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Presidential Address: The Education of a Neurosurgeon: The Two Cultures Revisited

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It must often seem to some individuals as well as to many groups that their problems are somehow unique and that their concerns are different from the rest of society. We know, however, that such is not the case, that the difficulties we face within our personal lives and within our profession are but a reflection of the turmoil found within the greater world of which we are but a tiny part. Our nation stands at a cultural crossroads where, on the one hand, many people's lives are driven by technology, by a scientific program which has simultaneously left them physically enriched and spiritually confused while, on the other, a smaller group of individuals engage in humanistic pursuits that often appear fulfilling, otherworldly, and impractical.

More than 30 years ago, the British novelist and scholar C. P. Snow delivered a lecture in which he bemoaned the mutual incomprehensibility of scientific and artistic speech, a situation he felt could only grow worse with the adoption of the technological mode by the newer economies of the East in apparent opposition to the traditional cultural fabric of Western-style democracies ([28]). Of course, he was unable to foresee, as we all were, the sudden collapse of East-West confrontation triggered by a startling growth in scientific information, technology transfer, and world-wide communications. Instead of intensifying conflict between nations, science and technology have served to shrink and homogenize the world while, at the same time, the size and sophistication of the scientific enterprise have accentuated apparent differences from the humanities within each society, including our own. Even more disturbing, however, is the growing evidence that most of our populace has become cut off from both lines of scholarly pursuit, the arts and the sciences having become equally incomprehensible to our citizenry. I believe that these educational developments are potentially ominous for the future of our profession and that the separation of the arts and sciences into two distinct cultures is an artificial and dangerous concept.

In 1989, a Gallup poll funded by the National Endowment for the Humanities discovered that more than 40% of college seniors could not identify the dates of the Civil War, 25% were unable to locate Columbus's voyage within the correct half-century, and a similar number could not distinguish the

thoughts of Karl Marx from the words of the United States Constitution ([7]). With such total lack of historical perspective, it is not surprising that these seniors could not correctly link major literary works with such authors as Plato, Dante, Shakespeare, and Milton. It was heartening to note, however, that slightly more than half actually had heard of *Moby Dick*, and that some students could recognize the Emancipation Proclamation. It comes as no surprise, therefore, that only 2% of our 3000 institutions of higher learning have core curricula, and that the further establishment of such programs of study is vigorously opposed by academics and political philosophers who believe that qualitative differences in knowledge cannot be defined, that what is taught needs to be politically correct, and that the ephemera of popular culture have an equal claim on our attention with the more generally accepted classics of Western Civilization ([2]).

Even if we rely on the hope that the products of such an education are not attracted to the field of medicine, how many of us have encountered insensitive young physicians and have wondered how they became that way? Discrepancy between professional attainment and the ideals of personal behavior has been termed professional dissonance and characterizes some physicians who may have made important contributions to society but who are otherwise self-serving, self-righteous or egotistical ([35]). When such behavior is displayed either by an academic careerist or an ostentatious entrepreneur, it is certain to distance our patients from our profession. Although cultural literacy is no proof against arrogant and hurtful behavior, it would benefit the civility of our nation if students exposed to Darwin in a science class also had to study the influence of Darwin's theory on social thought and literature.

In addition to disturbing changes in our general educational climate, the past 20 years also have witnessed an absolute decline in the pool of medical school applicants ([29]); this phenomenon occurred immediately after a tremendous increase in the number of medical school places as mandated by government capitation and research support ([13,18]). There is evidence to indicate that medicine as a career is not successfully competing with business and engineering for the best and brightest among our young. The number of medical students failing the National Board Examination has dramatically increased from 9.1% in 1984 to 16.1% in 1990, and there is talk of making the examination easier for social-political considerations ([21]). The decline in the number of applicants to medical school in the past decade has resulted in a decrease in competition from 2.8 applicants for every position in 1975 to 1.7 applicants for every position in 1985. Some have speculated that the steadily declining performance of graduating residents in internal medicine on the written Board examination is related to this trend ([19]). The decline in Board scores from 1984 to 1988 has been cumulative and is independent of the quality of the resident's training program; as a result, the American Board of Internal Medicine is developing an absolute pass-fail criterion, because it can no longer trust the level of performance of its reference group. In the past year, a modest increase in the number of medical school applicants has occurred without a corresponding improvement in either their undergraduate performance or their achievement test scores ([14]). Recent evidence indicates a decline in the proportion of American papers being submitted to and published in our leading journals of clinical investigation ([30]); although this situation is most frequently blamed on decreased federal support for research, problems in the quality of our applicant pool are certain to compound the issue and could conceivably turn the United States into a net importer of medical knowledge and technology.

The daily problems that we encounter in our practices are frequently cited by physicians as reasons contributing to the diminishing allure of a medical career ([22]). However, it is also possible that our

society simply does not educate enough people with sufficient love and knowledge of the arts and sciences to adequately supply a profession uniquely dependent on the interaction of both creative disciplines. From 1970 to 1986 there was a 17.6% drop in the share of undergraduate degrees awarded in the arts and sciences and an 11.8% increase in business degrees ([33]). Since novel proposals for the reform of medical education often are predicated on a sophisticated tripartite view of human nature, that is to say, as biological organisms, members of society, and individuals with unique personal characteristics ([32]), can we really hope for such programs to succeed if their intellectual adventure must be communicated to students who are narrowly educated and culturally impoverished? Since medical schools of necessity must concentrate their efforts on transmitting the scientific underpinnings of the profession, physicians, their friends, and their families must remain socially engaged about general education and the preparation of entering students in the social sciences and in the arts. Unfortunately, it is not clear that the relationship of medical students and clinicians even to biological science can be taken for granted. In another recent essay provoked by Snow's Two Cultures, a medical student and molecular biologist expressed his concern about the estrangement that many perceive between the separate worlds of those who practice medicine and those who practice science([27]). He went on to hypothesize that the root cause for physician antipathy toward science was a failure to recognize it as a genuinely creative human endeavor ... inspired by awe and curiosity. Of course, any disjunction between medicine and either art or science would have greatly surprised Aristotle, himself the son of a physician, who expressed the relationship between physicists and physicians as follows: ... We may say of most physical inquirers, and of those physicians who study their art philosophically, that while the former complete their works with a disquisition on medicine, the latter usually base their medical theories on principles derived from Physics ([1]).

These words, written more than 2200 years ago, are astoundingly prescient in view of the deep interest that molecular biologists, mathematicians, and physicists have evidenced in the functioning of the brain and a philosophy of mind. Aristotle also anticipated the importance of the scientific questions a physician asks even if the chemist has most of the answers.

Given that the cultural literacy of our population is declining and that the number and quality of medical school applicants is arguably depressed, how may we continue to attract the best and the brightest of our students to neurosurgery? Is a neurosurgical residency program in the business of training or in the business of education? Are we enrolling the student in a guild and communicating a skill or are we producing a scholar of the nervous system, an operating neurologist, a compassionate and informed healer of the sick? I would argue that it is time to heal the rift between the arts and the sciences, to recognize the inherent artificiality of separating the two most creative endeavors of humanity, and that we need to give time to this effort in training programs, in our journals, and at our meetings.

It must be obvious that subtle threads of connectedness between the arts and the sciences have existed throughout history. How could we expect otherwise when the development of each discipline must be conditioned by the temperament and philosophical milieu of its times? Edgerton speaks of a cultural Zeitgeist or historical paradigm by which the creative process is molded in the forge of culture and history. He gives as an example the contemporaneous careers of Cezanne and Maxwell, the first an artist who realized that the painted world need not obey Renaissance laws of perspective (Fig. 1) and the second a physicist who mounted an early challenge to Newton's law of inertia ([9]). I would add that the invariance of the speed of light was established during the very years when van Gogh and Cezanne began to employ a more uniform light in their paintings and by this method, among others, ceased to model figures in a conventional manner (Figs. 2 and 3).

Sometimes the mutual influence of the arts and sciences can be witnessed at play within single individuals who consciously use the knowledge and skills acquired in one sphere to inform their judgment and performance in another. One thinks immediately of Leonardo and Eakins (Fig. 4), who performed dissections to advance their painting skills, or of Blake inventing a type of printing process in order to publish his illustrated poems. When both art and science abandoned a purely descriptive mode, it became much more difficult for individuals to become respected practitioners in both arenas. The current emphasis on the unseen rather than the seen in the case of science, on the quark, the muon, and the gene, has as its parallel the importance of philosophical abstraction, linguistics, and the theory of signs and meaning in recent painting and poetry. Atomic particles and their energetic tracks became visible in modern bubble chambers at about the same time that swirls of pigment appeared in the paintings of Jackson Pollock (Figs. 5 and 6). Nuclear fears and anxieties in the 1950s and 1960s had as their correlate the almost religious and openly cosmic panels of Rothko (Figs. 7 and 8). When science began its obscure and arcane inquiry into the fundamental building blocks of the atom and diverted much of its attention from the horrid consequences of previous nuclear research, the minimalist art of the 1960s similarly stripped abstract expressionism of its angst and carried on a cool-headed investigation of primary forms. Do we doubt that a common sensibility is at work in the physics of quarks, flavor, and charm, and in the building block aesthetics of Sol Lewitt or Tony Smith (Figs. 9 and 10)?


Figure 1


Figure 2


Figure 3


Figure 4

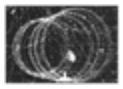
Figure 5


Figure 6


Figure 7


Figure 8


Figure 9


Figure 10

The mutual interactions of the arts, the sciences, and the times we live in are further compounded by influences extended between diverse sciences and between the arts. I have previously written on how ideas about the brain's structure and function are frequently conditioned by the dominant technology of an era, so that telephone and telegraph analogies were common at the time of their invention, only to be succeeded by models of the brain based on the transistor, the computer, and

the liquid crystal display ([25]). Because we live in an age when, for better or worse, a functioning neuron has been physically attached to a silicon chip ([11]), it behooves us to explore the philosophical and spiritual consequences of such events. Watson ([34]) has proposed that 3% of the funds earmarked for the Human Genome Project be used to support activities in the area of ethical and social implications; he has stated that our genetic code represents the most important set of instruction books ever found by human beings. Is it possible that our view of ourselves and the art and artifacts that we produce will not be conditioned by this new view of the brain and its instruction manual?

Following the lead of Aristotle, physicists, molecular biologists, and neurophysiologists not infrequently have turned their attention to art and philosophy in an attempt to understand the ultimate implications of biology. Erwin Schrodinger ([26]), a German physicist, was among the first to link the study of the gene to a view of the mind and the brain. He was fascinated by the ability of living matter to apparently violate the Second Law of thermodynamics by constantly creating order rather than entropy or disorder. He viewed the genetic blueprint of the brain as a nearly rigid means of producing more order from preexisting order in contradistinction to the statistical or probabilistic methods employed by physical laws (and physicists) to bring order from disorder in the rest of the universe (Fig. 11). Nearly 40 years later, the convergence of the brain sciences and molecular biology could not be more obvious, but in Schrodinger's day such an insight clearly depended on an ability and interest to read and think widely. In *The Two Cultures and a Second Look*, Snow ([28]) expressed his opinion that ignorance of the Second Law of thermodynamics on the part of a writer was equivalent to ignorance of Shakespeare on the part of a physicist.

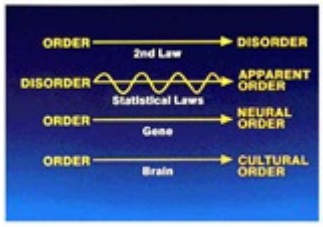

Figure 11

Surely, narrowness of interest will not help us confront the problems that beset us. Wide ranging curiosity and knowledge have been characteristic of those whom we consider to be the scientific and technical giants of our profession. The rich intellectual heritage of neurosurgery is a vital part of our professional culture and constitutes a long distance signaling of common concerns and points of view, a world consciousness, if you will, similar to the interconnectedness of neurons at the extremities of the brain. Unless we accept responsibility for the transmission of interdisciplinary advances from other sciences, medical specialties, and the arts to our physicians in training and unless we ourselves maintain a life-long commitment to learning, it is inconceivable that neurosurgeons will continue to take part in the universal conversation.

In the parallel lives of Cezanne and Maxwell, as of Einstein and Picasso, we can see a world view expressed and shared; each of them helped to invent the world we inhabit by selecting certain facts for emphasis and by deciding what not to look at. The process of intuition is critical to the process of selection and the power of creative delight is essential in achieving artistic or scientific completion. Indeed art and science share many other characteristics, almost all of which apply equally well to medicine; as listed by Cavell, these include: precision, accuracy, authority, apprenticeship, argument, rhetoric, definition, community, example, experimentation, and stubbornness ([6]). In a moving essay written before his death from cancer, Anatole Broyard, the

former editor of the New York Times Book Review, described his ideal doctor as being like a writer who has a voice of his own, something that conveys the timbre, the rhythm, the diction and the music of his humanity because when he makes a difficult diagnosis it depends as much on inspiration as art does ([3]). I would add that art, science, and medicine also require courage and concentration. Herbert von Karajan has described how deep knowledge of a new symphony can overcome the fear of conducting it, and likened his skills to that of a great surgeon because the experienced surgeon is able to apply his real concentration at the decisive moment ([20]).

With so much in common, why is mutual hostility and lack of communication so often observed between the two cultures? Perhaps it is because the way things are said in science is almost always less important than what is said, whereas the way a concept is expressed in art is almost always more important than what is expressed ([8]). Or perhaps the level of rhetoric and noise is so much greater in art than in science because of the artist's need to address a public. This may have been true in the past when science and medicine were carried out by individuals with little immediate hope of impact on the wider world, but modern science such as the Human Genome Project or the Decade of the Brain (Fig. 12) is often Big Science and must address itself to society for support and understanding. Furthermore, it is a paradox of our times that much of contemporary poetry and music has been written without any thought of an audience other than one's artistic peers, an attitude which has further alienated the general public. It is not the process or attitude, therefore, of art and science that separates them but their products, the tangible differences in the nature of the artifacts which they each produce. Artists correctly perceive science as responsible for our technology and incorrectly blame scientists for its misuse (Figs. 13 and 14); in turn, scientists fail to recognize that art is a largely rational process with practical consequences for the real world. As Cavell ([6]) has said, The wish to make something, to counter destructiveness, to leave the world marginally better than you found it, to mend it, is at the heart of both the arts and the sciences. I would put it to you that it is at the heart of medicine, that the wish to create and heal is the moral force and guiding principle of our profession.

Figure 12

Figure 13

Figure 14

We are spending 11.4% of our Gross National Product on health care but only 6.8% on education ([4]); it is as if our belief in the physical perfectibility of the body is greater than our hope for moral and intellectual enlightenment. We know that what counts in medical care cannot always be counted nor that everything we enumerate or can measure really counts ([17]), nevertheless we persist in the belief that the health care system can be salvaged by cost containment alone without serious attention paid to our personal beliefs and habits ([4]). We face a series of moral conundrums in which not everything that can be done for some will be available to all and when some things that might be done for everyone will never see the light of day. In just the past few months, the ethics of randomized clinical trials, the efficacy of conventional cancer care, the rationing of health services for older Americans, and the plight of the uninsured have all come under fresh scrutiny ([5,10,12,16]). The attainment of wisdom in medicine, a knowledge of our ends as well as our means, appears to be

a moving target, especially in regard to the relationship of medicine to the rest of society. In such circumstances an educated public and a broadly educated profession are more critical than ever.

Any attempt to prioritize the arts or the sciences in the education of a physician is doomed to failure. The plastic arts inform the eye and enhance the three-dimensional vocabulary of the brain with a myriad of visual incidents of potential value to every surgeon. Music and poetry exercise the facility for abstract thinking and deep emotion, they offer the mind the clearest examples of the intangible link between the rational and the irrational. Mathematics and physics provide models of scientific thinking, now common in the biological sciences, and have invented the tools that we have appropriated for our ministrations to the sick. Nowhere is the relevance of the full breadth of humanistic pursuits to the work of the physician more obvious than in regard to the student of the brain. Neurologists and neurophysiologists have been keenly interested in perception and the neuronal machinery of the visual system; psychiatrists and psychologists have studied art and its archetypes to construct a theory of mind ([23]). Ethology and neurophysiology have been linked in an effort to study the neuronal basis of aesthetics in painting, poetry, and music; and the efficacy and technology of modern neurosurgery are rooted in contemporary physics and biology.

There is a real sense in which a properly conceived and executed operation shares the aesthetics of an elegant proof in mathematics, the order of notes in a symphony, or the disposition of color and shape in great painting. The master surgeon works with concision and makes each move appear inevitable in its logic. There is a ballet-like rhythm to the sequence of steps that the surgeon and each member of the team makes individually and in concert. There is an illusion created of effortless grace and efficiency based on a lifetime of study and enforced discipline. And when satisfactorily concluded, such an operation shares the moral attributes of a hazardous voyage that has been successfully negotiated, for in medicine, as in art and science, there is no reward without risk.

Although education has always been the foremost role of this organization, it has only infrequently served as the theme of this address. Rededication to our central mission was explicitly recognized in 1989 when the logo was amended to include the motto dedicated to neurosurgical education (Fig. 15). The Congress has always sought to bridge the gap between residency training and independent practice, to keep the spark of inquiry alive, to burnish our curiosity, to challenge us to continue in a life-long practice of learning and self-teaching, for ourselves and for our colleagues. As chairman of the Joint Committee on Education, I can personally attest to the diligence and dedication with which your officers and young members serve to promote our many worthy endeavors in undergraduate, graduate, and continuing medical education. Many of the innovations we take for granted at our national meetings, the format of our leading journals, the intellectual involvement of the sections, the recruitment of young surgeons into altruistic volunteerism, the application of computer technology to learning, and the promotion of ethical standards were either strongly fostered or initiated within the committee structure of the Congress. Dedication to neurosurgical education is not just a slogan, it is a patently successful strategy for dealing with the future. It is the effective transfer of information, whether in regard to surgical technique, basic neuroscience, or the social and political forces impacting the organization and delivery of health care that must remain our primary responsibility.

Figure 15

In 1951, Philip Gordy wrote Bland Cannon that the Congress should be an association of contemporary neurosurgeons. What a felicitous phrase, contemporary neurosurgeons! His committee rejected naming the new organization the *American* Congress of Neurosurgeons because this suggestion was viewed as tending to destroy the international connections of the association. The founding members expressed their desire to hold an annual meeting during which they might exchange technical information and experience, join in discussions and study of developments in fields allied to neurological surgery, honor their living leaders, and express their views on various aspects of the principles and practice of neurological surgery. The organization was inclusive from the first and proposed an annual membership fee of $15 for those members just out of residency and non-payment of dues for those recalled to the military. Furthermore, the original charter of incorporation contained the principle of promoting the public welfare through the advancement of neurosurgery by the dissemination of scientific knowledge. From the outset, therefore, the Congress was inclusive, sensitive to the needs of the younger members of the profession, outward-looking and international in scope, contemporary in its bearing, and educational in its stance. The founders did not view it as a guild and neither should we.

The vitality of a learned profession depends upon the altruism of its members in service to the public, to their colleagues in other disciplines, and to the special needs of neurosurgeons throughout the world and at every stage of their professional lives. These concepts from the original charter have been reiterated in our newly adopted Mission Statement, and the history of their observance over the past 40 years has been collected and recently published ([31]). Although there is much to be proud of in this record, we must not let our absorption in problems of the moment divert our attention from the eternal verities of a profession uniquely devoted to the healing of the organ of our humanity. I have taken the liberty of a public address to speak of my private beliefs: the importance of culture and the interdependence of the arts and sciences as the educational foundation of a humane and intellectually vigorous profession (Figs. 16 and 17). In doing so, I have followed the advice of the philosopher-poet Friedrich Schiller who, in his Letters on the Aesthetic Education of Man (1795), exhorted his readers to give their contemporaries what they need, not what they praise. The only real threat to a learned profession is the spread of ignorance among its members, and education on a continuing basis is its only effective remedy.


Figure 16


Figure 17

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