Information Arts

Intersections of Art, Science, and Technology

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1.1

Art and Science as Cultural Acts

What do art and science have to do with each other? *Information Arts* takes an unorthodox look at this question, focusing on the revolutionary work of artists and theorists who challenge the separations initiated in the Renaissance. It points toward a possible future in which the arts can reassume their historical role of keeping watch on the cultural frontier and in which the sciences and arts inform each other.

Research has become a center of cultural innovation: its results are radically influencing life and thought. Our culture needs to participate in defining research agendas, conducting inquiries, and analyzing their meanings. Artists should be hungry to know what researchers are doing and thinking, and scientists and technologists should be zealous to know of artistic experimentation. The future will be enriched if this expansion of zones of interest becomes a part of the definition of art and science.

Scientific and technological research should be viewed more broadly than in the past: not only as specialized technical inquiry, but as cultural creativity and commentary, much like art. It can be appreciated for its imaginative reach as well as its disciplinary or utilitarian purposes. Like art, it can be profitably analyzed for its subtexts, its association to more general cultural forces, and its implications as well as its surface rationales.

Art that explores technological and scientific frontiers is an act of relevance not only to a high-brow niche in a segregated corner of our culture. Like research, it asks questions about the possibilities and implications of technological innovation. It often explores different inquiry pathways, conceptual frameworks, and cultural associations than those investigated by scientists and engineers. (I have adopted the convention of referring to scientific inquiry and technological innovation as techno-scientific research, even though their activities can be quite different.)

Anthropologists claim that we increasingly live in an "information society" in which the creation, movement, and analysis of ideas is the center of cultural and economic life. In our culture, scientific and technological information is a critical core of that information. This book is called *Information Arts* because the art of such a culture must address that information if it is going to be vital.

Here, then, are the questions *Information Arts* is attempting to answer:

What kinds of relationships are possible among art, scientific inquiry, and technological innovation? How might art and research mutually inform each other?

How are artists investigating techno-scientific research? How have they chosen to relate to the world of research? How does research further their artistic agendas?

How do art historians and cultural theorists understand the interactions between culture and research?

How do researchers conceptualize? What agendas motivate their work? What future developments are likely to call for cultural commentary and artistic attention?

A Quiz

We are at an interesting place in history, in which it is sometimes difficult to distinguish between techno-scientific research and art—a sign that broader integrated views of art and research are developing. The section below offers the reader a "quiz" to illustrate this point. It briefly describes research activities mentioned in this book. The reader is invited to determine which activities have been carried out by persons describing themselves as artists and which by those describing themselves as researchers. (For the sake of the quiz, all are identified as "researchers." Answers are provided at the end of this chapter.)

Research	Art	
—	—	Researcher J.T. developed a method of using genetic engineering to encode messages in bacteria.
—	—	Researcher S. developed an arrangement so that persons far away could control his body through electrical stimulation.
—	—	Researcher E.K. created a system in which several geographically dispersed participants shared the body of a robot that they mutually controlled.
—	—	Researchers C.E. and U.W. bred a line of mice with a special proclivity for eating computer cables.
—	—	Researcher P.D. developed a method for modulating sound onto the flow of dripping water.
—	—	Researcher J.M. developed a computer display that could visualize the underlying intellectual structure of a group of articles and books.
—	—	Researcher R.B. developed colonies of small robots with a repertoire of simple behaviors that can evolve complex intelligence skills through learning and communication.
—	—	Researcher H.S. developed a "fertility bra" that used pheromone receptors to flash indicators when the woman wearing it was in a fertile period.
—	—	Researchers created a video composite representation of participants in a video conference in which nonactive participants faded with the level of their activity.
—	—	Researchers at M.R. developed a device that is sensitive to hugs and can react to things it hears on the television.
—	—	Researcher R.G. invented a toilet with biosensors that provides instant urine-based analysis of biological characteristics, such as drug presence or emotional arousal levels.

Which is which? The confusion is a significant cultural event.

Revisiting the Relationship of Art and Techno-Scientific Research

Historical Separations

The arts and the sciences are two great engines of culture: sources of creativity, places of aspiration, and markers of aggregate identity. Before the Renaissance, they were united. Science was called natural philosophy. Philosophers were as likely to speculate about art and science as about religion and truth. Similarly, in tribal societies the philosopher, shaman, and artist were likely to be the same person. Visual and performance arts were integrated into the fabric of rituals and daily life. The artist who sang stories or carved ritual objects was likely to be the person who was especially observant and wise about the ways of the heavens, the weather, animals, plants, the earth, and life and death.

In the West, the Renaissance initiated an era of specialization. Science became codified as a segregated set of processes and worldviews. While its accomplishments in providing new understanding of old mysteries increased confidence in its claims, art moved in its own direction, largely ignoring the agendas of science. During the Industrial Revolution, science inspired technology and technology inspired science. Research and invention spread into every corner of life, but mainstream art seemed oblivious. Increasingly, it became less likely that an educated person would be well versed in both areas of culture. In the 1960s commentator C. P. Snow developed his influential "Two Cultures" theory[1] that concluded that those in the humanities and arts and those in the sciences had developed sufficiently different languages and worldviews that they did not understand each other. Note that this book will concentrate on the arts, but much of the analysis holds more generally for the humanities.[2]

The Urgency for Reexamination

Can art and science/technology remain segregated in the twenty-first century? *Information Arts* seeks to revisit the relationship of art to scientific and technological research, exploring the pioneering work of artists with emerging research and the prospects for future mutual influences. Several cultural forces combine to make a reexamination of the disconnection critical.

Influence on Life Technological and scientific research are spreading their influence into every corner of life, from medicine, communication, and government to domestic life, education, and entertainment. Commercial innovators scan for research in hopes of creating new industries and fortunes. In earlier eras, the influence of research seemed more limited; there were long periods of continuity in everyday life. How can the arts keep watch on the cultural frontier if they ignore such omnipresent features of life?

Influence on Thought Science and technology are changing basic notions about the nature of the universe and the nature of humanity. New communications technologies challenge ancient ideas about time, distance, and space. New probes peer into the biological heart of life and identity and the origins of the stars. All fields that ask philosophical questions, such as art, must take heed.

Critical Studies and Cultural Theory These disciplines challenge traditional ways of studying culture and question the wisdom of trying to understand the arts, humanities, and sciences in isolation from each other and of segregating "high" and "low" culture. Critical theory deconstructs long-standing sacred cows, such as science's privileged claims to truth and objectivity, as well as art's claims to a special elevated sensitivity. Artists and scientists are seen as creatures of culture, and their work is understood within larger psycho-political-economic-cultural frameworks. Critical theory takes on concepts such as truth, progress, reality, nature, science, gender, identity, and the body. The compelling energy of this analysis is one important indicator of the wisdom of tearing down the walls between disciplines such as art and science.

Artistic Activity The increasing level of artistic activity using computers, the Internet, and other areas of scientific interest suggests the impossibility of understanding the future of the arts without devoting attention to science and technology. Twenty years ago, when I first started my artistic experiments with computers, it was hard to find similarly involved artists or relevant critical perspectives. Now there is an explosion of interest. Some artists want to assimilate the computer to traditional artistic media, for example, by treating it as a fancy paintbrush or camera. Many others, however, recognize the computer as the tip of a techno-cultural iceberg. They understand that the most interesting work is likely to derive from a deeper comprehension of the underlying scientific and technological principles that have guided the computer's development, and from participation in the research flow that points to the technological future.

Organization of the Book

Information Arts aims to be a resource in the reexamination of the relationship between research and art. It proposes to accomplish this in several ways.

Presentation of Artists Artists have begun to engage the concepts, tools, and contexts of scientific and technological research, and their work is provocative and intriguing. No unified compendium of this work exists, yet this is the best source of information about new kinds of relationships between art and research in the future. I have conducted extensive research to identify artists working with scientific and technological research and have included both established and emerging artists. Where possible, I have incorporated excerpts of the artists' own statements, descriptions, and images. I have also offered commentary by others when useful.

Overview of Theory Cultural theorists, art historians, and artists have begun to write about many issues in techno-culture that are germane to the discussion of the relationship between art and science/technology. For each of the major sections of the book, I have presented brief overviews of theoretical writing on the topic and indications of controversies where they exist.

Overview of Research Agendas This book explores the possibility of viewing art and research as a unified cultural enterprise and of understanding researchers' worldviews—their goals, category systems, and visions of the future. For each section of the book, I present overviews of what practitioners in those fields see as the most important research agendas. Indeed, it is a basic premise of this book that art practice and theory in areas of science and technology can best proceed only with profound investigation of these agendas.

Methodology Creation of this book raised a wide variety of methodological questions: How does one locate exemplary artists and researchers working at the frontiers of inquiry? How does one assess the quality of works? How have my own biases affected the choices and analysis? These questions are considered in Appendix A: Methodology.

Sections of the Book I have organized the book using categories of research to differentiate sections. Sections cover major branches of scientific inquiry, such as biology, physical sciences, and mathematics, and areas of technological foment, such as computers, alternative interfaces, telecommunications, and robotics. Within each section, chapters focus on particular research arenas.

The Deficiency of Categorization

Artists resist categorization. Artworks are typically multilayered, addressing many themes simultaneously. Many artists purposely try to confound preexisting categories. The technology used may not be the most important element.

Why was this book organized in accordance with scientific disciplines and technological categories? How were artists and artworks placed in particular categories? As an author I confronted the challenge of developing an organizational system for considering art and artworks. Since *Information Arts* investigates the role of scientific and technological research, I adapted practical, low-inference categories focused on scientific disciplines and areas of technology. Thus, if an artwork used biological materials or sought to comment on biological issues such as genetic engineering, I placed it in the biology section of the book. The artist may or may not consider the link with biological research as important as many other issues addressed in the artwork besides biology. As an aid to preserving the way the artists framed their work, I have included artists' own descriptions and rationales wherever possible. Also, the overviews of theory relevant to the areas of research provide additional interpretive perspectives. The book attempts to cross-reference works that explore multiple research areas simultaneously.

How Does Research Function in Various Artists' Works?

The artists in the following chapters integrate techno-scientific research in a variety of ways. For some it is a central focus of their art; for others it is an incidental feature. Even for those for whom the connection is central, a variety of theoretical orientations shape their work. Here is a brief overview of the variety of approaches, starting with those in which the research is central. Note that any given artwork might mix several of these approaches.

Exploration of New Possibilities The artist's work itself functions as research into the new capabilities opened up by a line of inquiry. For example, in investigating artificial intelligence and speech recognition technology, artist Naoka Tosa created Neuro Baby, a computer-generated character that attempted to read the emotional tone of a visitor's speech and react appropriately (see chapter 7.6).

Exploration of the Cultural Implications of a Line of Research The artists use the new capabilities to create work that explores the narratives and conceptual frameworks that underlie the research. For example, artists David Rokeby and Paul Garrin created an installation called *White Devil,* which used motion detection technology to create a

video projection of a guard dog that snapped at visitors wherever they moved. In part, the installation commented on the implications of surveillance technology by using the technology itself (see chapter 7.4).

Use of the New Unique Capabilities to Explore Themes Not Directly Related to the Research The technologies provide a new way to address any number of issues not directly related to the technology. For example, my *Father Why* installation used motion detection to explore a variety of emotions related to my father's dying. Visitors' movements into the places of sadness, anger, nostalgia, and resignation activated sound events related to each emotion. The longer they stayed there, the deeper the exploration of that emotion. The event was mostly about these conflicting emotions; the movement detection provided a visceral way to ask visitors to confront them: How long would they stay with a particular emotion before they would need to flee by moving their body? (See chapter 7.4.)

Incidental Use of the Technology Research provides a wealth of new images and materials. Some artists find the new images intriguing or beautiful but are not especially interested in the underlying inquires that led to those outcomes or in their cultural implications. The power of the work presented in the following chapters suggests that all levels of involvement with the technology are valuable.

What Areas of Technological Art Are Included? Which Are Not?

When I started this project I hoped to create a comprehensive compendium of science-and-technology–inspired art. I defined art broadly to include media and the performing arts in addition to visual arts. However, I quickly realized that this comprehensive approach was impractical. The difficulties I encountered raised interesting questions in thinking about techno-scientific art.

What Is Technology? What Is High-tech Art?

Where should one draw the line? Every creation system beyond the basic apparatus of the body is a technology. At various points in history, charcoal, paints, sculpting tools and techniques, ceramics, and printmaking apparatus were state-of-the-art technologies. More recently, photography, cinema, electric machines, lights, radio, recording technology, and video were considered high technology. Now, however, when people talk about high-tech arts, they are not talking about these technologies.

Technological art is a moving target. The artistic gesture to move into an area of emerging technology that is radical in one era can end up being unnoteworthy a few years later. It takes an act of artistic vision and bravery to decide to work with techniques,

tools, and concepts from a still raw area of technology not yet accepted as a valid area for the arts. It is a challenge to work with a medium before anyone defines it as a medium. Yet several years later, when the technology has matured and a body of artistic work and commentary has appeared, the choice does not have the same meaning. At the early stages of an emerging technology, the power of artistic work derives in part from the cultural act of claiming it for creative production and cultural commentary. In this regard, the early history of computer graphics and animation in some ways mimics the early history of photography and cinema.

Information Arts generally focuses on art that addresses research activity emerging in the last seven years. I did not extensively consider video art, kinetic and light sculpture, sound art, electronic music, laser art, and holography. Although there continues to be experimental work in these fields, they are not currently considered emerging technologies, and they have well-developed aesthetic and analytic traditions of their own. *Information Arts* does not consider the popular media of science fiction, literature, cinema, and television, which offer interesting arenas of mutual influence between science and art but call for an analysis outside the scope of this book.

Because of the accelerated pace of technological innovation, even newer technologies are rapidly passing into the stage of institutionalization. Fields such as computer graphics, computer animation, 3-D modeling, digital video, interactive multimedia, and Web art, which were revolutionary a few years ago, have become part of the mainstream. Enormous amounts of work are being produced, the variety of aesthetic rationales has multiplied, and the technologies have been integrated into commercial software and media production. Artistic experimentation is quickly being assimilated. For example, computer graphic visual effects that represented innovative artistic exploration a few years ago are now part of the standard Photoshop filters available to the millions who own the software. Computer animations in 3-D and effects that were known only by a few media experimenters are now becoming standard features of movies and commercials. Interactive computer events that were of interest only to experimental artists fifteen years ago are now part of fields such as computer-assisted education and games. In one of the most remarkably speedy transformations, Web art experiments are devoured by the steamrolling commercial and media expansion of the World Wide Web almost as soon as they are invented.

This book will not consider computer graphics, computer animation, and digital video except at their more experimental fringes. Also, although it does consider artistic work with interactive computer media and Web art, a comprehensive analy-

sis of these rapidly expanding and commercializing genres is beyond the scope of this book.

The Assimilation of Art into Research and Commercial Production

The pattern of sequential technological invention, artistic experimentation, and commercial assimilation is a fascinating part of the story of how the worlds of art and research relate to each other, and is only partially analyzed in this book. Some of the artists described in the following chapters eagerly pursue product development for their artistic ideas, and some are supported as part of corporate research labs whose ultimate goal is economic exploitation. Others resist these connections and passionately defend their independence.

In part, this book is an examination of these questions: Where do researchers and artists get their ideas? How do they explore their ideas? How are techno-scientific research and art research different? What happens to the explorations over time? Does mainstream assimilation somehow destroy the validity of the work as art?

Definitions and Theoretical Reflections

Art, science, and technology are culturally laden terms. Indeed, debates over the boundaries of the terms *art* and *science* regularly engage philosophers and historians of art and science. What is art? What is science? What is technology? What are the similarities and differences among the three? What does it mean to call someone a high-tech artist? What is art that is influenced by science? What is science that is influenced by art? This chapter examines these questions, offers a brief clarification of my usage, and identifies shifting criteria that make a definitive answer elusive.

In recent years, critical theory has been a provocative source of thought about the interplay of art, media, science, and technology. Each of the major sections of this book presents pertinent examples of this analysis. However, in its rush to deconstruct scientific research and technological innovation as the manifestation of metanarratives, critical theory leaves little room for the appearance of genuine innovation or the creation of new possibilities. While it has become predominant in the arts, it is not so well accepted in the worlds of science and technology. This chapter analyzes the special problems that this disjunction poses for techno-scientifically influenced artists and examines various stances that artists can take in working with research.

Science and technology are sometimes conflated together; even scholars of the fields acknowledge some lack of clarity. Similarly, artists working with emerging technologies

and those inspired by scientific inquiries are often lumped together. This section explores these confusions.

What Is Science?

Science textbooks and philosophers and commentators on science propose a number of defining elements. This set of core ideas includes the following: an attempt to understand how and why phenomena occur; focus on the "natural" world; a belief in empirical information; a value placed upon objectivity, which is sought through detailed specifications of the operations that guide observation; the codification into laws or principles (wherever possible precisely expressed in the language of mathematics); and the continuous testing and refinement of hypotheses.

The underlying assumptions of the scientific approach are that the natural, observed world is real, nature is essentially orderly, and objectivity can be achieved through self-discipline and the reliance on techniques such as the calibration of instruments, repeatability, and multi-observer verification.[3]

This core encompasses variations in emphasis. For example, empiricists emphasize the role of observations, while rationalists focus on the logical processes of theory construction and derivation. Some stress induction built from observation; others focus on deduction drawn from theory.

Critical theorists see science as a modernist delusion. They see the self-constitution of scientist/observer as a continuation of cultural texts focused on domination and exploitation. They challenge the possibility of objectivity, noting the pervasive influences of gender, social position, national identity, and history. They focus on issues such as the social forces and metanarratives that shape the questions and paradigms used in inquiry; the role of socially constructed frameworks at all stages; and the interaction of the observer and the observed phenomenon. Radical constructivists doubt our ability to discover truths applicable across all times and cultures.

Many analysts have contributed to the critique of science. For example, in *The Structure of Scientific Revolutions,* Thomas Kuhn notes the way dominant paradigms shape the questions that get acceptance and support. In *Against Method,* Paul Feyerabend critiques assumptions of scientific rationality, noting that nature gives different answers when approached differently. In *Simians, Cyborgs, and Women: The Reinvention of Nature,* Donna Haraway analyzes the metaphoric language of science, its authoritative voice, and its unacknowledged patriarchal underlife. Having ethnographically studied life in laboratories, Latour in *Science in Action* proposes an actor-network theory of science in which organizations, persons, animals, and inanimate materials combine to shape scientific theorization. In *Picturing Science, Producing Art,* Peter Galison and Caroline Jones

investigate the way representation deeply influences the conceptualization and processes of research.

In the humanities, this kind of critique predominates. Scientists and technological innovators, however, believe in the ability to discover universal truths and assert that reform can overcome those places where scientific process falls short of its aspirations to universality and objectivity. As evidence of science's validity, they point to the accomplishments of the scientific worldview in building robust, cross-substantiating theoretical structures, and in predicting and controlling the material and organic world.

Any attempt to cross the disciplinary borders between art and science will confront this disjunction—today's incarnation of C. P. Snow's "Two Cultures" theory. Some of the artists in the following chapters have created works that join the critique, creating installations that highlight aspects of science that fail the classical hygienic view. Others implicitly accept the power of the canon, building on the formulations of prior research and using processes of experimentation and theoretical elaboration.

What Is Technology?

High-tech artists do not necessarily engage science. An examination of the relationship between technology and science is useful for understanding the range of artistic work related to research. Technology is seen as "knowing how," while science is seen as "knowing why." Engineers and technologists are seen as primarily interested in making things or refining processes, not in understanding principles. Many histories of technology are essentially histories of invention—the objects, tools, and machines that people made and the processes that made them.[4] Melvin Kranzberg and Carroll Pursell believe that this definition is too broad. In *Technology in Western Cultures,* they define it more narrowly, as

> man's effort to cope with his physical environment—both that provided by nature and that created by man's own technological deeds, such as cities—and his attempt to subdue or control that environment by means of his imagination and ingenuity in the use of available resources.[5]

The relationship of science to technology is quite complex; it became a focus for philosophers of science and technology. Contemporary definitions of technology sometimes call it applied science—the application of scientific principles to solving problems. However, since technology predates science, it should be seen broadly, as human attempts to shape the physical world: "[technology] for much of its history had little

relation to science, for men could and did make machines and devices without understanding why they worked or why they turned out like they did."[6]

Developers of technology used many techniques in refining their methods, including learning from other practitioners, observing all aspects of their environment, and experimenting based on instinct, and trial and error. The goal was rarely the development of scientific principles. Certainly, the experiments of many artists in finding appropriate innovations to accomplish their artistic goals could fit this description.

With the Industrial Revolution and the refinement of science in the eighteenth century, technology began to draw more on scientific understanding to help solve its problems. In the twentieth century, scientific research became a major source of new technologies, and most manufacturers included scientists in their industrial research labs.

Historically, technological research is considered somehow less "pure," and less lofty than science.[7] The origins of these attitudes lie deep in the history of Western culture. Among the Egyptians and the Greeks, fabrication was done by slaves or low artisans, and concern with the material world was considered less important than focus on more essential qualities:

> Making, even in the form of art, was often mistrusted as inimical to virtue or the pursuit of the highest good because it focused attention on material reality . . . [it] was not considered important as a contribution to the understanding either of the ends of human life or of the first principles of being.[8]

The distrust of "making" continued into the Christian Middle Ages. Just before the Renaissance, however, philosophers started to reexamine these notions. For example, in *City of God,* St. Augustine noted that technological accomplishments were the exercise of "an acuteness of intelligence of so high an order that it reveals how richly endowed our human nature is," as well as a sign of divine benevolence.[9]

With the Enlightenment came a positive attitude toward technological prowess. For example, Francis Bacon proposed that science should serve technological innovation, and suggested that the understanding of nature often becomes clear only when trying to manipulate it technologically:

> Bacon proposes a reconstruction of science to produce "a line and race of invention that may in some degree subdue and overcome the necessities and miseries of humanity." . . . Mind must utilize art and hand until nature "is forced out of her natural state and squeezed and molded" because "the nature of things betrays itself more readily under the vexations of art than in its natural freedom.[10]

Currently, science and technology work together and inform each other. Technology developers often must work in areas where scientific understanding is not sufficient. Attempts to develop real-world devices and solutions result in new scientific questions and understanding. For example, the development of new instruments—such as a more powerful collider—may give rise to new categories of questions in physics; the development of new medications may result in information about physiology and organic chemistry.

As researchers attempt to create technologies that simulate human psychic functioning, they create possibilities that then call out for scientific study. For example, computers, once created, become part of the natural world. Cognitive scientists and artificial-intelligence researchers create new insights about the nature of mind and society; user-interface researchers study the methods by which humans and machines can interact. Scientists are confronted by new questions about the nature of mind and the relationship of material reality to human thought. Technology and science goad each other into a parade of new disciplines.

Philosophers of science and technology continue to grapple with the nature of this relationship. Edwin Layton proposes an interactive model in which science and technology are seen as "mirror images" of each other, using common methods and drawing on common intellectual heritages; technology does not only exploit the "golden eggs" created by science.[11]

This interactive model of technology probably comes close to describing what is meant when something is called high technology, or high-tech art. High-tech artists, like their counterparts in technology development settings, are engaged with the world of science. They draw on theoretical formulation and research results from scientific inquiry. They use systematic methods of experimentation borrowed from science to advance their agendas. The results can inform further work by technologists and scientists.

Cyril Stanley Smith, a historian of science and technology, reflected on the relationship of technology and science and the role of artists in the process in his book *From Art to Science: Seventy-Two Objects Illustrating the Nature of Discovery.* In it, he observes that in the areas of chemistry, physics, and materials sciences, artists and artisans discover and use "subtle properties of matter" before they are even noticed by research scientists.[12]

This is the type of interaction that engages many of the artists in this book. Stanley wrote his book in 1978, before the digital technologies of communication, simulation, representation, and information had accelerated to their current levels.

One way to differentiate between science and technology is by intention. Technology developers usually focus on specific utilitarian goals, while scientists search for something

more abstract: knowledge. So what is the best way to describe the research undertaken by the artists described in the following chapters? Many focus on the interface between science and technology. A few concentrate more specifically on more classical "scientific" inquiries. Some act like technologists, seeking utilitarian applications of scientific knowledge and processes to further artistic goals. Others engage the scientific world in more open-ended inquiries analogous to those of scientists.

Throughout the book, the artists' work will return to questions about science and technology. What is the relationship of thinking and doing? What does it mean to view the analysis of mind and society as science? How pure can science be? What can we really know of the physical world, since it is seen through the lens of our conceptual frameworks?

What Is Art?

The art presented in this book is best understood within the context of the radical shift in the boundaries of "art" over the last century. Previously, art was produced in historically validated media, presented in a limited set of contexts for a circumscribed set of purposes, such as the search for beauty, religious glorification, or the representation of persons and places. Within a view that stresses conventional media and contexts, it is easy to wonder how the activities described in this book can be called art. However, this century has generated an orgy of experimentation and testing of boundaries. New technological forms, such as photography and cinema, have already raised questions about art. Artists have added new media, new contexts, and new purposes. The art world has assimilated much of this experimentation, of which a partial list follows:

- Extension beyond "realistic" representation (e.g., abstract painters)
- Incorporation of found objects (e.g., Picasso's collage and Duchamp's urinal)
- Movement into non-art settings and intervention in everyday contexts (e.g., Schwitters's Merzbau apartment and Russian AgitProp)
- Presentation of live art (e.g., Dada and Futurist performance)
- Use of industrial materials, products, and processes (e.g., Bauhaus, photography, kinetic art, electronic music, and Warhol's Brillo boxes)
- Conceptual art (ideas as art, with deemphasis of sensual form)
- Earth art (work with natural settings with resident materials)
- Interactive art (dissolution of the border between the audience and artists, for example, living theater and interactive installations)
- Performance and happenings (e.g., Allan Kaprow)

- Public art (work with site-specific materials, social processes and institutions, and community collaborators)
- Exploration of technological innovations (e.g., video, copiers, lasers, and holography)

This experimentation has left the philosophy of art in turmoil. It has become difficult to achieve consensus on definitions of art, the nature of the aesthetic experience, the relative place of communication and expression, or criteria of evaluation. However, there is some agreement on these features: art is intentionally made or assembled by humans, and usually consists of intellectual, symbolic, and sensual components. For example, the Getty Museum Program in Art Education offers this definition:

> Art-making may be described as the process of responding to observations, ideas, feelings, and other experiences by creating works of art through the skillful, thoughtful, and imaginative application of tools and techniques to various media. The artistic objects that result are the products of encounters between artists and their intentions, their concepts and attitudes, their cultural and social circumstances, and the materials or media in which they choose to work.[13]

Many of the artists described in this book use unorthodox materials, tools, and ideas inspired by the worlds of science and technology. Some are present in non-art contexts, such as laboratories, trade shows, the Internet, and the street. Some intend to intervene in everyday life or the worlds of science and technology. For many, the artistic rationale guiding their work is alien to the art world. *Information Arts* investigates these artists' work as a continuation of the expanding inclusiveness of the definition of art. Some of the work could even be viewed as the attempt to revisit unresolved issues from movements, such as conceptual art, and art and life interventions. Since the book explores the boundaries between art and techno-scientific inquiry, understanding the limits of art is significant. For example, on what basis can the work of researchers and techno-scientific artists be differentiated, or is such a distinction even important? The work and analysis of the artists described in this book contributes to this ongoing debate.

Although the institutional theory has many adherents, it is not universally accepted, as philosophers struggle to identify theories that can work in the face of the last century's experimentation. Some radical revisionists, claiming that the concept of art has been corrupted by the easy inclusion of the experiments, seek to reestablish some core definitions more closely related to historical forms. Others continue to search for a phenomenological basis for the aesthetic experience. Critical theory wants to explode the concept of art and questions its continued usefulness. The artists who work at the frontiers of science and technology throw fuel on the fire as they seek to move the definition of art

Although the art world has assimilated much of the historical experimentation, the gestures do raise perplexing conceptual problems: (1) Much of the public has not yet accepted these extensions as valid art. How can this long-lasting resistance be explained? (2) Some critical theorists deconstruct the actions of the avant-garde not as radical breaks, but as part of the cultural and economic structure of the art world. They point out the function of these gestures in generating novelty and note the ease with which the mainstream art world can assimilate them. They suggest that high art is not so different from popular media and question the viability of the category, "art."

to include their activities. *Information Arts* can be seen as an investigation of these moving boundaries and the cultural significance of including techno-scientific research in a definition of art.

Similarities and Differences between Science and Art

How are science and art similar? How are they different? This analysis is useful for understanding the prospects for future relationships.

Differences between Art and Science	
Art	Science
Seeks aesthetic response	Seeks knowledge and understanding
Emotion and intuition	Reason
Idiosyncratic	Normative
Visual or sonic communication	Narrative text communication
Evocative	Explanatory
Values break with tradition	Values systematic building on tradition and adherence to standards

Similarities between Art and Science

Both value the careful observation of their environments to gather information through the senses.
Both value creativity.
Both propose to introduce change, innovation, or improvement over what exists.
Both use abstract models to understand the world.
Both aspire to create works that have universal relevance.

In "Principles of Research," Albert Einstein stated that the artist and the scientist each substitute a self-created world for the experiential one, with the goal of transcendence.[14] In "The Contribution of the Artist to Scientific Visualization," Vibeke Sorensen describes artists as "organizers of large amounts of data"; "people who find unusual relationships between events and images"; and "creative interdisciplinarians." She continues:

> Artists are . . . people who create something completely original and new, something beyond the known boundaries of the information base. By using or inventing new tools, they show new uses and applications that synergize and synthesize fields. Artists push the limits of technologies, bringing them to previously unattained goals. Artists as well as scientists work with abstract symbols, representations for various realities and working tools. Even the language used by the two groups is similar. Scientists working with mathematics frequently describe a particularly good explanation or solution as "elegant" . . . The intellectual bridge of abstraction and aesthetic consideration is fundamental to both groups.[15]

A less benign critical analysis asserts that science and art both make questionable truth claims and attempt to create privileged positions, but in reality participate in the system of symbols and narratives that shape the culture.

In a paper entitled "Theoreticians, Artists, and Artisans," Feyerabend observes that scientists play a large role in creating the phenomena they study, suggests that science could benefit from art's awareness of absurdity and paradox, and notes the dilemma surfaced by Plato. The only way we can know pure being is by making inferences about it through imperfect senses that observe base matter. Plato considered artisans and artists as lowlifes who worked far from the core of a universe accessible only by contemplation. Feyerabend traces this distrust of observation to the present day, in which theoreticians are accorded higher status than empiricists.[16]

Feyerabend notes that scientists must create massive theoretical structures to link observation and the underlying "reality." Although scientists pride themselves on objectivity, they are similar to artists in their construction of artificialities.[17] He further asserts that difficulties arise from the extraordinary faith that science places in theoretical structures and the manipulations derived from them. He questions the wisdom of distrusting the world of real things and actions.[18] Feyerabend concludes that science is in many ways very similar to art, in which researchers build research structures and operations to represent their thoughts:

Crary further calls into question the very notion of a smoothly running, technologically ruled world. He critiques Jean Baudrillard's writings, saying that they exclude "any sense of breakdown, of faulty circuits, of systemic malfunction . . . of disease, and of the colossal dilapidation of everything that claims infallibility and sleekness."[22]

Along these lines, the movie *Blade Runner* is often cited as an example of a cyberpunk dystopia in which technology has helped to erode order and a sense of history:

[T]he city of *Blade Runner* is not the ultra modern, but the postmodern city. It is not an orderly layout of skyscrapers and ultra-comfortable, hypermechanized interiors. Rather, it creates an aesthetic of decay, exposing the dark side of technology, the process of disintegration, postindustrialization, and quick wearing out.[23]

Optimists, however, see information technologies as democratizing access to information, humanizing labor, deepening thought, building community, and empowering people throughout the world. Stewart Brand propounds some of these beliefs in his account of MIT's Media Lab:

We have already seen the arrival of personal computers make multitudes broader in their skills and interests, less passive, less traditionally role-bound. That's renaissance. We've seen people use VCRs to stop being jerked around by the vagaries of network scheduling, build libraries of well-loved films, and make their own videos. We've seen satellite dishes by the quasi-legal million employed to break the urban monopoly on full-range entertainment. . . . Each made audiences into something else—less "a group of spectators, listeners, or readers" and more a society of selectors, changers, makers.[24]

John Sculley, the former CEO of Apple Computer, described a related vision of the technologically enabled future in the book *Interactive Multimedia:*

Imagine a classroom with a window on all the world's knowledge. Imagine a teacher with the capability to bring to life any image, any sound, any event. Imagine a student with the power to visit any place on earth at any time in history. Imagine a screen that can display in vivid color the inner workings of a cell, the births, and deaths of stars. . . . And then imagine that you have access to all of this and more by exerting little more effort than simply asking that it appear. . . . They are the tools of a near tomorrow and, like the printing press, they will empower individuals, unlock worlds of knowledge, and forge a new community of ideas.[25]

Those who work in any number of emerging technologies would describe the probable implications of their work in similar terms. Conferences, trade shows, and journals burn with intellectual foment, excitement, and eagerness to invent the future. The scientific research agendas described in the following chapters are full of optimism and methodological self-assurance.

Do these scientists and technologists live in the same world as the culture analysts? The discordance between the worldviews of culture theoreticians and those who work with new technologies may be essential for understanding the contemporary era in a unified cross-disciplinary way. One conceptualization is that each group lacks information. For example, a critical theorist might note that technologists delude themselves about the amount of autonomy they have in their research, the underlying metanarratives shaping their behavior, and the ultimate cultural ramifications of technology. It is also possible that the interpretative tone of culture theorists stems from their experience of being acted upon by new technologies, while the optimism of scientists and technologists reflects their engagement in the processes of imagining, inventing, developing, and enabling the new technologies.

Artists who work with emerging technologies face a dilemma: they stand with feet in both worlds. On one side they are invited to help create the new technologies and elaborate new cultural possibilities; on the other, they are asked to stand back and use their knowledge of the technology to critically comment on its underrepresented implications. This bifurcation causes critical discord in regard to the work of these artists because of the different stances they can assume. In particular, established critics might ignore or consider work that entertains the progressive worldviews of the technologists to be naive. The section below details different responses that artists can make to this confrontation of zeitgeist.

The Status of Substantive Things and Organisms in a World Dominated by Image and Media

In a postindustrial information economy, most people are seen as working with mediated abstractions rather than with real things. Because of the power of computer representations, workers in many businesses don't see the real objects of their business during the workday. Telecommunication substitution of mediated symbols for physical presence highlights this trend. Baudrillard's conceptualization of a hyperreality dominated by media images and circulating signifiers and codes increasingly disconnected from their referents speaks to the questionable status of things and organisms. Virtual reality tech-

nology promises to increase the power of representation to substitute for material experience. Some ecologists suggest that a mediated world might be good, because the endless production and consumption of things is suicidal. Donna Haraway's "Cyborg Manifesto" points toward a future when bodies themselves might be decreasingly relevant. The perception and meaning of even fundamental "realities" such as disease and sex are profoundly shaped by ideology.

The assessment of the decline of the importance of the material world is a critical issue for the arts and culture at large. On a basic level, the diminished importance of the physical seems overstated. Birth, death, health, disease, and the everyday realities of eating, moving, and sex are still essential to human experience. Many of the world's peoples still struggle to survive and spend their days contending with the physical world, while even in the developed world there is a growing uneasiness about the incompleteness of computer simulations and representations of reality. In his article "How Engineers Lose Touch," Eugene Ferguson posits that fatal design flaws in advanced technology such as the *Challenger* are due to "inexperience or hubris or both and reflect an apparent ignorance of . . . the limits of stress in materials and people under chaotic conditions. Successful design still requires expert tacit knowledge and intuitive 'feel' based on experience."[26]

Historically, the arts have spanned both the material and the representational—working with images at the same time as they celebrated the substantiality and sensuality of real things, as in sculpture and architecture. As Walter Benjamin noted in "Works of Art in the Age of Mechanical Representation," technologies such as photography and cinema decreased the importance of presence and "aura."[27]

Questions of materiality and corporeality are critical for artists working with new technologies. The imaging, communications, and information technologies they work with are key facilitators of this mediated world. The work they do helps to explore and settle new worlds of representation. Yet, it is not inevitable that new technologies only work with representation. The technologies that manipulate physical things, for example: robotics, nanotechnology, material sciences, alternative energy research, and biotechnology, have been less accessible to artists and the general public. These technologies will be increasingly important and point toward futures when technologically mediated material things have increasing importance. The following chapters review artists and researchers working at the cutting edge of virtuality; they also present artists and researchers who do not accept the inevitability of a vision in which materiality becomes unimportant.

The Difficulties of Locating a Rationale for Action in a Deconstructed Milieu

Postmodernism and deconstruction can lead to difficulties for the very people who propound them. If originality, genius, and avant-garde status are outdated, then what is the role of the intellectual, critic, or artist? What is the origin and justification of their need to create, and what is the motivation of anyone else to listen?

In *What's Wrong with Postmodernism,* Christopher Norris notes that some poststructuralists used deconstruction in a way that was much more epistemologically radical than intended:

> For Saussure, this exclusion [of referential aspects] was strictly a matter of methodological convenience, a heuristic device adopted for the purpose of describing . . . the network of relationships and differences that exist at the level of the signifier and the signified. For his followers, conversely, it became a high point of principle, a belief—as derived from the writing of theorists like Althusser, Barthes, and Lacan—that "the real" was a construct of intralinguistic processes and structures that allowed no access to a world outside the prison-house of discourse.[28]

He further states that the validity of a writer's arguments depends on assumptions of truth and value, even though this contradicts their theories. Similarly, he notes that Baudrillard's writings make no sense without some claims to truth:

> His work is of value in so far as it accepts—albeit against the grain of his express belief—that there is still a difference between truth and falsehood, . . . the way things are and the way they are commonly represented. . . . [I]t just does not follow from the fact that we are living through an age of widespread illusion and misinformation that therefore all questions of truth drop out of the picture.[29]

Artists, critics, and intellectuals who entertain these critical theories must resolve these contradictions for themselves and their audiences. On what basis can artists claim that their productions deserve an audience and provide a unique viewpoint? In the postmodern world, what does it mean to say that one person has a clearer vision than another?

Artists' Stances in Integrating Research

With the current prevalence of critical theory and postmodern analysis in art-world discourse, artists can stake out their own theoretical stances; they must choose which assessments and theoretical propositions to accept or reject. Artists who work with

emerging technologies have a variety of stances available to them: (1) continue a modernist practice of art linked with adjustments for the contemporary era; (2) develop a unique postmodernist art built around deconstruction at its core; (3) develop a practice focused on elaborating the possibilities of new technology. In reality, the work of artists interweaves these approaches.

Continuing the Modernist Practice of Art with Modifications for the Contemporary Era

Some artists' work with emerging technology is essentially no different from the work of artists who use traditional media. They see themselves engaged in a specialized aesthetic discourse and nurture their personal sensitivity, creativity, and vision. Even though they may proclaim the "revolutionary" implications of a particular technology, they aspire to be accepted by the mainstream world of museums, galleries, collectors, and critics (or, for some, cinema and video). They work on concerns and in modes developed for art in the last decades, such as realism, expressionism, abstraction, surrealism, and conceptual work. They believe that art will continue to renew itself, find ways to appropriately connect with its host cultures, and develop relevant new movements in the future. In fact, they see themselves as essential to progress in art, and seek to cultivate the unique and "revolutionary" expressive capabilities of their new media and tools. They believe that the art world will ultimately incorporate even unprecedented technologies and approaches, such as image processing, interactivity, algorithmic systems, Internet art, and virtual reality.

This stance has certain limitations. First, within the context of the widespread acceptance of critical theory, now that commodification and co-optation are part of the record, the art world cannot remain so self-confident about its cultural niche. Artists are not really independent in the world of the arts. Even in 1934, Bertolt Brecht described the process:

> For thinking that they are in possession of an apparatus that in reality possesses them, they defend an apparatus over which they no longer have any control and that is no longer, as they still believe, a means for the producers, but has become a means against the producers.[30]

Furthermore, it is likely that the mainstream art world will only reluctantly accept new technologies, both because they are not tied to developed traditions and because certain features, such as the ease of duplication, further erode a sense of aura of artworks. The one-hundred-year search by photography (and more recently by cinema and video) for acceptance into the canon are good models of what may be expected.

Finally, the connection to popular culture of some of the new technologies, such as digital imaging, interactive media, and Web art, raises high-art–low-art issues. Because the new technologies are used extensively in mass media and the home, it is hard for artists to develop styles that are not read as derivative. Also, the use of these technologies in industries such as advertising, education, and science obfuscate distinctions between design and fine arts. Artists seeking to participate in traditional-art-world discourse with new tools must contend with these other references. They can choose, like cinema, to develop a hybrid popular high-art form, or they can seek to develop uniquely appropriate aesthetics.

Deconstruction as Art Practice

Many artists who have found these theory-based analyses compelling have been attempting to develop an approach in which deconstruction itself is a main agenda. The theories provide concepts, themes, and methodologies for creating artworks that examine and expose the texts, narratives, and representations that underlie contemporary life. Even more, the work can reflexively examine the processes of representation itself within art. Roland Barthes describes the process in "Change the Object Itself":

> It is no longer the myths which need to be unmasked . . . it is the sign itself which must be shaken; the problem is not . . . to change or purify the symbols but to challenge the symbol itself.[31]

Science, technology, and their associated cultural contexts are prime candidates for theory-based analysis because they create the mediated sign systems and contexts that shape the contemporary world. They are the tools of power and domination that rely on unexamined narratives of progress, power, representation, and nature.

In this kind of practice, artists learn as much as they can about working with techno-scientific research so they can function as knowledgeable commentators. In one typical strategy, artists become technically proficient enough to produce works that look legitimate while introducing discordant elements that reflect upon that technology. Theory, writing, and art production become interwined in intimate ways. Many of the artists described in the following chapters work in this subterfuge mode of destabilizing the representations of what is considered normal.

The worlds revolving around digital technologies are seen as ripe for critical analysis because of their assurance of the rationality of their directions and their totalizing pretensions. In theories described in later chapters, art is seen as a "parasite" or disruptor, standing outside the dominant narratives. Jonathan Crary describes the opportunities for artistic action in the world of digital technology:

association will emerge. And in this emergence we can expect to see, as we are beginning to see, new orders of art practice, with new strategies and theories, new forms of public accessibility, new methods of presentation and display, new learning networks, in short, whole new cultural configurations.[36]

This century is characterized by an orgy of research and invention. Knowledge is accumulating at high speed; unanticipated branches of knowledge, industries, social contexts, and technologies have appeared. These developments are affecting everything from the paraphernalia of everyday life to ontological categories. As the pace continues, predictions about future discoveries and their consequences are impossible. Optimists in the scientific community predict that further research will enhance the material, intellectual, and spiritual quality of life for all the world's people. Analysts such as those in the Extropian movement believe that research is about to usher in the next stage in human evolution.

Taking advantage of unique traditions of the arts, such as valuing iconoclasm and interdisciplinary perspectives, artists can choose to be a part of the efforts to create these new technologies and fields of knowledge. Furthermore, this artistic stance calls for artist participation in other fields beyond the digital technologies that are focused on in this book, such as new biology, materials science, and space exploration. Chapter 1.2 elaborates on this approach.

Summary: The End of Timelessness?

Where are the timeless masterpieces? The rapid pace of research is part of developments in the industrial age that clash with the hopes for art's timelessness. In the past, masterpieces were expected to transcend time and space. During this century, that tradition has been eroding with the loss of "aura" in technologically reproducible work, the ascendance of temporary art forms such as live art and installation, and the power of style and media to rapidly reshape consciousness. Nonetheless, as evidenced by the activities of museums of modern art, many hope that even contemporary art can produce timeless masterpieces.

Information Arts presents the best of research-inspired art. Many are considered masterpieces of the genre. But will they always be? The imaginative reach and innovative vision of some of these artists in mastering an area of research to create eye-opening and thought-provoking works is stunning. But the power of these works may be bounded by their sense of timeliness. After the research world has moved on, they might not seem so significant and moving. Indeed, I know this from painful personal experience,

as I see some of my experimental computer artwork of fifteen years ago become quaint and archaic. Curiously, many of these old works can never be experienced again, since the requisite technological infrastructure has disappeared.

These are interesting times for the arts. The linkage of art to emerging research may hasten the redefinition of timelessness. We may need to invent a new meaning for the term *masterpiece.* Think of a masterpiece as a work of art that seizes the cultural moment, or as a work that senses the cultural leap represented by a line of research and uses the magic of the arts to expand what it means and explores what it might become. After the moment passes, the masterpiece will have served its place in history. Like landmarks in science, such as Gallileo's new vision of the universe, these artworks' timelessness is their audacity, even though the new ground they break may become common ground. Readers are invited to contemplate the masterpiece life expectancy of the artworks described in the following chapters.

Notes

In the quiz at the beginning of this chapter, the first five items were created by researchers who define themselves as artists; the others were created by scientists and technologists.

1. C. P. Snow, "The Two Cultures and the Scientific Revolution" (Cambridge: Cambridge U Press, 1964).

2. In the last decades, scholars have analyzed the relationship of art and science/technology. They have reviewed the history, noting some influences of these enterprises on the arts, for example, the impact of non-Euclidean geometry and relativity on early twentieth-century painters, the import of technology on the Bauhaus, and the influence of Freud on the Surrealists. Generally, however, the mainstream art world has pretended that art could mostly ignore the technological and scientific revolutions. Art focused on science and technology was treated as a minor footnote. See my forthcoming book *Great Moments in Art and Science* for analysis of this history.

3. Derived from science articles in *Encyclopaedia Britannica.*

4. C. Singer, *History of Technology,* vol. 1 (New York: Oxford University Press, 1954).

5. M. Kranzberg and C. Pursell, *Technology in Western Culture* (New York: Oxford University Press, 1967), p. 4.

6. Ibid., p. 6.

7. J. Gaston, "Sociology of Science and Technology," in P. T. Durbin, *A Guide to the Culture of Science, Technology, and Medicine* (New York: Free Press, 1980), p. 467, and E. Layton, "Through the Looking Glass," in S. Cutcliff and R. Post, *In Context* (Bethlehem, PA: Lehigh University Press, 1989), p. 42.

8. C. Mitcham, "Philosophy of Technology," in P. T. Durbin, op. cit., p. 283.

9. Ibid.

10. Ibid., p. 284.

11. E. Layton, in S. Cutlcliff and R. Post, op. cit., p. 35.

12. C. S. Smith, *From Art to Science: Seventy-Two Objects Illustrating the Nature of Discovery* (Cambridge: MIT Press, 1980), p. 23.

13. Getty Museum Program in Art Education, ⟨http://www.artsednet.getty.edu/ArtsEdNet/Browsing/Liata/2.html⟩.

14. A. Einstein, "Principles of Research," in A. Einstein, *Essays in Science* (New York: Philosophical Library, 1934).

15. V. Sorensen, "The Contribution of the Artist to Scientific Visualization," ⟨http://felix.usc.edu/text/scivi1.html⟩.

16. P. Feyerabend, "Theoreticians, Artists, and Artisans," in *Leonardo,* vol. 29, no. 1. p. 26.

17. Ibid., p. 27.

18. Ibid., p. 25.

19. Ibid., p. 27.

20. For an introduction to these concepts, see S. Wilson, "Dark and Light Visions," ⟨http://userwww.sfsu.edu/~swilson/⟩.

21. J. Crary, "Eclipse of the Spectacle," in Brian Wallis, ed., *Art after Modernism* (Boston: D. R. Godine, 1984), p. 291.

22. Ibid.

23. Annette Kuhn, ed., *Alien Zone* (New York: Verso, 1990), p. 63.

24. S. Brand, *Media Lab* (New York: Penguin, 1987), p. 252.

25. J. Sculley, "Foreword," in S. Ambron and K. Hooper, eds., *Interactive Multimedia* (New York: Harper & Row, 1988), p. vii–ix.

26. E. Ferguson, "How Engineers Lose Touch," *American Heritage of Invention and Technology,* vol. 8, no. 3 (winter 1993), p. 36.

27. W. Benjamin, "Art in the Age of Mechanical Reproduction," in *Illuminations* (New York: Schocken, 1966).

28. C. Norris, *What's Wrong with Postmodernism* (Baltimore: Johns Hopkins Press, 1990), p. 185.

29. Ibid., p. 182.

30. Bertolt Brecht, "Epic Theatre," quoted in Walter Benjamin, "Author as Producer," in B. Wallis, ed., *Art after Modernism: Rethinking Representation* (Boston: D. R. Godine, 1984), p. 306.

31. R. Barthes, "Change the Object Itself," quoted in Craig Owens, "Allegorical Impulse," in B. Wallis, op. cit., p. 235.

32. J. Crary, op. cit., p. 294.

33. P. Brown, "Reality versus Imagination," in J. Grimes and G. Long, eds., *Visual Proceedings: Siggraph 92* (New York: ACM Press, 1992).

34. S. Wilson, "Research and Development as a Source of Ideas and Inspiration for Artists" and "Industrial Research Artist: A Proposal," ⟨http://userwww.sfsu.edu/~swilson/⟩.

35. G. Kepes, *The New Landscape in Art and Science* (Chicago: P. Theobald, 1956), pp. 19–20.

36. Roy Ascott, "Art and Education in the Telematic Culture," in *Leonardo* Electronic Art (Suppl., 1988), p. 8.