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PROMOTING THE UNIVERSE:

Why is it so difficult to build a scientific culture in 21st-century America?

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David Cutler for The Chronicle Review

In 1980, Carl Sagan's 13-part television series, *Cosmos,* burst into American homes. With special effects that were dazzling at the time, and at a cost of more than $6-million ($15.6-million in 2010 money), it was a hit, becoming PBS's most widely watched series. It gave rise to a best-selling book and turned the telegenic Sagan into a media star, who got a record $2-million advance for his own new book, *Contact*.

From all that, you might have thought that America was embracing science, and certainly Sagan's own fields of astrophysics and astronomy, as never before.

You'd have been wrong.

For all the hype about how much we spend on scientific research, and for all the calls for more money for teachers in the STEM disciplines (science, technology, engineering, and math), America does not have a culture that values science. According to the National Optical Astronomical Observatory, by 2009 America faced "a severe shortage of jobs for astronomers, and it's not expected to get better anytime soon." The U.S. Department of Labor says that there were 1,500 American astronomers in 2008 (including people in space technology), and that by 2018, we can hope for 1,700. In 2001 the National Academies of Science felt compelled to advertise to young people the dubious incentive that an astrophysical degree might qualify them for jobs as movie special-effects advisers.

By contrast, the Labor Department reports that in 2008, America had 91,100 dealers who operate table games at casinos and can expect 108,400 a decade hence. In 2008 the country was served by 24,400 casino slot-machine managers, 258,100 professional athletes, coaches, umpires, and related sports workers, and 759,200 lawyers. The latter two figures are expected to reach 317,700 and 857,700, respectively, by 2018.

In its 2008 update to *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future,* the National Academies reported that under a third of American eighth graders were proficient in math; only about a fifth of fourth graders and a third of eighth graders knew even basic math; in 1999, 69 percent of American math teachers in the fifth through eighth grades lacked math certification; 93 percent of physical-science teachers in those grades in 2000 lacked physical-sciences certification or even a major; and American 15-year-olds ranked 27th out of those in 39 countries in 2003 in their ability to apply math to real-world problems.

The number of bachelor's degrees in physics relative to total degrees awarded in 2004 was half that of 1956 (the year before Sputnik, which was a time of dangerous educational neglect). In 2001, American industry spent more on tort litigation than on research. Federal funds for research in the physical sciences, relative to gross domestic product, were 45 percent less in 2004 than in 1976, and the federal

government's annual investment in physical sciences, mathematics, and engineering together equaled the increase in American health-care spending incurred every six weeks.

In 2008, the U.S. Department of Energy's under secretary for science, Raymond L. Orbach, told the Universities Research Association, an international consortium of research universities: "We are now at a perilous moment in the history of funding for science in the United States." Absent new financing, he warned, "the future of the physical sciences will be in jeopardy. Opportunities will be lost forever, for science, and our country." He noted that financial constraints on science "represent the will of the people, as expressed through their elected representatives." Those statements look even gloomier when seen against the Nobel-winning economist Joseph E. Stiglitz's projection of the eventual cost of the U.S. occupation of Iraq at over $4-trillion, compared with the $7-billion budgeted in 2010 for the National Science Foundation.

A pretty grim reflection on the state of science in the country of Jefferson, Franklin, Edison, Einstein (by naturalization), and Buckminster Fuller.

How do we reconcile this dismal picture with the unprecedented resources invested in Sagan-style mass-media science entertainments? It's clear that whatever its other merits, bringing charismatic performers into American homes together with factoids, Hollywood special effects, and glamorous talk-show publicity doesn't necessarily translate into the successful public promotion of science.

To fathom why, we need to look at how we got to this point.

For most of history, science's effort to understand the universe has been part of a wider set of philosophical speculations about reality. That integrated philosophical probing enabled science to grow and command public respect. Religions—including Judaism, Christianity, and Islam—have been important players in intellectual alliances going back for centuries. The Roman Catholic Church disputed scientific cosmologists like Galileo not because the church opposed cosmological science per se, but because of intellectual rivalry. In *The Sun in the Church: Cathedrals as Solar Observatories* (Harvard University Press, 1999), the historian of science J.H. Heilbron documented the adaptation of Italian cathedrals during and after the 1400s to track the movement of the sun to calculate the occurrence of the vernal equinox (knowledge necessary to celebrate Easter). By the mid-1600s, ecclesiastical observations yielded solar data of unprecedented accuracy. Arguing that the heliocentric theory was most solidly affirmed by pretelescopic observations conducted in the 1600s under the church's aegis, Heilbron startlingly identified the papacy as an encourager of at least some areas of astronomical scholarship.

That connection between religion and astronomy continued into the modern era. A 1917 edition of *School Science and Mathematics: A Journal for All Science and Mathematics Teachers* contains an article titled "A Plea For the Study of Elementary Astronomy," which declares: "Astronomy has done more to establish the marvelous unity of matter, of energy, and of God, than all other sciences combined."

Turn now to secular intellectual history, and you'll see a similarly porous boundary between science and philosophy. Science's two most successful ambassadors in the early 20th century were the physicist Einstein and the philosopher John Dewey. Both represented science as closely linked to extrascientific moral values, social issues, and philosophical speculation. Einstein's public presence as a Gandhi-like moral teacher, reflecting on the metaphysical imponderables of his subject, was arguably as great as his scientific reputation during his lifetime. In 1930 he wrote in *The New York Times,* "I maintain that the cosmic religious feeling is the strongest and noblest motive for scientific research." By persistently seeking links among science, religious cosmology, and issues like human rights, Einstein promoted a holistic view of intellectual progress in which science and religion were allies in the pursuit of human welfare, enlightenment, and dignity. He also thought and wrote about science's implications for secular philosophy. Indeed, his impact on general philosophical thought was so pronounced that the distinguished Library of Living Philosophers devoted a volume to him in 1949. Such broad cultural impact greatly enhanced Einstein's credibility and prestige as someone with valuable things to say to the whole of society, not just to his fellow physicists.

Dewey's moral authority was immense. The late historian Henry Steele Commager said no public issue was settled in America until Dewey had spoken. A philosopher of education, Dewey argued that teaching a subject effectively meant relating it to the full spectrum of emotional and practical life. That unity in his thought is illustrated by the remarkable range of his activities, which contemporary philosophers would find hard to match. He was respected as an academically authoritative commentator on scientific method, psychology, art, the theory of democracy, the history of philosophy, and the political issues of his day, including women's rights, race relations, and the achievement of international peace. Dewey saw science as something to be integrated into both good citizenship and personal fulfillment, in a way America has today largely forgotten.

There are many other examples of the overt philosophical context behind the popularization of science in the 20th century's first five decades or so. In the 1950s, the evolutionary anthropologist Loren Eiseley's hauntingly poetic essays, combining scientific popularization; metaphysical speculation on humanity's relationship with nature; and large philosophical ideas like time, religious feeling, and literary references, appeared in magazines as diverse as *Scientific American, Harper's* and the *Saturday Evening Post*.

Now consider that the index of Sagan's *Cosmos* (1981), a book ambitiously subtitled "The Story of Cosmic Evolution, Science and Civilization," references neither Marx nor the Bible.

We have no equivalents of Einstein and Dewey today.

It is not necessary to espouse an ideology to see that the public communication of science once had an exciting philosophical context that related cosmic history to human history. If we detach science communication from its philosophical roots, we cannot compensate for the loss by simply allocating big budgets for special effects. By reducing the glory of science to entertainment without philosophical context, we trivialize and handicap it, making science indistinguishable from movies and television series that may have even better special effects but no educational value.

It is like assuming that because Judith Krantz and Stephen King sell books in the millions, and books contain words, America must be a highly literate society. Not so. In a 2005 study for Unesco, the education professor Talmadge C. Guy notes that there are "between one in five and one in three adult Americans with sufficient difficulty in reading or computation to be challenged by the ordinary tasks of everyday life and work.'" Guy goes on: " For a society as economically and technologically advanced as the United States, it might seem implausible that such a large proportion of the adult population is in need of literacy education."

Ironically, popular fiction—if not recent science—has intuited that cosmic themes make communication sense only if they are related to ordinary human aspirations. Isaac Asimov turned for philosophical content in his science-fiction stories to political struggles inspired by the 18th-century historian Edward Gibbon's *The Decline and Fall of the Roman Empire* and produced a version of the Ten Commandments for robots. Ray Bradbury wrote of Martian colonists who took with them not only their family values but all of Earth's political problems as well. *Star Trek* scripts have drawn on emotional and social issues like the Vietnam War and race relations. *Avatar* recounts themes of cultural conflict and mysticism from multiple old literary sources.

If science has many springs, including extrascientific ones, it's fair to recognize that they have also shaped the sorry state of communicating science in the late 20th and early 21st centuries. It is not the fault of science popularizers alone. One contributor was the general cultural ferment of the 1960s, which associated science with the atom bomb, militarism, and sinister industrial forces ruining the environment. That had the effect of repositioning science's moral authority in a direction counter to the status accorded Einstein and Dewey as moral teachers.

Today's situation has also been affected by trends in the philosophy of science, which have diluted our ability to appreciate the importance of one of science's most human features, the grail quest. This figures decisively in scientific history but is embarrassing to many scientific thinkers. For our purposes, a grail quest is a determined, even obsessive scientific effort energized by emotions, motives, beliefs, and interests that transcend science. Such impulses can range from the petty and disreputable to the noble, quixotic, messianic, or marginally sane. The history of chemistry, for example, is intertwined with that of alchemy, a mystical quest whose objectives included the artificial production of gold, the prolonging of life, the banishment of most if not all ailments, and the attainment of insight not only into the physical world but also into the spiritual principles underlying reality.

Psychopolitical backgrounds drive much science yet can seem antithetical to the aloof reasonableness that many scientists prefer to project. They are thus largely absent from the key works of two of the 20th century's most influential philosophers of science, Thomas Kuhn and Karl Popper. In Kuhn's *The Structure of Scientific Revolutions* (1962), scientific advance was presented as collective piecework: Each scientist quietly contributes to knowledge within the guiding framework of shared theoretical paradigms. As findings pile up, paradigms morph into new ones. Popper's account was quite different. In *The Logic of Research* (1934), translated from German into English as *The Logic of Scientific Discovery* (1959), and in other works, he imagined science as driven by challenges to orthodoxy from bold contrarians.

For all their differences, Kuhn and Popper shared an alienation from the grail-quest element in science. Popular mythology has amusingly captured this side of science in the adventure films about the archaeologist Indiana Jones. In quests involving archaeological trophies of supernatural provenance (including, aptly, the Holy Grail, or cup from which Jesus is supposed to have drunk), Indy sums up several traits of scientific enterprise: the commingling of religious and scientific cravings; the competitive scheming for credit; the interweaving of scientific events with extrascientific political history like the cold-war race for dominance; flamboyant egos; vainglory.

That climate of scientific ambition is manifest in sagas like the races to unravel genetic structure, demonstrate the existence of various subatomic particles, and solve longstanding mathematical puzzles. It hangs over the origins of artificial intelligence and space research, many of whose pioneers were geeky teenagers inspired by inchoate philosophical and quasi-religious visions derived from pulp fiction.

The philosophical motive behind computer work is also conspicuous in two contemporary figures: Marvin Minsky, a pioneer in artificial intelligence and robotics, and Ray Kurzweil, developer of computer systems that write music, read an unprecedented variety of typefaces, read books to the blind, transcribe the human voice into text, and synthesize the sounds of musical instruments. Both men grew up reading

science fiction, and both believe in the promise of computerization coupled with nanotechnology to transform the human species into a new form of life.

For many dignified scientists, that sort of extrascientific "visionary" background to science smacks of being offensively reminded of your shabby family on the wrong side of the tracks. The Victorian era and the early 20th century were notable for creative encyclopedists—what are now called Renaissance minds. Hegel, Marx, and Spencer were all polymaths who offered a total conception of life. The situation changed radically in the early 1900s. World War I destroyed the old sense of historical meaning. Then a longer-term development decisively created modernity: professional specialization. The 20th century fragmented knowledge into academic fiefdoms, not least among philosophers, who retreated from attempts to explain reality to the general public and concerned themselves with minutiae that they explored in highly technical vocabularies incomprehensible to lay readers. For a time, figures like Einstein and Dewey filled the vacuum in the information marketplace, but eventually that generation was succeeded by a new breed of scientist, who valued specialization and retreated from philosophical engagement with the public. Add to that the way the moral authority of science was eroded in the 1960s, and it's clear why the popularization of science evolved away from an integration with morals and holistic philosophy toward a kind of entertainment based on media celebrities. That was the world from which Carl Sagan arose.

Yet if we are to meet the scientific and technological challenges of the 21st century, we must find how to communicate them more viscerally and compellingly. One way is to teach the philosophy of science more widely to all ages, showing scientific experience as the often messy, emotional, and intensely human activity that it is. Another way is to open our eyes to the many divergent quarters from which scientific motivation clearly comes. If it happens to come from a source that is politically unpalatable to us, that should be our private affair. The public interest needs all the support for science it can get.