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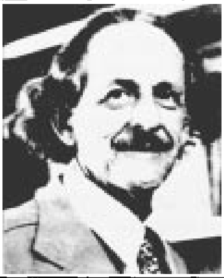

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Art and Science. Part 2. Science for Art's Sake

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Concluding a two-part discussion on connections between the worlds of art and science, this essay examines ways in which science and technology have been applied in art. Computer graphics, holography, and orbiting "space art" are discussed. Also considered are scientific techniques used to study, restore, and conserve art objects. This essay touches only briefly on a few of the aspects and issues involved in the study of art and science; it is a topic that will be addressed again in forthcoming essays.

In the first part of this essay, we began what is an admittedly formidable task: examining, in the limited space of these pages, various interrelationships and connections between the worlds of art and science.[1] We discussed some of the theoretical and historical connections between these two areas. We also examined a few instances in which images, although produced primarily for scientific purposes and by scientific means (such as the electron microscope), possess qualities of form, composition, and aesthetic appeal that undeniably qualify them as "art." In this second part of the essay, we will look at relatively new media in which science has been applied *expressly* for the creation of art. We will also discuss the use of scientific techniques in the restoration and preservation of artworks.

Computer Art

The computer is one scientific tool that has been pressed into service for artistic ends. These days, in the aftermath of the "computer revolution," with fairly sophisticated personal computers and graphics software now available even in toy stores, it may be somewhat difficult to think of a time when creating graphic, artistic images on computer was an unusual, even revolutionary, activity.

Artist and computer-graphics consultant Frank Dietrich, Palo Alto, California, discussing the history of this medium, dates the development of computer art to 1965, when the first exhibitions were held in the US and the Federal Republic of Germany (FRG).[2] This art form was initially developed not by artists, but by scientists; Dietrich mentions in particular Bela Julesz and A. Michael Noll, Bell Laboratories, Murray Hill, New Jersey, whose artistic efforts derived from their research on visual phenomena, such as visualization of acoustics and the foundations of binocular vision.[2] Noll is one of several scientist-artists profiled in *Science & Technology in the Arts*, a book examining ways in which art and science were blended in a variety of media and applications, particularly during the late 1960s and early 1970s.[3]

Dietrich traces the first decade of computer art, encompassing the development of the first graphics languages and the advent of the microcomputer. He mentions the work of Harold Cohen, an artist who learned programming and "taught" a computer to emulate his style. Cohen's expert drawing system, created in 1973 at the Stanford University Artificial Intelligence Laboratory, California, is dubbed Aaron. Cohen's program for Aaron included a repertoire of forms and shapes, the ability to establish compositional relationships between these forms, and a system of rules to guide the computer in creating never-ending variations with a distinctive style.[2] Cohen and Aaron, along with full-color reproductions of Aaron's work, have been featured in the popular press.[4]

The world of computer-generated graphics has expanded phenomenally since its infancy 20 years ago. A recent article in *THE SCIENTIST®* discussed the latest applications of computer graphics in scientific simulation.[5] Computers developed for simulation, design, and image-processing are also providing vivid and striking works of art. One example is the work of David Em, a computer technician at the Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California. Using programs developed to simulate the surfaces of planets, Em has created a variety of colorful and fantastic images, some of which were featured in a recent issue of *Smithsonian*.[6] Quoted in the article, Em likens his studies of electronic light to the studies of natural light undertaken by the painters of the Impressionist school.

With computer graphics and animation now being employed in numerous fields—not only in science and industry but in motion pictures, advertising, and publishing—more and more schools are offering courses in computer graphics. The School of Visual Arts, New York, now offers a Master of Fine Arts degree program, believed to be the first graduate program in computer arts.[7] Discussing the future of computer art, scientist-artist Herbert W. Franke, Puppling, FRG, points out that the field is immature, since computer technology itself is a relatively new science that is still evolving. Franke assesses the impact of developments in high-resolution and three-dimensional imaging. He also notes that in the future a combination of computer graphics and holography can be expected.[8]

Holography, of course, represents another merging of art and science. I have discussed this technology previously, in connection with a piece of artwork at ISI®: "World Brain," by Gabriel Liebermann, a unique holographic engraving.[9] Liebermann recently returned to Philadelphia to tell me of his new ventures in computer graphics. He has formed a new company called Imag:Graphix in Fremont, Nebraska.

In his 1972 book *Science and Technology in Art Today*, Jonathan Benthall, Royal Anthropological Institute, London, UK, discusses various technological art forms that were emerging in the early 1970s—including holography. As he notes, the theoretical concepts of holography were stated as far back as 1947; it was the invention of the laser in the early 1960s, however, which furnished the source of required "coherent" light waves, that made full implementation possible.[10] Creating a hologram involves directing a beam from a laser through a mirror, which splits the beam in two. Half the beam is directed at the subject; the light waves are diffracted by the features of the object and are reflected through a piece of exposed film. The other half of the beam shines directly onto the film to act as a reference. The resulting "interference pattern" becomes the basis for the hologram—a three-dimensional, perfectly detailed image of the object.

Within the art world, holography has been somewhat slow to achieve recognition and respect, according to Chris Titterington, assistant curator of photographs, Victoria and Albert Museum, London. This is beginning to change, however; in Titterington's own museum, the photography department has begun to acquire and show holograms as part of its main collection. Titterington discusses several notable examples of holographic art, including new works by Susan Gamble and Michael Wenyon, who in 1987 were appointed artists-in-residence at the Royal Greenwich Observatory, Sussex, UK. Among their many projects are holograms based on experiments set out in Sir Isaac Newton's *Opticks*.[11] Holographic artist Margaret Benyon and physicist John Webster also review holography, discussing their own work as well as the important early contributions by such artists as Bruce Nauman, Carl Frederick Reuterswärd, and Peter Nicholson.[12] The work of Soviet holographers should not be overlooked. Some years ago in London, in fact, while en route to Moscow, I encountered a contingent of scientists from Leningrad who were exhibiting their holograms as part of a Soviet exhibition entirely devoted to the topic. I had read about the exhibition in *New Scientist*.[13] After dinner at a London pub, I was presented with some striking holographic representations of jewels from the Kremlin Museum. When I arrived in Moscow, this caused some temporary consternation in the customs department.

Computer graphics and holography, although highly technical in nature, are at least earthbound phenomena. Recently, controversy flared over proposals to place art in an entirely new environment: Earth orbit. Artist Pierre Comte, Paris, France, discusses the ARSAT (for "art satellite") project that he initiated. The plan involves launching a satellite aboard a conventional rocket. Once in orbit, the satellite would automatically inflate and expand into a system of "masts" supporting an ultralightweight, square sail. Designs for various versions of this reflecting satellite range from one covering 20,000 square meters to a "Helios" version covering 300,000 square meters. A photograph in Comte's article shows a model of the Helios ARSAT dwarfing a comparably scaled model of the Eiffel Tower.[14]

As it happens, the Eiffel Tower figured prominently in the controversy surrounding "space art." As science journalist Gary Taubes reports, ARSAT was runner-up in a contest devised by the New Society for the Promotion of the Eiffel Tower to celebrate the structure's 100th birthday. The winner was another proposed space satellite, the Ring of Light, a giant necklace of 100 mylar balloons, each 18 feet across. Together, the balloons would reflect enough sunlight that the loop, 15 miles in circumference, would appear plainly to the naked eye in the night sky, in a size comparable to that of the full moon.[15] (ARSAT, according to Comte, would shine with "10 times the brilliancy of the full moon."[14])

Astronomers, whose observations depend on highly light-sensitive instruments, raised an immediate cry of protest. Paul Murdin, Royal Greenwich Observatory, for example, in a *New Scientist* piece entitled "Art vs. science: the battle for the stars," pointed out the considerable potential for irreparable damage to the light-detectors and other delicate instruments used with telescopes. Along with condemning the Ring of Light, Murdin decried the prospect of ARSAT, noting that such an object passing within sight of an observatory would render the observation of other celestial objects virtually impossible.[16] Because of the vehement objections of the astronomical community, plans for the Ring of Light were eventually abandoned.[17]

Science in the Service of Art

If the furor over orbiting art represents one area where science and art come into conflict, the use of scientific techniques to study, restore, and conserve artworks (and to protect their integrity against the determined efforts of forgers) demonstrates a more harmonious and beneficial relationship (although, as we'll see, even this area is not entirely free of disagreement).

Many of the scientific techniques used to study artworks are reviewed by Robert L. Feller, Research Center on the Materials of the Artist and Conservator, Mellon Institute, Carnegie-Mellon University, Pittsburgh, Pennsylvania. For example, much useful knowledge about pigments, dyes, and other materials used by past artists has been provided by neutron-activation analysis. This technique, in which elements made radioactive by bombardment with neutrons are identified through their decay characteristics, provides a "fingerprint" with which to distinguish the sources of minerals that may otherwise be very similar. This fingerprint can help pinpoint the likely date and source of materials in a particular work, helping to resolve questions about its origins or authenticity.[18]

Feller describes a battery of other techniques, such as thin-layer chromatography and high-pressure liquid chromatography, which are employed to characterize colorants. Carbon-14 dating is also used to assess and authenticate the wood, canvas, and other materials in artwork. Feller also discusses various imaging techniques, such as X-ray imaging, autoradiography, and infrared photography—all of which are telling art historians more about how artists applied their materials.[18]

Stuart Fleming, scientific director, Museum Applied Science Center for Archaeology, University Museum of Archaeology and Anthropology, University of Pennsylvania, Philadelphia, discusses in particular how scientific methods are used to detect art forgeries. X-ray photography, for example, can reveal hidden images underneath a painting's surface. These details become visible when the X rays are absorbed by the heavier elements in the pigments used in both the surface and the underlying paintings.[19] Often it is the artist who has painted the images underneath the surface, using and reusing canvas in an effort to conserve valuable materials. Occasionally, however, a tellingly anachronistic image is revealed—a subject in seventeenth-century garb, for example, under a painting ascribed to a fifteenth-century master.[20] In this way, unfortunate curators discover that one of their most prized paintings is not quite what it seemed. Other applications and procedures pertaining to radiographic analysis of paintings are discussed by A. Everette James, Jr., Department of Radiology and Radiological Sciences, Vanderbilt University School of Medicine, Nashville, Tennessee, and colleagues.[21]

Infrared photography has also been useful—for example, in detecting undersketches consisting of charcoal and bone black, neither of which permits significant X-ray absorption. Still another technique is autoradiography—in which a painting on a canvas is rendered slightly radioactive by exposure to low-energy neutrons, thus transforming various elements in the pigments into radioactive isotopes. Through the decay of these isotopes, areas of pigment containing mercury, manganese, copper, sodium, and other elements can be detected.[18,20] As Fleming notes, this method was effective in uncovering the work of a turn-of-the-century imitator known as "The Spanish Forger," who specialized in fifteenth- and sixteenth-century Renaissance works. Autoradiography of his paintings revealed the presence of emerald green, a copper arsenite not known to be used by artists until after 1814.[20]

Scientific methods are applied to artworks not only to evaluate them, but to restore and conserve them. Physicist John F. Asmus, University of California, San Diego, discusses the use of high-intensity light, including lasers, to halt the erosion of outdoor sculpture caused by oxides of sulfur and other pollutants in the air. Laser action, he points out, which constitutes a "lesser attack" on the stone than would occur through mechanical or chemical procedures, promotes the emergence of a "favorable patina" on a cleaned surface. In addition to the divestment of black sulfation from marble, notes Asmus, laser cleaning techniques were successfully tested in removing tarnish from silver threads in ancient textiles, corrosion from bronze, and encrustations from stained glass, among other applications.[22]

Restoration, however, has also engendered its share of conflict—or, at the very least, philosophical differences of opinion. The cleaning and restoration of the Sistine Chapel in Rome, for example, has occasioned a whole new view of Michelangelo's painting style. The vivid and fanciful colors being uncovered strongly contradict the long-held image of Michelangelo as a restrained and sober colorist.[23] While many scholars and historians applaud the opportunity to reassess a master's work, some remain skeptical. James Beck, for example, discussing the Sistine Chapel project in *Arts Magazine*, writes of the "irreversible character" of such "radical restorations." Noting other recent instances in which initially vivid restorations of works have now turned flat, he wonders what effect the cleaning will have on the frescoes in years to come. He questions whether it would have been "safer and sounder" to wait until the techniques were absolutely certain not to disrupt the integrity of the frescoes.[24]

Restoration also raises various ethical questions, as discussed by Michael Wreen, Department of Philosophy, Marquette University, Milwaukee, Wisconsin. Wreen considers the example of Michelangelo's *Pietà*, damaged in 1972 by a disturbed man wielding a hammer and subsequently restored to its original appearance. Such an instance, as Wreen notes, inspires debate between purists, who argue that this kind of restoration (he terms it *integral* restoration) is objectionable since it is not the work of the original artist, and those (Wreen among them) who find such restoration aesthetically acceptable.[25] Needless to say, the ethics of restoration and conservation make for a very involved philosophical issue.

On the Study of Art and Science

As I mentioned in the first part of this essay, this is a large and complex topic, not

Table 1: Selected list of associations and organizations that promote and study the use of science and technology in the arts and/or promote the interaction of artists and scientists.

American Institute for Conservation of Historic and Artistic Works
3545 Williamsburg Lane, NW
Washington, DC 20008

Association for Preservation Technology
Box 2487, Station D
Ottawa, Ontario K1P 5W6, Canada

Association of Medical Illustrators
2692 Huguenot Springs Road
Midlothian, VA 23113

Computer Arts Society
50-51 Russell Square
London WC1B 4JX, United Kingdom

Guild of Natural Science Illustrators
P.O. Box 652
Ben Franklin Station
Washington, DC 20044

International Arts-Medicine Association
19 South Twenty-Second Street
Philadelphia, PA 19103

International Committee of ICOM for Conservation
Research Laboratory, Museum of France
34, quai du Louvre
F-75041 Paris Cedex 01, France

International Institute for Conservation of Historic and Artistic Works
6 Buckingham Street
London WC2N 6BA, United Kingdom

International Society for Music in Medicine
Sportkrankenhaus Hellersen
D-5880 Ludenscheid, Federal Republic of Germany

International Society for the Arts, Sciences, and Technology
c/o Roger Malina
P.O. Box 421704
San Francisco, CA 94142-1704

Society of Engineering Illustrators
c/o Robert A. Clarke
Autodynamics Corporation
30900 Stephenson Highway
Madison Heights, MI 48071

United Kingdom Institute for Conservation of Historic & Artistic Works
c/o Conservation Department
Tate Gallery, Millbank
London SW1P 4RG, United Kingdom

easily circumscribed or limited. Interestingly, however, we could locate no *Science Citation Index*® (*SCI*®) or *Social Sciences Citation Index*® (*SSCI*®) research fronts that pertain solely to art and science. This may be a measure of how broad and diffuse the field is. It should be noted, however, that we do not cluster the data from the *Arts & Humanities Citation Index*™ (*A&HCI*™) database, as we do with the *SCI* and the *SSCI* databases. Therefore, there are as yet no research fronts derived purely from *A&HCI* data. In spite of this, the *A&HCI* and related products are unquestionably pertinent to this discussion, covering many of the topics discussed here. Recently, the online *Arts & Humanities Search*® was mounted on DIALOG.

While we were unable to identify any "core" works through our standard co-citation clustering analysis, there are certainly works worthy of mention. C.P. Snow's 1959 book *The Two Cultures and the Scientific Revolution*, discussing the apparent gulf between science and the humanities, is one such work.[26] This book has been cited approximately 200 times since publication—a lower number than one might expect, considering how familiar the "two cultures" concept has become (perhaps the idea has been "obliterated"—so accepted into the common wisdom that it is no longer acknowledged by explicit citation). Arthur Koestler's *The Act of Creation*, examining creativity in various spheres (including art and science), is another applicable work.[27] This book has been cited approximately 400 times since publication in 1964. It is also important to recall that we have not yet created a *Book Citation Index* that would better reveal the impact of such works. This product is one that I hope ISI will be able to launch one day on CD-ROM!

The organizations listed in Table 1 also provide evidence of the breadth of and variety in this topic. Some of the organizations are involved in art conservation and restoration, while others pertain to scientific and medical illustration. We mentioned the International Society for the Arts, Sciences, and Technology, San Francisco, California, in Part 1 in connection with the journal *Leonardo*, which the society sponsors.

Another organization in Table 1, the International Arts-Medicine Association (IAMA), Philadelphia, was mentioned in our 1986 essay on poetry and science.[28] This group is devoted to exploring the relationships between activities in the arts and human health. Issues examined by the group include the health problems of performing and visual artists and the use of art as a therapeutic tool. This group also promotes the use of art to rehumanize health education and health institutions. IAMA members will be participating in the upcoming International Arts-Medicine conferences to be held in Jerusalem, Israel, this spring and in Palm Springs, California, in the fall.

Conclusion

This brief, highly arbitrary overview of selected issues in art and science has left a good deal of ground uncovered. The whole field of music—the technology of musical instruments, for example, or an update of my previous discussion of computer music[29]—was omitted here. Also left out was the subject of dance, another topic that is of considerable medical and scientific interest.[30] And there are countless other disciplines and issues to be examined. Clearly, this is a topic to which we shall return in the future.

* * * * *

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