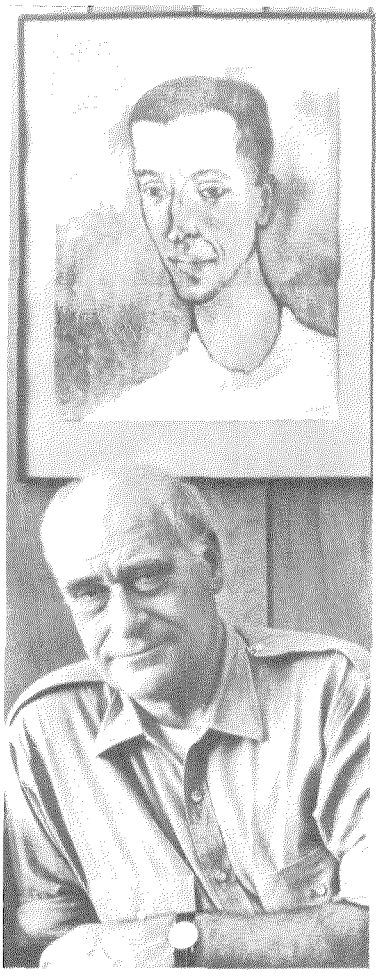
Meaning in Art and Science

by Gunther S. Stent



Gunther Stent with a portrait of Max Delbrück painted in 1947 at Cold Spring Harbor by biochemist Efraim Racker.

IN THE FALL OF 1974, in the first issue of the new journal *Critical Inquiry*, there appeared a 50-page essay on the relationship of art and science by the University of Chicago musicologist Leonard B. Meyer. Meyer begins his essay by pointing out that for the past few decades that relationship has been the subject of confusing debate. Much of that confusion Meyer attributes to doubtful analogies made by such people as "Gunther S. Stent, a molecular biologist [who recently] considered some of these matters . . . [and whose] discussion is representative of a viewpoint not infrequently espoused by scientists, and occasionally by artists and laymen as well. . . . Like a number of other writers, Stent contends that in essential ways science and art are comparable." Although Meyer expresses his sympathy for attempts to bring the so-called Two Cultures together, he doubts that their viable union can be achieved by ignoring or glossing over important differences. He says that he will argue "that Stent's union is a shotgun marriage, not one made in heaven, and that his attempt to wed different disciplinary species results not in fecund but barren misconceptions." What then is at the root of Stent's misguided attempt? It is, says Meyer, that "like many scientists (as well as a goodly number of artists and laymen), Stent fails even to recognize the existence of the humanist — that is, the theorist and critic of the arts." Meyer thus believes that a shotgun marriage between the Two Cultures is bound to fail because artist and scientist can only cohabit in a *ménage-à-trois*, with a humanist taken in as a housemate.

I felt honored that a brief popular article on art and science which I had published two years earlier in *Scientific American* (December 1972) had become the subject of a lengthy scholarly essay by a leading theorist of the arts. But I was taken aback by Meyer's critique, because I had believed all the while that in my article I presented merely a watered-down version of what I thought were Meyer's very own views; his book *Music, the Arts and Ideas* had actually been the main source of my ideas about the nature of art in the first place. I responded with a brief, aggressive rejection of Meyer's critique, and my response was, in turn, followed by a conciliatory rejoinder by Meyer and a final comment by the editor of *Critical Inquiry* expressing general agreement with both of us.

In the intervening years I have wondered why these debates about the relation of art and science are so confusing, why it seems self-evident that art and science are essentially similar and yet essentially different. Finally I came to realize that at the root of the difficulty is the unsolved, and possibly insoluble, deep problem of semantics, namely to say what it is that we are saying about a structure when we say that it has "meaning."

My article was inspired by my reading (and preparing a review) of the many reviews of James D. Watson's autobiography, *The Double Helix* (1968). Probably more than any other book, Watson's personal account of his and Francis Crick's discovery of the structure of DNA contributed to the latter-day demise of the traditional view that science is an autonomous exercise of pure reason carried out by disembodied, selfless spirits inexorably moving toward an objective knowledge of nature. The reviews of *The Double Helix*, almost all of them written by scientists, turned out to provide (mainly unwittingly) as much insight into the sociology of science and the moral psychology of contemporary scientists as does the book itself. Sir Peter Medawar was one of the few initial reviewers who recognized the considerable literary merits of Watson's book. He predicted that it would become a classic, not only in that it

will go on being read, but also in that it presents an object lesson on the nature of the creative process in science.

But the biochemist Erwin Chargaff, who himself has an important role in Watson's story, found as little merit in Watson's literary attainments as he had in Watson and Crick's discovery of the DNA structure in the first place. Not only did Chargaff not care for Watson's book, but he declared that scientific autobiography is a most awkward literary genre. The reason for this awkwardness is, according to Chargaff, that scientists "lead monotonous and uneventful lives. . . ." But why *are* the lives of scientists so monotonous and uneventful, in contrast to the exciting lives of, say, artists, who make much less trite biographical subjects? Because, according to Chargaff, there is a profound difference in the uniqueness of the creations of artists and scientists: "*Timon of Athens* could not have been written, *Les Demoiselles d'Avignon* could not have been painted, had Shakespeare and Picasso not existed. But of how many scientific achievements can this be claimed? One could almost say that, with very few exceptions, it is not the men that make science, it is science that makes the men. What A does today, B and C and D could surely do tomorrow."

Picasso's Les Demoiselles d'Avignon *(1907). (The Museum of Modern Art, New York; acquired through the Lillie P. Bliss Bequest).*

On reading this passage, I was surprised to find Chargaff embracing the "great man" view for the history of art, that is to say, regarding the development of art as wholly contingent on the appearance of a particular succession of unique geniuses, while at the same time viewing the development of science from the Hegelian or Marxist perspective of historical determinism, which sees history as shaped by immutable forces rather than by contingent human agency. Since I found it hard to believe that Chargaff would really hold such incoherent ideas, I suspected at first that he had made his point about the irreplaceability of Shakespeare and the replaceability of Dr. A only to downgrade the importance of Watson and Crick's discovery. But I soon discovered that my suspicion was quite mistaken. In the following months I asked many scientific friends and colleagues whether they too think that the achievements of art are unique whereas the achievements of science are inevitable, and hence commonplace. To my surprise, I found that most of my respondents agreed with Chargaff in believing that we would not have had *Timon of Athens* if Shakespeare had not existed, but if Watson and Crick had not existed, we would have had the DNA double helix anyway. Therefore, the deficiencies of the proposition of differential uniqueness of the creations of art and science do not seem to be as self-evident as I had thought at first. Accordingly, I wrote my little article to show why this proposition has little philosophical or historical merit.

Here we reach my first, albeit just sociological, disagreement with Meyer, because he claims that my view is not infrequently espoused by scientists. But since in his critique Meyer restates Chargaff's proposition as a self-evident truth, it would be *his* view, and not mine, which according to my experience is not infrequently espoused by scientists. Certainly all the scientists quoted by Meyer turn out to share his view, except for C. P. Snow and Thomas Kuhn as whose accomplice he regards me in the shotgun-marriage plot.

In order to examine the proposition of differential uniqueness of creation, I provided an explicit statement of what I understood to be the meaning of the terms "art" and "science." Both art and science, I wrote, are activities that endeavor to discover and communicate truths about the world, about the reality in which we live our lives. Thus art and science share the central features of

discovery and communication, and hence both involve the search for novelty and the encoding into a semantic medium the meaning of what has been discovered. Where art and science differ fundamentally is in the domain of reality to which the semantic contents of their works mainly pertain. The domain addressed by the artist is the inner, subjective reality of the emotions. Artistic communications therefore pertain mainly to relations between private phenomena of affective significance. The domain of the scientist, by contrast, is the outer, objective reality of physical phenomena. Scientific communications therefore pertain mainly to relations between public events.

This dichotomy of domains does not mean, however, that a work of art is wholly devoid of all outer meaning. For instance, a Canaletto painting communicates something about the public phenomenon that was Venice of the *settecento*. Nor does it mean that a work of science is wholly devoid of all inner meaning. For instance, Freud's *The Interpretation of Dreams* is addresssed mainly to the private phenomena of the subconscious. Hence, despite this fundamental difference in their principal foci of interest, art and science actually form some kind of thematic continuum, and there seems to be little point in trying to draw a sharp line of demarcation between them. In any case, the transmission of information and the perception of meaning in that information constitutes the central content of both the arts and sciences. In other words, works of art and works of science are not merely there. They have a semantic content; they are meant to mean something. A creative act on the part of either an artist or a scientist would then be his formulation of a novel, meaningful communication about reality. Meyer refers to this understanding of the meaning of "art" and "science," of which as we shall see, he disapproves, as "Stent's definition." I was greatly surprised to find myself as the eponym of a mere paraphrase of explications that I had gleaned from the standard writings on this subject, above all from those of Susanne Langer and Meyer himself.

So I was now ready to ask whether it is reasonable to claim that only Shakespeare could have formulated the semantic structures represented by *Timon*, whereas people other than Watson and Crick might have made the communication represented by their paper, "A Structure for Deoxyribonucleic Acid," published in *Nature* in April 1953. Here it is at once evident that the exact word sequence of Watson and Crick's paper would not have been written if the authors had not existed, no more than the exact word sequence of *Timon* would have been written without Shakespeare, at least not until the fabulous monkey typists complete their random work at the British Museum. Thus paper and play are both historically unique semantic structures. But in assessing the creative uniqueness of a linguistic structure we are not concerned with its exact word sequence; we are concerned with the uniqueness of its semantic content. And so I readily admitted that it was very likely that meanwhile, even without Watson and Crick, other people would have communicated a satisfactory molecular structure for DNA. Hence the semantic content of their paper would not be unique.

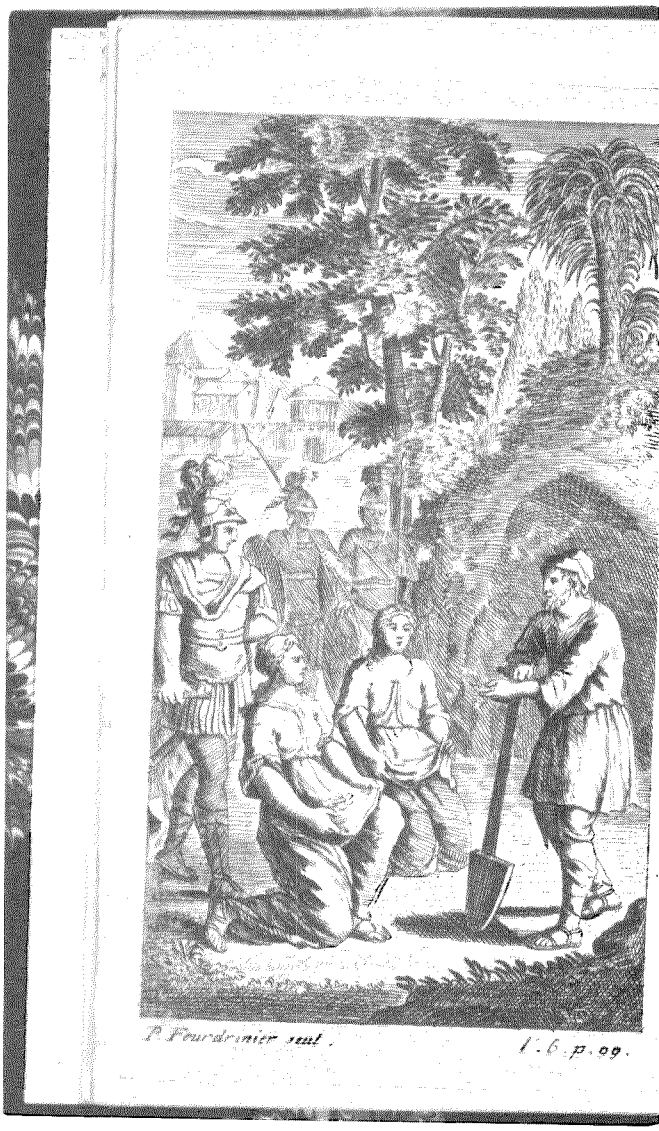
As for the semantic content of Shakespeare's play, however, I pointed out that the story of the trials and tribulations of its main character, Timon, not only *might* have been written without Shakespeare but in fact *was* written without him. Shakespeare merely reworked the story of Timon he had read in William Painter's collection of classic tales, *The Palace of Pleasure*, published 40 years earlier, and Painter in turn had used as his sources Plutarch and Lucian. But then the creative aspect of the play is not Timon's story; what counts is the novelty of the deep insights into human feelings that Shakespeare communicates in his play. He shows us here how a man may make his response to the injuries of life, how he may turn from lighthearted benevolence to passionate hatred toward his fellow men. Can we be sure that *Timon* is unique as regards the play's semantic essence? No, because who is to say that had Shakespeare not existed, no other dramatist would have communicated very similar insights? Another dramatist would surely have used an entirely different story to treat the same theme (as Shakespeare himself did in his much more successful *King Lear*), and he might have succeeded in pulling it off.

Hence we are finally reduced to asserting that *Timon* is uniquely Shakespeare's because no other dramatist, although he might have communicated to us more or less the same insights, would have done it in quite the same exquisite way as the Great Bard. But here we must not shortchange Watson and Crick by taking for granted that Drs. B, C, and D who

eventually would have found the structure of DNA would have found it in just the same way and would have published a paper that produced the same revolutionary effect on contemporary biology. On the basis of my personal acquaintance with the people engaged in trying to uncover the structure of DNA in the early 1950s, I expressed my belief that if Watson and Crick had not existed, the insights they provided in one single package would have come out much more gradually over a period of many months or years. Indeed, as Sir Peter Medawar found in his review of *The Double Helix*, the great thing about Watson and Crick's discovery was "its completeness, its air of finality." Medawar thought that "if Watson and Crick had been seen groping toward an answer, . . . if the solution had come out piecemeal instead of in a blaze of understanding, then it would still have been a great episode in biological history." But it would not have been the dazzling achievement that it, in fact, was.

Why, then, is it that so many scientists seem to believe in both the uniqueness of artistic creation as well as in the commonplace, inevitable nature of scientific discoveries? One reason I put forward was that most scientists simply are not familiar with the working methods of artists. They tend to picture the artist's act of creation in the terms of Hollywood: Cornell Wilde, in the role of the one and only Frederic Chopin, is gazing fondly at Merle Oberon, as his muse and mistress George Sand, while he is sitting down at the Pleyel pianoforte and, one-two-three, he composes his Preludes. As scientists know full well, science is done differently: Dozens of stereotyped and ambitious researchers are slaving away in as many identical laboratories, all trying to make similar discoveries, some of them succeeding and some not. They know that the vast bulk of by no means negligible research papers are published by the unknown yeomanry of science, and not by its immortal geniuses.

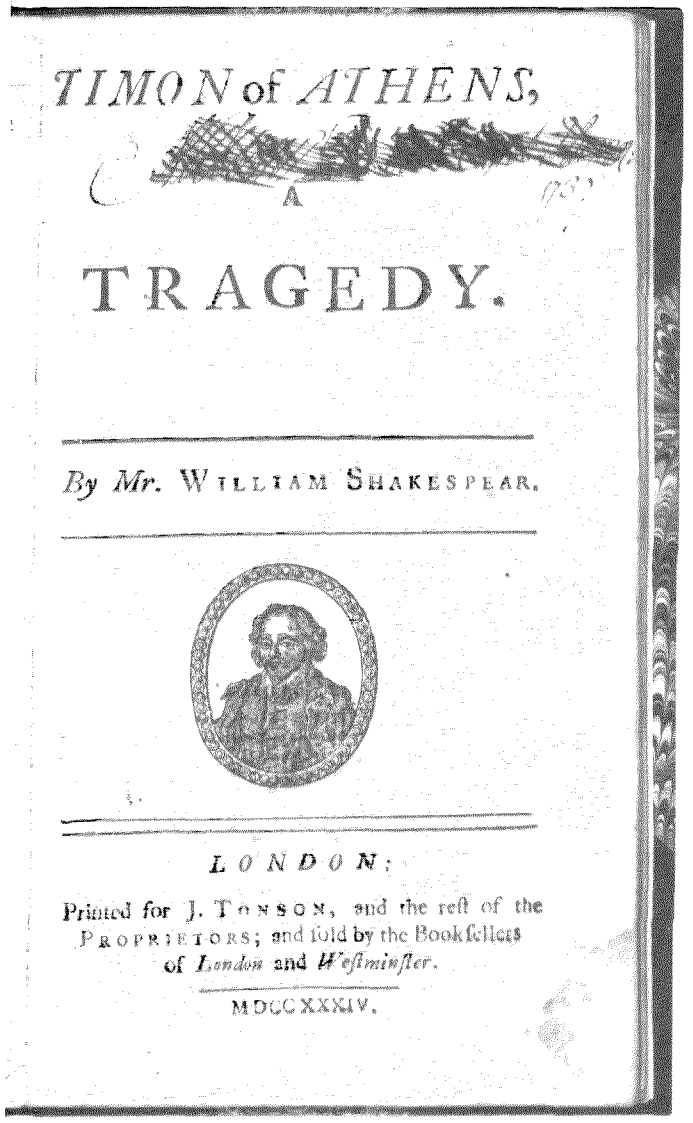
Artists, we might note, tend to conceive of the scientific act of creation in equally unrealistic terms: Paul Muni, in the role of the one and only Louis Pasteur, is burning the midnight oil in his laboratory. He has the inspiration to take some bottles from the shelf, he mixes their contents and, Eureka, he has discovered the vaccine for rabies. Artists, in turn, know that art is done quite differently: Dozens of stereotyped and ambitious writers, painters, and composers are slaving



Title page and frontispiece of a 1734 edition.

away in as many identical garrets, all trying to produce similar works, all using more or less the same knowledge and techniques, some succeeding and some not. They know that the vast bulk of by no means negligible books, pictures, and tunes are produced by the unknown yeomanry of art, usually for mundane purposes, and not by its immortal geniuses.

A more serious obstacle is the apparently widespread confusion between works on the one hand and their contents on the other. A play or painting is a work of art, whereas a scientific theory or discovery is not a *work* of science but the *content* of a work such as a book, paper, letter, lecture, or conversation. Thus, as formulated, Chargaff's proposition of differential uniqueness is not even false; it is nonsensical, because it compares a *work* of art (*Timon*) with the *content* of a work of science (the DNA double helix).



TIMON of ATHENS,

A

TRAGEDY.

By Mr. WILLIAM SHAKESPEAR.

LONDON:

Printed for J. TONSON, and the reſt of the PROPRIETORS; and ſold by the Bookſellers of *London* and *Weſtminſter*.

MDCCXXXIV.

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Not only Chargaff but even Meyer, a theorist of the arts, seems unable to keep in mind the difference between works and their contents. For he is going to "cut through [Stent's] Gordian argument with a sharp but simple distinction: Namely there is a profound and basic difference between scientific theories, which are *propositional,* and works of art, which are *presentational*" (emphasis in original). Meyer's antinomy is patently false, because *all* works, of science as well as of art, indeed all semantic structures, are "presentational" (in Meyer's sense being a concrete pattern that can be occasion for experiences that are found to be enjoyable, intriguing and moving). By contrast, the quality of being "propositional" (in the logico-philosophical sense of being a statement that affirms or denies something, so that it can be characterized as true or false) pertains not to works but to their contents. And here it is the case that not every "presentational" structure necessarily has a propositional content. For instance, Meyer rightly points out that a natural phenomenon, such as a sunset or Mount Everest, is a presentational structure without propositional content. One of our principal agenda items will, therefore, have to be the question of whether the contents of works of art do or do not resemble the contents of works of science in being propositional. We will return to this central question later.

A second reason I advanced for the belief in the inevitability of scientific discoveries is the support which that belief appears to derive from the often-told tales of famous cases in the history of science where the same discovery was made independently two or more times by different people — for instance, the independent invention of the calculus by Leibniz and Newton, or the independent recognition of the role of natural selection in evolution by Wallace and Darwin. As the study of such "multiple discoveries" by Robert Merton has shown, however, on detailed examination they are rarely, if ever, identical. The reason they are said to be multiple is simply that in spite of their differences one can recognize a semantic overlap between them that is transformable into a congruent set of propositions.

As a third reason, I proposed that whereas the cumulative character of science is at once apparent to every scientist, the similarly cumulative character of art is not. For instance, it is obvious that no present-day working geneticist has any need to read the original papers of Mendel, because they have been completely superseded by the publications of the past century. Mendel's papers contain no useful information that cannot be better obtained from any modern textbook or the current literature. In contrast, the modern writer, composer, or painter still needs to read, listen, or look at the original works of Shakespeare, Bach, or Picasso, which, so it is thought, have not been superseded at all. In spite of the seeming truth of this proposition, it must be said that art is no less cumulative than science, in that artists no more work in a traditionless vacuum than do scientists. Artists also build on the work of their predecessors; they start with and later improve on the styles and insights that have been handed down to them from their teachers, just as do scientists. To stay with our main example, Shakespeare's *Timon* has its roots in the

equipment, and to Dr. G. E. R. Deacon and the captain and officers of R.R.S. *Discovery II* for their part in making the observations.

[1] Young, F. B., Gerrard, H., and Jevons, W., *Phil. Mag.*, **40**, 149 (1920).

[2] Longuet-Higgins, M. S., *Mon. Not. Roy. Astro. Soc., Geophys. Suppl.*, **5**, 285 (1949).

[3] Von Arx, W. S., Woods Hole Papers in Phys. Oceanog. Meteor., **11** (3) (1950).

[4] Ekman, V. W., *Arkiv. Mat. Astron. Fysik. (Stockholm)*, **2** (11) (1905).

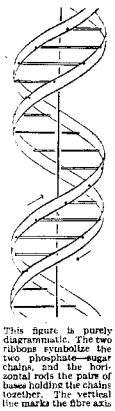
MOLECULAR STRUCTURE OF NUCLEIC ACIDS

A Structure for Deoxyribose Nucleic Acid

WE wish to suggest a structure for the salt of deoxyribose nucleic acid (D.N.A.). This structure has novel features which are of considerable biological interest.

A structure for nucleic acid has already been proposed by Pauling and Corey[1]. They kindly made their manuscript available to us in advance of publication. Their model consists of three intertwined chains, with the phosphates near the fibre axis, and the bases on the outside. In our opinion, this structure is unsatisfactory for two reasons: (1) We believe that the material which gives the X-ray diagrams is the salt, not the free acid. Without the acidic hydrogen atoms it is not clear what forces would hold the structure together, especially as the negatively charged phosphates near the axis will repel each other. (2) Some of the van der Waals distances appear to be too small.

Another three-chain structure has also been suggested by Fraser (in the press). In his model the phosphates are on the outside and the bases on the inside, linked together by hydrogen bonds. This structure as described is rather ill-defined, and for this reason we shall not comment on it.



This figure is purely diagrammatic. The two ribbons symbolize the two phosphate–sugar chains, and the horizontal rods the pairs of bases holding the chains together. The vertical line marks the fibre axis

We wish to put forward a radically different structure for the salt of deoxyribose nucleic acid. This structure has two helical chains each coiled round the same axis (see diagram). We have made the usual chemical assumptions, namely, that each chain consists of phosphate diester groups joining β-D-deoxyribofuranose residues with 3′,5′ linkages. The two chains (but not their bases) are related by a dyad perpendicular to the fibre axis. Both chains follow right-handed helices, but owing to the dyad the sequences of the atoms in the two chains run in opposite directions. Each chain loosely resembles Furberg's[2] model No. 1; that is, the bases are on the inside of the helix and the phosphates on the outside. The configuration of the sugar and the atoms near it is close to Furberg's 'standard configuration', the sugar being roughly perpendicular to the attached base. There is a residue on each chain every 3·4 A. in the z-direction. We have assumed an angle of 36° between adjacent residues in the same chain, so that the structure repeats after 10 residues on each chain, that is, after 34 A. The distance of a phosphorus atom from the fibre axis is 10 A. As the phosphates are on the outside, cations have easy access to them.

The structure is an open one, and its water content is rather high. At lower water contents we would expect the bases to tilt so that the structure could become more compact.

The novel feature of the structure is the manner in which the two chains are held together by the purine and pyrimidine bases. The planes of the bases are perpendicular to the fibre axis. They are joined together in pairs, a single base from one chain being hydrogen-bonded to a single base from the other chain, so that the two lie side by side with identical z-co-ordinates. One of the pair must be a purine and the other a pyrimidine for bonding to occur. The hydrogen bonds are made as follows: purine position 1 to pyrimidine position 1; purine position 6 to pyrimidine position 6.

If it is assumed that the bases only occur in the structure in the most plausible tautomeric forms (that is, with the keto rather than the enol configurations) it is found that only specific pairs of bases can bond together. These pairs are: adenine (purine) with thymine (pyrimidine), and guanine (purine) with cytosine (pyrimidine).

In other words, if an adenine forms one member of a pair, on either chain, then on these assumptions the other member must be thymine; similarly for guanine and cytosine. The sequence of bases on a single chain does not appear to be restricted in any way. However, if only specific pairs of bases can be formed, it follows that if the sequence of bases on one chain is given, then the sequence on the other chain is automatically determined.

It has been found experimentally[3,4] that the ratio of the amounts of adenine to thymine, and the ratio of guanine to cytosine, are always very close to unity for deoxyribose nucleic acid.

It is probably impossible to build this structure with a ribose sugar in place of the deoxyribose, as the extra oxygen atom would make too close a van der Waals contact.

The previously published X-ray data[5,6] on deoxyribose nucleic acid are insufficient for a rigorous test of our structure. So far as we can tell, it is roughly compatible with the experimental data, but it must be regarded as unproved until it has been checked against more exact results. Some of these are given in the following communications. We were not aware of the details of the results presented there when we devised our structure, which rests mainly though not entirely on published experimental data and stereochemical arguments.

It has not escaped our notice that the specific pairing we have postulated immediately suggests a possible copying mechanism for the genetic material.

Full details of the structure, including the conditions assumed in building it, together with a set of co-ordinates for the atoms, will be published elsewhere.

We are much indebted to Dr. Jerry Donohue for constant advice and criticism, especially on interatomic distances. We have also been stimulated by a knowledge of the general nature of the unpublished experimental results and ideas of Dr. M. H. F. Wilkins, Dr. R. E. Franklin and their co-workers at

Watson and Crick's famous publication of the discovery of the DNA double helix. Reprinted with permission from Nature.

works of Aeschylus, Sophocles, and Euripides. It was those authors of Greek antiquity who discovered tragedy as a vehicle for communicating deep insights into feelings, and Shakespeare, drawing on many earlier sources, finally developed that Greek discovery to its ultimate height. To some limited extent, therefore, the plays of the Greek dramatists *have* been superseded by Shakespeare's. Why then, have Shakespeare's plays not been superseded by the work of later, lesser dramatists, say by Shaw's or Brecht's?

Here we do encounter an important difference between art and science, namely the feasibility of paraphrase. The semantic content of a work of art — a play, a cantata, or a painting — is critically dependent on the exact manner of its realization; that is, the greater an artistic work, the more likely it is that any omissions or changes from its original structure detract from its full meaning. In other words, to paraphrase a great work of art — for instance, to condense *Timon* for the *Reader's Digest* — without loss of semantic content requires a genius equal to the genius of the original creator. Such a successful paraphrase would, in fact, constitute a great work of art in its own right. The semantic content of a great scientific paper, on the other hand, can later be paraphrased without serious loss by lesser scientists. Thus the simple statement "DNA is a double-stranded, self-complementary helix" does communicate the essence of Watson and Crick's great discovery. But it took the writing of *King Lear* to paraphrase (and improve on) *Timon* and indeed *King Lear* has superseded *Timon* in the Shakespearean dramatic repertoire.

The last reason I adduced for the widespread acceptance of the proposition that artistic creations are unique and scientific creations are not is the prevalence of an incoherent epistemological attitude toward the phenomena of the outer and the inner world. The outer world, which science tries to fathom, is often viewed from the standpoint of materialism, according to which phenomena and the relations between them have no objective existence independent of the human mind and this real world is as we see, hear, smell, and feel it. Hence the outer world and its scientific laws are simply there, and it is the job of the scientist to find them. At the same time, the inner world, which art tries to fathom, is often viewed from the standpoint of idealism, according to which phenomena and relations between them have no reality other than their invention by the human mind. Hence there *is* nothing to be found in the inner world, and artistic creations are cut simply from whole cloth. Here B or C or D could not possibly find tomorrow what A found today, because what A found today had never been there in the first place.

This incoherent epistemological attitude is also held by Meyer, who argues that only scientists discover truths; they do not create anything, except maybe intrinsically ephemeral theories. After all, "the structure of DNA was what it was before Watson and Crick formulated a theory of its structure." The reason for this is, according to Meyer, that "we assume evidently on good grounds, that while our theories explaining nature may change, the principles governing relationships

in the natural world are constant with respect to both time and place." Artists, by contrast, he says, do not discover anything; they create their works, which had no prior existence.

In the 1960s and 1970s, Immanuel Kant's definitive resolution of the age-old epistemological conflict of materialism versus idealism made its impact on the human sciences, under the general banner of structuralism. Structuralism emerged simultaneously, independently, and in different guises in several diverse fields of study, for example in psychology, linguistics, anthropology, and biology. Both materialism and idealism take it for granted that all the information gathered by our senses actually reaches our mind; materialism envisions that thanks to this sensory information reality is *mirrored* in the mind, whereas idealism envisions that thanks to this sensory information reality is *invented* by the mind. Structuralism, on the other hand, provided the insight that knowledge about the world of phenomena enters the mind not as raw data but in an already highly abstracted form, namely as structures. In the preconscious process of converting the primary sensory data step-by-step into structures, information is necessarily lost, because the creation of structures, or the recognition of patterns, is nothing else than the selective destruction of information. Thus, since the mind does not gain access to the full set of data about the world, it cannot mirror reality. Instead, for the mind reality is a set of structural transforms abstracted from the phenomenal world. Any set of primary data becomes meaningful only after a series of operations has so transformed it that it has become congruent with structure preexisting in the mind.

Thus neo-Kantian, structuralist metaphysics leads to the recognition that every creative act in art and science is *both* commonplace *and* unique. On the one hand, every creative act is commonplace, in the sense that there is an innate correspondence in the transformational operations that different persons perform on the same primary data from inner and outer worlds. On the other hand, every creative act is unique, in the sense that no two persons are quite the same and hence never perform exactly the same transformational operations on a given set of primary data. I therefore concluded my article by paraphrasing Orwell, saying that even though all creative acts in both art and science are both commonplace and unique, some creations may nonetheless be more unique than others.

Taking Meyer's essay as a paradigmatic contribution to the debate concerning the relationship between science and art, we can see that the source of the confusion in that debate is not so much the invocation of doubtful analogies as the intractable nature of the underlying cognitive problems. To bring these problems into focus, let us first disperse the epistemological fog reflected in Meyer's pronouncement that the term "discovery" pertains only to science, whereas the term "creation" pertains only to the arts. As we already noted, a scientific theory is an abstraction made from what Meyer calls the "natural world," which presents our senses with a near infinitude of phenomena. Hence in their work scientists necessarily select only a small subset of these phenomena for their attention. Thus, contrary to the naive materialist outlook that Meyer brings to the discovery of the DNA double helix, the structure of the DNA molecule was *not* what it was before Watson and Crick formulated it, because there was, and still is, no such thing as the DNA molecule in the natural world. The DNA molecule is an abstraction created by century-long efforts of a succession of biochemists, all of whom selected for their attention certain ensembles of natural phenomena, according to an evolving set of transformational rules. In other words, the DNA double helix is as much a creation as it is a discovery, and the realm of existence of the double helical DNA molecule is the mind of scientists and the literature of science, and not the natural world (except in so far as that world includes also minds and books). Hence as applied to science, the distinction between discovery and creation is devoid of philosophical merit.

However, Meyer's central objection to what he calls "Stent's definition," which explicates art and science as activities that endeavor to discover and communicate truths about the world, lies in his claim that the concept of truth is simply not applicable to art. If this claim were valid, then the contents of works of art could not be propositional (inasmuch as they would not be statements that affirm or deny something that could be characterized as true or false), and hence artists could not be said to "discover" anything. Artists would merely create presentational structures without propositional content, just as God creates sunsets, no one of

which has a content of which it can be said that it is true or false. All the same, Meyer admits that, unlike sunsets, "great works of art command our assent. Like validated theories, they seem self-evident and incontrovertible, meaningful and necessary, infallible and illuminating. There is, without doubt, an aura of 'truth' about them." But Meyer insists, as indicated by his putting the word in quotation marks, that in this connection "truth" is being used only in a metaphorical sense. Why? Because according to the naive materialist standpoint from which Meyer approaches this deep problem, a literally true scientific proposition states what is actually and objectively the case, that is, is directly observable in the real world. And since there are no imaginable observations that could test the validity of the *content* of a work of art, it could be said to be "true" only in a metaphorical but not in a literal sense.

Viewing our cognitive relation to the world from the standpoint of structuralism, however, leads to a different literal concept of truth. Inasmuch as reality, to which truth relates, is a set of structural transforms which each person abstracts from a world of things, things that are, as pointed out by Kant, in themselves intrinsically unknowable, the notion of truth has to be more relaxed. Namely, a scientific proposition is true (for me) insofar as it is in harmony with my internalized picture of the world (that is, my reality) and commands my assent. This literal meaning of truth is obviously not an objective one, but a subjective one. It leads to the concept of objective truth only as long as I am convinced that a proposition that is true for me would also command the assent of every other person qualified to make this judgement. Here the ideal of an absolutely objective truth is reached only if God also assents to the proposition. And so from the structuralist viewpoint the use of the term "truth" in connection with the content of a work of art is not metaphorical at all: It is the very same literal usage as that applied to the content of a work of science. It is exactly by their command of assent that we come to believe also in the truth of scientific propositions. In the 35 years that I have spent as a working scientist, I have personally validated (if indeed validation is at all possible), or even examined the published records of the validation by others, only a small fraction of the scientific propositions which I believe to be true. The remainder simply command my assent, for the same reasons that Meyer cites as the basis of the aura of truth of great works of art.

Finally we come to the problem of the semantic content of the works of art and science. The semantic difficulties that seem to lie in the way of discussing "semantic content" are unwittingly highlighted by the editor of *Critical Inquiry.* In his summing up of our little wrangle, he expressed his belief that there can be meaningful works of art without semantic content. This belief is clearly paradoxical (or oxymoronic), since the adjective "semantic" means "having or related to meaning." Meyer, by contrast, can hardly deny that works of art have semantic content. In one of my favorite chapters of his *Music, the Arts and Ideas* he showed that the transmission of information by the artist and perception of the intended meaning of that information by an audience is the central feature of art, or rather of *traditional* art. By contrast, latter-day "experimental" or *transcendental* art, such as chance music and abstract expressionism, differs from its traditional forerunners precisely in that it has abandoned the semantic function. Works of transcendental art do resemble sunsets or mountains in that, just as those natural phenomena, they are merely there, without intended meaning, for the audience to make of them what it will. Transcendental art is, therefore, not only excluded from "Stent's definition" of art, but, thanks to Meyer's own analysis, provides an exception that proves the rule.

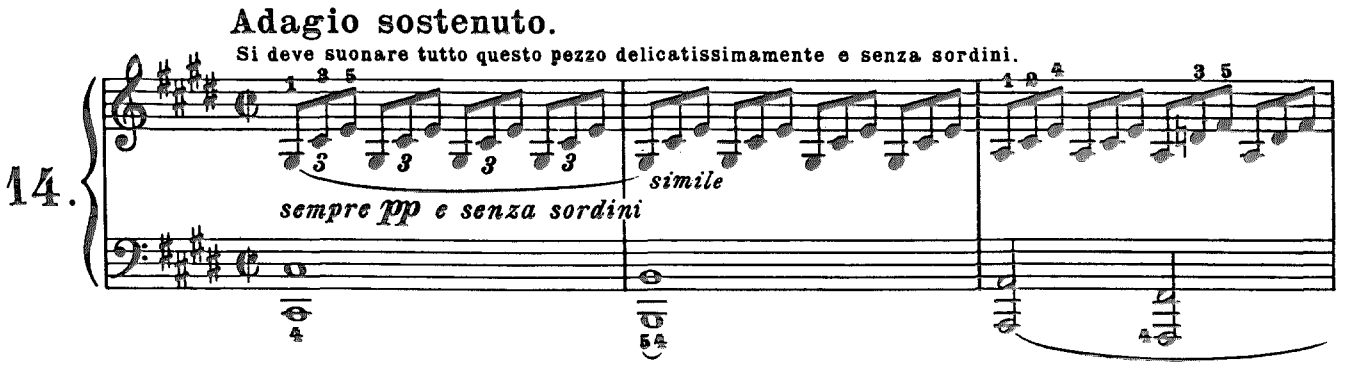
Let us now return to the question of whether, or in what sense, the semantic content of works of art could be propositional. Meyer proposes that a work of art is a "concrete exemplification of relationships," in other words, that although the work is concrete, its content is abstract, in the sense that the artist has created it in order to allow a percipient to recognize the exemplification of something more general than the work itself. But how does the percipient manage to understand the relationships that are being exemplified? According to Meyer, the percipient submits the work to a semantic analysis based on what Meyer refers to as "propositional habits." What then is the difference between the propositions of science and the propositional habits of art? Habits, unlike scientific theories, Meyer says, are not explicitly formulated. So it follows that the content of works of art is propositional after all

(in that a relationship being exemplified can be characterized as either true or false) but that, unlike the explicit propositions embodied in the text of a work of science, the propositions embodied in a work of art are merely implicit in its structure. This certainly is a profound and basic difference between art and science, but not one that will "cut through [Stent's] Gordian argument with a sharp but simple distinction." Instead, it points to the fact that it is their differential use of language which places an obstacle in the way of a felicitous union of the Two Cultures (rather than the failure to set up a *ménage-à-trois* with a humanist as housemate). The propositions of science are explicitly formulated, being stated in ordinary verbal discourse, the modality that the human brain has evolved to employ for explicit communication. The propositions of art, by contrast, are implicitly formulated, being embodied in tonal and visual structures, modalities for whose semantic processing the human brain employs means other than those it calls on for the processing of speech.

Armed with this insight, we can now reconsider the thematic continuum presented by art and science with regard to their principal foci of interest in inner and outer reality. To use a mathematical metaphor, this continuum is a scalar whose metric is the degree of concern with outer reality. Music, which appears to be the purest art form and has the least to say about outer reality, lies at one end of this continuum. Accordingly, music shows the least thematic overlap with science, which lies at the other end. The content of works of music is more purely affective than that of any other art form, because musical symbolism very rarely refers to any models of outer reality, to which it could never do justice anyway; the meaning of musical structures thus relates almost exclusively to inner models. Musical symbolism is able to dispense with outer models because, according to Susanne Langer, "the forms of human feelings are much more congruent with musical forms than are the forms of spoken language; music can *reveal* the nature of feelings with a detail and truth that language cannot approach." Hence music conveys the unspeakable; it is incommensurable with language, and even with representational symbols, such as the images of painting and the gestures of the dance. So-called "program music," such as Respighi's *Pines of Rome*, which *does* refer to models of outer reality, appears to be another exception that proves the rule, in that program music is generally accorded rather low aesthetic merit.

Thus the position of an art form on this continuum — that is, its relative proximity to science and the extent to which it is addressed to outer reality — seems closely related to the degree to which its symbolism is embedded in language. The visual arts — painting and sculpture — are still relatively "pure" art forms, as is poetry which, although it does resort to language as its medium, uses words in a quasi-musical form. But literature and drama, with their mainly linguistic symbolism and their close thematic ties to outer reality, but still addressing the inner reality of feelings, seem to lie halfway between music and science. Science is, of course, wholly dependent on language as its semantic modality, bearing in mind that mathematical notation has to be regarded as merely a time- and effort-saving shorthand mode of expressing complex logical relations between ordinary words.

All the same, the semantic transactions of art still pose a most difficult problem. What *is* the meaning of the propositions which are implicitly formulated in works of art? To what do the relationships exemplified by works of art actually refer? What are they about? Evidently the difficulty of answering these questions increases as we progress from science toward music in the thematic continuum. At the musical end of the continuum, where symbolism is incommensurable with language, these questions cannot be answered (verbally) at all. For instance, according to a



legend quoted by Meyer, Beethoven, when asked what the *Moonlight* Sonata means — what it is *about* — went to the piano and played it for a second time. Meyer finds Beethoven's answer not only appropriate but compelling. But Meyer thinks that if a physicist were asked what the law of gravity is about and answered by letting some object fall to the ground, our inference would be that the physicist is disingenuously witty — that he had not responded properly.

I agree that Beethoven's response seems more reasonable than that of the uncooperative physicist, but not for the reason given by Meyer, namely that the *Moonlight* Sonata is not about the world and does not refer to something. Rather, Beethoven's response is reasonable because he was asked a question for which there is no adequate verbal reply, whereas the physicist's response is unreasonable because he *could* have said something. This then is the paradox: Logic demands that since the *Moonlight* Sonata, exemplifying a relationship, has some meaningful content — as opposed to a sunset, which has not — it must refer to something, must be about something. Yet we cannot say what that something is. In thus being generally speechless regarding the meaning of music, we resemble the split-brain patients studied by Roger Sperry, who can recognize familiar objects seen in the left half of their visual field but are unable to identify these objects verbally.

As we move away from music toward science in the thematic continuum, through the visual arts to literature and drama, verbal explanations of the meaning of art works, though still formidably difficult, become at least possible. Indeed it is the very task to which hermeneutics is dedicated, the discipline originally concerned with the interpretation of sacred and profane texts but which has been extended more recently to making explicit also the implicit meanings that are hidden in a broad range of semantic structures. There would be massive unemployment among contemporary hermeneuticians if Meyer's assertion that the contents of works of art do not refer to anything and are not about the world were actually true. Suppose, to stay with our original example, having just seen a performance of *Timon*, we asked a Shakespearean scholar what does the play mean — what is it *about* — and he simply took us back to the theater to make us see *Timon* for a second time. Would we not consider his response as disingenuously witty and as nearly improper as that of the physicist? That is not to say that if the scholar did give us his verbal interpretation of *Timon*, it would fully capture the semantic essence of the play. As we already noted, because of the difficulty of paraphrase, our scholar would have to be a genius equal to the Bard to accomplish that task. Nevertheless, depending on his hermeneutic skills, he could go some considerable distance toward giving us an idea what the play's deep meaning, and not just its plot, is about. What would be most likely missing from the scholar's verbal interpretation of *Timon* is precisely that part of the play's meaningful content which is not embedded denotatively in the text and which arises from it connotatively, thanks to the contextual situation created by Shakespeare. The obstacles in the way of foreign-language translation of verbal works of art would seem to reflect that same difficulty of paraphrase, as expressed in such homely saws as "*tradutore, traditore*" and "poetry is what is untranslatable in literature." Yet the fact that a poem cannot be rendered full justice in translation does not show that it is not about the world, that it does not refer to anything.

So we have traveled a long way from Chargaff's reflections on the triteness of scientific autobiography to the bottomless depths of epistemology and cognitive philosophy. As for marriages made in heaven, that of the Two Cultures would not be the first in which the spouses turn out to have some difficulties in talking to each other. So maybe it would be a good idea after all to keep a hermeneutic humanist as an interpreter in the Arts and Sciences household. □