across science and industry that crosses disciplines and takes advantage of the complex science and disruptive breakthroughs we are now seeing. This is a third crossroads, less visible than the first two, but coming up on us.

The introduction of this study posited that inquiry was at the heart of science, and it is time to go back to that point. The nature of scientific inquiry has grown more complex, and although individual inquiry will remain central and irreplaceable, we need to figure out mechanisms to encourage collaborative and collective inquiry. If science research is going to require advances that bring to bear a multitude of disciplines, and science development is going to require collaboration between academia and a wide variety of business enterprises, new organization mechanisms are going to have to be put in place.

We need to start thinking about this fundamental collaborative organizational issue. This problem is deep because of the range of institutions that already exist that must focus on it, from businesses, small and large, to academia, to government bureaucracies, and research institutions.

The federal government is only one part of this problem but plays a significant role because of its support of the other players. It has nearly the identical structure for science policy and management that science leaders like Vannevar Bush and William Golden put in place at the outbreak of the cold war (30)⇓. We have a mix of science agencies: some support academic fundamental research (e.g., the NSF and the NIH), others back fundamental and applied science in line with specific agency missions (e.g., the Department of Defense, the Department of Energy, and NASA). Different agencies support different disciplines and evolving technologies. The president’s science advisor is listened to by some presidents and ignored by others. There is no centralizing force that can assure cooperation across stovepiped agency lines and no entity that can budget across these lines. The science advisor’s Office of Science and Technology Policy struggles to attempt this but has only weak authority. There are important advantages to the decentralization and overlap in the current system. It is difficult to guess where scientific advances are going to come from, and the current decentralized system allows many safety nets that would be lost if science investment was to be dictated by a single, centralized bureaucracy.

But let us look at a typical problem of new complex science: nanotechnology. An attack on this promising area requires cooperation across many disciplines and across many agency stovepipes. Only limited mechanisms exist to organize cooperation on this kind of problem between agencies and to coherently budget for it. And nanotechnology is not an isolated problem—this kind of problem will be what science is about in the future. Genomic advances, for example, are inherently interdisciplinary, requiring extensive collaboration between biological sciences and information technology (which itself is interdisciplinary). Work on the human genome actually originated at the Department of Energy from computing advances supported there. We need to keep the advantages of a decentralized model, but we also need to build collaborative options into it. The president's science advisor, who doesn't operate a competing program barony, may be a place to locate strengthened authority to assemble interagency and interdisciplinary collaboration efforts.

The profound problems for the overall science enterprise created by the funding imbalance between life and physical sciences arise in part because some baronies have proved less successful than others in putting together the political support required in our robust democracy to secure federal funding. There also may be a budgeting role that the science advisor can play between mission agencies, the Office of Management and Budget, and the large number of balkanized congressional committees, to surmount the budget imbalances that now afflict U.S. science. Such budgeting support role could help empower the science advisor into a more vibrant role advising the president on science policy.

CONCLUSION

Science's success at the end of the 20th century also brought new challenges. The first crossroads concerns how science will build the support for the investments that will be needed for it to thrive. We must move toward a stronger science advocacy effort in the physical sciences and engineering and the life sciences have pointed the way. The second crossroads concerns talent. To remain robust and continue to lead in U.S. economic growth, the physical sciences and engineering must produce more talent through reforms at all levels of education. The third crossroad is less clear, but concerns our organizational structure. Are the federal science agencies that sustain fundamental science organized to create the complex new innovation networks science will require?

This paper tries to evaluate several key questions about science and its future. Grace Hopper, the computer scientist and Navy admiral, once said in a commencement address about “Asking Questions,’
“No computer is ever going to ask a new, reasonable question. It takes trained people to do that. And if we’re going to move toward those things we’d like to have, we must have … people … to ask the new, the reasonable questions…. A ship in port is safe, but that is not what ships are built for…. And I want every one of you to be good ships and sail out and do the new things and move us toward the future.’ (31)⇓

Footnotes

↵ [1] Reprinted from Technology in Society, vol. 24, no. 1, 2002©, with permission of Elsevier Science.

↵ [2] Mr. Bonvillian is Legislative Director and Chief Counsel to U.S. Senator Joseph Lieberman. The views he expresses are his own and not necessarily those of his senator.

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