Trans. Nat. Acad. Sci. & Tech. (Phils.)
1985.7:1-6

THE SCIENTIST AS AN ARTIST*

Paulo C. Campos
President, National Academy of Science and Technology, Philippines

This occasion is too important and your time too precious to be occupied with just reports on the activities of our Academy. I had these things mimeographed for everybody to read.

This morning, I shall share with you some thoughts and ideas that I feel would interest you. Many scientists have dwelt on the subject before. It is not strictly scientific. It is really more philosophical and covers the whole panorama of science and our work as scientist, THE SCIENTIST AS AN ARTIST.

The image of the scientist today in the minds of laymen is likely to be unduly conditioned by the impact of technology on modern life. Technology is easily confused with science, to which it is related in somewhat the same way that journalism is related to poetry. As a result the scientist and the artist are often considered to be almost diametrically opposed in their methods of operation, the artist basing his activities primarily on emotion tempered by reason and the scientist his on reason not tempered by anything. Indeed, science is supposed by many to carry out its operations so implacably under the dictates of blind logic that it is likely to overreach itself, and to land man in situations which are very disturbing to the humanist.

TNT so disturbed a Swedish industrialist who made lots of money on its manufacture and sale that he set up the now famous Nobel prize. Atomic bombs and star wars are further examples. In the realm of biology – people are beginning to be bothered by ethical, moral, and sometimes legal implications of test tube babies, artificial hearts, and even some areas of genetic engineering.

Typical of a common misunderstanding regarding the forces that drive the scientist is a statement Dr. Zhivago (in Boris Pasternak's novel of that name) make in his diary: "Progress in science is governed by the laws of repulsion, every step forward is made by the refutation of prevalent errors and false theories . . . Forward steps in art are governed by the laws of attraction, are the result of the imitation of and the admiration for their beloved predecessors."

It is hard to agree with this statement; I believe that science progresses, not by negation but in a manner similar to those which stimulate progress in art. It was Sir Isaac Newton himself who said, "If I have seen further it is by standing on the shoulders of giants."

---

*Address delivered during the 7th Annual Scientific Meeting of the Academy, July 18, 1985 at the Philippine International Convention Center.

The work of the true scientist is primarily directed and conditioned by aesthetic values. Advances in science result, not from purely rational considerations, but from the search for beauty, the seeking out of order, harmony, symmetry, and balance. No scientist could ever, without aesthetic guides, thread his way through the impenetrable thicket of all the possible deductions that result from a purely logical approach. Inspiration comes to the mind when apparently random fancies, welling up from the subconscious, are seen to fit into previously unperceived patterns. The creative imagination that invokes and evaluates such patterns is the major tool of artist and scientist alike.

Every scientific hypothesis or discovery is a work of art. It arouses in observers feelings of beauty to the degree that it appears as true, and feelings of interest to the degree that it is new, disciplined, and fitting. The panorama of modern science is like a vast mural painting on which thousands of artists have been filling in detail over the centuries, a hypothesis and its subsequent verification here, a discovery and its explanation there. At times it can be seen that certain areas of the mural need working over, to bring out a previously unperceived degree of order, or to smooth together sections in which overlapping detail does not match. Seldom must an area of the mural be blanked out completely. When this happens the scientist painters have many traces to guide them, and never need start again at the very beginning.

The greater a scientific hypothesis the more closely do the drives responsible for it resemble those which produce a great work of art. Einstein himself described his first tentative probings in the direction of relativity as being guided by the need for symmetry and order. He might have been describing the approach of Beethoven, or Michelangelo or Milton, to the working out of their respective inspirations.

Like a work of art, a scientific generalization needs technical understanding for its appreciation. My colleague in the visual arts and I stand mute before an abstractionist painting, they savoring it, I, feeling inadequate before what seem to be the scratching of an adolescent. Later we stand together before a model of a human torso and are mute again, but now it is my turn to be stimulated, and to have imagination expanded. I am filled with wonder that in a very short formula is compressed the behavior of all the electric charges and magnetic fields that man has ever met, whether in the nucleus of an atom, a beam of light, an electric motor, or a cosmic ray from a distant nebula.

The same concentration of information that one finds in a picture as the Chinese proverb say is better than 10,000 words, or the poetic turn that stimulates a hundred echoes in the mind, is found in science in such equation as Einstein's $E = mc^2$. The vast vistas of truth thus bundled in a tiny package can be bulked out in the mind of the beholder in accordance with his understanding. The very process of so bulking them out will, indeed, increase his powers of comprehension.

The scientist feels that he has achieved one of his goals when he has "explained" something. By this he means that he has viewed a phenomenon from all sides, and has seen that it fits comfortably into the mural that relates other

"explained" phenomena. "Explanation," involving as it does according to Webster the process of "laying out flat," seems to me to have been originally an artistic term. The scientist lays things out flat for the same reasons the painter does, so he can see them, perceive their relationships, and if necessary rearrange them.

By looking at pictures of atoms more frequently our ability to specify how atoms will behave in various circumstances, increases. As we mature in aesthetic appreciation our need diminishes for pictures of atoms which resemble so closely the things that we see in the everyday world.

Like earlier men with their gods, we are able to visualize the unknown only in terms of the known. So the scientist has come to recognize that his molecules and neutrons and nuclei are artistic products of his creative imagination. They cannot look like the real thing, which is unseeable, but the pictures have validity in the degree that they enable him to predict molecular or nuclear happenings correctly.

The sweeping beam that paints the picture on a television tube is a stream of electrons impinging on a fluorescent screen. These electrons have been seen by no one, but are found to behave like tiny particles of electricity which can be weighed and measured by appropriately delicate means. So the artist-scientist paints them in these terms on the mural and sees that they are parts of atoms, emit radiation, and can be expected to perform various other electronic tricks. But the picture distorts if pushed too FAR, and the electron model is found unable to explain some newly observed facts. Then a quick repainting job is done; the electron in the mural is set to spinning, and is hastily, dressed up with waves to guide it.

When the atom was found by Rutherford to contain electrons it was natural to think at once of the analogy with planets in the solar system. How pleasant it is to visualize in the microcosm 1,000,000,000 suns, each with planets circling about. Somebody had painted a detail of great beauty on the mural by showing that the distances of the nearer planets from the sun bear a simple mathematical relationship to one another, and had by this means even located a missing planet where the asteroids were later found. Kepler discovered that a planet sweeps out in its orbit equal areas in equal times, no matter whether it is falling toward the sun or climbing from it. How exciting to imagine this harmonious music of the universe transferred to the inner reaches of the atom. What a beautiful example of order if in the microcosm one should find the same mathematical beauty as is seen in the cosmos!

Looking at neighboring areas of the mural soon showed that this picture could not be exact. If it were true the atom would quickly collapse in a tiny flash of light as its electrons spiraled hurriedly into their nuclear sun. Many scientists were downcast at this failure of the universe to obey their imagined order. Then in 1913 Niels Bohr showed that what was needed to understand the atom, at least as an emitter of radiation, was to deliberately suppose that everyone had been misled by the paintings of the hydrogen atom in other parts of the mural, and assume that an electron can stay put in an orbit indefinitely, radiating no light unless it jumps to another orbit.

The point for us is that the new laws thus found to govern the motion of electrons in atoms, proved incredibly more beautiful and stimulating. And as a result, widely separated parts of the mural, previously out of order at the edges, could be fitted into a remarkable new unity when repainted in terms of these new assumptions.

Then came the great perception that the 90-odd kinds of chemical elements that exist on earth are not 90 different entities, but are merely differing assemblies of three basic particles, neutrons, protons, and electrons, in various numbers and patterns. Tin is tin and oxygen is oxygen, not because they were spilled out of different bags at the Creation, but because tin comes into being when electrons are sent circling around a nucleus having 50 positive charges, and oxygen when there are only eight.

Thus, through the work of a host of artistic scientists, the great explanation dawned of why there is a Periodic Table of the chemical elements, and why each atom has its individual properties. Soon it became possible even to achieve some mastery over the transmutation of atoms. As the world has learned the new model of the atom works. It is a dynamic model, and will continue to grow. From time to time new details will have to be painted in and some of the present ones will need revision. This will be because atoms will be subjected to new probings and investigations.

The aesthetic triumph of explaining all molecules as simple assemblies of atoms, and all atoms as arrangements of three basic types of particles, fills any new scientist with stirrings similar to those which overwhelm a young sculptor on first beholding the Oblation of Tolentino or Rizal's Life Over Death.

Like art, science has a periodic need to burst the bonds of the classical. To get the greatest aesthetic pleasure from contemplation of any sort of imaginative creation requires some degree of novelty. As Western architecture has moved from the romanesque to the gothic, to the baroque, to the modern; as painting has passed through its classical, romantic, impressionistic, and abstractionist periods, so has science periodically made great shifts in emphasis.

After people had become accustomed to the fact of a two-dimensional world, it was necessary to find new ways to look at things. Gesture was added to give the illusion of movement. When Leonardo da Vinci began his work, perspective in painting was new. Much later in its turn the cubist school introduced a new type of artistic perception, which instead of requiring the observer to have a roving eye which could look at things one after another, attempted to view a scene from several perspectives at once, in the hope that new aesthetic values could be captured. Each new artistic movement was built on what had been done before, and each was to some degree freed from the old limitations. So it is with the quantum theory – the theory of relativity, and the whole of modern physics. In science as in art the old is *supplemented by the new* rather than supplanted by it.

Einstein did not prove that Newton's law of gravitation was wrong. He showed rather that it was limited and consisted of a special vision, strikingly broad

in its day, but only a part of a much greater vista which Einstein perceived and flashed to a startled world. Newton was one of the giants on whose shoulders Einstein stood to discover this amazing spectacle, which to our amazement, showed time and space, and again matter and energy, as to some degree one and the same. Both men, in their discoveries, experienced emotions vaster and deeper even than those which Rizal experience when he wrote his now immortal "Mi Ultimo Adios". Columbus and Magellan take their hats off before the artist and the scientist as explorers.

The scientist is just as likely as his artist cousin to suffer from temperament, and for the same reasons. Both Newton and Einstein, in their young and more productive days, were quite as insufferable to their companions as the deaf Beethoven, found sitting at noon in a darkened room, his piano cluttered with dirty dishes, with a chamberpot beneath. Yet there he was, in the words of his biographer, "blending silence into symphonies."

The similarities between Beethoven fitting together a symphony and Einstein constructing a hypothesis are amazing. The inspiration welling from the subconscious is molded and polished, examined and adjusted, recast and refurbished, until the edifice so slowly erected bears the obvious stamp of exactness and of truth.

In the words of James B. Conant: "Scientific discovery begins, not in the findings of the laboratory, but in the glimpses of the imagination. The true scientist takes off as the true poet does, not from the notes on his desk, but from a hunch, a feel in the bones, an intimation."

The artist must always be willing to forsake the literal and photographic for the sake of deeper truth. This may be thought a basic prerogative of art, but the scientist too must choose among various levels of trueness as he decides which complexities of an experiment to ignore.

The artist must rely on many aesthetic feelings for his value judgments. His response to truth, after a certain amount of analysis, is largely instinctive and intuitive. Art is meant to be appreciated by the individual. The scientist, however, is trained to dissociate his science from his individuality. He wants to find out how the universe would behave if he and all others who probe it were removed. Even in science each thinker, no matter how great, is finally led by aesthetic considerations. After almost a score of years of argument with Bohr, Einstein said of Bohr's position: "To believe this is logically possible without contradiction, but it is so very contradictory to my scientific instinct that I cannot forego the search for a more complete conception." Though the greatest scientist of many a century is speaking, surely this is an artist talking.

Almost legendary is the now famous "conference at the summit" between Einstein and Bohr. The lesson that concerns us here, however, is not the merit of the arguments, but the fact that Einstein, led to water by logic, could not be satisfied because of the depth of his intuitional thirst.

"Art," says Andre Malraux, "is an age-old struggle to remold the scheme of things." This statement can be paraphrased to fit both science and technology, and

to differentiate them. Technology remolds the things themselves; science remolds the scheme of things.

Much aesthetic satisfaction comes to the scientist from his occasional ability to use his concepts for predicting. Darwin found, in Madagascar, a very unusual orchid, with throat so deep that it could not possibly be pollinated by any insect known. The great evolutionist promptly predicted that a capable moth would be found, for otherwise this race of orchids would long since have been lost. Sure enough, the moth eventually was discovered, its foot-long nectar-sipping tube coiled in a delicate spiral for portability.

Quoting Malraux again: "It is perhaps not a mere coincidence that of all the great masters of painting, the one who had the most far-reaching influence was the only painter for whom art was not his sole interest in life, Leonardo da Vinci." Leonardo was not a scientist, for his inventions lean more to a technology that was centuries too soon, but he had the genius of both science and technology as well as art.

In conclusion, the resemblances of science and art are far greater than their differences, and deserve more emphasis. Together they share the basic elements of beauty: reduction of chaos to order, of complexity to simplicity, and above all, of universality.