I have spent the last 20 years as an artist and as a writer reflecting on the issues of art and technology and art and science. I have been an editor of the Leonardo international journal of art & science for 15 years. For much of that time the field was marginalized as a minor footnote to the mainstream of art. There are signs that this is changing. Mainstream institutions and academics are showing more interest. There are 7 sessions this year on art/science and art/technology. It is entirely possible in 10 years the balance of sessions at the CAA will be exactly opposite of what it is now with the majority reflecting on art addressing science and technology.

We are at an important cusp as the arts try to figure out what to do about the realities of the 21st century. There are great opportunities and also much possibility of misunderstanding the moment. I would like today to try to clarify some of the confusion and throw light on the opportunities and challenges. More details about what I have to say will be available in my book *Information Arts* which is going to be published by MIT Press this Fall and also on my websites.

Today I will concentrate on myths and confusions in thinking about art/science/technology.

**Different models of working with science/technology:**

There is much confusion because artists approach science and technology in a variety of radically different ways. Even though they are sometimes interrelated it is useful to highlight the differences.

- **Continued modernist practice:** Some artists seek to appropriate contemporary technologies to create new kinds of images, sounds, installations and performances - for example, digitally processed photography, computer music, or computer controlled sculptures. They see the new technologies as tools that give profound new ways of doing what artists have historically done. Certainly new issues must be addressed, but the agenda is not radically different from historical practice. Artists focus on creating objects and events in specialized art settings such as museums and galleries, which they hope will enter the world of art discourse and the art marketplace. Even technological art such as interactive computer media, immersive virtual reality, and web art can be easily assimilated to the fundamentals of the model.

- **Critical practice:** Some artists believe that the centrality of science and technology requires a radically different response from the arts. In this they continue and update traditions of conceptual, performance and situationist non-object based art. In this view the arts main role should be to deconstruct cultural patterns of integrating science and technology to clarify underlying meanings ignored in the over-hyped flow of normal technological and commercial life. Artists acquire expertise in the technical worlds in order to understand them better and to use the technologies to subvert and analyze them. These artists often seek to place their art in everyday technological mediated settings rather than specialized art locales. (more on this model later)

- **Art as research:** Some artists believe the most powerful response is to become researchers themselves. They attempt to enter into the heart of scientific inquiry and technological innovation to address research agendas ignored by the mainstream and to integrate commentary and play into the research enterprise. I believe this opens up enormous opportunities for the arts.

**Potential Pitfalls in Critical Practice:**

Technically sophisticated artists are ideally suited to function as commentators. They are relatively free of the utilitarian and disciplinary blinders that keep those that work at the heart of the techno/scientific mainstream from understanding the subtexts and
unexplored implications of their own innovations. In fact this critical perspective has become a major position for artists and theorists working with emerging technologies. While this is an extremely powerful role for the arts, there are some dangers. If the arts relegate themselves to the sidelines as the snipers, I fear they marginalize and isolate themselves from the possibilities of helping to shape research agendas.

Also the position often has its own blindness. Almost all research and technological innovation is written off as the playing out of dark forces of commercial, military, and governmental domination and exploitation. Researchers and the institutions of science are caricatured as either evil or naive. The possibility of genuine innovation or insight is dismissed as nearly impossible. While much of this analysis is cogent, it is not the whole story. Many of the artists and theorists working from this perspective may have never set foot inside a research lab. Many researchers (especially those working on basic research) start from interesting places of curiosity, celebration, defiance of accepted wisdom, desire to explore that which does not yet exist, and the desire to create new possibilities and understandings. In these they actually function much like artists. Also, most researchers have a very different worldview than the postmodern critique of the possibilities of universal knowledge and progress; they do not share the radical epistemological doubts that many critical theorists posit as the true meaning of our times. I fear that the orthodoxy of critical technological critique may be the current iteration of the classic two-culture problem described by CP Snow. That is, the arts/humanities and science/technologies are talking different languages and do not understand each other.

**Art as Research:**

Some of the artists I studied have staked out a different role for themselves. They did not accept the role of artist as consumer of gizmos. Indeed, they chose to work in areas where the research has not yet solidified. Also did not accept critique and deconstruction as their only role. Let me give a few examples:

- Ken Rinaldo & Nell Tenhaaf - explorations in Artificial Life
- Naoka Tosa - Digital entities that can understand human emotion
- Eduardo Kac - Genetic engineering of a fluorescent dog
- Tissue and Culture - sculpture constructed from stem cells
- Ken Goldberg - Telepresence
- Kitsou Dubois - Dance in zero-gravity
- My own - Information Visualization - Crimeyland

While integrating many of the doubts and perspectives of critical theory they are more open ended about the possibilities of science and technology, not seeing it as doomed to perpetuate the past in only one way. These artists see science and technology as key languages of our age and see enormous possibilities for the arts to become vital actors in these worlds. They attempt to learn enough so they themselves can become researchers. They pursue research agendas ignored and abandoned by mainstream commerce and science as unprofitable, uninteresting, or in questionable taste. My book elaborates on details of this approach, which I cannot explore today.

Note that this approach has its own pitfalls. How can artists learn enough to become literate in these fields? How do they get access to the tools needed to conduct research? How do they integrate art and research perspectives and avoid the conceptual and economic seductions of the techno-scientific world? Already efforts underway - Xerox PARC, Interval, Interactive Institute in Sweden, Arts Catalyst..

**Genetic Engineering as an example these models:**

Genetic engineering promises to be major techno-cultural issue for the near future.

-Artists working within the classic modernist process often ignore it because it does not lend itself to object making. Ironically, in the near future once the technology diffuses to consumer culture, I can foresee biological sculpture assimilated into classic
- Artists working within the critical tradition has mostly positioned themselves against it, creating interventions that question the dominant claims about its status as progressive technological marvel. They explore the interleaving of the research with multinational capitalism. Often these artists must become quite sophisticated about the research. For example, one of my ex-graduate students is a member of the bay area "Hexterminators" artist group which seeks to create public awareness by street performance. They dressed as various kinds of mutations handing out brochures that explain the technology and they undertook research based supermarket interventions in which they marked the foods that have been modified. Certainly this kind of work is important and sophistication about the research is a resource in its execution.

But I get worried if artists see their only possibility as opposition to the research and blanket denial of it as new human possibility. This feels like many instances in history where the public stood against research without the sophistication to understand the research. For example, the texts opposing vaccination and inoculations when they were first introduced read much like the texts against genetic engineering. These scientific sins against nature were going to violate the body have unknown detriment on future of life. While there are certainly research directions that should be questioned, the line of inquiry is such a profound step for humanity that it deserves a deeper response than superficial applause or dismissal. For example, many artists proclaim the genetic engineering of plants with insect resistance genes as an atrocity. They seem unaware of its origins in the attempt to offer an alternative to the indiscriminate spraying of insecticides into the air and ground.

Another response is for artists to get actively involved in genetic engineering as art activity. Perhaps artists could produce useful or interesting modified organisms for reasons other than commercial profit. If genetic engineering is to become a major activity of our culture then artists should be involved in setting research agendas and conducting research just as other sectors of the culture.

**Access to research capabilities**

The real lesson of the computer revolution: Undoubtedly some of you are skeptically shaking your heads. How are artists going to learn enough or get access to research settings so that they could function as serious researchers in a field like genetic engineering? Is actual genetic engineering a valid activity for the arts? The exact same attitudes prevailed 20 years ago when some of us artists started working with computer technology. Artist colleagues were skeptical. They did not see any relevance of computers to the art world. Furthermore, the electronics and programming were seen as highly specialized - certainly beyond the artist's mind. The machines themselves were seen as expensive and complicated - inaccessibly locked away in university and corporate research centers.

Some think that with the major meaning of the computer arts revolution is the digital images and sounds now possible. This a fundamental misunderstanding of history. The most important lesson of the last 20 years is that significant technological innovation and science could happen outside established institutions and that artists could participate in the heart of the research process and help shape its research agendas. Binary math and programming that were once thought masterable only by PhD's are now mastered by pre-teen hobbyists. Esoteric research topics can have profound cultural impact. These are the lessons we need to build on.

**Future areas of artistic research.**

My students who have mastered digital technology think they have a free ride into the future. I warn them that it is not so easy. The future actually lies in many areas of research now considered esoteric and irrelevant just like computers once were. Artists can best serve their historical role of "keeping watch on the cultural frontier" by proactively moving into these areas long before developers or the art world declares them as available. Here are some areas I identify in my book which are going to be culturally significant. There is some artistic activity in some of them; many have no artistic activity yet.

Here are some samples

see [Emerging Technologies Links](#), [Artists and Technologies Links](#)

- Biology (microbiology, genetics, animal and plant behavior, the body, brain & body processes, body imaging, and medicine)

- Physical Sciences (particle physics, atomic energy, geology, physics, chemistry, astronomy, space science, and
GPS technology

- Mathematics and Algorithms (algorists, fractals, genetic art, artificial life); Kinetics (conceptual electronics, sound installation, and robotics)

- Telecommunications (telephone, radio, telepresence, web art)

- Digital Systems (interactive media, VR, alternative sensors - touch, motion, gaze, personal characteristics, haptics, activated objects, artificial intelligence, 3-D sound, speech, scientific visualization, surveillance, information systems)

So how easy is it going to be for artists and technologists/scientists to collaborate?

**Science and Technology are not the same thing:**

Many people are sloppy in their thinking about these terms. Any art that uses new technology is often referred to as art and science. Many artists have started to work with new technologies but many less are working with science. Science and technology are often conflated together. Historically science was seen as being interested in why and technology was interested in how. In the contemporary world, however, the relationship has become more complex with new technologies opening up unprecedented areas of scientific inquiry and science providing many ideas for new technologies. Artists have been much more involved with technology than science.

**Special problems between art & science:**

In my research there were many more instances of mutual influence between art & technology than art & science. Technology has a long history of respect for freelance innovators and people who break out of established paradigms. It respects processes of trial and error, hunches, inspiration, discovery through craft, play, and invention in addition to careful theory based experimentation and respect for paradigms. Edison is a good example. Artists and technological innovators share much ground in these approaches. Labs interested in technological innovation have invited artists to be part of research efforts and some artists have been eager to learn about technological research. The influences between science and art are more problematical. It gets more interesting when artists take the time to learn the scientific context of the innovation rather than just playing with the gizmos.

**Not a 2-way street:**

The influence has not been symmetrical. While there are some notable exceptions of artists influencing technological research, there is much more influence going the other way. Artists have been eager to adopt the fruits of technological research and others have been much influenced by the concepts and contexts of science. Scientists and even technologists to some extent do not believe that artists have much to tell them about their business. Scientists tend to invest respect in a researcher's disciplinary credentials and in membership in established networks. Many are quite engaged by the classical worlds of art, theatre, and music but do not see art as relevant to their professional work as researchers. In part this is because they do not understand contemporary arts reach beyond objects and performances. They might respect artists' ability to reflect on the social implications of research (like a politician or philosopher) but they do not believe artists (or anyone else) have any special expertise or perspective that actually might be relevant to the framing of research agendas, the conduct of research or the interpretations of results.

**The Prospects for art/ techno-science collaboration:**

Let me offer some brief examples from my own work. Over the years I have been a developer for new technology companies, consultant to NSF research projects, and artist-in-residence at research centers. My own art works have often focused on emerging technologies still in their formative stages. The involvements have been judged valuable by me and my collaborators; yet it is often difficult to trace concrete results.
- I was a consultant to an NSF Project to develop artificially intelligent tutors for teaching science. 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. I didn't have much influence on it. Since that time I have created a variety of art installations that examine dialogs with machines including "Is Anyone There" which had a computer call 5 pay telephones every hour on the hour for a week and try to talk to whoever answered.

- I was an artist in residence at Xerox PARC, the research center that is credited with innovations such as the visual interface, laser printers, and ethernet. There are chapters about several of the collaborations reported in the Leonardo book Art and Innovation. The mutual influence is subtle in many cases. I worked with researchers Jock MacKinley and Polle Zelleweger who worked in the Information Visualization group. We decided to work together on the World Wide Web when it was known primarily to researchers. We had a productive time creating the shadow server. It lived in the background as you surfed the web. Every time you made a choice it, put images and texts from pages you could have chosen in the background. We called it the "road not chosen". I did it because I was interested in the experience of wondering "what if" as we make choices in life. They liked it because it offered checks on researchers process as they moved through material. More details are available in my chapter of the book Art & Innovation.

What of the future?

Science/Technology literacy will need to become much more widespread. They will cease to be ghettoized as only for tech heads. Arts will need to be much more integrated. Several efforts around the world are under way now to integrate art and technology development. For example, the interactive Institute in Sweden has five national art and theatre schools linked with research institutes. Similarly the I3 in the European Community have tried to forge links. The US is behind in all this. The motivation is economic - Europe feels like they are behind the US and Japan in technological innovation and are desperate to catch up - even to the extent of including artists. My book describes several of these efforts. The most interesting developments, however, will come when science and technology begin to be seen as the cultural activities that really are and when doing research becomes part of doing art.

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