1.2

Elaboration on the Approach of Art as Research

This chapter briefly elaborates on the possibilities of art as research, in which artists develop new kinds of knowledge and applications ignored by mainstream scientific and corporate research and push scientific inquiry in unanticipated directions. It explores the meanings of approaching art as research and the rationales, agendas, and working methods of this kind of art.

Can the Arts Offer Alternatives in Setting Research Agendas, Interpreting Results, and Communicating Findings?

Historians of science and technology have documented the determinants of which research is supported, promoted, and accepted,[1] and what products win in the marketplace. As research increases in general cultural importance, it becomes more dangerous to totally rely on market forces. Valuable lines of inquiry die from lack of support because they are not within favor of particular scientific disciplines. New technologies with fascinating potential are abandoned because they are judged as not marketable. Our culture must develop methods to avoid the premature extinction of valuable lines of inquiry. The arts can fill a critical role as an independent zone of research, in which artists integrate critical commentary with high-level knowledge and participation in the worlds of science and technology.

For the last twenty years my artistic practice as artist and researcher has included monitoring scientific communication, working as a developer, and being an artist in residence at several think tanks. These years as what I call a shadow researcher have been illuminating. Tracking and undertaking research at a distance, I have learned of intriguing developments that never saw the light of day. I have seen many inventions and emerging technologies killed because marketing departments judged that no money could be made. I have seen entire R&D departments and their years of research blown away by the winds of corporate politics. Government and corporate support for basic research has almost disappeared, and the concern with the bottom line has shortened the payback horizon to the point where few risks are taken. I have encountered debates in the scientific community that devalue approaches that do not fit favored paradigms.

The invisible hand of the marketplace might not be so wise. Judgments that make short-term sense for stockholders may not necessarily benefit the culture. The peer review referees of scientific journals cannot always see beyond their disciplinary blinders. Scientific and technological research have such critical ramifications for us all that we can ill afford the premature elimination of these ideas and efforts.

The Lesson of Computer Art: Many "high-tech" artists believe that they have addressed the future by becoming computer artists working with digital image, sound, and interactive multimedia. They have misunderstood the real significance of artists' work with computers during the last decade and a half: the fact that artists were experimenting with microcomputers at almost the same time as other developers and researchers. Artists were not merely using the results of research conducted by others, but were actually participating as researchers themselves.

New technologies, such as genetic microbiology, promise to have a similar or even greater impact on life and thought. Artists should identify future trends that could benefit from the artist-research inquiry.

What Is a Viable Role for Artists in Research Settings? What Can Researchers Contribute to Art and What Can Artists Contribute to Research? What Can High-Tech Companies Gain from Artists Being Involved?

A good model would provide mutual benefit and cross-fertilization, such as Bell Labs's involvement of artists in sound research, which was instrumental to telephony, electronic voice research, and electronic music. Also, artist Sonia Sheridan's residency at the 3M research center in the 1970s simultaneously influenced the development of color copier technology and shaped her development of a program at the Art Institute of Chicago. More contemporary examples include the artist-in-residency programs initiated by Xerox's Palo Alto Research Center (PARC) and Interval Research, which experimented with mutual definitions of research agendas. The Xerox PARC experience is described more fully in the MIT Press book *Art and Innovation.*

These contemporary examples are qualitatively different from earlier collaborations between artists and scientists-engineers. For example, in the 1960s, EAT (Experiments in Art and Technology) and the Los Angeles County Museum collaborations in art and technology did not profoundly address the role of artists in research; rather, the engineers functioned as technical assistants or the artists dabbled with new technologies.

The contribution that artists can make to research and development is that they often approach problems in ways quite different from those of scientists and engineers, as demonstrated by the crucial role played by designers and artists in computer human interface research over the last years. The arts can function as an independent zone of research. The concept of artist could incorporate other roles, such as that of researcher,

inventor, hacker, and entrepreneur. Even within research labs, artist participation in research teams might add a perspective that could drive the research process and continue to contribute at all stages.

The Choice of Research Agendas, Definitions of Research Questions, and Adoption of Metaphors

Artists might very well value research according to criteria quite different from those of the commercial and scientific worlds. They might see aspects of the problems missed by the other researchers. The arts could become a place where abandoned, discredited, and unorthodox inquires could be pursued.

My experience as a artist and consultant to a National Science Foundation–funded project to investigate artificial-intelligence (AI) tutors to teach science illustrates an example of an artist's contribution to the definition of research questions. The project was testing a variety of strategies for software tutors: the soundness of the theories would be judged by how student learning was affected. I noted that students reacted to the tutors similarly to how they reacted to humans. Did the tutor seem sympathetic? Did it manifest any kind of personal knowledge of the student? Did it have an interesting "personality"? My artistic intervention was to suggest that one could not address the question of AI tutoring without paying attention to the dramatic aspects of the interactions. Some of the scientists in the project assumed that as artistic consultant, my main role was, stereotypically, to beautify the reports submitted to the government.

Research Process Decisions, Interpretation of Results

The arts can offer insights into the significance of research results and the design of research activities. The field of scientific visualization can illustrate this point. Donna Cox, one of the artists described in following chapters, working as an artist with the National Super Computing Center at the University of Illinois, helped devise animations to visualize complex bodies of information about natural phenomena. The scientists reported that the visualizations helped them understand the meaning of their data and devise subsequent inquiries.

The Representation of Potential User Perspectives

Research and development attempt to create products that will be used and valued by the public, but sometimes developers ignore the settings in which the products will function. Artists can provide insight on nontechnical responses and ideas for better addressing the needs and perspectives of the general public. For example, one automaker decided to use emerging speech synthesis capabilities as warning signals in their cars. A

speech synthetic voice would speak warnings such as "Your seat belt is unhooked" or "You are going too fast." But consumers found the expressionless voice, with its unchanging repetitions, annoying and even slightly sinister; 90 percent deactivated it and the product was discontinued. One might imagine that artistic involvement in the design of the synthetic voice and its repartee might have had more comfortable or engaging results.

Communication of Findings, Consideration of Cultural Implications

Science and technologists often must communicate outside their disciplines. Artists can make presentations of research come alive; furthermore, they can identify implications that may be ignored or not understood by other researchers. Artist-researchers Arthur Elsenaar and Remko Scha are known for their investigations of artificial intelligence, speech synthesis, and the role of facial muscles in communication. They regularly give presentations to both art festivals and research meetings in which their artificial character Huge Harry explains the implications of the research. Huge Harry is effective in demonstrating the research in a direct and lively way, and in raising questions about both its positive and negative ramifications. For example, in some of the demonstrations Huge Harry applies electrical stimulation to the facial muscles of his human assistant to demonstrate the roles of particular muscles and the capability of the face to generate expressions outside those normally encountered. An audience member watching this might certainly think about more than the function of specific muscles.

Art Characteristics Useful for Research

What artistic perspectives can contribute to research? Several traditions of the arts are potentially valuable:

- A tradition of iconoclasm means that artists are likely to take up lines of inquiry devalued by others.
- The valuing of social commentary means that artists are likely to integrate widely ranging cultural issues into their research.
- Artists are more likely than commercial enterprises to incorporate criteria such as celebration and wonder.
- Interest in communication means that artists could bring the scientific and technological possibilities to a wider public.
- The valuing of creativity and innovation means that new perspectives might be applied to inquiries.

The recent history of the personal computer illustrates the need for an independent research function and the role the arts might serve. Early developers, such as Apple Computer founders Steve Wozniak and Steve Jobs, found little support for their ideas about the personal computer. Supervisors signed waivers on the ideas because they could not imagine any market for a desktop computer. Similarly, the discipline of computer science was mostly uninterested in software and hardware issues related to these computers. Advances often came from individuals who worked outside traditional academic and business channels. Teenagers became world experts, nerds became billionaires, and artists made significant contributions in fields such as interface design and image-sound processing.

Similarly demonstrating the value of art-research cross-fertilization, the SIGGRAPH (the ACM international organization for computer graphics research) annual meetings have included an art show since their beginnings. These shows have been influential in several ways. Artists have been able to learn about emerging computer graphics research and technologies so that they could start experimenting with them. In parallel fashion, researchers have become acquainted with artistic work that pointed to new research directions.

Reliance only on traditional lines of research might have resulted in a much longer wait for the developments that have profoundly shaped the last decades. This story could potentially be repeated many times in many other fields of inquiry if alternative venues for research are developed. The arts could well serve an important function of independent vision if artists were prepared to learn the knowledge, language, work styles, self-discipline, and information networks that are instrumental in their fields of interest.

Preparing Artists for Research

What must artists do differently than they always have done to prepare to participate in the world of research? They must broaden their definitions of art materials and contexts. They must become curious about scientific and technological research and acquire the skills and knowledge that will allow them to significantly participate in these worlds. They must expand conventional notions of what constitutes an artistic education, develop the ability to penetrate beneath the surface of techno-scientific presentation to think about unexplored research directions and unanticipated implications, and learn about the information sources used by scientists and engineers to engage emerging fields, including academic and professional journals, trade shows, academic meetings, Internet resources, and equipment supply sources.

The parameters of the science and technology education required is not yet clear. Can artists find the right mix of objective and subjective processes? Can artists learn enough to engage in research at a nondilettante level? Scientists and technology researchers who have devoted their entire professional lives to educating themselves about topics being investigated might be skeptical. Yet, many times history has shown that topics once considered esoteric and beyond the reach of nonspecialists have become understood and accessible to much wider publics. Indeed, this demystification may be one of the main accomplishments of artists working with research.

At the same time, artists must keep alive artistic traditions of iconoclasm, critical perspective, play, and sensual communication with audiences. They must be willing to undertake art explorations that do not neatly fit in historically validated media and offer their work in new contexts.

The Integration of Research and Art

Research is shaping the future in profound ways. Our culture desperately needs wide involvement in the definition of research agendas, the actual investigation processes, and the exploration of the implications of what is discovered. Artists can significantly contribute to this discourse by developing a new kind of artist-researcher role.

Historical Precedents

Art and research were not always separate. The pre-Renaissance integration of the two may shed light on future possibilities. This section offers a brief summary of the historical relationships between art, science, and technology.

Paleolithic In the Paleolithic era, some of the greatest accomplishments were simultaneously monuments of art and science. The Paleolithic cave paintings have been identified as the first significant act of painting; they are also one of the first illustrations of scientific observation. Some analysts propose that their power comes in part from the painters' careful observation of animal physiology and behavior. Paleolithic metalsmiths are renowned for the aesthetic power of their metalwork. They were also critical in the history of chemistry, being the first to identify different metals and their characteristics.

Stonehenge is a another example of the early fusion of artistic, religious, and scientific functions. Although there are debates about the extent of its accomplishments, its monoliths are carefully placed to indicate the positions of heavenly bodies at various times of the year. In all of these Paleolithic examples, the pioneering in art and science went hand in hand.

Renaissance Leonardo da Vinci is well-known as history's greatest integrator of art and science. He was by no means unique in having interests that spanned art and science; educated persons were expected to do so. The ateliers of his era included science and engineering as regular parts of their curricula. For example, illustrations of the artists' studios included skeletons for studying anatomy and structural components for studying engineering. Even more, the ethos of the time included the idea that one could not be a good artist or scientist without interest in the other field.

1870–1930 By this time, science and art had already become clearly separate fields. However, even during this period, many analysts trace important influences on abstract art coming from the invention of photography and the investigations of non-Euclidean geometry and elementary particle physics. These scientific and technological inquiries challenged traditional ways of seeing and conceptualizing the physical world. The questioning freed and provoked artists to represent the new world views. The influence of artists on scientists is less clear, although the general cultural questioning may have created a milieu that encouraged scientific questioning.

New inventions also stimulated artistic experimentation in fields such as photography, cinema, sound recording, electrical machines and lights, radio, and electronic music. In the early days, artists often acted as developers. For example, experimentation in chemistry and optics was intrinsic to the role of photographic artists. Artists assumed a variety of stances toward technological change, ranging from the urge of Bauhaus and Socialist art to participate within industry, to Futurist glorification of technology, to the ironic Dadaist commentary.

Art and Science/Technology Collaborations

This section briefly reviews contemporary initiatives to integrate art with research. They illustrate a full range of the roles for artists, from being principal architects of the efforts to consultants on projects intitiated by others. Chapter 8.1 describes other institutional arrangements that encourage and inform collaborative effort.

PARC PAIR

Xerox's PARC initiated an artist-in-residence program called PAIR. PAIR adopted an open-ended strategy in which artists and researchers mutually defined a problem to work

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PAIR: ⟨http://www.pair.xerox.com/⟩

on, with the definition of the problem becoming part of the collaboration. The Web site explains that PAIR itself is a research project focused on the possibilities of collaboration: "One way that PAIR attempts to bridge the gap between the artists and the scientists is to use technology as a common language. In making our pairings we try to find artists and scientists who use the same, or similar technologies, though often in very different ways. Another equally important aspect of PAIR is to bring the fine arts directly into the work environment for the mutual benefit of both the artist and the corporation." Documentation of the PAIR program is presented in a book called *Art and Innovation,* edited by Craig Harris.

Banff Centre for the Arts

For many years the Banff Centre for the Arts sponsored innovative artist residencies in which artists could experiment with the latest technologies in the mountain environment of the center. The center provided technical support and a critical community as a spur for the work. The residencies have focused on a series of themes, such as virtual reality and the body. The Center also supports indigenous people's cultural explorations with new technologies such as their providing net.radio access to indigenous story tellers and running "summits" to bring together technological innovators, artists, and theorists to investigate topics such as Emotional Computing, Living Things (biotechnology and nanotechnology), and Living Architecture.

Interval Research

Interval Research included artistic collaboration as part of its research activities. One line of research, called New Media Experiments, supported artists to investigate emerging technologies in the production of award-winning works. Interval collaborated with many arts institutions, such as art schools and museums, and the journal *Leonardo.* The Interval Web site explained their interest in artistic activity and the faith in its contribution to the research enterprise:

Interval has a deep interest in the relationships between new media form and new media content. Most uses of new digital media rely upon style and aesthetic sense developed in prior forms, an approach that does little to explore the real potential. We are interested in exploring new possibili-

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Banff Centre: ⟨http://www.banffcentre.ab.ca/CFA⟩
Interval Research: ⟨http://www.interval.com/research/NewMed-old/index.html⟩

ties with these new media, in content as well as form. These explorations are often inspired by and relevant to the arts community.

There are several reasons why these "New Media Experiments" have value at a research lab such as ours. First, they provide stimulation and provocation to our research community, often acting as magnets to bring together unconventional combinations of skills and talents. They can also provide content to test tools (and even tools to test content). Some of these projects are means for collecting data, both through explicit query as well as through observation. These projects may lead researchers down unforeseen paths and result in new discoveries and intellectual property.

In spite of Interval's innovations and its integration of art with research, Paul Allen, the major underwriter of the effort, closed the organization in spring 2000. Allen noted that he wanted to narrow the focus to application development instead of the basic research that had been Interval's hallmark.

ART+COM

Founded in 1988, ART+COM is a German organization focused on research that integrates the perspectives of computer technology, communication, and design. It believes that the most innovation comes from an open interdisciplinary process and describes itself as a "melting pot for new ideas and new technologies, where specialists from the arts, from science, and from industry come together to combine their ideas and goals. The method of working at ART+COM is characterized as an openness towards new projects and novel approaches, the readiness to question old patterns and ways of thinking and the ability to speed up complex development-processes." The organization has distinguished itself by winning awards at international festivals and its commercial development work.

F.A.B.R.I.CATORS

Based in Italy, F.A.B.R.I.CATORS attempts to develop methods to "combine and use art and technology in the design and production of projects, interactive art pieces, multimedial projects, VR installations, creative interfaces, worked out on the basis of the integration of multidisciplinary expressions and disciplines, such as: art, culture, technol-

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ART+COM: ⟨http://www.artcom.de/about/welcome.en⟩
F.A.B.R.I.CATORS: ⟨http://www.mediartech.com/en/⟩

ogy, architecture, design." It combines low and high tech in the "elaboration of bizarre and efficient invention."

ATR Lab

The ATR Media Integration and Communications Research Laboratory in Japan believes that art can have a major role in research and defines its major objective: "In pursuing new communication schemes that facilitate mutual understanding beyond differences in place, time, language and culture, we are exploring basic technologies for both realistic multimedia communications and hyper-realistic communication environments for better sharing thoughts and images between humans and machines." It supports research initiatives in these areas, the reconstruction and creation of communication environments, communication support, mental-image expression and transmission, and human communication processes. It includes artists and researchers working collaboratively and presents its work both in art and technical venues. For example, its researchers have presented workshops on "Face and Gesture Recognition," "Technologies for Interactive Movies," and "Lifelike, Believable, Communication Agents." It believes that art can significantly contribute to the development of new communication technologies and supports the experimental artworks of several artists described in this book.

Canon ArtLab

Canon Japan established a division called the Social and Cultural Program Operations Center (CAST), which recognizes Canon's responsibility to *"Kyosei":* "Under Canon's philosophy of *'Kyosei'*—living and working together for the common good of mankind, diversified activities are promoted by Canon-group companies all over the world in the field of social contribution and cultural support." One of these activities is the ArtLab, which aims to "pioneer new artistic realms through the integration of science and art" by innovating with new digital technologies developed by Canon through collaborations between artists and engineers. ArtLab's activities include exhibitions, public lectures, the on-line documentation of artists' works, and research support for artists. Several of the artists in this book have been supported by ArtLab.

ATR Lab: ⟨http://www.mic.atr.co.jp/index.e.html⟩
Canon ArtLab: ⟨http://www.canon.co.jp/cast/index.html⟩

Arts Catalyst

Arts Catalyst is a U.K.-based organization that offers public lectures, workshops for students, publications, exhibitions, and research opportunities on which artists and scientists can collaborate. Their brochure explains their challenge of old dichotomies:

> The Arts Catalyst is a science-art agency promoting real collaborations between artists and scientists. Founded in 1993 . . . it uses innovative art practice to break down the invisible walls between science and the public. We see art as directly applied to the scientific environment—not simply illustrative of science. Never afraid to confront issues in science, subjects covered include human fertility, nuclear power, Darwinism, quantum physics, space exploration and the forthcoming total eclipse of the sun. We work across all the artforms—specialising in collaborations with museums, galleries, scientific laboratories, and other sites.

Some projects and conferences have included "Searching" (exhibition and supported projects to look at SETI—the Search for Extra Terrestrial Intelligence); "Eclipses, Life and Other Cosmic Chances" (art-science consideration of the 1999 eclipse); "GravityZero" (a collaboration between Kitsou Dubois, a choreographer, and space scientists); "Atomic" (supported projects and an exhibition focused on radioactive debris); "Parallel Universe" (a conference on non-Western science); and "Eye of the Storm" (panels with artists and scientists reflecting on scientific controversies in areas such as genetics, evolution, artificial consciousness, and the end of nature).

STUDIO for Creative Inquiry—Carnegie Mellon University

The STUDIO provides a context for interdisciplinary research in the arts by providing artist residencies, commissions, and facilities. It has won numerous grants to pursue inquires at the intersection of science and the arts. It makes extensive use of the artistic and technical resources of Carnegie Mellon University. Some areas of focus include biology, ecology, and robotics. Examples of specific projects (many described in this book) include: "Nine Mile Run Greenway Project," "Tracking the Human Brain," "Building Electronic Communities," "Acid Mine Drainage and Art Project," and "Sex and Gender in the Biotech Century."

Arts Catalyst: ⟨www.artscat.demon.co.uk⟩
STUDIO for Creative Inquiry: ⟨http://www.cmu.edu/studio/⟩

Interactive Institute

The Interactive Institute is part of a major effort by the Swedish government and industry to create a new network of "studios" that will foster the collaboration of artists with researchers in the development of new technologies. Each studio links art institutions with industry collaborators. Some of the themes of the studios include: "Emotional and Intellectual Interfaces," "Smart Things and Environments for Art and Daily Life," "Narrativity and Communication," "Space and Virtuality," and "Games." With significant funding, the studios offer seminars, workshops, technical support, and funding for research projects.

Cultural Institutes, European Cultural Backbone, I3

As part of its concern about maintaining future competitiveness, the European Union has initiated efforts to encourage cultural institutes in which artists collaborate with researchers in developing new technologies. It is based on the premise that Europe has rich media traditions that can inform innovation in a way not necessarily following the American model. Efforts are under way in several countries, such as the "Virtual Platform" in the Netherlands. These approaches are being considered for incorporation into major European Community–sponsored research efforts, such as the I3 (Intelligent Information Interface). A report, "Cultures of Electronic Networks," summarizes some of these perspectives:

Economic growth will depend on the existence of a new media culture which is innovative, diverse, inclusive and challenging. Cultural activity in digital media is driving innovation at all levels, with a constant movement of skills, ideas, individuals and infrastructures across different sectors. Innovative market activity can only be upheld insofar as the "nonprofit" creative research it depends on is fostered on a permanent, continuous basis, and sufficient fluidity is encouraged between the commercial and "non-profit" sectors. . . . The talented and fleet-footed organizations which comprise this network of innovation are small and fledgling. They straddle traditional boundaries and explore the creative spaces between different sectors and media forms. . . . A technical infrastructure for cultural activity needs to be implemented along the same lines as the well-established frameworks of the scientific and academic networks. . . . To be effective, culture as much as science requires its domains of primary research, which need to be supported by appropriate environments and resources (e.g., independent research laboratories for media art).

Interactive Institute: ⟨http://www.interactiveinstitute.se⟩
Cultural Institutes: ⟨http://competence.netbase.org/panel2/rapport2.htm⟩

Centres of Excellence, Technology Media, and Creativity

Artists and analysts in Canada have been attempting to forge new kinds of collaborations that link art, technology development, and scientific research. They seek to establish a "new genre of hybrid cultural research institution in which artists mediate between networks of technology design and diffusion." They propose that countries that hope to be innovators in the future must tap the perspectives of artists in research. In a paper, "New Media Culture in Europe," Michael Century reviews the history of collaboration from institutions such as EAT and IRCAM through 1980s institutions such as SIGGRAPH, Ars Electronica, and ZKM, discussed in chapter 8.1. He reflects on concerns about the commercial co-optation of artists:

> [critical intellectuals harbored] a deep ambivalence about these institutional developments, fearing that they would serve only to accelerate the public acceptance of automation in everyday life, on the one hand, and to co-opt artists "with their purported creativity" into becoming commercial application designers, on the other.

He concludes, however, that artistic involvement has not followed only this pattern but rather entered into the innovation and diffusion processes in many more complex ways, building on the tacit knowledge and innovation traditions of the arts. He forecasts great opportunities in areas such as improving the usability of information technology applications and in the "cultural quality of social informatics."

Souillac Charter for Art and Industry

The Souillac Charter for Art and Industry is another European effort to define a framework for the collaboration of artists and industrial researchers. Some of the analysis is based on the ideas of Don Foresta, a pioneer in telecommunications art, to define "new communication spaces." The charter proclaims a new kind of space developing:

> A new communication space is growing. . . . Searching for its own logic and a cultural, social and political identity. What this space will mean to society is not yet clear, its final content is uncertain, and how it will effect culture open to healthy speculation and necessary experimentation before its final specificity is defined.

Centres of Excellence: ⟨http://www.music.mcgill.ca/~mcentury⟩
Don Foresta: ⟨http://www.iic.wifi.at/iiceng/forestacp.htm⟩

He links the new spaces with scientific insights that expanded beyond Euclidean space and the interactive flow of multiple points of view that characterize the contemporary world. Foresta sees art as a critical resource in developing the possibilities of these new cultural spaces and new technologies in part because artists anticipate the "psychological atmosphere" of their era. The charter identifies several areas of research that could benefit:

It is a visual space, a communication space, an organisational space, the space of how we imagine reality. . . . Every mode of communication has at one of its extremes a form of expression we call art. Art, being the densest form of communication, is often the supreme test of any means of communication. . . . The technologies of communication today permit a full exploration of the potential of this new space, making them an expression of the values that we are attempting to define as we reinvent our society according to the new artistic and scientific givens.

Wellcome Trust

The U.K.'s Wellcome Trust primarily funds biomedical research. It also supports a significant "Sci-Art" effort the encourage collaborations between researchers and visual, media, and performance artists. Each year it has a competition and selects projects to support, such as the 1997 projects "Primitive Streak" (fashions based on embryo development) and "Exposing the Phantom" (self-perceptions of people who experience phantom limbs). The program explains its perspectives:

Flair, creativity, inspiration, interpretation: science and art share similar vocabularies yet are often compartmentalized into their own mutually exclusive worlds. The Wellcome Trust has developed schemes to break down the barriers between the two dominions, stimulating a cross-fertilization that may ultimately benefit both. For art, the chance to gain inspiration from science's insights into the natural world; for science, an opportunity to view an entirely new perspective on research.

Future Possibilities

What is science? Let us define science as an accumulation of worldviews, questions, metaphors, representations, and processes that attempt to understand the nonhuman world. It is also the accumulated body of knowledge that these inquiries have generated.

Wellcome Trust, "Sci-Art" — Web link to winners: ⟨http://webserver1.wellcome.ac.uk/en/old/sciart98/⟩

Artists are engaged with science in a variety of ways—joining in the critique of its claims, building on its accumulated knowledge, and participating in the inquiries at the fringes of its understandings.

What is technology? In its widest meaning, it is the process of inventing and making things, which includes much of art. In its more restricted sense of "high tech," it is the contemporary activities of research and development aimed at producing new materials and processes. Critics note that technological development is aimed at control and exploitation. High technology often builds on knowledge generated by science, but sometimes it races ahead of science into uncharted ground.

What is art? In the last century its definition has been expanded far beyond conventional media, contexts, and purposes. Neveretheless, we can ascribe to it the following set of characteristics. Typically, it is undertaken for nonutilitarian purposes. It usually intends to move or provoke an audience for aesthetic, intellectual, and/or spiritual purposes. In the West it is more likely than other disciplines to value personal, idiosyncratic vision and perspectives, to prize iconoclastic stances outside of established institutions, and to promote individual creativity.

This book asks how art, science, and high-tech research can influence each other. The appropriate contours of this involvement are not yet defined. Much experimentation is required. How can artists function independently from established research centers? When artists work within research settings, how can those centers learn to be open enough to benefit from the unorthodox contributions that artists might make? How can artists learn to involve themselves in the ways and byways of researchers without losing touch with their artistic roots? Young artists who become involved as researchers can be seduced by the recognition and economic rewards of research so that they quit functioning as artists.

Artists do not act exactly like researchers. Contemporary art often includes elements of commentary, irony, and critique missing from "serious" research. Scientists and technologists strive toward objectivity; artists cultivate their idiosyncratic subjectivity as a major feature of what they do. The "research" that artists create would work like art always does—moving audiences through its communicative power and unique perspectives. Still, it might simultaneously use systematic investigative processes to develop new technological possibilities or discover new knowledge or perspectives.

Frank Oppenheimer, the scientist who established the world famous Exploratorium museum of science and art in San Francisco explained the rationale for the combination:

> Art is included, not just to make things pretty . . . but primarily because artists make different kinds of discoveries about nature than do physicists or biologists. They also rely on a different

basis for decision-making while creating their exhibits. But both artists and scientists help us notice and appreciate things in nature that we had learned to ignore or hadn't been taught to see. Both art and science are needed to fully understand nature and its effects on people.[2]

In the essay "Boundaries and Categories," biologist Stephen J. Gould notes that science often helps art in concrete ways, but that art offers a more subtle aid to science. Of literature, he says:

Fiction is often the truest pathway to understanding our general categories of thought and analysis, and artifice often illuminates the empirical world far better than direct description. This paradox arises because we can best understand a natural object or category by probing to and beyond its limits of actual occurrence—into realms that science, by its norms of discourse, cannot address, but that art engages as a primary interest and responsibility.[3]

He also notes the power of artists to confront scientists with the assumptions of their categorical schemes and concepts:

[W]e scientists face a special problem of denial and inattention to our personal prejudices, for our "official" methodology proclaims objectivity, and we can therefore be maximally fooled.

Artists can therefore be most useful to scientists in showing us the prejudices of our categorizations by creatively expanding the range of nature's forms, and by fracturing boundaries in an overt manner (while nature's own breakages, as subtle in concept or invisible to plain sight, are much harder to grasp, but surely understandable by analogy to artistic versions).

Perhaps the segmented categorization of artist and researcher will itself prove to be an historical anachronism; perhaps new kinds of integrated roles will develop. Signs of this happening already appear. Some of the hackers who pioneered microcomputer developments may one day be seen as artists because of their intensity and culturally revolutionary views and work. Similarly, some art shows, such as Ars Electronica's, now define research ideas as core themes (for example, artificial life) and invite researchers as key presenters along with artists. Research has radically altered our culture and will continue to do so. We must ask what role art might play in this process.

Though it seems incontrovertible that neither artists nor scientists can stand completely outside of a cultural or economic milieu, the creative leaps made by inventors, scientists, and artists amaze and inspire me. They do seem to create genuine new possibilities and for a moment stand above the cultural flow. The artists' works described in

the following chapters are remarkable in the unusual perspectives they use to explore research. Neither the research, nor the art, however, is complete in itself. Together they make a full picture of what the research really is and what it could mean.

Notes

1. Thomas Kuhn, *The Structure of Scientific Revolutions* (Chicago: University of Chicago Press, 1970).

2. F. Oppenheimer, "Mission of the Exploratorium," ⟨http://www.uinta6.k12.wy.us/WWW/MS/8grade/Info%20Access/KEXPLORI/AIR.htm⟩.

3. S. J. Gould, "Boundaries and Categories," ⟨http://138.87.136.7/cfa/galleries/gould.html⟩.