

CONCLUSION: ART, SCIENCE, AND TECHNOLOGY STUDIES

The politics of knowledge categorization reveal that the zoning of knowledge as art or as science is not a stable proposition. Categorizing knowledge involves constant maintenance. Actors marshal resources in service of showing how objects, people, and ideas fit into the communities of art and science. As soon as contexts change or definitions shift even slightly, liminal objects can slip out of a category or people can come to be understood as outside a knowledge community. At the same time, actors are willing to participate in and coproduce these categorizations because of the recognition and access to resources that belonging in a knowledge community can provide. In turn, efforts to situate items as art or as science can give STS scholars an opportunity to compare how knowledge categories are constructed. Aesthetic knowledge can become points of comparison for ASTS scholars, whether they hail from science and technology or from art. The practical effect is a better understanding of knowledge systems by STS scholars and practitioners working with art and science. Embracing a constructivist position helps show that the strength of the knowledge claims and the relative power of art and science are more related to context than to the specific practices by each group or the internal processes of knowledge certification within the two knowledge communities.

The frontiers of art and science as knowledge-making communities have yet to be fully probed by STS. This book indicates some of the multiple conceptual and programmatic affinities between some artistic communities and STS. If STS scholars are unable to open to our interests in art, much will remain unknown. Artists whose practices are different but whose concerns are aligned with ours will remain outside the STS tent when much might be gained through our interactions. The number of curators, facilitators, and collaborators who work with such artists who have STS backgrounds reveals something about their potential value inside STS. Their methodologies do not simply align with STS but are often drawn directly from it. If art continues to be excluded from STS, or is included only as a form of outreach, what we might learn from these artworks and artistic practices will remain black boxed. In its most obvious and closely aligned form, STS scholars should pay more attention to art's development of techniques that are appropriated by science communities. Much as historians of art have sought to consider the technical means by which mediums of art were created, STS scholars must do more to understand the history of the visual, aural, and rhetorical traditions that have hailed from the arts and that make up the evidence in the scientific community. And yet this too is not enough. Scholars of STS should consider the possibility that there are important observations about knowledge systems to be made from vantage points other than the classical ontologies, social relations, and institutions of science, technology, and engineering. The cases in this book provided a basis for a reflexive program of excavating the ways in which art and science ideas are intertwined in STS work. They serve as a call to consider new methods and forms of practice and to take STS to its logical conclusion: to treat all types of knowledge claims as social processes and insist that contexts really do count, even when it comes to defining our own subject. If the STS community heeds this call, it may find that its work has been rooted as much in the realm of constructed art as in the realm of constructed science. Closer examination of these affinities may reveal that the tools used to construct these knowledge forms share more than we might have guessed.

In short, STS has as much to offer art as it does science, and much to add to its own conceptual toolkit by comparing the two. Intervening with

the tools of STS, it is possible to offer some reconciliation between the embattled positions of the rational and the nonrational. In STS, modes of production-knowledge need not necessarily be based on recognizably scientific principles to warrant attention and analysis. Concepts of rationality and objectivity can be given histories, presenting an opening to study art, artists, and artistic practice using STS tools. This book has suggested that many of the ways of encountering scientists, engineers, and other knowledge producers in STS, including ethnographies, interviews, and archival research, are equally useful in understanding the knowledge-making practices at the border of art and science. Less commonly used methods derived from visual studies, art history, and curatorial practice also add value to this endeavor and should be considered essential in the development of the species of STS inquiry devoted to art: ASTS.

Understanding aesthetic knowledge serves to enrich STS by contributing to the theory of science and technology practice. ASTS helps problematize science more fully and deepens understanding of social construction by emphasizing that the major differences between art and science relate to their social standing and relative power as institutionalized knowledge communities. The position of ASTS that both categories are equally socially constructed advances the social constructivist project and strikes a blow against residual realism in STS circles. It acts as a corrective to the tendency in STS to create differences between science and technology and to tailor different analytical approaches to these social entities. ASTS suggests a wider world of knowledge communities that can be grasped if science is no longer treated as a uniquely special form of knowledge.

This book has argued for the role of STS in the analysis of the art-science phenomenon, particularly with regard to understanding the knowledge categories of art and science. This position allows analysts to see art and science as actors' categories marshalled around resources rather than as stable decontextualized practices. We have seen that methods can be devised to examine science and art that are neither inimical nor minimizing of either knowledge community. STS's concepts of symmetry and treatment of knowledge communities can be useful in developing such methods. Indeed, whether scientists or artists like it or not, institutional changes are bringing issues of symmetry, particularly around research, to the fore. For example, one recent challenge is the emergence of the

research PhD over the Master of Fine Arts (MFA) as the practice and teaching credential expected of artists. This new education hurdle creates an academic gap between more established artists and those who are newer to the field. At the same time, many in the art world complain that additional years of schooling translate into fewer years of individual practice. Artists are being institutionalized in new ways. Just as the professionalization of science in the nineteenth century had profound consequences for the practice of science, so too will art be shaped by this more extensively trained professional class. As the research PhD crystallizes as the currency of education in art, new questions are increasingly being asked about the role of art in research and the role of institutions as supporters and targets of artistic critique.

Another recent development relating to modes of entry for artists into institutions previously understood as made by and for scientists is the interaction between artists and Institutional Review Boards (IRBs) around definitions of research ethics in the arts. A number of artists have begun to seek the formal approval of IRBs, particularly in instances where universities' laboratories or resources are in use, such as with SymbioticA and Coalesce, and such approvals are required. Some artists, such as Jennifer Gradecki (*IRB# G10-02-066-01* 2010) and Adam Zaretsky (Doyle 2016), have critiqued the trend of science institutions' regulations extending control to art-making. Other challenges to science regulation have come from artists such as Joe Davis, Dan Dal Bo, and Ashley Seifert. In *Lucky Mice* (2018-ongoing), the artists worked with scientists in seeking IRB approval for an experiment on the heritability of luck in laboratory mice, a process central to the documentation and presentation of the artwork. More interventions of this type are sure to follow. At the same time, artworks and artistic modes have been increasingly placed in conversation with research frameworks responsible to the European Union. These frameworks seek to promote creativity and opportunities for science and innovation that are socially desirable and undertaken in the public interest. Such frameworks may involve public participation and feedback through forums or other informal science deliberation methods or may involve reflection on the part of scientists and innovators (Voarino 2019). For example, *Crossing Kingdoms* (2018) was an artist-led effort to consider the ways in which taxonomic kingdoms are violated and complicated by

modern biotechnological practice, particularly in synthetic biology.¹ In this project, SymbioticA's Ionat Zurr, Oron Catts, and Tarsh Bates worked with Jane Calvert's engineering life research group and synthetic biologists at the University of Edinburgh in considering how artist-led research might look.² They created an experiment involving the philosophy of fusion, exploring fusion in the sense that synthetic biology understands it (as the clustering of cells from different species) and in the broader sense of interdisciplinary collaboration. The group understood its work as a way to facilitate reflexive thinking and the entry of new modes of inquiry into the responsible research framework with a view to enhancing process efficacy (Szymanski et al. 2020).³

Besides overlapping with persistent concerns in the STS community, contemporary art-science addresses broader intellectual trends in both art and science. Many of the earliest bioart pieces resisted potential enrollment in the commercialization of life or critiqued the influx of funding and resources to biotech companies in the 1990s. Second-wave bioart emphasized the role of the nonhuman and featured works around animals and microbes, particularly those functioning as part of the systems of the human body. Other projects positioned new life forms as art in work enabled by the latest techniques in synthetic biology and were often framed in ironical and satirical ways, key elements of the traditional critical toolkit of the bioart movement. Bioartists continue to focus on concepts such as genohype and genetic privacy issues, but they also take on subjects that might not seem immediately related to art as biological process. New artworks are as likely to take aim at issues of climate change, labor, and gender, even as the more traditional interests in fragmented bodies, the semiliving, and animals persist (Catts and Zurr 2002).

Whether the case in question appears planted firmly in the category of art or science or whether it is a case of liminality, rhetoric and materials that invoke ideas are constantly being reconfigured. These new configurations are designed to achieve actors' political, aesthetic, and knowledge-making goals. These goals often involve actors working to make their creative products "count" as art or science, and comparing cases reveals different goals and methods for positioning work. It is the activity of the actors in positioning works that should receive our attention here. The engagements of individual artists with the categories of art and science

are idiosyncratic, but the efforts of artists to position themselves in terms of these categories have similarities. The Blaschkas literally contributed materially to science. Their models were vital cutting-edge heuristic apparatuses for understanding organisms. For them, contributing scientific models simultaneously accomplished their economic and identity goals, so that having their work categorized as scientific was a means of fulfilling both goals. Tactical media practitioners showed a willingness to be categorized in any way that was helpful to having their political ideas taken up.

Traditional modes of delineating art and science create difficulties for practitioners who do not adhere to these conventions yet hope to win acceptance in and funding from each sphere. On the other hand, eschewing these conventions opens the possibility of drawing on resources from both communities. Some actors explicitly work to create a borderland between art and science. Many bioartists, for example, distinguish between their employment of scientific ideas and techniques and doing science. They claim the former as their work and reject the latter, labeling the outcome of their work *art*. Similarly, some bioartists reject the term *bioart* because it elides art and biology. They claim instead to practice *both* art and biology. The slipperiness of the terms *art* and *science*, as used by these bioartists, undercuts the definitions of what counts as science and at the same time attempts to reinforce the shield that makes artistic practice a thing unto itself.

Tactical media practitioners consciously differ from this way of thinking about the flexibility of categories. Although the Blaschkas understood that a sort of boundary-work, in which they adhered to conventions from both science and artisanal glasswork, was needed to make their models appealing to scientists, tactical media practitioners intentionally work to leverage the categories for their political ends. Tactical media artists discuss and demonstrate that they consider art and science as resources for attracting particular audiences. Both groups interact with boundaries and play on them to garner the right attention for their work. Bioartists, such as those at SymbioticA, similarly invoke political and ethical goals for their work, but they claim to want to maintain the boundary between biology and art, even while creating projects that dissolve that boundary on many levels.

There is no single type of transition or traceable change in how the objects come to fit the definitions of art and science. These two categories continually change as a result of being manipulated by actors for specific purposes around the objects. During my interviews with tactical media artists, some artists stated that calling their work art or science was irrelevant. All that mattered to them was that people were exposed to their ideas, which often related to political issues, particularly critiques of capitalism.

This social difference is created by our system of labeling and categorizing acts of knowledge-making. These categories insist on distinctions, encoding each with power differences that result in structural differences. The hegemony of the sciences has led to and reinforces its own access to capital and government funding, particularly in the United States. These power differences between science and the arts give some actors reason to attempt to position works inside the tent of science. They also perpetuate some of the asymmetries that are observed in art and science collaborations and affect collaborative outcomes. Scientists have access to vastly more public funds than artists do, according to the agencies that serve the two groups. In the US context, the National Science Foundation (NSF) had a 2016 budget of nearly \$8 billion, and \$8.3 billion by 2020, whereas the National Education Association (NEA) had a 2016 budget of just under \$148 million, which grew to only \$162 million by 2020. The governmental funding for both groups is instructive. The NSF funds academic science awards, mainly to university-based researchers. The NEA primarily funds arts organizations in the US, which in turn distribute the money. Public art historians, arts management experts, and individual artists often point to a shift in attitudes about funding individual artists that has shaped arts funding over the past thirty years. This change in the way that art funding was distributed was based on Congressional reactions from Republicans, including Jesse Helms and Alfonse D'Amato, during the 1990s, when the NEA came under fire for its support of artists such as Robert Mapplethorpe. The artist's 1989 exhibition *Robert Mapplethorpe: The Perfect Moment* documented the homosexual male bondage, discipline, submission, and masochism (BDSM) subculture of New York City in the late 1960s and early 1970s. The exhibition was deemed obscene by some public officials and sparked a national conversation

about constitutionally protected free speech and arts funding. These changes were accompanied by new scrutiny of what should constitute public art. Funding for artists and scientists is of course not provided solely by the federal government: public grants from states and municipalities, private foundations, and university budgets are also important to both groups, so the sources of support are similar in kind, though there again substantive differences in available resources occur.

This financial disparity also has more philosophical implications. Usually the funding disparity is defended as a difference in the economic contributions of science, but even in the face of evidence of economic contributions by the arts, this bias has proved durable. The old adage that if a peace department were created and given the funding of the military, peace might break out everywhere is relevant here. If artists were given the kind of support that scientists have enjoyed in the postwar Big Science era (Galison and Hevly 1992), the arts might be expected to take a similarly respected and transformative role in society. A close look at liminal cases raises the possibility that naturalized differences and their accompanying social roles owe more to the positioning of their makers, champions, and detractors than to an assessment of their practices or outcomes. The thriving interest in art-science work that has grown over the past twenty-five years speaks more to changes in institutional interests and investments of effort and resources to create multidisciplinary projects than to a newly emerging phenomenon. Indeed, the phenomenon is present in all cases when actors work to categorize their efforts and be recognized as producing science, art, or both.

In practice, definitions of art and science are moving targets. They oscillate between the idea that art and science are expressed and symbolized through the objects that they produce, and the idea that art and science are ways of attending to an object, so that the same objects can be subjected to the practices of either domain. Different knowledge networks assign the Blaschkas' work value in different ways. In the case of the Blaschka models, when they were placed in their science context, their curator at Cornell University, Drew Harvell, hoped to garner attention for the cause of marine conservation. Although the Blaschkas certainly imagined scientific uses for their models, they could not have had an inkling of this particular use of enrolling the public in efforts

to protect the environment, particularly oceans. Across campus at the Johnson Museum of Art, the models would be treated as examples of craft practices from their particular historical period. Although the Blaschkas talked extensively about their craft, the concept of craft versus art was very much contested by the Arts and Crafts movement of the late nineteenth and early twentieth centuries, led by William Morris, Walter Crane, and T. J. Cobden Sanderson. Though the Arts and Crafts movement looked to raise craft practice above industrial trends, one effect of their socialist art philosophy was the blurring of distinctions between art and craft, which they saw as aesthetically and politically unsound. The easy distinction between art and craft has been further complicated through the recognition that the difference between art and craft was too often the identity status of their makers. In particular, it has been associated with edification of craftwork as a political act related to the elevation of women's craft works to art status. The Johnson Museum of Art has defined art in a way that includes craft, and this is how the Blaschka models are framed in that context.

The fact that the medium of glass as an expected material for craft and fine artworks is also helpful to the museum's curators in setting up a context in which the Blaschka models are a coherent part of the museum's narrative of art history. Although glass has been used for a variety of industrial, technical, and scientific purposes, its long tradition in the arts makes it easier to accept as part of a history of art than, for example, plastic models, which are often included in science center or design collections but are rarely included in art collections. The medium of photography, like glass, has been seen as flexible enough to join the arts, though it also maintains an important standing in science as a method for documenting experiments or providing evidence of direct and indirect observation. Changing definitions of art, that is, its expansion to include some documentary photography, were also necessary for the acceptance of science photographs into art collections. Berenice Abbott's science photographs have only recently begun to be treated as artworks, which has meant that her career has often been understood as divided into an art period and a science period, thereby masking the relationship between her contributions. In the art network, Abbott's relationship to science is understood through her documentary work and realist aesthetic. Many

other photographers have worked for scientists, but few have their work included in art collections. The context of Abbott's portraiture and subsequent documentaries certainly plays a role in how her science images are read and their value as artworks.

Conflicts do arise between the use of a network in a project and the project's ability to critique that network. For example, in the case of tactical media practitioners, this played out in the work of the group Preemptive Media in the project *AIR* (2006). *AIR* provided handheld sensors to community members at a variety of urban sites to measure the concentration of pollutants in everyday environments. On one hand, Preemptive Media, like many involved in community-based citizen science projects, wanted to create and spread knowledge about air pollution. This required that they rely on some scientific principles and engineering protocols to create functioning air quality sensors. They also wanted to use their handheld sensors to undermine the scientific standard of stationary sensors and to raise awareness about the flaws in the government's air quality monitoring system. These practitioners employ the technical signs and the scientific language of air quality. They insist on their right to work with materials and to verify ideas that are conventionally understood as inherently scientific, but they do so to challenge the categories they worked within and to reflect on this boundary.

Similarly, the case of the Blaschkas might, on the surface, appear to be what has often been treated in science studies as a typical hegemonic relationship in science: glass artisans serving up their craft for use by scientists. Looking more closely, we find that the Blaschkas contributed to science with their models and that their story reveals an effect of aesthetics in science. The reuse and preservation of these models in art and science contexts shows the high degree of interpretive flexibility that these objects possess. Recontextualizing the models can transform their meaning to viewers. Furthermore, the power of the objects in the art or science contexts may be derived from the power ascribed to the object in the other context. The categories themselves are not blurred. Instead, the practitioner's creation was designed to fit into both networks; it is created to be a liminal object. The tactical media movement of the 1990s did precisely this to serve their political ends. At another level, however, there is an implicit critique of technology's power and ability to be subverted for

precisely the types of political maneuvers that these actors regard as necessary to their practice. The bioart movement displays this self-conscious paradox: the actors call themselves artists yet use the techniques and protocols of scientists to create their work. Their work uses and critiques science, yet they insist that it is art.

IDENTITIES AND SKILLS

Two of this book's major themes, identity and skilling, particularly warrant direct comparison here because of their reoccurrence and importance as resources for actors in compelling others to accept work into art and science networks. Seeing these themes across the work of artists engaged with science shows the importance of identity and skilling in situating work. Artists are perpetually involved both as workers in the scientific world and as social critics engaged with society's ideas about science and technology. Artists have long been close to science, allowing for both integration in and reflection on scientific practice.

Identities and skills are intertwined. Self-fashioning through chosen identities and mythologies serves an important role in helping actors position themselves and, thereby, their work. A patriarchal ancestral lineage as glassmakers was the ultimate marker of identity for the Blaschkas, who claimed that their skills were the result of inherited ability. This claim surely fit well with the then-rising scientific tide of the heritability of traits. SymbioticA artists have chosen a lineage that emphasizes both directions of influence between science and art in the persons of Alexis Carrel and Edward Steichen. Tactical media practitioners invent histories and characters to draw attention to their political causes.

Tactical media practitioners sometimes create fictive identities to forward their causes, but the Blaschkas also selected and promoted their identity markers to gain acceptance as observers of the natural world. Although different in kind, these actions are not different in cause. Both engaged the science of their day, if for different purposes. Tactical media artists position themselves ironically and satirically to parody capitalistic control of knowledge, whereas the Blaschkas attempted to extend their representations to meet scientific demands. Bioartists fall somewhere between these two positions. Although they do emphasize

aspects of their identities to position themselves as artists or scientists in different contexts, this positioning takes many forms, with different degrees of self-reflexivity. Certainly, intentional fictions are part of the self-fashioning landscape, but more often simple additions and omissions, reflexive or not, shape the way in which objects and information are received. Many contemporary artists, including tactical media practitioners and bioartists, present themselves in costume at performances, though it is hard to draw a line between wearing a lab coat or wearing a power suit to situate one's expertise and simple self-presentation by any public speaker. Sometimes performance or acting skills are utilized as part of their projects, but generally the audience is made aware that they are seeing an act, much as many public presenters are understood to have rehearsed their work in advance. Whether done in a self-reflexive manner or not, identity management plays a crucial role in positioning experts and individuals more generally, so it is no surprise that the actors in these cases work to position themselves, and thereby their work, in relation to the categories of art and science.

Considerable technical skill is required from all the artists in question. Not only did the Blaschkas need to master lampworking and, eventually, the details of creating colored glass, but their model-making also required scientific and technical skills. These skills included observational abilities, scientific drawing, and the ability to emphasize what their scientist-customers would consider the salient features of each organism. Tactical media practitioners also required a host of skills varying by project. These artists require promotional acumen as well as conceptual abilities and, in some instances, acting skills and the ability to create satire or a good joke from the often-serious matters at hand. Many of these artists also need to be familiar with the legal rules that may apply to their work. Additionally, tactical media practitioners need the technical skills to make their websites run, their pigeons with backpacks to fly, and their gels to work. These scientific and engineering skills must then be translated for audiences. Many projects are oriented toward community understanding; these projects then also require skills for working with the public. Bioartists face similar hurdles. They want their scientific projects to translate into ideas for audiences and must shape them to that end.

Bioarts face legal and ethical technicalities as well. In addition to the expertise required to gather the resources to conduct tissue culture or lab work with other living things, bioartists must also navigate the often-complex rules for safety and ethics boards. In addition, they must speak the language of science to fruitfully interact with the scientific community and be familiar with a myriad of lab work protocols. For actors who wish to work at the border of art or science or even undermine their separation, the proper skills are no small matter. They must acquire knowledge valued by both communities. Being recognized as having an eye for observation, a knowledge of equipment, a facility with technical language, or a way with tissue medium helps these artists to work credibly in science and in art. What is it then that these artists are able to create when they use their technical skills to bring audiences an artwork that uses science to critique science?

SEPARATING SCIENCE AND ART IS CONTEXT DEPENDENT

The recognition that the art-science boundary is constructed does not guarantee that the relative power of art and science will be rebalanced. Just as gender has not evaporated under the work of feminist scholars who sought to expose it as a social construction, it is unlikely that any amount of science studies work or number of examples will close the gulf that so many people are working to create between the arts and sciences.

Deconstructing the similarities and differences in specific examples, however, can provide insight into context-specific constructions, as well as the uses of this boundary. This is important work, but like the changes brought about under feminism that were supported by the work of academics but executed by activists, a dedicated group of artists and scientists must work to bring about a more equitable power balance. Just as the STS project that does not consider gender is rare today, ASTS scholars may look forward to a day when art will be considered as a potential subject in every STS study. It is the role of STS to bring science and technology into focus by uncovering the work of its practitioners whether or not they are regularly feted by the science world itself. Given an opportunity, art and studies of art methods may prove their worth as approaches to understanding new aspects of science and technology.

THE MICROSCOPE AND THE PAINTBRUSH

It is typical to associate art and science with different materials. This easy separation, however, is impossible to maintain in the face of the use that bioartists have made of microscopes and the use that scientists have made of artist-rendered representations, images, and models. The separation of types of materials seems to hold up only under the conditions of caricature, and then only in certain contexts. What we know in STS about the way in which scientists employ materials has gone a long way toward undermining the notion that scientists directly read from a material “book of nature.” Rather, their interaction is more like the representation associated with classical artists, who are thought to study a subject and then re-present it in another medium.

At the same time, the stereotypes of the artist with a paintbrush and the scientist with a microscope persist for those outside art and science worlds, respectively. Dismissing these ideas as confused public impressions may be to ignore the very sociological factors that are at work here, because people’s beliefs about what is or can be science or art may crucially inform those categories’ meanings. For example, some artists wear lab coats intentionally to play on the authority vested in the garment, and other artists perform complex experiments in the canonical avant-garde artist garb, all black. Bioartists and tactical media artists make use of expected emblems of science so that as STS scholar Michael Lynch suggested to me, even when they challenge those stereotypes, they reiterate them.

Another point of difference often raised is the divergent training and technical skills thought to be required in the work of each group. As we have seen, however, in the experience of Rudolf Blaschka, this assumption is often contradicted. Rudolf studied natural history and made extensive field trips to collect specimens, along with having training in drawing and lampworking. Many tactical media practitioners and bioartists have backgrounds in science and technical fields. Oron Catts and Ionat Zurr learned tissue culturing directly from Harvard Medical School-based Charles Vacanti, the foremost researcher in the field. Many of the scientists who exhibit images in galleries, for example, the nanoscientists involved in the Materials Research Society’s semiannual art competition,

have little or no artistic training. They offer up images from their work that are recontextualized as art. It is possible simply to dismiss this competition as amateurish, or even nonart, but the fact that these competitions exist at all raises questions about the way in which images are valued under conditions of recontextualization. Questions were raised, after all, in the early days of bioart about its legitimacy within the art-world, particularly in commercial galleries.

Moreover, there are probably those who would dismiss the training of Catts and Zurr in tissue culture as incomplete, thereby challenging their right to do science because they do not hold scientific degrees. At least among the scientists with whom they share laboratory space, however, there seems to be no disagreement that they are quite capable of performing the scientific practices required to maintain living cells, though not even the actors themselves would call their work science. The idea of scientific training as a distinguishing marker is thereby problematized. Training as a metric for differentiation then presents further ambiguities. With SymbioticA scientists working on art projects and scientists engaging in art competitions, it is not clear how to divide people by using their training.

Another approach would be to examine the institutions that these two knowledge communities have created and work with and through. An institutional point of view might see art and science as differentiated by their relationships to the state. Some artists might like to picture scientists as servants of state power, but, as STS has shown, science and the state have a much more complicated relationship (Wynne 1992; Jasanoff 2004; Mirowski 2011). Artists themselves have a dizzying array of relationships to governmentality and to science as well. Many artists in the tactical media and bioart movements are critical of other artists' relationships to both science and institutional power. In the case of the Wellcome Trust and *The Pig Wings Project*, for example, the bioartists believed that they were being led to take utopic or dystopic positions, implying that genomics was important enough, for better or worse, to warrant all the fuss. The exhibition questions were limited to two-dimensional space in which the primary questions were not the real meaning or value of the genome as the artists saw it, but whether the genome should be under state or private control. In other words, the gallery's question was a

recapitulation of many scientists' concerns, rather than an exploration of the genuine reaction of artists. These particular actors believed that it was their role as artists to contest this setup rather than to support one side or the other.

For similar reasons, bioartists also critique those who present images meant to celebrate science and discovery. They see the role of the artist as necessarily involving a reaction to science beyond admiration, though this is hardly a voice in unison. There are dissenters to this vision of the artist as standing against social and political institutions. Communications scholar Fred Turner argues that artists have been enlisted as agents of state power. Turner points to the relationship between Black Mountain artists and the emerging automation of production tasks as executed by American capitalists to suggest that artists are not outside state influence but indeed may act to reframe or even exert pressure on new technologies as they are put into practice (Turner 2006). In *Workshops of Empire* (2015), Eric Bennett showed the relationship between the early Iowa Writers' Workshop and the US government via (among others) the Farfield Foundation, a CIA front for supporting cultural organizations. He suggests that those relationships fostered an ongoing climate of commercially driven creative writing in the United States.

Frances Stonor Saunders has suggested a similar relationship between the CIA-backed Congress for Cultural Freedom and modern art, particularly abstract expressionism (1999, 2013). Given this background, it is perhaps not surprising that different views have emerged among artists on the subject. For example, in light of this history and the arrest of Steve Kurtz, who came under suspicion because of the materials in his home laboratory, artists such as Paul Vanouse are careful to avoid support that might have state linkages of this nature. On the other hand, some artists and art-related groups have been more amenable to these overtures. The intelligence community has been involved in offering opportunities for discussion about safety and regulation and direct support to community biolabs, which often support and work with artists.

In my interviews, I have observed that many artists have a negative reaction to the suggestion that they are science communicators or simply creating beautiful objects from scientific data. This sensibility is built on their collective identity, which demands that they engage in works

against state and corporate power. For many, this includes the power that they see vested in modern science. Similarly, the Blaschkas surely would not have tolerated the suggestion that they were creating merely decorative objects. Though beauty is a hallmark of the past and present descriptions of their work, this quality was connected to the idea that they were producing realistic representations of a sublime undersea world. The Blaschkas' style matched the needs of the moment: channeling the marine environment's forms and colors into a recognizable format that orients the viewer and creates a visual language of verisimilitude. Style was required for the models to be interpreted as science. Try as we might to pare these objects down to rational ideas, the nonrational is present as style in colors, forms, and positioning. Here, style is not simply auxiliary. Rather, it is part of what makes a Blaschka model "correct" in terms of contemporary conventions. Styles can make artwork more or less acceptable to the scientific community in a given context. Abbott's documentary-style photos projected a realism that the Physical Science Study Committee believed met their goals for pedagogical images.

In contrast, bioartists employ the apparatus of science styled to express critical ideas. In *Victimless Leather*, dim red lighting gave the bioreactor a mysterious, portentous quality at odds with notions of scientific transparency and objectivity. In this manner, the artists called attention to the fact that white, clean lab aesthetics are themselves a stylistic choice. Kelley (2016) has pointed out the way in which TC&A highlighted that lab aesthetics are active choices with consequences for interpretation. The aesthetics of surgeon and biologist Alexis Carrel's tissue culture lab used entirely gray walls and black floors and furnishings.⁴ Oron Catts commented in an interview on the work of Martin Couney at his "infant incubator" facilities in Atlantic City and Coney Island, whose aesthetics were in contrast to the celebrated Alexis Carrel's gray and black world. From 1903 to 1934, premature babies being treated in incubators were accessible to public visits for twenty-five cents. As part of his bid to style the facility less as a sideshow and more as a hospital, Couney insisted that nurses wear starched white uniforms and that doctors wear suits beneath their white coats. The choices made by practitioners in self-styling helps highlight the ubiquitous lab styles, which are often invisible to contemporary viewers because of their prevalence.

All the artists in question emphasize some form of contribution or critique. Bioartists object to characterizations that suggest that their work is auxiliary to science or that it translates scientific subjects for the public. Instead, these artists aim to contribute to debates around and inside science. In contrast, tactical media artists openly state that their goals are political. These agendas are frequently anticorporate, opposing state regulations understood as driven by business interests, or against the science-state complex. Like bioartists, they see their role as artists as necessitating critiques of power. These critiques sometimes require that the actors involve themselves in legal actions, directly interfacing with state power.

The Blaschkas' relationship with power involved their economic concerns and the introduction of style into the scientific objects that they made, because one of their foremost goals was to sell models inside the scientific community. The Blaschkas also wanted to contribute to scientific knowledge, but it was important to them not simply to copy the illustrations of scientists but also to do hands-on observations in their own garden and in the field. They and other artists who worked to contribute directly to the representational culture of science understood themselves not simply as working for scientists but as contributing to scientific knowledge through their observations and by spreading their findings to the community via their models. An account of the Blaschkas that reaches beyond the assumptions that artists are hired and disciplined by scientists to create proper models reveals the contributions that these artists made to creating new and innovative representations to circulate through scientific communities and for use in pedagogical contexts. For the Blaschkas, the role of artisan involved more than serving scientists. They understood themselves to have particular expertise in observation and "tact." They contributed directly to the scientific enterprise by providing the material means for scientific study and by introducing style elements, notably from Art Nouveau and photorealism, into the representation of specimens.

Careful studies of other artists who at present are understood as working for scientists would likely reveal more instances of contributions that go beyond simple commissioning. The Blaschkas were participating in a kind of revolution, however, in making space for themselves as glass artisans in the natural history community. The power to certify their models as part of natural history rested, as it does in all science communities, in

the individuals that make up the scientific network. This made constant interaction with researchers and institutions vital to their success. Their agency extended beyond their roles in business and marketing to being contributors in the scientific enterprise.

KNOWLEDGE AND AESTHETICS

Eagleton's understanding of aesthetics as intimately related to the body and yet missed by the Enlightenment gaze is also present in many bio-artworks. SymbioticA artists seek to render the uncontrollable quality of corporeal life and lived experience in works such as *Victimless Leather* and concepts such as the aesthetics of care, which challenge assumptions that biology can be predictably and reliably controlled (Catts and Zurr, 2013). Stengers, Catts, and Zurr point out that it is fundamental to science as we know it to subjugate other forms of knowledge, and the resulting omissions risk informing a potentially universal, yet incorrect, impression of what lies beyond its ambit.

These tensions create openings for ASTS as a means of understanding both art's role in terms of science and the value of art as a competing meaning-making system. If the aesthetic is political (the uncontrolled part of society's experiential life), science studies must take it into account when it applies its tools, which are already honed to deal with experience and practice. Amid the rationalist bid to control society's knowledge sphere (to use Stengers's term, 2011), art offers another view of the world according to science and, moreover, a means of critiquing it, albeit in the art community's terms. The difficulty is that to be assessed by science as legitimate, the critique must play by science's rules, which makes impossible external or, indeed, any unauthorized voices.

Nevertheless, artists have managed to use the culture of science (apparatus, language, and subjects) to build very robust critiques. In the case of projects such as *Pig Wings*, for example, these interventions take the form of scientists attempting to harness the work of artists and their access to the public imagination. Expectations of the role of artists in the Enlightenment project is part of the rhetorical posture that scientists often strike in assuring the public that all is well in hand, even in the face of the complexities of working with living things. If science offers the public "what"

and science studies offers “how,” then art has the potential to offer the unexplainable content of experience.

AESTHETICS IN CONTEXT

Evidence of an actor’s identity work may be encoded into a tissue culture artwork or a display of glass sea creatures, yet the power of these objects is usually derived from experiencing them as material arguments. When we experience these arguments, we experience the politics of the aesthetic in Eagleton’s terms, the feeling of something outside rational knowledge and its connection to elite values. Attesting to this absence is precisely what motivates many bioartists. It is what they encounter in trying to keep tissue culture pieces alive in the gallery. If we were admiring the accuracy or correctness of their works as science, dozens of other descriptions or configurations of objects would do as well. What we admire is that the messiness has been left in. There is something more there than what is required.

With this in mind, the example of the Blaschka models can be seen in two ways. In one view, they can be interpreted as containing something later recognizable as style. Subjectivity is always present, but in the case of these models, their style did not affect their acceptance as scientific. There was an element of subjectivity in the models that a community of people seeking objectivity tolerated. Perhaps what counted as an accurate model was dependent in part on the Blaschkas’ choosing an aesthetic that appeared to be correct in contemporaneous scientific eyes, thereby enabling sales and use by prominent science institutions. Alternatively, the style of the Blaschka models can be seen as so integral to their ability to be interpreted as representations of marine life that we cannot imagine separating the lifelike qualities that the artists imbued in their work from the scientific points that the model buyers were after.

By the same token, Abbott’s work can be understood as embodying an artistic perspective that appeared artless to her scientific colleagues but that derived its power from realist aesthetics honed in the worlds of portraiture and documentary. The relationship of the pictorial and the real is present across the cases in this book. I mention it here because of the frequent confusion about the nature of “realistic” depictions in both science and art. The pictorial strain in art, like the Blaschka models, is sometimes

recognized as being realistic in science. The fact that a given style is considered realistic by a particular audience, however, or even deemed at a certain time to be acceptable as a means to convey objectivity, is not a sure or stable thing. Both Patricia Piccinini's sculptures and the Blaschka models can fool the eye, particularly in photographs, into believing that something real, rather than representative, is happening. The models are also pictorial in the way in which they purport to resemble real marine specimens, while deploying the conventions of Art Nouveau.

In the case of works such as *Latent Figure Protocol*, the artist is also playing with pictorial possibilities, but in an attempt to wrestle with the meaning of images (in this case from DNA fingerprinting) that science produces. Bioartists create pictorial objects that look like something symbolic (as in *The Pig Wings Project*), but they do not focus on the thing that they actually want to represent—the living cells. In *NoArk II* (Catts and Zurr 2009), the viewer familiar with their work will deduce that the apparatus is a bioreactor of some sort, but the artists are working with materials that cannot be seen in their accompanying apparatus. The care for the cells is made visible through feeding nutrients and temperature gauges. The authenticity of their artistic creations does not come from resembling something real, but from the medium or form through which it is constructed. In this way, bioart might be said to be formalist, because it draws value from its form, though certainly it is not formalist in the sense that all one needs to understand of the work is included in its form.

There are other ways besides the pictorial to understand tactical media or bioart. A project such as *Fish and Chips/MEART* involves creating the materials to support a thought experiment: what if fish neurons could control a robotic arm? What would a fish draw? Here, the emphasis is not on the drawing that the arm creates but on the cyborg configuration of the robotics and the fish neurons. The piece works partly as a philosophical problem and functions like conceptual art, particularly for many viewers who are unable to see the piece in person and experience it primarily as online documentation. The style of the piece is part biotechnology and part Leonardo's workshop. *Fish and Chips* was originally shown at the Ars Electronica's Brucknerhaus in Linz and functioned as a transplanted laboratory. These installed labs provided means and context for such an experiment, where a common feature of early bioart pieces and moving toward or away from these aesthetics remains a tension in

exhibition of art in this area.⁵ The remaking of labs in cultural spaces deserves further attention in the ongoing conversation in science policy and citizen science about bringing art out of the laboratory and into social space. The interesting effect of carrying the context of technical apparatus into the space is in stark contrast to many contemporary curatorial techniques that make use of white cubes or at least minimal effects. In the current period, bringing the studio into the gallery is a gesture in itself. One effect of rebuilding labs that function more and often less as those in scientific spaces, where works were frequently created, is the way in which this exposes the groups of researchers needed to create such works. This point is important for STS scholars because the remaking of labs in cultural spaces exposes elements of big science as the lone artist genius is sublimated to the obvious logistical and technical complications of many workers and apparatus creators who are rendered visible in recreating laboratories to support or even simply stage such works.

Side by side with a host of experimental apparatuses, understood conventionally as being scientific, *Fish and Chips* or its successor *MEART* might be hard to pick out. Yet it has an aesthetic in Eagleton's sense. Seeing the robotic arm scratch back and forth over a huge sheet of paper, knowing that the arm is controlled by impulses from fish neurons, is an experience qualitatively different from either reading about it or simply imagining such a machine. It might be possible to reduce *Fish and Chips/MEART* to publishable scientific data on neurological impulses, but something else happens in witnessing the robot arm vibrate and scratch across paper. That left-out-something is the aesthetic.

THE FUTURE OF ASTS

The stage is set for fruitful studies of art and science through ASTS. A complete understanding of the power dynamics that have emerged between art and science requires further reckoning. Those who would analyze the dimensions of art and science relations should look to investigate the traditions of protest art focusing on science and technology, science as a power structure ripe for critique, public art as intervention in citizen science, and the role of artists in formulating new ideas to solve science and technology problems, which offer alternatives to other methods

and designs. Further work in ASTS will surely call on STS methods and synthesize new methods from art history and visual culture, particularly those that help draw the focus to artists' material practices. ASTS scholars are sure to continue to examine scientists as image makers and the aesthetic modes that they develop for judging their work. Consolidating these studies to consider how those practices intersect with and depart from similar concepts in the art world would provide an interesting comparison. Artists such as the Blaschkas offer an alternative way of thinking about artists as contributors to science, but they might also usefully be compared to other artists working in similar conditions. When I selected this case for study, I hypothesized that the artists identified more closely with the scientific community than the artistic one. It turns out that the Blaschkas derived a large part of their power as skilled glassworkers by emphasizing their artisanal lineage, however.

Another avenue that deserves much more attention is the analysis of art created wholly by scientists, such as those that appear in de Ridder-Vignone's studies of nanoart galleries (2012). This is likely to yield interesting perspectives on how the creators of these artworks position themselves. A study of the situation of science work as art work might reveal how the power of these categories works in enabling the transit of boundaries. Such an analysis would compare interestingly to the science community's acceptance of the *Fish and Chips/MEART* project and its attending scientific publications, an enterprise that emphasized the nature of the experiment and larger philosophical questions related to scientific instrumentation rather than the specifics of individual data points based on the impulses of fish neurons. Such projects also raise questions about the accessibility of this type of art. The concept of *Fish and Chips/MEART* could be reduced to a few sentences of explanation. To fully grasp the work, however, required fairly sophisticated knowledge of how the remotely located chip connects with the drawing arm. In addition to the barriers to understanding the medium and the creative process, considerable contextual information is needed to grasp the piece's cultural critique of the cult of the lone genius. The work did not break science down for uncritical public consumption. Instead, it required the maker and the audience to have the correct pairing of technical skills and social understandings.

Such combinations are often required of STS scholars in different proportions. Conversely, many of the artists treated in this book contributed to scientific projects, shaped public policy/communication, and intervened in politics. I have written elsewhere about the ways in which STS might open the door to science-engaged artists and the ways in which this could benefit science study practices (Rogers 2020). STS communities have hitherto shared scientists' perceptions of artists as under-laborers, yet examining art as a new aspect of STS will surely deepen our understanding of who makes science and how it is made. Our studies may benefit not only by what can be learned about science through artworks or art methods but also from welcoming those who argue through materials rather than through texts.

In art and science, materials and labeling schemes are deeply entangled. The problem of which came first, the material or the language, is intractable. The cyclical production of the definitions of art and science through materials and language, and the inherent reliance on what people say and make to constitute each, mean that neither is ever fully stabilized. Like STS challenging the whiggish history of science, the contemporary art movements examined here challenge visions of art's relationship to science. In turn, these artists offer STS a chance to open new fields of inquiry in the study of knowledge hierarchies.

STS has been a proving ground for the application of feminist, postcolonial, and Marxist ideas. Though power dynamics of erasure and silencing still exist in the practice of science, as they do in STS itself, the ASTS agenda aims to recover skills, knowledge, and contributions. Wearing an ironworking smock rather than a pressed lab coat no longer means that you will be ignored as irrelevant to the scientific project. The contributions of scientists who were women and laboratory assistants, who were frequently women, have been repainted into the scenes of scientific discovery. Once not even a subject in the history of science, nonwestern science and medicine is now a primary focus of STS efforts.

Many ASTS scholars have begun their efforts by observing that scientists and artists are expressly being brought together in increasing numbers for facilitated projects, and the examination of these collaborations can yield a great deal of information about the way in which science and art are categorized today. The emerging dialogues and art-science pairs

being directed toward problems best approached in a multidisciplinary fashion offer the possibility for close studies of these collaborations. Some such studies have already been undertaken, and some pairings have been facilitated by STS scholars (Halpern 2014; Calvert and Schyfter 2017). If the arts are to be treated symmetrically with science in understandings of how knowledge is produced, however, ASTS scholars will need to begin to construct analyses beyond this. To study these interactions, scholars will have to resist the temptation to resort to categories already reified in many such collaborations in which assumptions about artists and scientists have created metrics for valid outcomes and measures of success. Such ways of seeing the potential of collaborative projects are ultimately limiting. The capacity of STS to understand how to treat knowledge claims symmetrically can yield a clearer sense of the flexibility of the constructed categories of art and science, even in cases where these roles have been rigidly defined.

Categories are not easy to maintain, but being recognized as part of an art community, science community, or both comes with rewards that can help actors achieve their aims. Whether the categories are sought cynically does not detract from the credit and influence wielded by those who are successful in positioning their work as part of these broader knowledge networks. The cases in this book offer ways of thinking about how we might categorize art-science relations and point the way toward comparative analyses of knowledge categories. Up to now, these relations have been couched in a host of familiar themes: science as a muse for the arts, the arts as a way to communicate and popularize science, the instrumentalization of art for science, aesthetic judgment in science, issues of creativity and imagination within science and art, and science as a subject of protest. Our understanding of these relationships changes when we understand art and science as being categories coproduced by actors for purposes as specific as their contexts: to position work as authoritative, to make science accessible to particular publics, and to offer social and political critiques. Attention to the construction of art and science and their constitutive areas of knowledge reveals commonalities and frees us from inaccurate divisions so that we may better understand knowledge-making and its accompanying meanings.

