THE SCIENCES AND THE ARTS: THEIR ALLIANCE IN EDUCATION

Harold G. Cassidy
Professor in Chemistry, Yale University

Address given 9 March 1962, The Harvard Club, New York

Ladies and Gentlemen: Although there were only two occasions upon which I met Alfred Korzybski, my recollection of those occasions is vivid. Both took place at Yale University where he gave a series of lectures in 1949, and on both occasions the power of his mind illuminated the talk he gave and the discussion period which followed. I know that his teaching has been an important force in our culture, and I am honored to be invited to join you here in remembering him.

What I shall do first is to discuss the sciences and the humanities in terms of methods of communication and of points of view. I will start in a way that I have used before: I shall compare a portion of a poem with a portion of a scientific work[1]. This gives us something concrete to start with. These two fragments are meant to represent the type of communication used by humanists and by scientists. They are truly fragments, for each is torn, out of context, from a longer work. The poet whose work I have thus excerpted is Francis Thompson[2]. The scientist is Sir Isaac Newton[3]. I choose a poet and a physicist in order to draw as sharp contrasts as possible.

The Poet

. . . When to the new eyes of thee
All things by immortal power
Near or far,
Hiddenly
To each other linkèd are
That thou canst not stir a flower
Without troubling of a star . . .

The Scientist

$$F_{gravit} \propto \frac{m_1 m_2}{s^2}$$

The differences between these two fragments are marked. The one carries a statement in rich language—each word or phrase is festooned with connotations. It is quite likely that no two people would receive precisely the same message from this kind of writing. The poem, in general, must be expected to carry quite a private message from the poet to each of his readers who can hear him. There is the highest probability that each of us, from his reading of the poem, receives a picture in some way unique. The formula, on the other hand (couched in bare symbols in a kind of language which is deliberately denotative—that is, as denotative as possible) does, with very high likelihood, carry the same message to all people trained to read it. Or, more correctly, to people who are trained in physical science. In a very general way of speaking, both of these communications speak to the same philosophical idea. The poet expresses a hope, or a dream, or an insight perhaps; the scientist, a measurable fact. We could ask at this point the kind of questions which are frequently asked in this area. I would like to speak about some of these questions.

First, we might ask whether it is possible to translate between these two kinds of statements. To this question I will reply with one Yes and two No's. The Yes answer is that I am making such a translation now in showing the similarities and differences between these methods of communication and the results of using them. When I point out that the scientist uses highly abstract constructs, weaving them together in the bonds of mathematics to produce a theory which nevertheless is in direct contact with Nature through the rules of operation, and when I continue by pointing out the quantitatively deficient but qualitatively precise language of the poet by which he creates participation by his reader in his own vision or insight, then I am doing, in a sense, a translation. I am showing what each means in a common language.

I am not sure but that this is as far as one can go, and I base this statement on two considerations. The frames of reference of the two creative men are so very different that there may be very little in common through which to make a direct translation. It is certainly not so that one is a special case of the other in the sense, for example, that Galileo's frame of reference was a special case, as it later turned out, of Einstein's relativistic frame of reference. No Lorentz Transformation exists for the Sciences and the Arts. There is also another reason, I think, why this is about as far as we can go. It is that these different methods of communication reflect differences in the authors which we may call temperamental. I would like to illustrate what I mean by an example or two.

Let us take a trivial case first. A few days ago a friend, a Senior at Yale, complained about this problem. His room-mate had nicked himself with his razor, and on remarking that he was all full of cuts, my friend said, 'I know something with more cuts; a line, Dedekind cuts, an infinite number.' Well certainly, it was a horrible pun! But his room-mate blew up and called him all sorts of names for using that incomprehensible reference. Yet he had thought, he told me, that the room-mate also a Senior, might have remembered this expression from his calculus course and, he continued, the friend would have been quite pleased if on some suitable occasion he had come out with some comment as 'Do I dare to eat a peach?' because *everybody* studies T. S. Eliot. Well, this is a trivial example, but it is diagnostic, I think.

A more serious aspect of this matter can be illustrated in connection with the poet Goethe. A book by Sir Charles Sherrington, entitled GOETHE ON NATURE AND ON SCIENCE[4], was called to my attention by Professor Lounsbury. It is the heavily documented publication of a lecture which he delivered. I rely upon this as the work of an expert scientist—he was a neurophysiologist—speaking on a subject that he studied closely. As I speak on this matter I would ask you to remember the towering greatness of Goethe the poet, because what I have to say in an attempt to assess him from the point of view relevant to our discussion will show that he was no scientist. I want it to be made explicit that this is not meant as a derogation of the man. I have a feeling that one cannot be both. Interestingly enough, Goethe says more than once: 'I do not attach importance to my work as a poet, but I do claim to be alone in my time in apprehending the truth about colour.' (Sherrington, page 5)

Goethe had developed a theory of color in which he said, essentially, that Newton was quite wrong. Sherrington offers comments about this (page 8)

> Goethe held certain views as to what a scientific experiment should be, and the prism experiment did not conform with them. The prism introduced *'hunderlei'* complications, and dragged in mathematics unwantedly. They had been introduced by a mathematician (Newton—Goethe seems habitually to have thought of Newton less as a natural philosopher than as a mathematician), though they were not part of the subject. The prism was an extraneous accessory. With Goethe the prism stood for 'mathematics'. Goethe argued too that the prism implied a naive attempt to analyse not colour but light itself. 'Light', he said, 'is an elemental entity, an inscrutable attribute of creation, an *"Einziges"* which has to be taken for granted.' To try to analyse light was a shallow blunder. And the manner of the attempt! Through a tiny hole to admit a poverty-stricken thread of light into a darkened room, when by going into the open day any amount of it could be had— . . .

Goethe was an untiring observer of Nature. He had a tremendous curiosity. Yet it is a fact that all of the scientific ideas that he developed have failed to stand the test of time. I think that it is germane to our discussion to inquire how this could be. Perhaps the answer, if there is one, might help us in our present problems. I might add, parenthetically, that it is good to choose to compare and talk about such men as Newton and Goethe—their work is in the past, and we can look at it with some perspective. If I tried to deal with contemporary instances I fear it would be much more difficult.

One possible clue is given by Sherrington. He says (pages 29-30):

> Were it not for Goethe's poetry, surely it is true to say we should no longer trouble about his science. Such as it was, it is as science not important. Its importance lies in the light it throws on Goethe the poet, and on his conception of Nature. It documents him a poet-pantheist. He thought about Nature over and over. He abounded in originality. His enthusiasm as an observer of Nature was great. But a new fact he met with was apt to send him on a flight of imagination into the unknown. Creative genius in literature, in science his genius longed to create. It could not always abide the waiting for further experiments and more knowledge. Science has to follow experiment where possible, even where the imagined seems extremely probable. Goethe, though devoted to science, had not at root the scientific temperament. He had not, for instance, along with the urge to discovery the sublime detachment of the scientific thinkers.

My wife has suggested that there might be in Goethe's work a suggestion of the following kind. It is quite clear that the scientific approach to the world is based on the belief that order can be found among all the diverse appearances of the world. If in the surge of creative insight a person develops an ordered structure of thoughts and ideas, what is more natural than to conclude that because it is ordered it is also scientific. This is far from a necessary conclusion, as we know, because many formal systems can be developed that are far from meeting the correlates in reality, and also many very internally consistent ideological systems have been built up which do not fit Nature very well. I think we can throw considerable light on this whole issue by considering certain aspects of the activity of all workers in the fields of the humanities and the sciences.

II

In general we see three activities being practiced side by side, but with different emphases depending both on the person who practices them and on the state of his work. These are the analytical, the synthetic, and the activity which tests out or reduces to practice. I have discussed these activities at some length elsewhere[1], but we need to recall them here for the sake of the issue. The analytical activity is that of collecting data, information, bringing together samples, describing, and so forth. It is an exceedingly important activity and can be extremely detached, in the sense that it merely reports or collects what is observed. However, as soon as someone collects a certain amount of material, whether the material be written or in the form of objects, one begins to see relationships. Relationships of likeness allow one to gather together these things into categories. Relations of unlikeness help one to discriminate and contrast these categories. In this process, already, one has departed from the analytical in the direction of the synthetic. The synthetic activity is that in which laws are formulated, hypotheses are devised, theories are generated. This is an activity which brings together relationships at higher levels of abstraction. Yet it is important to note that in this synthetic activity one can go wrong in many ways. One can also go wrong in his analytical activities in the sense that some defect of a physical nature, perhaps, can cause him to make erroneous observations. For example, color-blind people will observe differently from those with normal sight; people who cannot hear well may miss important sounds; people who lack a sense of smell for particular odors would certainly not recognize their presence. At the synthetic levels conceptual blindness may occur and, in fact, would be very difficult to detect even by the most conscientious person. It is therefore necessary to test the results of one's synthetic activities—the generalizations—by reducing them to practice and applying them to concrete cases. The way Nature behaves is our ultimate test, and if the synthetic activities yield results which predict the way Nature will behave then we feel somewhat confident in them.

Now I have said that all of these activities are carried out by humanists and scientists. A critic of Art may gather together in one way or another many examples of the period that he is studying in an analytical activity. Examining these he arrives, by some intuitive process, at a generalization which he might call the theory of the art of that period. He must now attempt to apply this to other instances to see whether his generalization will hold. Similarly, the scientist must test out his generalizations by reducing them to practice. I might add that in the theoretical disciplines, that is to say in the humanities and the sciences, the first two kinds of activity are more emphasized as objectives than the last. The last one, however, must not be neglected. Reduction to practice is chiefly emphasized in the technological disciplines of all kinds. These are the counterparts of theoretical disciplines or, one might say, of clusters of theoretical disciplines. For example, law is the technological aspect of jurisprudence; medicine, of the host of biological sciences as well as a number of humanities; religious practice, the technological aspect of theology. Every humanistic or scientific discipline has its technology.

Now we can return to an examination of Goethe's science. We are looking, still, at the possibility of translation. Sherrington says (page 15):

> In following Goethe's 'science' we are helped by his having laid down principles which in his view should govern scientific observation. One of them is that the conditions for observation be kept as simple as possible, and for that reason should eschew apparatus. Prominent in his objection to the prism experiment was that the prism introduced heaven-knows-what complications. Essential for scientific observation was *Anschaulichkeit* 'obviousness' or 'naked clarity.' This clarity could dispense with mathematics. Goethe was not himself equipped in mathematics, and he regarded the role of mathematics in science with distrust. Mathematics led to the introduction of propositions which were not truly contained in the original proposition. They had brought calamity to optics. He did not see that a use of apparatus is to simplify conditions. Nor again, that mathematics can be a main means toward obtaining *Anschaulichkeit*.

One sees here almost an intentional limiting of observation to the purely analytical level. But it is not thoroughgoing, perhaps, since it avoids the use of apparatus. Certainly, however, it seems as though the synthetic side, in spite of the development of 'theories' was definitely slighted. This could partly be accounted for by Goethe's distrust of that greatest of synthetic tools—mathematics. Finally, it would appear that Goethe never repeated any of Newton's experiments which he criticized so strongly. In this way there never was the test of reduction to practice which we see as a requirement on any kind of intellectual work of this type.

One of Goethe's theories which he held in very great esteem was that Nature kept in mind in the development of a plant an 'ideal' leaf (Sherrington, page 22):

> Concrete leaves, in all their vast variety, were variants of an ideal leaf. His fancy pictured an 'ideal' plant, and Nature calling forth from the stem of it a manifold of side-growths, of leaves, petals, sepals, stamens, each and all of them just modifications of the ideal leaf. The very wrappings of the seed, the shell of the nut, the flesh of the apple, were all modifications of the leaf . . . Goethe was so pleased with this conception that he presented it at one time to the philosopher Schiller. After hearing him out Schiller said: 'That is not a fact: it is an idea.'

I think this gives us the final clue to the distinction we are trying to make. Ideas are not necessarily facts. For the scientist, a fact must be validated by its connection to as many other facts as possible, and by its acceptance through their own observations by other scientists. An idea, on the other hand, may have intrinsic properties quite unrelated to fact, or even to any reality which could be called public. Nevertheless, it may be a fitting subject for investigation in the humanities.

III

I have sometimes wondered whether the *occupation* of scientist and the *occupation* of humanist, when practiced at the highest level possible, are not mutually exclusive. This might possibly be argued. Certainly, Goethe, the immortal poet, was no scientist.

I think it could properly be said without much fear of contradiction that when the humanist attempts to imitate a scientist two possibilities exist. Either he does a very thorough and good job of the matter and becomes a scientist, or he fails, and in the process loses his integrity as a humanist. I rather suspect we have seen a good deal of this in the last fifty years. At the same time if a scientist attempts to become a humanist he runs analogous dangers. For as he moves away from the attempt to be objective in denotative terms he may still remain objective but not understood, except in some private language of the receiver himself. He would then no longer be speaking in scientific terms.

Now let us look again at the language that is used by poet and scientist. It is plain to be seen that they differ. And the difference goes very deep—deep down to the level of understanding.

When I first developed this contrast between a portion of a poem and a portion of a scientific work, I presented it to a group of teachers at Yale. One of the men present objected. He said that I had 'stacked the cards' because 'the poem could be understood by anyone,' and the formula by 'hardly anybody.' Now I was prepared to accept the latter statement. He certainly did not seem to object to the poem, although he suggested that a poem with more hidden imagery might be preferable as a contrast to the formula. So I attempted to explicate the formula for him by comparing the two masses m_1 and m_2 with his and his neighbor's masses, the distance between him and his neighbor and, although the formula does not hold in this simple form when objects are so irregular as human beings (that is, not spherical) and so close together, I pointed out that with the proper formula it would be quite possible to calculate the gravitational force between him and the neighbor. I was somewhat carried away by this statement, and pointed out to the group that each person in the room was connected to every other person by a gravitational attraction which manifested itself in a minute (but nonetheless, in principle, measureable) force. It appeared that this fact was new to the majority of people present: that all of us in that room were connected in a web or nexus of gravitational forces. The man I was indirectly answering looked at me and, with an expression of distaste on his face, said: 'I find that a most repulsive notion.' Or words to that effect. It seemed to me, therefore, that he had not understood Francis Thompson's poem for this was essentially what the poem was saying. 'All things . . . Near or far . . . To each other linkèd are.' He apparently did not object to the statement by the poet, but when the matter was put the other way, it was brought home to him in a manner which he found repulsive. Could it be that it was only made quite clear? Or was some more subtle factor involved?

Let us look at another contrastive pair of statements, reversing the dates of the two: a contemporary physicist, Einstein; a poet of the time of Newton, William Blake. Again, both statements are taken out of context, both speak to great and enduring themes:

The Poet	*The Physicist*
What immortal hand or eye Could frame thy fearful symmetry?	$E = mc^2$

We do not need to repeat all we have said. Here again we see the essentially private message in one, the public statement of the other.

Now one of the reasons that the public statement *is* public, is that it is couched in mathematical symbols, and that it can be manipulated by the rules of algebra and calculus. Here we come upon a possible important source of difficulty. There is a body of opinion that sees the mathematical aspect of science as a stumbling block to the non-scientist. I would like to consider this opinion for a few minutes.

IV

You will remember that Goethe was not equipped in mathematics, and regarded with distrust its role in science. We find some of this same distrust prevalent now-a-days, though it is being replaced, I think, by an equally dangerous view in which the mathematician is regarded as a sort of wizard. Sir Charles P. Snow has spoken his opinion that a kind of mathematical blindness exists in some people. I am inclined rather to look upon it not as blindness, but as a state of being maimed by some childhood accident—yet perhaps capable of remedy through occupational therapy. Support for this view comes from the response I get when I ask an audience some of whom are not scientists, whether they were bitten by a mathematics teacher in high school—or a chemistry or physics teacher.

At the same time I have enquired of psychologists and others who might know, whether there is really a measurable difference that would classify people into two exclusive classes: those who can and those who can't. None of them will give me a categorical answer. Therefore I tend to trust what they do seem to say—that as usual with human beings, we are dealing with a distribution. Most of us are in the middle of this distribution range, a few are at the extremes. At one extreme might be Snow's blindman; at the other the mathematical genius.

But we are mostly concerned, here, with the large number of people in between. And perhaps we can help them. It has seemed to me that we can help them by means of geometry. Many people who are allergic to algebra find geometry quite acceptable—is this a reflection of the difference in ease of comprehension between discursive and presentational symbolism for these people? At any rate, a good deal of quite basic science can be handled in terms of vectors, and made quite clear to a person who has forgotten his trigonometry and algebra, so that he may suddenly realize that he knows enough to go back and recapture these tools. Even relativity can be explained in geometric terms by using the Minkowski ideas. Statistical mechanics can be introduced by the use of diagrams of marbles in boxes, and here simple counting can give sufficient information on which to understand the meaning of the Second Law of Thermodynamics. The fact is that one *can* get along quite tolerably without calculus. Our data in science often comes to us through discrete observations which are later connected up into a continuous record. Such discontinuous observations can be made to approach the continuous by making the discontinuities smaller and smaller. I have in this way quite often succeeded in teaching some calculus to a group of students who later were genuinely surprised to learn that they had overcome this 'bugbear' and even felt no pain.

I suggest, therefore, that it is quite possible to meet every objection that I have heard raised about teaching science to humanities students. There are, at the same time, some serious warnings that I must give. Science survey courses, in which a student learns to write the structures of all the vitamins, never having had a course in organic chemistry or biochemistry; or courses in which the student approaches science in the third hand way that comes from studying what someone thought someone else thought about what a scientist did, may be interesting, but are not in my opinion satisfactory. This is why I distrust case-history approaches. Further, the student should be confronted with contemporary science, and it should be taught through good demonstrations. Ideally, the humanities student should have laboratory experience, I think, but practically, this is not possible. Most laboratory work of this kind turns out to be manual training—because there is too little time to teach it or because the student is inept with his hands—or it turns out to be *demonstration,* rote rehearsal of recipes, masquerading under the name of experiment. I think under these conditions a good demonstration done by the teacher, with suitable audiovisual aids, and with proper explanations and introductions, is the best approach. It would, however, be most healthy to give the student some personal feeling for the intransigence of inanimate matter.

I have digressed in this way in order to show how some of the thoughts I have brought you might be reduced to practice. I have not described several of the bridges that can be built between the sciences and the arts because it would take more time than we have—and because I have already dealt with them in my book[1]. I would like, now, to conclude.

V

What do we learn from this discussion? I think it is that the humanities and the sciences bear striking similarities in terms of the activities of analysis, synthesis, reduction to practice. In each case analytical results bear a minimum of meaning. Synthetic results are important carriers of meaning and the meaning that they carry becomes manifest and embodied when reduction to practice is carried out. I think we learn that in judging the quality of the activities of scientist or humanist it is evident that only when all three activities are conjoined does the resulting work have the greatest stature. It seems to me that the solution for our problem of the relation between sciences and humanities—really I mean the relations between scientists and humanists—is for each to understand these areas of functional similarity while appreciating the differences. It is not impossible for the humanist to be an amateur in some scientific area, nor for the scientist to be an amateur in some humanistic enterprise. The expert in one area can always recognize expertness in another, and give honor to it. As far as I can see, it is not a matter of competition. The world is so full of diversity that it requires the utmost effort in many different areas to comprehend even a small part of it. We group these efforts into categories that we call the sciences and the humanities or the arts. These are the results of efforts made by human beings to apply reason and feeling to the solution of their problems and inner urges. I think we should insist on the dominant place of reason in these matters since it links scientists with humanists. It is one of the links in the chain that has lifted human beings above their animal origins. To be reasonable, it seems to me—as reasonable as one can be—is the responsibility one takes on in being a human being. In this connection I remember some wise words by Lewis Mumford Jones. He said in effect that irrationality is discovered by the rational being, and not the other way around. I think we have here one of the directional arrows that are found in this world. I believe that the still, small voice is yet rational.

REFERENCES

1. Harold G. Cassidy, THE SCIENCES AND THE ARTS: A NEW ALLIANCE. New York: Harper & Brothers, 1962.
2. Francis Thompson, 'The Mistress of Vision,' COMPLETE POETICAL WORKS OF FRANCIS THOMPSON, The Modern Library, p. 184.
3. For an elementary exposition, see Gerald Holton, INTRODUCTION TO CONCEPTS AND THEORIES IN PHYSICAL SCIENCE. Cambridge: Addison-Wesley Press, 1952.
4. Sir Charles Sherrington, GOETHE ON NATURE AND ON SCIENCE. Cambridge University Press, 1942; 2nd ed., 1949. The quotations are given with the permission of the Press.

HAROLD G. CASSIDY, born in Havana, Cuba, October 1906, received his BA (1930) and MA (1932) from Oberlin College. After teaching chemistry at Oberlin and doing chemical research for the Merrell Company of Cincinnati, Ohio, he went to Yale for the PhD (chemistry, 1938). He remained there, rising to full professorial rank in 1958.

Professor Cassidy is equally well known for his work in the field of chemically reactive polymers and for his studies relating the sciences and the humanities in modern higher education. During World War II he was with the Office of Scientific Research and Development and worked on the Manhattan Project and a project of the OEM (Office of Emergency Management). He is academic representative-at-large of the Gordon Conferences of the American Association for the Advancement of Science, a Fellow of the AAAS and the New York Academy of Sciences, associate editor of the American Journal of Science (1948--), and a member of various chemical societies. At Yale he has served on numerous university committees, including the Course of Study Committee and the Yale College Executive Committee. He has published six books and some seventy articles in scientific and scholarly publications. The most recent book, entitled The Sciences and The Arts: A New Alliance, was published by Harper and Row just before he gave the Alfred Korzybski Memorial Lecture.