Art and Science in the Age of Digital Reproduction: From Mimetic Representation to Interactive Virtual Reality

Bernard Frischer
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Departments of Classics and Art History, University of Virginia. USA

Resumen

Este artículo sitúa a las humanidades digitales en general y a la arqueología virtual en particular dentro del largo contexto de la evolución de las artes y las ciencias desde la antigüedad a través de la Edad Media y del Renacimiento hasta el presente, el período posmoderno.

Palabras Clave: *ARQUEOLOGIA VIRTUAL, C.P. SNOW'S TWO CULTURES, ARTES Y CIENCIAS.*

Abstract

This paper places the digital humanities generally and virtual archaeology in particular into the larger context of the evolution of the arts and sciences from antiquity through the Middle Ages and Renaissance to the present, postmodern period.The argument is made that the basis of virtual reality representations of cultural objects is not primarily mimetic but interactive and that in this sense virtual archaeology reflects larger trends in contemporary science and the arts.

Key words: *VIRTUAL ARCHAEOLOGY, C.P. SNOW'S TWO CULTURES, ARTS AND SCIENCES*

1 Introduction:
C. P. Snow's "Two Cultures"

C. P. Snow's famous Rede Lecture, "The Two Cultures," was given in 1959, so this year is the fiftieth anniversary of a talk that had an enormous impact on its age. Given how influential that the lecture has been, we will undoubtedly see many retrospective assessments in the coming months. I want to begin with Snow because the thesis of his lecture relates directly to the topic I plan to address today: the art of science, the science of art, or, as we might paraphrase it, the interrelationship of science and art. As you will see when I reach my conclusion, I believe that this interrelationship has direct bearing on our activity as virtual archaeologists who strive to remain true to the exact science of antiquity even as we try to take advantage of the new technology of digital graphic arts as powerful tools of illustration and discovery.

It is best to begin, then, with Snow's own summary of his thesis. To quote him:

> In our society…we have lost even the pretence of a common culture. Persons educated with the greatest intensity we know can no longer communicate with each other on the plane of their major intellectual concern….This is serious for our creative, intellectual and, above all, our normal life….The most pointed example of this lack of communication [concerns] two groups of people, representing what I have christened 'the two cultures.' One of these contain[s] scientists, whose weight, achievement and influence did not need stressing. The other contain[s] the literary intellectuals….In the condition of our age…Renaissance man is not possible. But we can do something. The chief means open to us is education….There is no excuse for letting another generation be as vastly ignorant, or as devoid of understanding and sympathy, as we are ourselves. (Snow 1969: 60-61)

So Snow posited two cultures that cannot communicate with each other and glare at each other with ill-concealed hostility. One culture consists of scientists, the other of what he called "literary intellectuals." Snow did not take sides in this division: as a writer and a scientist, his goal was to help bridge the gap, not in his own generation but in the next. And his means of doing that was educational reform: budding scientists need to study more humanities; students of the humanities need to learn something about math and science.

Snow's Rede Lecture grew out of some very particular circumstances, and it was explicitly aimed at England and its educational system in the 1950s. He did not contrast scientists and artists, as our theme might have required, but scientists and "literary intellectuals." This is another example of how Snow's thesis is rooted in a very specific situation. But despite these features, I think that Snow's famous lecture is a good point of departure for this paper. For all its particularism, Snow's talk does raise the perennial question of the relationship between the arts and the sciences and does so in the most extreme fashion: instead of seeing that relationship as nuanced across a wide spectrum of human behavior, he sees it as one characterized by hostility, lack of communication, and incomprehension. I would like to argue that Snow exaggerated the problem of the "two cultures" in 1959 when he gave his lecture, and he is even more wrong today—at least if we examine the question not, as Snow did, on the level of the interpersonal interactions of specific scientists and literary intellectuals at the high tables of Cambridge and Oxford, but on the more profound level of the nature of art and of science.

And so we must start with a definition of terms. What do we mean by "art" and by "science"?

2 Defining Our Terms

Let me avoid answering that for a moment by citing a passage in *Passage to Modernity,* a wonderful book by Louis Dupré, who was Professor of Philosophy and Religion at Yale:

> …artists of the early Renaissance continued to view themselves as creating in unison with nature: mind and nature relate harmoniously to one another. As a microcosmos, the person occupies a central position within nature. According to Leonardo, the mind recognizes itself in the natural form upon which it then bestows its own formal perfection…. Observation of nature's forms must conspire with creative imagination to realize the truth of nature. Because of the aesthetic importance of observation, Leonardo…considers science and art united. Thus he…concludes that painting is a science, indeed the higher one, since it intuitively reveals the unique, internal structure of its object, which cannot be learned as other sciences can (Dupré, 1993: 49; cf. Kuhn, 1970: 161).

I start with Leonardo da Vinci and the Renaissance because I want to challenge any presupposition you may have that "art" and "science" have unambiguous significations and are natural and eternal opposites. In fact, the contrary is the case. Until the late 19th century when the term "physical sciences" was first coined, "art" and "science" were synonyms. We still hear a faint echo of this when we talk about "*the art of* solving puzzles, or "*the art of* computer game design," to cite just two of thousands of hits that I got when Googling the phrase "the art of…" We also hear it when John Ziman, the distinguished theoretician of contemporary science, calls science "the art of the soluble" (Ziman, 1978: 28) and we can detect the synonymy in the title of Martin Kemp's book, *The Science of Art. Optical Themes in Western Art from Brunelleschi to Seurat* (Kemp, 1990). It may not be irrelevant to note that Kemp is one of our greatest experts on da Vinci. Also pertinent is the fact that since its very origins with the Ionian thinkers such as Thales, philosophy has embraced both what we today call "science" and the "arts."

So our terms "art" and "science" have a history, and when we use them, they carry with them traces of that history. If we want to say anything useful about "the art of science and the science of art" and avoid terminological confusion or ambiguity, we will need to understand that history, at least in its broad strokes.

3 The Ancient Model

The Renaissance idea that the sciences and arts are synonymous goes back to antiquity. Our word "art" derives from the Latin *ars*, which the Romans used to translate the Greek term *techne*—the root of our word "technology." "Science" derives from the Latin word *scientia*, a translation of the Greek term *episteme*. *Scientia* and *episteme* simply meant "knowledge"—knowledge about anything, not specifically about atoms, molecules, stars, life forms, etc., as it does today. Aristotle (*Post An.* 100a) understood *episteme* to mean a body of knowledge about existing things that are unchanging and eternal. Knowledge of such things can be codified, taught, and learned (*Nic. Eth.* 1139b). Complementary to, but less precise than *episteme* is *techne*. *Techne* is the knowledge of things that might exist (but do not necessarily exist) and that are brought into existence not by themselves but by an efficient cause that is their maker (*Nic. Eth.* 1140a). Such things might be actions or objects. Thus, Aristotle divides *techne* into two branches, the practical, concerned with actions, and the "poetic," concerned with objects. A *techne* involves *logos*, or a "rational quality" (*hexis meta logou*) which must be applied in accordance with the truth (*alethous; Nic. Eth.* 1140a). So a *techne* has a necessary relationship to *episteme*, the study of the truth about unchanging and eternal things. For Aristotle and, as Dupré rightly noted, for the Greeks generally, knowledge is possible because nature is infused with *Logos*, or Reason, and humans are first and foremost rational creatures. This means that for the Greeks, the work of knowing is mimetic: to know something is to be able to describe it accurately in its essentials, which is to say its rational elements.

Hence for Aristotle and the Greeks, the key tool in the knowledge worker's toolkit is logic. As we will see, other tools came later. I will call this notion of what knowledge is and what tool is suited to discover it the *Ancient Model* (see figure 1), anticipating my invocation in section 4 of Alfred Crosby's use of the term *New Model* for the period 1250 to 1600.

Ancient Model: Logic

Greek	Latin	English
τέχνη	*Ars*$_1$	Art
□πιστήμη□□□	*Scientia*$_1$	Knowledge

Goal: mimetic representation of reality

Figure 1. The Ancient Model.

In the Hellenistic and Roman periods, Aristotle's sharp distinction between *episteme* and *techne* was lost, and the terms came to be used interchangeably. Thus, in his influential book on education, the late-antique writer Martianus Capella called the following the seven "liberal" *arts,* that is the subjects that any free-born (*liber*) man ought to have mastered: Grammar, Dialectic (or Logic), Rhetoric, Geometry, Arithmetic, Astronomy and Music. So, for Capella and in western universities until the seventeenth century, the arts included disciplines such as mathematics and astronomy that we today naturally consider sciences. Thus when Galileo came to the University of Padua in 1592, he was hired as an "artista," a professor of the art of mathematics, having been recruited by Antonio Riccoboni, the professor of Humanities.

When you finished your bachelor's degree in one of these arts, you then were eligible to proceed to the master's and doctorate in the faculties of medicine, theology, or law. Whatever you studied at whatever level, you had to be highly proficient in Latin and Greek, since all the textbooks in all disciplines were texts by ancient writers such as Aristotle, Cicero, and Galen (on the concept of the "arts" see Kristeller, 1990: 163-227; on the medieval university, see Le Goff, 1993: 65-166 and Leff, 1992; on the Renaissance university, see Grendler, 2002). At this phase, then, it would not make sense to talk about "the art of science and the science of art," since art *meant* science.

To be clear about our use of these terms, let us call this Art$_1$ and Science$_1$, and we can say that:

$$\text{Art}_1 = \text{Science}_1$$

Both operated under the Ancient Model of knowledge primarily obtained through the tool of logic and aimed at a mimetic description of reality.

4 The New Model

When did this paradigm of the branches of knowledge break down, and why? Perhaps the key figure was Galileo, who, to be sure, was not without his medieval predecessors such as Roger Bacon in the thirteenth century. Like Bacon, Galileo held that mathematics was "the gate and key" to knowledge about the physical world (Crosby, 1997: 68). Unlike Bacon, Galileo had many students and lived in the age of Gutenberg.

So Galileo's readership and influence were far-flung.

It was Galileo who started a new paradigm of scientific research based on the apparently simple idea that you could quantify key characteristics of matter such as force, energy and mass (figure 2). What had held things up? Aristotle and the Ancient Model!

In his *Metaphysics*, Aristotle denied point-blank that math could be applied to physics. Mathematics is "theoretical" and concerns what is eternal and immovable. But physics deals with things constantly moving and perishing, which are anything but immovable and eternal (*Met.* 1026a; see, in general, Crosby, 1997: 12-14). For a Bacon or Galileo to be possible, a new model of knowledge was needed.

Alfred W. Crosby, in his excellent book, *The Measure of Reality. Quantification and Western Society, 1250-1600*, sees this New Model gradually evolving in tandem with the introduction of the money economy in the thirteenth and fourteenth centuries. Crosby quotes a fourteenth century scholar at Oxford who wrote that "every saleable item is at the same time a measured item." Even time came to have a price once it could be divided into units smaller and more absolute than the ancient hour, whose value fluctuated seasonally and geographically until the invention of mechanical clocks around the 1270s (Crosby, 1997: 84). Within a few centuries, Kepler would compare the universe to a vast clockwork. The new device had given birth to a new and powerful metaphor (Crosby, 1997: 110-111). And let us not forget that Copernicus wrote a treatise on money in which he anticipated the quantity theory of money and even Gresham's Law. The New Model, then, is based in part on the addition of a second tool to the knowledge worker's toolkit. Next to logic, we now have applied mathematics.

New Model: Logic, Mathematics, Visualization

Greek	**Latin**	**English**
τέχνη	*Ars*$_2$	Art
□πιστήμη□□□	*Scientia*$_2$	Knowledge

Goal: mimetic representation of reality

Figure 2. The New Model.

Why could mathematics not have been used as a knowledge-producing tool in antiquity? Crosby is undoubtedly correct in attributing this to the simple fact that in antiquity "its symbols and techniques were inadequate" (Crosby, 1997: 110-111). A new symbolism was required. With Roman numerals, even the procedure of addition was time-consuming. And then there was the lack of the concept of zero. It took until the sixteenth century for the Arabic system of numbers and notation to come into widespread use in Europe. Until then, we should not be surprised to find the knowledge-worker's toolkit to be limited to logic alone.

Further progress came in the early 1400s with the rediscovery Ptolemy's *Geography*, with its map of the world, which divided the earth into the familiar system of latitude and longitude. This gridding of the earth allowed maps to become more and more accurate and introduced the idea that space, like time, could be divided into small units and measured with precision—not that Ptolemy did: his calculations were, in fact, far from accurate, which explains why when Columbus got to the New World, he thought he was already at the islands off the coast of China, some 10,000 miles away (Crosby, 1997: 97-98). A second work of Ptolemy, rediscovered around the same time was his *He Megiste Syntaxis*, better known by its Arabic title of *Almagest*. This work presented a detailed geocentric model of the heavens. Its inelegant use of epicycles inspired Copernicus in the sixteenth century to propose his heliocentric model. Here it is important to note three things. First, Copernicus did not primarily base his argument on new observations. Second, Copernicus felt licensed to propose the heliocentric model because it had already been developed in antiquity by Aristarchus of Samos. Hence, his attack on Ptolemy does not constitute an early skirmish in the Battle of the Ancients and the Moderns, which was to break out in France in the next century. It is rather a case of one ancient authority pitted against other ancient authorities. Since none of the heliocentric texts survived, in a sense Copernicus was philologically recon-structing the line of argument they could have made. Finally, for Copernicus, the criterion of success in his enterprise was less truth than beauty. As he wrote about his geocentric predecessors, "…they [could not] elicit or deduce…the structure of the universe and the true symmetry of its parts. On the contrary, their experience was just like some one taking from various places hands, feet, a head, and other pieces, very well depicted, it may be, but not for the representation of a single person; since these fragments would not belong to one another at all, a monster rather than a man would be put together from them" (Copernicus 1978). As Robert Westman (2008) has noted, Copernicus' image is based on the opening lines of Horace's *Art of Poetry*, which compares a bad poem to the painting of a monster with the head of a woman, neck of a horse, wings of a bird, and tail of a fish.

Copernicus sees the strength of his alternative theory in the fact that it can connect the old data points in a new way so as to make the picture of the universe symmetrical and beautiful rather than monstrous and ugly. The root of this new criterion of truth comes from the fifteenth-century Neoplatonic philosophy of Marsilio Ficino. As Dupré showed, in Ficino's thought, Nature is an aesthetic work, and hence to perceive the truth of Nature is to perceive its beauty (Dupré 1993: 200-202).

Oddly, Copernicus' *De revolutionibus* had an unintended contribution to make to the progress of knowledge: unbeknownst to its dying author, Copernicus' text was edited by the theologian Andreas Osiander when it was being prepared for the printer in Nuremberg in 1543. Osiander added a preface that most readers thought must have been written or at least authorized by Copernicus himself. In this text, Osiander called the heliocentric theory a hypothesis which "need not be true nor even probable; it is sufficient if the calculations agree with the observations" (quoted *apud* Gingerich 2005: 139). Osiander thus introduced the powerful concept that a scientific theory could be proposed not as a mimetic representation of reality but as a thought-experiment or *jeu d'esprit* (on Osiander's preface see Kusukawa, 1999).

A key moment in the formation of what Crosby calls the New Model occurred in the early seventeenth century. That is when Galileo did three things that were to have a powerful effect on science down to the present day. He violated Aristotle's injunction against applying mathematics to the study of physical objects. Although he made some errors, Galileo undertook experiments to establish the time-squared law for uniformly accelerated change. He also concluded that objects retain their velocity unless a force—such as friction—acts upon them, refuting the generally accepted Aristotelian hypothesis that objects "naturally" slow down and stop unless a force acts upon them. Galileo also showed the power of observation by using the new invention of the telescope to visualize the heavens, making new discoveries (such as the four, large moons of Jupiter) that are impossible for the unaided eye to see. And so a third tool entered the knowledge-worker's toolkit: visual devices such as microscopes and telescopes to bring within the range of human vision objects too small or distant to be perceivable. Once again, the reason for the absence of these tools from the Ancient Model is obvious: they did not yet exist.

I have noted that Osiander's preface to Copernicus' *De revolutionibus* characterizes the purpose of the work as a mere hypothesis, not a claim that the heliocentric model is an accurate mimesis of the solar system. This softer claim is actually not very characteristic of practitioners of the New Model. More typical is Galileo, who wrote, for example, in the *Starry Messenger*, "I have observed the nature and material of the Milky Way. With the aid of the telescope this has been scrutinized so directly and with such ocular certainty that all the disputes which have vexed philosophers through so many ages have been resolved, and we are at last freed from wordy debates about it" (Galilei, 1957: 49). "Wordy debates" are, of course, Galileo's disparaging way of referring to the use of logical reasoning alone. Armed with the new tool of the telescope, the knowledge-worker in the age of the New Model can forward a very strong claim to understanding the precise characteristics of his object of study.

Galileo's contemporary, Kepler, was able to improve on Copernicus' heliocentric model by replacing Copernicus' circular orbits of the planets with ellipses, arriving at this correct conclusion solely by use of mathematics and the data of Mars' orbit. Within fifty years of the deaths of Kepler (1630) and Galileo (1642), Newton, in the *Principia mathematica* (1687) was able to take Galileo's terrestrial laws of motion and apply them to heavenly bodies such as the Moon and the planets, thereby giving a principled explanation for Kepler's observations about planetary motion (cf. Kline, 1967: 337-339).

By the beginning of the eighteenth century, Crosby's new quantitative-visual model had been firmly established as Newton's work swept all before it, as Feingold has reminded us in his recent book *The Newtonian Moment*. But the term for this branch of knowledge was still philosophy, or natural philosophy, not "science." Not surprisingly, the full title of Newton's classic work was the *Philosophiae Naturalis Principia Mathematica*, or *The Mathematical Principles of Natural Philosophy*. For the sake of terminological clarity, let us call this "Science$_2$."

As we have seen, the chief characteristics of science$_2$ are quantification, visualization, model-ing, and experimentation. Note that these are not always all utilized, but they are all in the scientist's toolkit. For example, in the field of astronomy, experiments were not possible for Copernicus, Kepler, Galileo and Newton. At best, they could quantify, observe, model and run thought experiments.

If in the seventeenth century natural philosophy embraced the new tools of quantification and visualization, then we may well wonder if there was already a foreshadowing of C.P. Snow's opposition of what we today would call art and science. Surprisingly, the answer is no.

Art itself was evolving in the same direction. Indeed, the move toward the new model actually occurred in what we now call the arts *before* it occurred in the sciences, and so we now change our nomenclature for "art," too. Starting from fifteenth-century Florence, painting had undergone what William Ivins has called "the rationalization of sight." By this concept—which has been quite influential among scholars of New Media—he means that the imprecise sense of perspective found in much of Roman painting and European Gothic painting, starting with Pietro Cavallini and Giotto, had undergone a revolution with Leon Battista Alberti's formalization of Brunelleschi's discovery of a simple but logical scheme for pictorial perspective (Ivins, 1975: 9; on Brunelleschi and Alberti, see [anon.], 2006: 371-378). According to Ivins, Alberti's innovation came from a shift of sensibility: for the Greeks, geometric properties were ultimately derived from the sense of touch, not vision. This can be exemplified by the key issue of perspective painting: the treatment of parallel lines. In Euclid, parallel lines, by definition, never meet. "If we get our awareness of parallelism through touch, as by running our fingers along a simple molding," writes Ivins, "there is no question of the sensuous return that parallel lines do not meet. If, however, we get our awareness of parallelism through sight, as when we look down a long colonnade, there is no doubt about the sensuous return that parallel lines do converge and will meet if they are far enough extended" (Ivins, 1975: 8). The famous Albertian window used in perspective painting since the mid fifteenth century reflects exactly the same powerful combination of tools seen 150 years later in the work of Galileo, Kepler, and Newton: mathematics and visualization. And as in the work of those natural philosophers, the criterion for success was, of course, beauty and the goal the mimetic representation of Nature.

The invention of perspective was not simply a technical innovation useful for painters and architects. By a circuitous route that started with the engineer-architect Girard Desargues and his student Blaise Pascal in the seventeenth century, it led in the nineteenth century to the development of projective geometry, of which Euclidean and non-Euclidean geometries are special cases (Kline, 1967: 232-249). As Morris Kline put it, "this subject born of art makes its primary contribution to mathematics as an art" (Kline, 1967: 248). Of course, this story about how modern geometry developed in the positive interaction of fine artists and scientists has many, many more twists and turns. Those interested can be referred for the details to the splendid account in Martin Kemp's book, *The Science of Art,* whose premise is (to quote the Introduction) "that there were special kinds of affinity between the central intellectual and observational concerns in the visual arts and the sciences in Europe from the Renaissance to the nineteenth century" (Kemp, 1990: 1).

Crosby's "New Model," which we have called science$_2$, is first attested two centuries earlier in the fine art of painting, whose theoretician was Leon Battista Alberti and whose poster boy was Leonardo da Vinci. At this point, then, we also must distinguish this sense of the word "art" from art$_1$. We have called it art$_2$. Here, again, we find that art and science are not polar opposites, as they were in Snow's essay. Of course, we are now using the word "art" in the sense of the "fine arts," not in the sense of art$_1$, the traditional liberal arts of Grammar, Logic, Rhetoric, etc. That sense was not to develop before Vasari, who in his Lives *of the Most Excellent Painters, Sculptors and Architects*, coined the term "*le arti del disegno*," the "arts of design," or what the French were to call the *beaux arts* and what we call in English the "fine arts." Since the universities had no place for them, painters, sculptors and architects banded together in academies, of which the first was started in 1563 by Vasari himself in his native Florence (cf. Kristeller, 1990: 181-183).

At this point, we can begin to detect a divergence between the old liberal artists and the new fine artists and natural philosophers. The liberal artists show few signs of rebelling against what Crosby called the Old Model that was pre-quantitative and non-visual. There are, to be sure, some exceptions such as Pierre de la Ramée, better known as Petrus Ramus, who developed a new, anti-Aristotelian logic in mid sixteenth-century Paris and who loved to make his points through the use of illustrative diagrams (Ong, 1958). Ramus' influence is hotly debated: Walter Ong downplayed it (Ong, 1962: 79-80; see also Sellberg, 2006); Ernst Cassirer and, more recently, Timothy Reiss, see a direct line connecting Ramus to Bacon, Galileo and ultimately to Frege (Reiss, 2000: 54-55).

On the other hand, even the old artists of grammar, rhetoric, logic, and ethics were somewhat affected by the spirit of the age, which, after all was the Renaissance and the time when humanism flourished. For the humanists studying the Greek and Latin authors, it was not yet possible to use the tool of quantification, let alone of experimentation. For that, we have to await the late twentieth century and the development of the fields of quantitative linguistics, literary stylometrics, and virtual archaeology. But it was possible to challenge ancient authority, as Galileo did; and by the early nineteenth century it would be possible to visualize textual data in the form of the genealogy of manuscripts, or the discipline we call stemmatics (Bordalejo, 2006).

As in the case of the fine arts, in challenging ancient authority the liberal artists were far ahead of the scientists. Probably the greatest challenge made by a Humanist to ancient authority occurred in 1440 when Lorenzo Valla used legal, linguistic and historical arguments to challenge the authenticity of the Donation of Constantine. This was a key text upon which the primacy and power of the Bishop of Rome rested because in it the Emperor Constantine the Great allegedly gave Pope Sylvester I and his successors ownership of property in Rome, Italy, and in other provinces of the Roman empire including Judea, Greece, and Africa. Valla's challenge set off a chain reaction that, as noted by Hans Küng (1996), caused a paradigm shift in Christianity. Before Valla, authority flowed from the Pope in Rome. After Valla, Martin Luther and John Calvin, authority was rooted in the Bible. No wonder that in sixteenth-century Italy, there was a saying: "scuola di grammatica, scuola di eresia" (see the chapter with this title in Seidel-Menchi, 1987), or, "school of humanities, school of heresy."

As for the visualization tool called stemmatics, it took centuries of groundwork by philologists following in the wake of humanists such as Valla and Erasmus until the breakthrough could occur in 1850 with the publication of Karl Lachmann's edition of the ancient Latin poet Lucretius. Lachmann was able to show the family descent of the surviving manuscripts and to take an imaginative leap beyond the surviving witnesses of the text to derive the characteristics of their common ancestor, or what we call the archetype. Lachmann was able to show that this lost manuscript, called *Omega*, contained 302 pages with 26 lines to a page. He was also showed that the archetype was a copy of a manuscript written in a minuscule hand, which in itself was a copy of a manuscript of the 4th or 5th centuries written in rustic capitals. These results were astounding and constituted a kind of reverse-engineering of the thousand-year process of scribal copying. Since Lachmann, the use of a genealogical table to visualize the family relationships of the manuscripts of ancient authors has become a standard practice. Sometimes the picture that emerges can be quite complicated. But precisely for that reason visualization has proven to be a useful technique in the field of stemmatics because it makes apparent emergent properties that might otherwise get lost in the overwhelming mass of data (cf. West, 1973: 7-59). In the field of archaeology, we had to wait over a century for a similar breakthrough in data visualization. I refer to the Harris matrix, which was invented in 1973 (Harris, 1989). We might note that in the field of the old liberal arts, the criterion of success was never beauty, a concept not part of the humanists' critical vocabulary before the development of the new field of aesthetics in the eighteenth century (Kristeller, 1990: 186, 196-204).

5 The Modern Model

As noted, Lachmann lived in the nineteenth century, and this was the time when Crosby's New Model started to pass out of fashion. Some of the major features that a detailed version of this paper would have to delve into include the development of the modern research university by Wilhelm von Humboldt; the resulting explosion of specialized knowledge with an attendant breakdown in communication, ultimately leading to C.P. Snow's two-culture thesis (for the influence of the Germanic model in the U.S.A. see Lucas, 2006: 177-181); rapid progress in basic scientific knowledge leading to what can be called the *Modern Model* for science; and inevitable repercussions positive and negative on the artists of both the ancient and of the modern model. If language reflects consciousness, then it is doubtless significant that it was toward the end of the nineteenth century that the term "science" in its contemporary sense replaced the ancient term "natural philosophy" still used by Galileo, Newton, and all the other early modern researchers in this field.

Let us start with what, for lack of a better term, I have called the Modern Model (figure 3). Crosby's account ends in 1600 so we should not be surprised that by the late 19th century his New Model had been replaced. The key development this time is less the addition of new tools to the knowledge-worker's toolkit than the end to which they are employed. Instead of the mimetic goal of the arts and sciences of the New Model, now scientists understood their tasks to be not so much modeling reality as exploring the properties and limits of the models themselves. We may simplify and say that play replaces mimesis, though we hasten to note that play can be a very serious thing, as scholars of play (Smith, 1984; Huizinga, 1955) and a popular cultural critic such as Steven Johnson—author of the popular book *Everything Bad Is Good for You* (2005)—would insist.

Modern Model: Logic, Mathematics, Visualization, Thought Experiments

Greek	Latin	English
τέχνη	*Ars*$_3$	Art
□πιστήμη□□□	*Scientia*$_3$	Knowledge

Goal: playful representation

Figure 3. The Modern Model.

"Science$_3$" is what we may call this new, ludic kind of science, of which Osiander was the harbinger.

An early influential exponent of the Modern Model was the late nineteenth-century physicist Ernst Mach, who wrote:

> If ordinary 'matter' must be regarded merely as a highly natural, unconsciously constructed mental symbol for a relatively stable complex of sensational elements, much more must this be the case with the artificial hypothetical atoms and mole-cules of physics and chemistry. The value of these implements for their special, limited purposes is not one whit destroyed. As before, they remain eco-nomical ways of symbolizing experience. But…we are on our guard now, even in the province of physics, against over-estimating the value of our symbols (Mach, 1914: 310).

So for Mach, as for Ockham and the nominalists of medieval philosophy (Dupré, 1990: 39-40), the work of scientists is a mental construct, and it is going too far to take concepts like atoms and molecules as really existing parts of reality. Of course, in Mach's lifetime, atoms could not yet be seen under the microscope. That was not to happen until the development in the twentieth century of the electron microscope and the One-Ångstrom Microscope. Moreover, as a brilliant student of optical illusions, Mach had reason to distrust the evidence of the senses. And if Mach downplayed the role of observation, he also was dismissive of logic as a tool of discovery.

Thus syllogism and induction do not create new knowledge, but merely make sure that there is no contradiction between our various insights and show clearly how these are connected, and lead our attention to different sides of some particular insight, teaching us to recognize it in different forms. Obviously, then, the genuine source from which the enquirer gains knowledge must lie elsewhere (cited *apud* Pojman, 2008).

So in his version of the Modern Model, the emphasis necessarily falls on mathematics and modeling. The poster boy for this was, of course, Albert Einstein.

As Science$_3$ developed and succeeded, it caught the interest of government, especially in time of war. The most obvious example is the Manhattan Project, which gave us the atom bomb and proved that Einstein's famous thought experiments of roty years earlier were very serious and deadly games indeed. The atomic bomb reminds us that the game of the modern model was one that was not arbitrary and purely fanciful but was played according to the rules of the "falsifiability" principle of Karl Popper (Popper, 1965). It also reminds us that by now science had evolved from the activity of isolated indivudals or small research groups into a large-scale, collaborative Enterprise. According to the US government, at its peak, the Manhattan Project employed more than 130,000 people (www.cfo.doe.gov/me70/manhattan/retro spect. htm). In the era of Big Science (Weinberg, 1961), collaborative research by teams of researchers has become the norm. Scientific papers no longer have a single author, and lists of dozens or hundreds of co-authors are by no means unusual.

Meanwhile, other knowledge-workers were implicitly operating on the assumption that if scientific research is a mental construct, then it need not necessarily take its point of departure from observations of reality but can become a self-reflexive activity. By "self-reflexive" I mean that it can take the methods and procedures of science and imagine what would happen if the reality-based constraints were removed. The clearest example of this is non-Euclidean geometry, which was developed in the 1820s and 30s by Bolyai and Lobachevsky. It takes as its point of departure the assumption that parallel lines do meet and works out the consequences. Bolyai "ends his work by mentioning that it is not possible to decide through mathematical reasoning alone if the geometry of the physical universe is Euclidean or non-Euclidean; this is a task for the physical sciences" (anon., 2009A). Of course, twentieth-century physics did find that in certain respects the universe is non-Euclidean and that non-Euclidean geometry—especially as developed by Riemann—is thus very useful. But in terms of the research program of the Modern Model, that is almost beside the point. In the early twentieth century, we can cite the mathematics of David Hilbert, who held that "mathematics is…a series of games" (Anglin, 1996).

In the fine arts, too, a major shift had occurred away from mimesis toward ludic self-reflexivity, which we may call Art$_3$. This is doubtless related to the invention of the daguerreotype in the 1830s and the even better calotype, invented by William Henry Fox Talbot in the 1840s. Now, for reality to be outputted through the use of optics or optical theory no longer required the assistance of an artist. Instead, visual data could pass through a lens and be recorded directly onto a photographic plate or film. Stereographic photographs were even given the status of "wholly reliable transcriptions of retinal images, themselves unfailing equivalents to the external world they signified" (Schiavo, 2003: 127). As Walter Benjamin (1968) put it, "photography freed the hand of the most important artistic functions which henceforth devolved only upon the eye looking into a lens." And, as Benjamin also noted, once freed, the hand of the artist no longer had to operate as the last cog in the wheel of mimesis. Instead, it could carry out the commands of the artist, who replaced the doctrine of mimesis with that of "*l'art pour l'art*, that is, with a theology of art" (Benjamín, 1968). Like Modern Science, modern art becomes ludically self-reflexive, more about itself than about nature. The history of modern art thus becomes the history of an ever-changing series of doctrines—Impressionism gives way to Cubism, Cubism to Dadaism, Dadaism to Surrealism, Surrealism to Abstract Expressionism, and on and on without stop, let us hope—at least if you enjoy the show as much as I do!

And what about artists in the original sense of humanists in the fields of grammar, rhetoric, and logic? Here, too, we can detect the Modern Model. This is particularly the case in philosophy, hermeneutics, and the sociology of knowledge, the foundational fields that inspire the day-to-day work of specialists in the various humanistic subdisciplines. All three are based on the same key idea found in Mach and in modern fine arts that the name of the game is reflexivity. In philosophy, one thinks here of Wittgenstein's late *Philosophical Investigations*, where the concept of the "Sprachspiel," or "language game," plays a key role. The Mach of modern humanists was perhaps the Heidelberg philosopher, Hans-Georg Gadamer, who died in 2002. His key work was published in 1960 with the ironic title, *Wahrheit und Methode*, "truth and method." The irony consists in the fact that, as was the case in Mach's system, in Gadamer's there is no method in the humanities that leads us to true knowledge in the sense of a mimetic repre-sentation of reality. Each individual lives in a set of particular historical circumstances that determine his behavior and outlook. When another individual—say a scholar in the humanities—looks back and tries to understand a text, painting, or other creation left by someone who lived in a different set of circumstances, there is no possibility of a completely shared understanding. This does not mean that we cannot understand a text, painting, or other human creation; only that we cannot understand it as its original author intended. We always understand it in our own way, no matter how much we try to be "objective," that is, to employ an historical method. Moreover, the work of art has a special property: it evokes a response in us and issues a challenge to us. Through interpreting a great intellectual achievement of the past, we do not simply express who we were before we opened the title page; we become transformed in our dialogical encounter with the object we are studying. In Gadamer, the work of art thus functions as Nature does in Mach: it is subject to interpretation, to what we might call "modeling," but not to straightforward mimetic transcription by a knowledge-worker in the manner of Galileo confidently describing the Milky Way, or Harris meticulously sorting out the relationships of all the stratigraphic deposits on an archaeological site.

6 The Postmodern Model

I conclude with our situation today, which is characterized by a Postmodern Model (figure 4). Like all preceding models, this model is not all-pervasive but sits atop archaic survivals of its predecessors, giving rise to a rich if seemingly contradictory state of affairs characterized both by neo-skepticism and neo-positivism in the arts and sciences. In the Postmodern model, the goal is no longer primarily play constrained by rules but playful, ironic self-consciousness. And its new discovery tool is informatics, an outgrowth of the Computer Revolution that started before World War II and took off in the post-war period. Informatics has been defined as "the study of the structure, algorithms, behavior, and interactions of natural and artificial systems that store, process, access and communicate information" (*Wikipedia*, "Informatics," seen June 15, 2009). The science that results from using this new tool we may call Science$_4$.

If Crosby was the theoretician of the New Model, then Thomas Kuhn with his influential "paradigm theory" of science plays that role for the postmodern model. According to Kuhn's famous book, *The Structure of Scientific Revolutions*, first published in 1962, previous understanding of what science is was too often determined by reading textbooks (Kuhn, 1970: 10: Ziman, 1978: 38-42), not the actual communications of scientists. When we approach science through textbooks, everything is compendious and clear. Science marches ever onward and upward without error or detour. But that gives a very artificial sense of what science is really about, how it really happens. If the data of the theoretician of science focus on the process rather than the product, what is striking is less the neatness and positive results of science than its messiness and tentativeness. No discovery or theory is ever final; everything is subject to doubt, the requirement of replication, and the fate of reintegration into a new theory, or what Kuhn termed a "paradigm." Science is made by knowledge-workers organized into communities that are self-validating. Within these communities, all goes well during periods of what Kuhn calls "normal science" when a reigning paradigm accords well with the experimental results. But when this breaks down, a crisis and a "paradigm shift" inevitably occur. Moreover, the crisis may not arise only from discrepant data but from a change in world view. The world is seen differently, and different things are seen in the world. The paradigm shift involves a new metaphor that reorganizes the scene and exerts itself by force of its beauty, its aesthetics (Kuhn, 1970: 155).

Applying the lessons of Gestalt psychology—traceable to Mach's work on optical illusions—Kuhn shows how scientific revolutions can also arise from new ways of interpreting the text of Nature—something that Gadamer might have noted was an inevitable feature of the human condition. So the evolution of science is inevitable and unrelenting. This might lead to the depressing thought that all scientific knowledge is relative, that is, temporary. In the second edition of his book (1970), Kuhn tackled that head-on and came up with a Gadamerian answer: yes, in a sense all science is relative, but from the point of view of an individual or a particular generation of scientists you can still achieve the best theory possible given the state of the evidence and the compatibility of the theory with all other dominant theories in related branches of science. Relativity will mainly occur after your death, and even if it occurs while you are still alive, that is nothing to get depressed about because, according to Kuhn, scientists at heart are "puzzle-solvers" (Kuhn, 1970: 35-42, 206). Like devotees of crossword puzzles, they get pleasure from confronting ever-new puzzles to solve. I need hardly point out that puzzles are games, so Kuhn's theory has a strong ludic element. I would characterize it as simultaneously neoskeptical and neopositivistic. For the individual, it presents a view of science in which positive knowledge can be obtained; looking at the *longue durée*, Kuhn's picture is skeptical about the persistence of any single brick in the structure of knowledge.

Postmodern Model: Logic, Mathematics, Visualization, Thought Experiments, Informatics

Greek	Latin	English
τέχνη	*Ars*$_4$	Art
□πιστήμη□□□	*Scientia*$_4$	Knowledge

Goal: interactive representation

Figure 4. The Postmodern Model.

Of course, since Kuhn's book appeared, the scientists have continued solving the crossword puzzle of Nature with no sign of any slowdown caused by mental depression. To the contrary, the collaborative teams characteristic of Big Science in the Modern Model have become what Caroline Wagner calls the *Invisible College* of massive numbers of scientists dispersed around the world linked by the Internet where they apply grid computing to ambitious collaborative projects (Wagner, 2008: 1-14). The central, enabling role of informatics in such new scientific projects is striking.

The field of physics gives us an excellent example: CERN's Large Hadron Collider, or LHC. In the LHC, two beams of hadrons will shoot in opposite directions through the accelerator. When the beams collide, the energy will be high enough to simúlate conditions in the early universe. The particles that are generated may confirm or force revision of the Standard Model. These collisions are detected by sensors whose data are digitally expressed and processed at a rate of an estimated 300 GB/second, 27 TB/day, or 15 PB/year. They are so massive that they have to be culled for "interesting events" at an estimated rate of 300 MB/second in order to be processed by software and made available to thousands of scientists tied remotely to CERN through the LHC Computing Grid (*http://public.web.cern.ch/public/en/LHC/ LHC-en.html*, seen June 10, 2009). In other words, in postmodern physics, scientists study not the immediate sensory presentations of Nature but their digital representation. If these are created in a methodical, accurate way, the results can be no less valid than what can be learned from their real-world equivalents. But, of course, in postmodern science, the real-world objects of study are generally not subject to direct observation and manipulation because of constraints of time, distance, or scale.

Physics is not the only field where we can see this informatic turn. With the decipherment of the human genome, humanity has become self-conscious of its own coding and integration into the biosphere. The new fields of bioinformatics and computational biology have emerged in recent decades at the very center of the life sciences, bringing us such research programs as genomic sequencing, comparative genomics, and the modeling of biological systems, to name just a few hot areas. This is because, as with the LHC's subatomic particles, the genomic code is understood not directly but through its digital representations, and these are analyzed computationally. Thus, with the introduction of informatics, biology moves from a discipline primarily devoted to observation and experimentation to one reliant for new advances on the manipulation and analysis of digital data and models.

As with the previous three models, we once again find parallel developments in the fine and liberal arts. Specialized shows such as Ars Electronica and SIGGRAPH regularly feature the work of digital artists. They are also gaining access to our major museums. In 2008, the foyer to the Getty Center featured Tim Hawkinson's *Überorgan,* a large multimedia structure combining balloons, pipes, and music. The music is based on hymns, fragments of which are randomly activated by sensors as viewers pass by the installation. The artist describes it as follows:

> …the switches reinterpret the [musical] score. One would kind of flip-flop the orientation of the notes to the keyboard so that what's normally played at the high end is played at the low end. Another switch is the key that it's played in. All these switches are being activated kind of spontaneously just by viewers going through the space so there's no telling when it's going to shift. And so it really is played out a different way each time someone passes through (Hawkinson, 2008).

As those of us who have been fortunate enough to experience it can attest, the Überorgan plays *for* us and *with* us. Those who have not seen it can enjoy it vicariously on YouTube. Works of art like the Überorgan are excellent emblems of the informatic and interactive spirit of our age, which they both reflect and help to create. They also exemplify irony, as does much of body and performance art of the past several decades: they can never be repeated and only rarely preserved or documented. If one of the original drives behind the creation of art was an individual's desire to leave a mark or to create a monument recording his existence, then postmodern art does not fulfill this basic human need. But what postmodern art is good at doing is transcending the boundary betwen the individual artist and his audience. Now, the audience participates in the performance and helps co-create the art as it is experienced in ever new ways. And postmodern art also clearly illustrates how the boundaries between science, art, and technology have become very blurred. We may call it Art$_4$.

Play: The Video Games World was an enormous show with over 300 video games held at the Palazzo delle Esposizioni in Rome in 2002. In the summer of 2008, the Vancouver Art Museum held a show dedicated in part to video games as art, with exhibition of games such as the Sims, Grand Theft Auto, and Super Mario World. Increasingly, the game is not only the spirit of art, as it was in the Modern Model, but its very content. But in contrast to pre-digital games, the new games are interactive, with shifts of situation caused either by the human players, the randomized algorithms of the game, or both. The new postmodern aesthetic is thus no longer based on the traditional concept of mimetic content wrapped in a static, simple and symmetrical Beauty, on Kant's notion of the aesthetic experience as "disinterested contemplation" by an isolated viewer (Kant, 1982, para. 1-22). It is grounded instead on the aesthetic object's ability to engage through dynamism, adventure, imagination, and curiosity-arousal in a social context. One might make the case that the new aesthetic is indeed a conscious and enthusiastic embrace of Horace's monster, an impulse, "to destroy beauty," as the artist Barnett Newman characterized modern art in 1948 (*apud* M. J. Milliner). But we must also note that the new aesthetic is also Gadamerian in emphasizing the dialogical relationship of the observer, the other, and the art-object.

We should note in this regard that along with the new aesthetics is a complementary new anthropology associated with the discovery of mirror neurons by neuroscientists. In brief, a mirror neuron is:

> …a neuron which fires both when an animal acts and when the animal observes the same action performed by another animal (especially by another animal of the same species). Thus, the neuron 'mirrors' the behavior of another animal, as though the observer were itself acting. These neurons have been directly observed in primates, and are believed to exist in humans and other species including birds. In humans, brain activity consistent with mirror neurons has been found in the premotor cortex and the inferior parietal cortex ([anon., 2009B].

The first consequence of this discovery is the realization that mimesis is itself a game—indeed the first, constitutive primate game, which begins in humans in the first minutes after birth (Iacoboni, 2008: 47, 49). The second is that there is no isolated individual but only a constant redefinition of the individual self as it interacts with another self (Iacoboni, 2008: 133, 257). The third is that intersubjectivity is neurological (Iacoboni, 2008: 152, 155, 262-265). The fourth is that interactivity—whether real or virtual—is an essential part of what makes us human. This fact alone justifies the enormous project currently underway to make our media interactive (see Svanaes, 2000) and suggests that the future of virtual archaeology is bright indeed. The interactive digital cultural object is an expression and agent of our sense of cultural identity. With this realization comes a duty: it is incumbent on us as virtual archaeologists to understand the phrase "our sense of cultural identity" in as cosmopolitan a way as possible. Otherwise, the wonderful tool of interactive digital cultural objects can quickly become a weapon used by one particular culture to promote itself against all the others (Frischer, 2006).

In the humanities we have passed through the neoskeptical phase of poststructuralism when theoreticians like Jacques Derrida and Umberto Eco have wondered whether there is any method or criterion to limit how we interpret a work of art; or if, as Eco asked, it is "open-ended universe where the interpreter can discover infinite interconnections" (Eco, 1992: 39-40). But next to this skepticism run riot we also have something akin to the Large Hadron Collider, the so-called digital humanities generally and virtual archaeology in particular. Of course, since we are talking about the humanities, long the poor cousin of academic disciplines, we are comparing a mountain to a mouse in terms of the scale of the enterprise and its cost.

The digital humanities can be defined as the application of information technology as an aid to fulfill the humanities' basic tasks of preserving, reconstructing, transmitting, and interpreting the human record. The striking thing about this new field is how it has revolutionized many humanistic disciplines, making them resemble the natural sciences more than ever before in their long history. A case in point concerns collaborative research, something very rare in the humanities as recently as ten or twenty years ago. Now collaborative projects are sprouting up all over. The most impressive example is, of course, *Wikipedia*, started by Jimmy Wales in 2001. It proves what can be done, and how fast it can be done, when you invite the collaboration of just about everyone who is literate and speaks one of the world's major languages.

Digital humanists utilize advanced technology in various ways. Perhaps the most obvious way is simply the conversion of their objects of study—texts, paintings, buildings, and even whole cities—to digital format. Generally, this is quite simple and straightforward, and involves use of a new device that has revolutionized the field of archaeology: the 3D scanner. But sometimes 3D digitization is very difficult, as, for example, happened with our institute's complex project to digitize the Plastico di Roma antica, a enormous physical model of Rome in 320 CE (Guidi, Frischer, et al., 2007; Guidi, Frischer, et al., 2008). And even 2D digitization can sometimes still pose enormous challenges, as happens when you are trying to recover an ancient text scratched off a medieval manuscript, covered with another text, and then further damaged by fire. In pre-digital times, the only way such a scratched-off text—or "palimpsest"—could be read was if enough of the original letters survived that it could still be seen; or, if not, if you could pick up any faint traces through the use of ultraviolet light. But in the last decade, multispectral imaging has been employed with great success on a range of manuscripts. The most impressive example I can cite is the project to recover the texts of Archimedes and other ancient authors under the text of a thirteenth century monk's prayer book. Besides the normal difficulties encountered in reading any palimpsest, this particular medieval book presented the additional challenge that it was "charred by fire [and] devoured by mold" (Netz and Noel, 2007: 4). To read it, the humanist team of Reviel Netz and William Noel had to obtain the use of a powerful beam of synchrotron X-rays from the Stanford Linear Accelerator Center.

Scanning an object like a text or painting generally does not require such innovation and advanced hardware, but now that we have so many tens of thousands of digital representations of the artifacts humanists study, it is possible and even acceptable for the first time for humanists to use the tools of quantitative analysis, data-mining, modeling, and visualization. That is, like our colleagues in the sciences, we are able to make new discoveries by using digital technology to manipúlate and analyze the digitized representations of the objects we study.

Last year, I co-edited a book of pioneering studies showing how our new 2D and 3D technologies can act not simply as representations of knowledge but as tools for new discoveries (Frischer, Dakouri-Hild 2008). As an example, I would cite David Koller's project to scan in 3D and algorithmically reconstruct the 1200 fragments of an amazing map of ancient Rome made in about A.D. 210 at the enormous scale of 1:240. Thus far, Koller has published more than 20 joins (Koller et al., 2005; Koller et al., 2006; Koller, 2008), an amazing feat when you consider that scholars have been using traditional methods—their eyes and hands—to find joins for over four hundred years, so you would think that there are not still very many discoveries to be made.

The application of information technology in the humanities has also resulted in qualitative change to the way in which humanists have understood their central tasks of preserving, transmitting, and interpreting the cultural monuments of the past. Thus, from the Alexandrian librarians to Lachmann and other Classicists working in the Age of Gutenberg, philology was focused on reconstruction of the earliest version of an author's text and, ideally, of the autograph itself. This goal is understandable from many points of view, not least of all technological: when a text must be written in ink on a piece of papyrus or printed in ink on a piece of paper, then each word must be indelibly correct with respect to some base text. So the editor must make a single choice of which phase in the often long history of a text he will use as his base text. For the past twenty-two hundred years, since the Alexandrian librarian-editors Zenodotus and Callimachus, this choice has almost always come down in favor of the author's autograph or at least (if this is lost) the closest copy to the autograph. But in this decade, a new approach to philological editing has been developed—appropriately enough for Homer, the touchstone of the Alexandrians. Called a "multitext," this is a method that takes full advantage of one of the prime differences between print and digital publication, viz., the letters displayed on a computer monitor can be almost instantaneously changed. Based at the Center for Hellenic Studies in Washington, D.C., the "Homer Multitext" (Dué and Ebbott, 2007) has been described as follows:

> Instead of choosing between variants and 'plus verses' in an attempt to recover the *ipsissima verba* of Homer, we include them in a multitext format that embraces the fluidity of the textual traditions of the Iliad and Odyssey. The ideal medium for a multitext of Homer is not a traditional printed text but an electronic, web-based edition. Unlimited in its ability to handle complex sets of variants, an electronic multitext offers critical readers of Homer the opportunity to consider many possible texts at various stages of transmission. It allows the reader to select and navigate between multiple modes of transmission, and to recover a more accurate and accessible picture of the fluidity of the textual traditions in their earliest stages (www.stoa.org/chs/).

One can easily predict that the multitext approach to editing will spread throughout the humanities. It is based on the valid insight that, in the end, the author's autograph (still worth striving to reconstruct, even with the multitextual approach, as a valid stage in the history of the text!) is simply one of many versions, each of which has its validity, history, and impact. Indeed, what makes a text "classic" is, among other features, precisely the fact that its textual transmisión is long and complex: that is to say, the text has repeatedly become fixed and influential in different versions in ever-changing cultural situations. Digital technology is the perfect support for editing a text that does full justice to its classic stature.

In the humanities, as in the fine arts and physical sciences, digital technology is not only used to provide tools of discovery and communication but also interactive feedback. The work of digital humanities scholarship is never finished any more than is Hawkinson's *Überorgan*, a game of Grand Theft Auto, or an experiment in genomics or physics. The virtualizing of reality, and—via the virtual communities enabled by the Internet—of ourselves—means that we can study both Nature and its digital representation with equal confidence; indeed, we can no longer distinguish between the direct presentations of the senses and the processed presentations of our hardware, since today almost nothing is unprocessed (Frischer, 2008). True to our nature constituted by mirror neurons, we can enter into an endless loop of dialogue with our data, our virtual data, and our virtual colleagues. The endless dialogue that for Gadamer and Modernism played itself out between interpreter and object of interpretation from historical situation to situation now has become an embedded feature of postmodern culture. Or at least we have the opportunity to do so if we design our digital projects in ways that are "wiki"-based, which is to say open to contributions and modification by our users. In the case of virtual archaeology, this is the reason that my research team has been studying how we might create the world's first online, peer-reviewed journal in which digital archaeologists can publish their 3D digital models of cultural heritage monuments and sites in such a way that they can be run in real time. We call the proposed journal "SAVE," which stands for "Serving and Archiving Virtual Environments" (www.iath.virginia.edu/save/).

There are already several outlets where scholars can publish articles about their 3D models, illustrated by still shots or screen captures of video fly-throughs. *SAVE* will offer scholars the opportunity of publishing their models to the Internet with full interactivity, so that users can explore them at will. It will also offer peer-review, and require all models to be accompanied by metadata, documentation, and a related article or monograph explaining the history of the monument and its state of preservation, as well as an account of the modeling project itself. *SAVE* will furthermore provide secure transmission of the 3D models over the Internet, thereby protecting contributors' intellectual property.

SAVE is based on the model of "prosumption," a blurring of the gap between producers and customers in a situation where "customers participate in the creation of products in an active and ongoing way" (Tapscott and Williams, 2006: 126). The classic example cited by Tapscott and Williams is Second Life, which "has no preset script—and few limitations on what players can do. Residents create just about everything, from virtual storefronts and nightclubs to clothing, vehicles, and other items for use in the game" (ibid.).

SAVE might be thought of as Second Life for scholars. If Second Life harnesses human imagination to create a fictional world primarily for purposes of collaborative diversion and entertainment, *SAVE* intends to harness human creativity, disciplined by historical methodology, to recreate, with the greatest possible fidelity, the historical cultures that once actually existed across the globe. Thus the project of *SAVE* can be understood to mean collaboratively building up a virtual space-time machine that, absent true time travel, will offer scholars, students, and the general public the best opportunity we are ever likely to have to visualize the lost monuments and worlds of the past. That this activity is often carried on under the sign of "serious games" and "virtual worlds" is an indication of how closely the presuppositions of virtual archaeology reflect the Zeitgeist of the postmodern age.

So now, no less than in previous centuries, the boundaries between the arts and sciences are porous. For the first time on any large scale, scientists, technologists, artists and humanists are collaborating on projects that are epic in scale or in impact. On a more profound level, the similarity of the arts and sciences in tools and methods is becoming closer than ever. Of course, this does not mean that there are not exceptions. Indeed, this does not mean that the collaboration and similarity of which I speak is still exceptional. Earlier models in the sciences and arts—even the Ancient Model—continue to be applied by individual scholars. The adoption of the Postmodern Model is occurring at different rates in different fields and in different locations. But that there is a Post-modern Model more or less with the features I have described seems to me undeniable.

I think it is safe to conclude by asserting that if C. P. Snow were alive to observe how things have evolved since he gave the Rede Lecture fifty years ago, he would be very pleased, indeed, by this convergence between the arts and sciences. His lecture set off a debate in many countries about the need for general education requirements, interdisciplinary studies, and the like. By the 1970s, the reforms Snow called for were largely in place, at least in the United States. The timing could not have been better. When the Information Revolution occurred in the last decades of the twentieth century, a cadre of knowledge-workers was in place who had the training and values needed to apply what they had learned to exploit the new opportunities for communication and discovery afforded by digital technology.

So, I conclude by affirming that we owe a great debt of gratitude to C. P. Snow for his largely successful effort to open the door separating the disciplines of the sciences from those of the arts, but I must also note that, in the light of the relationship of art and science in the western world since the ancient Greeks, this door was relatively easy to push open.

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