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CLOSING THE KNOWLEDGE GAP BETWEEN SCIENTIST AND NONSCIENTIST

ILLUSTRATION: ALLAN M. BURCH

TAKASHI TACHIBANA, *widely regarded as one of Japan's most prominent journalists, has written more than 30 books. Trained in French literature and philosophy, in the 1980s he began to cover scientific topics. His most recent book,* Ten Billion Years Voyage, *addresses scientific research in Japan today.*

I am a Japanese science writer. For years I have been writing about all aspects of science including neuroscience, molecular biology, evolutionary theory, x-ray astronomy, elementary particles, computer science, artificial intelligence, robotics, and space exploration. In short—to borrow Erwin Schrödinger's expression from *What Is Life*[*]—I am a man of keen longing for unified, all-embracing knowledge.

Yet, since ours is an age of knowledge explosion, it is virtually impossible to know it all, or even for a reporter to cover it all. There are so many important fields in science, and their advancement is so rapid, that, like Alice's Queen of Hearts, I must run as fast as possible just to remain in place. Nearly all of my time is spent interviewing scientists in one field or another, watching their experiments, or reading their papers. Somehow I still manage at least to follow the most important scientific advancements. Yet, I have discovered that reporting what I have learned in terms that the general readership can understand is quite a different matter: It is far more difficult.

In his classic work *Two Cultures and the Scientific Revolution*,[†] C. P. Snow wrote that the chasm between scientists and literary intellectuals was so vast that they could not communicate with each other. For example in physics, Snow found the mid–20th century literati to be as ignorant about science as had been their Neolithic ancestors. And this situation that Snow lamented nearly four decades ago has only grown worse. The current level of basic scientific knowledge is so low that it is difficult to interest even the brightest layman or nonscience student in what modern science is doing. I border on despair at my inability to keep them interested long enough to correctly understand both a specific research project, and its aims. The chasm between scientist and nonscientist has widened to become a gulf. And it is the task of science and society to narrow that gulf through an intellectual shift of tectonic plates.

Modern scientists can no longer expect to live their lives in proud isolation because most significant scientific research requires substantial funding. A fortunate few enjoy private sources—problems with benefactors are another story. But in most cases government support, that is, tax money, is required to get research started and to keep it from grinding to a halt. When especially large sums are involved, taxpayers can be inquisitive, cost-conscious, and prone to finding fault, and in a democracy they must be taken into account. But public support requires a modicum of public understanding. If a project is very expensive, such as the superconducting super collider (SSC), or involves a highly controversial issue such as when human life begins—as in the debate over the use of near-term embryos for research—the final decision will always be political. Yet political decisions are not always rational, since public emotions can easily be influenced by irrational arguments. Vagueness, anxiety, fear, or abhorrence often prevail over rational judgment, and incorrect or even hostile (it is "absurd," "extravagant," "useless," or "diabolical") commentary about certain kinds of research spreads quickly.

C. P. Snow was talking mainly about intellectuals. But today the reactions of ordinary people and the mass media matter more. Since politicians are easily swayed by their perceptions of public opinion, key to promoting wise political decisions about scientific matters is a sound understanding of science among the general population and the media that feed, reinforce, and mobilize its views.

Alas, that understanding is presently lacking. The figure shows scientific discoveries, beginning with the 15th century, required by the Ministry of Education of Japan to be covered in Japanese high school science textbooks. This graph makes clear that we are not teaching our children about many of the great scientific achievements of our time. Hence the average high school graduate is unlikely to know, least of all appreciate, the numerous, life-changing discoveries that have taken place in the 20th century.

This graph only reflects the situation in Japan, but I suspect that there is little difference in this regard with textbooks of other countries. In most industrialized countries high school is the basic educational requirement. In Japan about one-half of high school graduates do not go on to university, so that their scientific knowledge effectively stops there. Half of the university students major in the humanities or social sciences, and the majority of those students do not take natural science courses, with the consequence that even for college graduates scientific knowledge has also effectively

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[*]E. Schrödinger, *What Is Life? The Physical Aspects of the Living Cell and Mind and Matter* (Cambridge University Press, Cambridge, 1944). Originally a set of lectures presented at Trinity College (Dublin) in 1943. [†]C. P. Snow, *Two Cultures and the Scientific Revolution* (Cambridge University Press, Cambridge, 1959). Originally a Rede Lecture presented at Cambridge University, 1959.

stopped with high school graduation. They will, of course, pick up fragmentary scientific knowledge through the mass media, but this is usually superficial in nature. Downplaying or inadequately teaching about the great innovations in science has created a situation where today's world is composed of people who might be classified according to their level of scientific knowledge on a scale ranging from Neolithic man through late–20th century man.

The 20th century has been an age of revolution in science. Quantum physics began the process by revolutionizing first physics and then all aspects of science and technology. Relativity theory followed, changing cosmology. Molecular biology fundamentally altered life science. The 20th-century revolution in science has given us a whole new way of looking at the world, vastly different from the way people in the 19th or earlier centuries saw it. Mother Nature looks different. The universe looks different. Life is different. But the changes have not been as thorough as they might have been because, while those with a more comprehensive scientific education can recognize that something important has occurred, the great majority of people do not even realize that a revolution has taken place.

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Understanding comes through knowledge. Only with knowledge and understanding can we, using the latest image-enhancing techniques, create novel and exciting images from both new and established data. When we look at a beautiful night sky, we may feel the same wonder and awe that our ancient ancestors felt. But with our knowledge of modern astronomy we can add things that our eyes cannot see: Imagining dark matter, gamma-ray bursts, black holes, neutron stars, or quasars as we look at the sky adds to our sense of wonder and mystery. With the development of new observatory techniques in the latter half of the 20th century, our information about the universe has exploded to an extent even greater than the information explosion brought on by Galileo.

With the enormous expansion of scientific knowledge has come an increasing tendency toward specialization into ever more minute areas and an understandable, if lamentable, corresponding tendency to use time "efficiently" by shutting out up-to-date information that appears to have no direct application to one's chosen field. This has led to an often counterproductive fragmentation of scientific knowledge: A biologist may know little about physics, and an expert in the physics of condensed matter may be totally ignorant of modern astronomy. Exacerbating this are the scientific turf wars and empire building that have resulted, in the main, from keen competition for funding sources.

Most nonscientists who like to think of themselves as knowledgeable about modern science really know only about technologies—and specifically those technologies considered likely to bring economic profits in the short term ("This research can strengthen our economy." "Our future lives can be made more convenient thanks to this technology."). This is also the mind-set of most government officials and lawmakers who consider themselves sympathetic to science and technology budget requests. Thus in countries that pride themselves on having substantial budgets for research in science and technology, most of the money is given to industry-connected technologies. Even when major funding is channeled to pure science, it usually targets an area of clear benefit to industry such as condensed-matter physics, useful for the semiconductor industry. Thus science for homo economicus and homo faber is flourishing, while science for *Homo sapiens* is diminishing.

Given this scenario, it seems that the ascent of man has been left in the care of homo ignorantis. Within this fortress, the "Better Living Through Science" crowd is busy trying to monopolize science and technology funding and is, in the process, choking off what remains of funding for pure research. As we struggle to counter their court intrigues, we may one day wake up to find barbarians at the gate, in the form of an upsurge in "new" science—that is, not science at all—promoted by one or another fundamentalist religious or occultist group ready to lead us into a new Dark Age.

How can we respond to these threats? We who understand real science need to court more allies, and this can be done by ensuring that far more people join us in that knowledge. What we must urgently do is renovate education and significantly raise the basic level of scientific knowledge, for, as C. P. Snow warned four decades ago, we must "educate ourselves or perish."

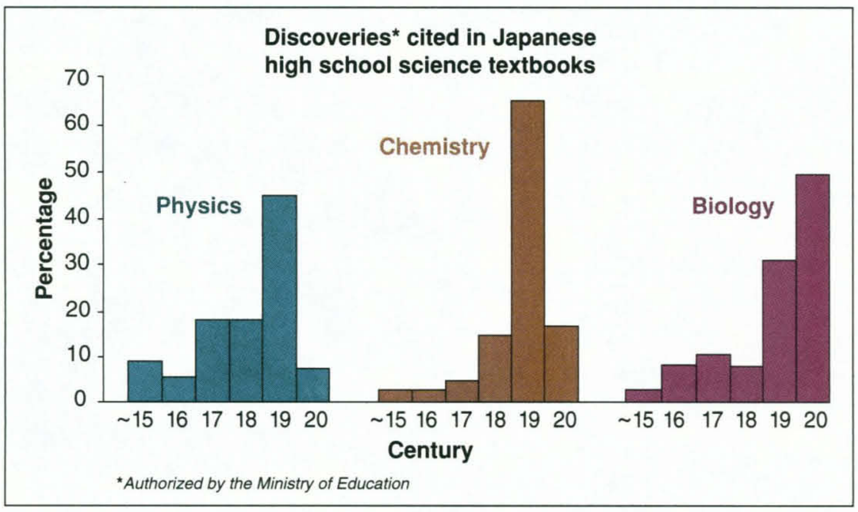

ILLUSTRATION: TERESE WINSLOW Y MIDORIKAWA *ET AL.*