

fragmentation of modern life that have separated the spheres of science and the arts.

My theme today is that after 2500 years of Western scientific thinking and the arts, we still need both. The acts of making art and doing science do not just complement each other, they intertwine. For the Greeks, as we shall see, scientific truth made itself obvious by its beauty; while artistry provided individual beautiful instances within which to recognize truths. My sources for these ideas, beyond my own experience, include especially the remarkable book *Measure for Measure*, by Tom Levenson.

Science behaves like other arts but is not identical to them: modern science puts its results to the test. But if we consider science as a form of art, we see that it is not so much about nature outside as it is about ourselves, and about making sense of the human condition. "Science can help us come to terms with our existence, to understand, and not just simply command [or control] our circumstances." (Levenson)

Even the most abstract science remains a human passion. "This is where science is closest kin to the arts."

THE PREHISTORIC ORIGINS OF MUSIC AND SCIENCE

I have been engaged for some years in a hobby about the origins of modern mass diseases. It is a hobby because it involves much teleological reasoning and relatively little opportunity for hypothesis testing, but it is an intriguing way of looking at modern behaviors and risks. The assumptions of evolutionary medicine go something like this:

All forebears of modern humans were hunter-gatherers (H-G). Thus, characteristics favoring survival in H-G subsistence cultures were central to the fundamental adaptations of human evolution. The recent epidemiological transitions leading first to agriculture, then to sedentary communities, civilization, and eventually to industrialization, occurred far more rapidly (in a mere 500 or so generations) than major physical adaptations can occur. It follows that modern humans remain hunter-gatherers metabolically. Discordance between modern lifestyle and this evolutionary legacy places serious stress on these adaptations, leading in affluent societies, to widespread maladaptations: elevation of risk characteristics, obesity, high blood cholesterol and insulin activity, high blood pressure and thrombogenesis.

man's metaphysical awareness of his environment, and in its highest forms may offer an illumination of the world much more valid and direct than any offered by formalized religion. But, like visual art, it also often retains functions it possessed at an earlier stage of evolution; for instance, man [today] enjoys dancing to music as much as [did] his primitive ancestors....” (Carrington)

There is no lack of theories about the origins of music. “Charles Darwin attributed song to the imitation of animal cries in the mating season. Rousseau, Herder, and Spencer argued that speaking with a raised voice was the beginning of song. A kind of ‘speech-song,’ or chant-like recitative, is ... found in many primitive cultures. It is ... possible that the whole [of] language is merely a levelled-down music; but it is more likely that sound-language is the older element from which developed both speech and song, speech driving toward the free rhythm and music towards the more regulated one.” (Carrington)

In the known primitive cultures, speaking, shouting, imitation of animals, and the rhythms of movement, all tend to musical forms. Anthropologists suggest that, “music has a unifying effect in human society. Melody liberates and gives objective form to amorphous feelings. Singing enables things to be said or hinted at which would be difficult to express in formal speech. An idea set to music is more general, or more ambiguous than the same idea expressed in words alone, subject as it is to a regular rhythm.” (Carrington) In language, something of the same kind occurs in proverbs, which probably for the same reason are still popular with primitive peoples.

The evolutionary view of the importance of music is strengthened by observations among native American tribes where: “Song and dance accompany all the events [of the tribe] and they are an essential part of the culture of the people. Although there are expert performers, everyone is obliged to take part in the singing and the dancing so that the separation between performer and audience that we find in modern society does not occur in more primitive society.... .” (Franz Boas).

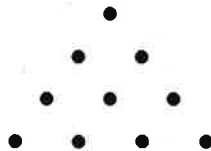
According to Schoolcroft, writing in the mid 1800s, “dancing is both an amusement and a religious observance among the American Indians and is known to constitute one of the most widespread traits in their manners and customs. It is accompanied in all cases with singing and, omitting a few cases, with the beating of time on instruments. It is believed to be the ordinary mode of expressing intense passion or feeling on any subject, and it is a custom which has been preserved with the least variation through all the phases of their

which rang a fifth.” (from Levenson) He went back home, it is said, and tied comparable weights to strings and plucked them to produce the harmonics discovered earlier.

Could this legend be true?

It was surely apochryphal. Hammers of different weight striking the same anvil give off the same tone at different loudness. The bell, not the clapper, sounds the note. Pythagoras was, nevertheless, a real person, and he used a monochord, a device like a guitar with a string strung against a body, the string divided into two lengths variable by a movable bridge, and with this scientific musical instrument he investigated the musical ratios producing the octave, and the natural harmonics of the fourth and the fifth.

The fundamental arithmetic of the musical scale was built up, therefore, of the relations between the numbers 1, 2, 3, and 4, illustrated in this Pythagorean mystical pyramid of the 6th century BC:



“The Pythagoreans were not scientists; they sought magic in numbers. But still, here is where science begins.” “Three thousand years separate us from the extraordinary sense of revelation Pythagoras must have felt at the moment he recognized what he was hearing. For the first time, ephemeral evidence of the senses could be accounted for by an idea that would hold true for anyone at anytime.” In their enthusiasm, they deduced a universe. They postulated that “the planets moving through the heavens gave off sounds, ‘the music of the spheres’ which exemplified the perfect organization of nature on the largest scale.” (Levenson)

Tradition has it that only the master, Pythagoras himself, could actually hear that perfect harmony. But a musical cosmology developed in which God’s hand stretched the monochord’s string as it passed through two octaves, from high G up among the angels, to the Sun at middle G, down past Venus, Mercury, and the moon, then through the elements of fire, air, and water, down to the resonant G of Earth on the bottom. God turned the tuning peg.

hydraulis was....so pleasant and charming ..that we all turned toward the sound, fascinated by the harmony.” (Levenson)

In this way, the pipe organ, then a new musical technology, was inspired by the study of physical questions. It was reasoning applied to the understanding of nature. With the organ, the connection between abstract mathematics and the natural world was made. It is one of few remnants of Greek scientific thought, all of which was to disappear with the Goths taking Rome in 410 AD, until the 12th century when Western man relearned from the Arabs what the Greeks had contributed, as well as from discoveries of China, India and Persia.

There followed a long period when the pipe organ became a symbol of advanced civilization. For example, it was borrowed from Byzantium by the barbarian court of Louis, son of Charlemagne, in 800 AD, as a display of power through technological mastery. It appeared that to possess an organ was to possess civilization.

Then came another long period in which science and music were unpopular with the Church. But music and the organ became a tool of the Church, a symbol of harmony between God and Man, in the eleventh century when it was brought into celebration of the Holy Mass. The organ dates then to the era “when a very small community of men created the first glimmerings of the notion that all of nature might be encompassed by a single theory” (Levenson) — a notion still entertained by a few such people as Steven Hawkings.

CHURCH MUSIC AND THE SCIENTIFIC REVOLUTION

Pope Gregory sought to replace the cosmology of Pythagoras with that of the Church. He elevated choral music to the worship service and in the sixth century AD systematically reorganized and codified the entire *schola cantorum*. His powerful, simple Gregorian chants evolved over the next centuries to a new major discipline of the church’s scientific quadrivium; arithmetic, geometry, and astronomy were now united by the science of music. Music became a principal tool of the Church, and was “seen to express essential characteristics of the human experience in truths that could be easily understood by all.” “The melodies heard at every service fixed listeners with the order of nature and of human affairs as God had designed it for the faithful.” (Levenson)

Thenceforth, the Church, specifically a priest, Guido d’Arezzo, around 1050 AD, led in the development of musical notation in a four-line staff. In the most

Kepler compared the speed of each planet at the point nearest the sun, when planets move the fastest, with their velocity farthest away. With the ratio of the two speeds he turned, as had Pythagoras and Newton, to the science of music and constructed planetary musical intervals. Mars covered a perfect fifth with the ratio 3 to 2, while Saturn sounded out a perfect third. Each planet produced its own song. Together, the Solar System generated the “glorious, interwoven sound” that for him confirmed the truth of his system.

Kepler’s musical astronomy does, in fact, work. The set of planetary tones fits remarkably well into an octave. (Yale professors Ruff and Rodgers, some years ago recorded the planet’s songs on electronic instruments and brought them up to audible range. I’m sorry not to have here their record of “*The Music of the Spheres*”).

Kepler’s heavenly music provided for him the link between his mind and God’s; his science was driven by the belief that such links existed throughout nature, that the patterns he expressed as harmony, as music, did exist in the real world. Hence, Kepler’s ecstasy at the celestial music heard in his mind’s eye. It was for him a revelation. His belief in the existence of such patterns of nature created what remains today as an esthetic of science; “when he recognized a given order, it appeared to him beautiful.” The very beauty and elegance of his invention served to reinforce his commitment that nature forms orderly patterns. Kepler is said to have restored to science the reward of intuition, insight; the sudden glimpse of harmony that Newton’s apparent rigor had seemed to eliminate. But Newton emphasized the same esthetic, saying: “It is the perfection of all God’s works that they are done with the greatest simplicity.”

This is the idea that made modern science possible, that any natural phenomenon can be understood within a framework of abstract, universal, and simple laws.

In the eighteenth century, Bach achieved his astounding marriage of precision and passion. Many find that Bach’s *Great Fugue* matches Newton’s mathematical arguments in its logic and formal elegance. The common evolution of science and music continued with Poincaré who wrote, “It is only through science and art that civilization is of value.”

things, utilitarian constructions such as a bridge or artistic ones such as a musical composition. And I cannot see more than a difference of degree between these highly sophisticated activities.”

Scientific creativity starts with an assumption based on a hypothesis that can be tested. The assumption precedes the empirical observation or experiment. The scientist, like the artist, achieves a form of internal representation or simulation of the phenomenon and its sources. The next stage is to verbalize or symbolize this simulation. The last state is the mathematical or logical term for the assumption. The more critical point of all is the ability to identify and see a problem, to ask a question in the first place. Central also is the ability to discard a less desirable idea for a better one.

Along the way is the importance of not disregarding oddities that appear in observations or experiments. They prove to be the source of many important discoveries. Retention of childlike imagination, playfulness, curiosity, independence, and rebelliousness are involved. “Orthodoxy is the enemy of creativity.” (Desmond Morris).

Throughout the process, boldness and courage are needed, to go to the new idea, approach, or method from the traditional one. And not be afraid to be laughed at. Along the way to creativity is coping well with inhibition, sterility, mistakes, failure, and anxiety, and, as well, with happiness and hubris. An important aspect of creativity is over-emphasis and over-simplifying to provide the most obvious and vulnerable hypothesis. (Keys over-simplified and testable hypothesis on diet.)

Then, “A kind of liberation is required before one is able to be creative.” (Magee). Einstein told Northrup in Berlin in 1928 that he would never have dared to overthrow basic Newtonian assumptions if he had not just recently read the Scots philosopher David Hume. Even the creative genius needs to be liberated from habitual patterns of thinking.

These characteristics of risk-taking mean “that a quality not only of intellect but also of character is involved in creativity.” (Magee).

I was interested that none of these brilliant, individualistic Nobel laureates mentioned qualities of communication or teamwork. Rather they quoted Gibbon: “Conversation enriches understanding, but solitude is the school of genius.”

act is often full of errors. Original thinkers make terrible mistakes. Those who give us a new way of thinking may be wrong on this or that. The first airplane is not the best. "We must not expect the innovator to produce something of supreme excellence, but we must be thankful to him for showing us the new direction."

The danger of relying on hunches, which the most creative scientists are prone to do, is that it leads to certainty rather than to the doubt needed for further exploration. (Example of Pauling)

The desirability of leisure or freedom from pressure was considered. "The mind of a man about to be hanged may concentrate wonderfully, but it will not be very creative."

THE ARTS AND MEDICINE TODAY

Closer to home for us in clinical medicine, Paul Rodenhauer, professor of psychiatry at Tulane, lectures eloquently about creativity in medicine, about the involvement of physicians in the arts, and on theories of creativity, with the probability that creativity can find a place in modern medicine. He points out how creativity fascinates the medical profession, but how medical education, medical practice, and society in general push us toward conformity and away from our creative attributes; how creativity is appreciated but not fostered.

"From selection for medical school of the most orderly, competitive, perfectionist, over-achievers, to the need to memorize massive amounts of material, the necessity to succeed on multiple choice exams and to master methods and procedures, perfectionist behavior is everywhere reinforced. Nevertheless, the average creativity score of medical students is [apparently] higher than that of architects, engineers, mathematicians, psychologists, or research scientists." (*The Pharos*)

He asks whether the profession should be actively recruiting creatively gifted students and whether medical education should cultivate creativity. In support, James Knight finds that creative students are better able to tolerate uncertainty and to question existing theories, are more likely to have the courage to be different and to be innovative through science, and possess a greater passion for learning, thus inspiring others. They may have a finer appreciation of human suffering, are more likely to be curious, sensitive, persistent, capable of intense concentration, and have a high tolerance of

The profession and the world may be better off that some successful artists never practiced medicine: consider James Joyce, Gertrude Stein, Percy Bysshe Shelley, John Keats, Hector Berlioz, Somerset Maugham, and Michael Crichton. One study of famous men in medicine implied that physician-writers Chekhov, Maugham, and Joyce personified mild, marked, and severe psychopathology, respectively. Physicians Havelock Ellis, Sigmund Freud, and William James were considered badly troubled. Berlioz' severe mood swings would probably have rendered him ineffective as a practitioner. A few flourished with strong identities and success in both medicine and the arts: Borodin, Albert Schweitzer, William Carlos Williams. And then there were the ambivalent and conflicted such as the surgeon Billroth, who wanted to be a pianist.

Although the metaphor is offensive to modern sensibilities, Chekhov had an interesting way of looking at his two passions, playwriting and medicine: "I feel more contented when I realize that I have two professions and not one. Medicine is my lawful wife, literature my mistress. When I grow weary of one, I spend the night with the other. Although this may seem disorderly, it is not so dull and besides neither of them really loses anything at all from my infidelity."

The profession seeks those easier to educate, conforming, convergent thinkers with more an exaggerated sense of responsibility than a capacity for brilliance. What then are the characteristics of creativity? Are they compatible with good medicine, good science, good practice, and with mental health? The lecturer's view of capacities and conditions for creativity include qualities of alertness and discipline, but also of "aloneness, inactivity, day-dreaming, free-thinking, similarities-detecting, gullibility, and remembrance of and inner replaying of traumatic events."

I am reminded of our experience as second-year medical students at Tulane in the days of Ochsner and Debaquey and George Burch, who was named chief of medicine that year, at age 34. He rode us unmercifully, admonishing us that if we were quitting work and going to bed before 2 am we had no business in med. School! We were amazed when this driven, brilliant man returned from a summer leave in London. There, Burch had daily encountered clinical investigators as bright as he, and grand rounders just as erudite. What astonished and changed him was that these same people went regularly to concerts and the theater and discoursed on the arts as fluently as on medicine. On his return, and for some time thereafter, Burch admonished us students: "If you don't have season tickets to the New Orleans Opera, you've no business in med. School!"

To Slom's
Sept. 9/22

our ancient authority, there remains a test that can be given to a scientific work, just as it is applied to art: is the result beautiful?

Einstein used this test and found his own theory simply too beautiful to be false. When asked at the time of the 1919 eclipse of the sun what he would do if the measurements being made of starlight bending should contradict his theory of relativity, he replied, "Then I would feel sorry for the good Lord. The theory is correct."

"The human ability to perceive structure, to recognize the quality of beauty, and to agree on what is elegant serves as a guide ..." a fallible guide, of course, to what idea has value and what is dross.

Finally, *"science and music are ultimately aesthetic endeavors. They give pleasure in the doing. The proof of having done them well lies in the coherence and beauty that the outcomes of both science and music present...."* (Measure for Measure)

I close with Rodenhauser's summary:

"Creativity [in the arts and in science] has deeply personal and spiritual implications. It provides affirmation, passion, expression, excitement, and experience of a universal nature. It provides the means to accept, transcend, or modify reality, perhaps to introduce a new version of reality, to make the ordinary extraordinary, and to advance knowledge and culture. Along with humanism in medicine, it ranks among the highest forms of giving." (The Pharos)

Well, I would love to have been a wizard here today and to have brought all these things closer together. Clearly, this dream was doomed. But I find in my life that medicine and music are not *that* disparate. There is more harmony than duality in their conjoined practice. I admit, however, to finding an even closer harmony between medicine and writing.

So, we leave unresolved the broader issues of the interaction of science and music and the arts. I believe, nevertheless, that we must keep trying to bring them together, at least in our own personal and professional lives.