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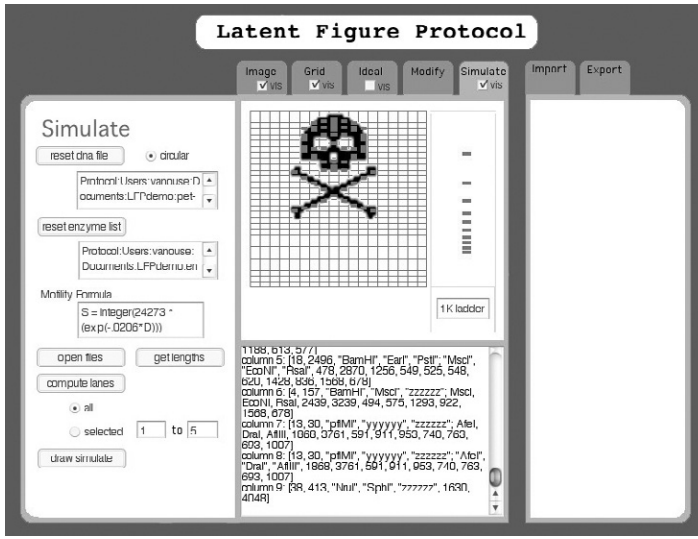
INTRODUCTION: ART IN SCIENCE AND TECHNOLOGY STUDIES

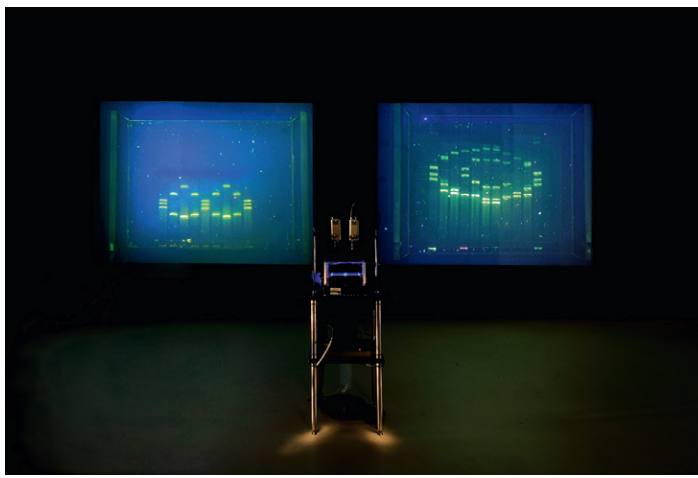
A man in dark clothing leans over a pile of plastic pipette ends, carefully squeezing the contents of one into a gel electrophoresis tray. Adjusting his lapel microphone, the man says that he will now manipulate the trays to create a series of predetermined images, beginning with a copyright symbol (figure 1.1). Before him, in a darkened gallery, an audience stirs. This is no science laboratory, at least as such facilities are conventionally understood. It is an art gallery, and the man in the white lab coat is engaged in a performance he calls *Latent Figure Protocol*. He explains that his work illuminates how gel electrophoresis operates and critiques our assumption that a sample can be called a DNA "fingerprint."

This is the work of Paul Vanouse (2007). But is it art or science, and at what point can or should the two be separated? And what does it mean to use these categories? In both art and science, the importance of the public and the politics of contemporary science are close at hand. In Vanouse's classic performance, viewers encounter the reverse engineering of DNA fingerprinting. Using known enzymes to cut specific lengths of DNA calculated using software he has created (Figure1.2), the artist is able to display a pictorial image of a "1" or a "0" or, for that matter, any image he chooses. In this way, the artist inverts the political aims of DNA fingerprinting and draws out new interpretations of this scientific image-making technology (Figure 1.3).

1.1 Paul Vanouse, *Latent Figure Protocol*, installation. *Source*: Photograph by Axel Heise. Transmediale Festival, Berlin, 2011.



1.2 Paul Vanouse, *Latent Figure Protocol*. *Source*: bespoke software written by Paul Vanouse, Macromind Director, 2006.



1.3 Paul Vanouse, *Latent Figure Protocol*, performance. *Source*: Photograph by David Familian, University of California Regents. Beall Center for Art + Technology, Irvine CA, 2013.

Vanouse trained as an artist rather than as a biologist or science communicator, and his work is displayed in art galleries. On their own, however, actors' categories or community norms may not be enough to decide whether a work is art or science. These categories are rhetorically shaped and operationalized, used to circumscribe bodies of knowledge, demarcate resources, delineate interests, and separate social groups. Practitioners engaging in rhetorical positioning make and unmake meanings, fitting objects into knowledge networks of art, science, or combinations of both.

Categories of art and science have important implications for how knowledge is valued that correspond to the relative power of art and science in our society. Enriching understanding of these categories can recover the important contributions of artists to past scientific enterprises, contextualize current art-science movements, and anticipate their future potential. Conversely, conceiving art and science as distinct knowledge-making enterprises can disrupt the relative power assigned to these areas in scholarly and public spheres.

Let us consider these two worlds, their similarities and differences. We conventionally treat art and science as necessarily separated even though these categories do not form a natural or even coherent split between materials or philosophies. Close readings of projects of science and art readily reveal overlaps. For different practitioners and audiences, what counts as art or science, and their associations, varies in interesting ways. Some argue that a third culture has emerged in the last thirty years or so as more art-science ventures have been created. Others assert that such a culture is not possible because the existing standards of both art and science are crucial to these emerging practices (Halpern 2014).

Yet there is a complex and unstable lineage of people and practices identified as both art and science. As constructed categories, art and science have coexisted much longer than the newly recognized movement of art-science suggests (Salter 2010).[1] Despite being neither natural nor stable in relation to people, objects, or practices, these categories do useful work in obtaining results sought by practitioners. It is this instability that underpinned the interest of STS in practices of categorization as means of readily illustrating the social nature of knowledge production. Such approaches were anticipated by an earlier generation of scholars,

such as the sociologist Harold Garfinkel (1967), whose social "breaching experiments" involved researchers engaging in unexpected behaviors designed to trigger interactions. Sociologists Susan Leigh Star and Geoffrey Bowker further developed methods of problematizing categorization (1999). In a similar vein but with a different target, feminist scholars like Judith Butler (1990) made clear the importance of supposed anomalies in understanding the rules of gendering.

Bowker and Star's *Sorting Things Out* (1999) offered a fully-fledged explanation of the power wielded by systems of classification. Classification makes possible, but also removes from circulation certain meanings. In the case of art and science, this has involved making those designations more exclusive. When something is labeled as science, it becomes more difficult to see in it the qualities of art, and vice versa. Those additional meanings are to some degree removed from consideration by the presence of the classification. How the elements of art and science categories are classified influence and sometimes constrain possible uses in the other category. As we will see in the case of the bioarts, sometimes the tint of power left by the object's association with science is precisely what the artists aim to address in their pieces. For example, the use by artists of tissue culture techniques that require specialized equipment, such as bioreactors installed in the gallery space draws attention to the fragility and specific needs of the life being housed in it, while creating room to redirect the scientific machine's power for the artist's purposes.

The availability of these two handy classifications causes some people to see the split as applicable everywhere, and yet either label defers the thing itself. Like "hands" being used to describe workers or "the crown" standing for the Queen, elements from either network can come to stand in for the whole. References to the Mona Lisa and microscopes conjure many associated ideas when they are mapped as fitting exclusively into the categories of "art" and "science." These stabilized clusters make it possible for bioartists to use white coats to signal scientific power without needing to establish a connection between lab coats and themselves or their work. Similarly, simply hanging scientific images in an art gallery without changing the image from what would be seen in a scientific article can cause the image to be re-read and produce entirely different meanings. The categories defy easy definitions that do not capture the

porosity of the boundaries. Instead, art and science are representationally understood through signs or example objects (white coats, gallery spaces) meant to explain the whole: synecdoche substituting for the indefinable.

In the past decade, a host of art-science projects have attempted to bridge the supposed gulf between these areas of knowledge. Some of the most interesting such work tends to naturalize the differences between the two areas and then celebrate moments of communication, overlaps in practices, and mutually useful outputs. One explanation for this approach is that much of the work at the intersection of art and science rests on assumptions that do not account for ideas about the social construction of science. In such work, science tends to be seen as verifying an objective truth.

On the other hand, art is typically seen as an interpretation of a subjective sense of the outside world. This normative difference masks the power relationships within and between the two areas of knowledge-making. Here, STS offers a solution. Bloor and Barnes called for treating theories symmetrically to understand how science operates. In this way of thinking, both accepted and rejected theories require explanation of the social processes surrounding their respective status at any given time (Bloor 1976; Callon 1986; Barnes, Bloor, and Henry 1996).

This principle can also usefully be applied to the study of art. It should not be assumed that the reasons that the sciences harbor specific powers and the arts harbor others are the result of any normative facts about these knowledge systems. Instead, social explanations should be sought for these respective power structures in a given context. Interpreting art through the lens of STS offers an opportunity to reflect on the ways that this field thinks of itself. By treating science and art as equally constructed and employing some of the same social processes to ratify knowledge, STS can offer a fuller account of these processes. Considering the affiliations between art and science makes available a vast body of literature in art history, the sociology of art, aesthetic philosophies, and visual culture for understanding processes of category construction. Indeed, the art-science symmetry is so frequently internalized in art that engages with science that many such works explicitly comment on this idea. In *Latent Figure Protocol*, for example, Vanouse displays the tension between the viewer's expectations of a powerful "objective" set of gel electrophoresis

bands and his doctored gels that produce specific images selected by the artist.

FRAMING ART IN SCIENCE AND TECHNOLOGY STUDIES

For decades, STS has sought to understand knowledge networks using the tools of the social sciences and humanities. Less discussed in STS are art networks. To be sure, the Society for Literature, Science, and the Arts and its journal *Configurations* have been recognized for some time as major forums for such studies. Some noted science studies researchers have explored issues of art, science, and knowledge production. In *Picturing Art, Producing Science* (1987), Caroline Jones and Peter Galison provided a catalog of central topics, with chapters by such scholars as Bruno Latour, Londa Schiebinger, Svetlanna Alpers, and Donna Haraway. In *British Naturalists in Qing China* (2004), Fa-ti Fan wrote about Chinese artists creating scientific botanical images for British naturalists. These images are especially notable for our purposes because the British naturalists had access to certain organisms only through the Chinese artistic rendering of them, as disciplined by British representatives in China. Among these scholars, Latour has perhaps gone the furthest in treating art and science symmetrically and taking up art methods by putting together the art exhibition and its catalog beginning with *Iconoclash* (2002) and *Making Things Public* (2005) and continuing to his most recent curatorial venture *Critical Zones* (2020). It is worth considering what may have caused some STS scholars to turn toward the arts. In the case of Latour, the modes of contact of art for reaching the public seem to have been central to the appeal as his focus has turned to the social knowledge and politics of climate change. Comparably, for the LifeSpace exhibition *Disentangle: Science in a Gendered World* (2019), a display of Londa Schiebinger's project *Gendered Innovations* (2019) demonstrated how accounting for sex and gender in the scientific process affects results. The work itself would have been recognizable to STS scholars but the format, a large infographic text located in the University of Dundee's Science Art Research Gallery in the School of Life Sciences was surely meant to reach a new population of viewers. The appeals of this work for STS scholars do not seem too different from those of scientists looking to make use of art for social ends

sometimes zoned inappropriate in scholars or scientists' own boundary-making. As some avenues of activism are unavailable disciplinarily, one potential solution appears in the form of appeals and activism couched in the aesthetics and language of art.

At the same time, there are also philosophical reasons why STS scholars may want to focus on art as a comparative knowledge-making community. Studying art and science through the same methods is the practical and theoretical extension of the implication that art and science construct our world through the social relationships inherent in their own ways of organizing people and manipulating materials. In a multitude of everyday examples, we have become accustomed to easily distinguishing the products of these two systems. Sometimes, however, those processes align and the products of art and science become difficult to distinguish. Where boundaries blur, these objects have the potential to give rise to new understandings of the power dynamics between art and science.

Representations are the realm of both scientists and artists, but images in particular have been associated with artists. Yet image-making is crucial in scientific work. This is likely why STS studies of the arts have tended to focus on image-making, sometimes to the dismay of artists whose activities extend well past visual representation. The drive toward image studies has resulted in a rather cursory conception of art as essentially *visual* representation in science. In the same way that some art about science would be well served to better understand the more nuanced view of science that STS has provided, if STS broadens its sense of what art is and where it might be found in scientific practice, this would surely enrich its findings. This would have further implications for understanding the nature of science. As Boris Castel and Sergio Sismondo (2002) suggest, if observers attend to what scientists really do, rather than recycle celebrated but now-discredited stereotypes such as the lone genius or the objective machine, they will readily see sciences as arts.

Some art areas that overlap with science have also found quick harbor in STS, albeit separated from one another. For example, integrating sound studies into STS has gone a considerable distance in facilitating the study of other senses converted into representations that are used by both scientists and artists (Pinch 2011; 2013. Categorizing the arts through their

mediums and focusing only on those elements that scientists use, however, can give rise to an emphasis on comparative technique. That may cause us to miss important epistemes and investigations of content that could explain why artists and scientists select one medium over another, particularly in situations where work may span the categories.

Art studies in STS have tended to be limited to those practices that seemed to have the potential to explain science. What STS considers "relevant" art might be expanded if art practices themselves are examined. The philosopher Dehlia Hannah's work on performative experiments, for example, suggests that studying artworks that mimic scientific experiments have the potential to help us understand the nature of experimentation as a practice of science. Hannah (2013) writes: "The emerging genre of performative experiments opens up a site of critical self-reflexivity within the methods and material of scientific practice itself, a site in which it is possible both to explore the cultural significance of scientific knowledge and to critique the empirical methods that are used to produce the scientific image of the world. Performative experiments are exemplary, in this respect, of a new form of critical literacy that arises at once within the sciences and the arts." This new form of artwork further clouds the separation between art and science by probing overlapping practices. It also has important implications for STS. Art and science themselves are not stable over time. Components may change, and with them, the relationship between art and science. Considering art and science as rhetorical devices can help us understand the fluidity of these categories and how an object can be labeled as art in one context and science in another.

Indeed, art may not be so different from science. Pioneering science studies figures such as Thomas Kuhn and Bruno Latour suggested as much when they reconceptualized areas of knowledge as the interactions between people and the objects they create. In his classic sociological work *Art Worlds* (1982), Howard Becker studied art using methods STS scholars would recognize from Latour's *Science in Action* (1987). In the spirit of Latour's call to follow scientists (1987), we may follow artists, attracted by the prospect of witnessing actors move liminal objects in and out of art and science worlds, and the worlds themselves changing and reorienting.

Becker argued that art is the act of a community. It is not simply that art is the physical product of an interaction of suppliers, dealers, critics, and consumers. Becker posited that art communities are held together by a belief in art, a claim that echoes studies of scientific communities. Becker's emphasis on the social aspects of art so resembles the ways in which STS scholars have approached science that it raises questions about the similarities and differences between these communities that are created and maintained and whether we can trust their self-imposed systems of categories. Becker defined what counted as art through participation and enrollment of individuals in a network, a notion not dissimilar from the network Latour posits for science. This book is rooted in an STS worldview in part because of how it treats conversations around art and science. Rather than tracing an art history or offering a specific set of definitions by which each concept is understood, I propose a more dynamic and flexible set of terms by making use of actor's categories and considering their understandings in context. Although this book primarily relies on actors' own words and actions to make sense of their lifeworlds, even for larger concepts related to the definitional terms at play in their particular cases, it is still useful to discuss some communities of practice working in this area and the definitions they collectively use. In the next section, I offer an overview of my methods in this book, and outline some of the terms regularly used by actors and those performing analysis whose terms of debate I make use of in this book.

APPROACHES FOR ART, SCIENCE, AND TECHNOLOGY STUDIES

This book explores art and science as categories through liminal objects. The cases were selected to showcase a diversity of contexts in which the idea of what counts as art or science is understood differently by the involved actors seeking to position themselves and their work in relation to these categories. By approaching the question through bounded cases built around specific materials and objects, it is possible to understand how these objects are fitted into art and science networks and knowledge communities and how arguments about their status are brought to bear on their position as well as the consequences of that positioning. The

cases examine how such objects have been selected to represent different aspects of the art-science construction across time and in different contexts. Observable changes to the categorization of objects point toward movements in the way that art and science are defined. The reader will be able to think of many cases in which an object that appeared to be science or art in one context dramatically changed through time, space, or another perspective. These changes may also be brought about as the way art and science are defined changes or through the work of actors who regularly move objects between these frameworks.

The cases in this book demonstrate different power relationships between art and science. An STS analysis of these art and science works is, for example, set apart from an art history analysis, by the critical/historical understanding of positivism by STS. These understandings give ASTS scholars a platform from which to critique science and to hold it up with art as a cultural product for analysis. This will facilitate a more fully realized theory of the works of artists who are engaged with historical and current science materials and practices.

The cases in this book are analyzed using tools from STS to understand objects that occupy both categories. Many more applications of these methods to artworks, especially those engaged with science and technology, can be made and would reveal an increasingly complex history of how the categories of science and art have been used to position objects, people, and ideas.

Accordingly, STS can see the art world not as outside its interests, but as embracing a new set of actors for analysis and as sharing some central concerns. The processes of classifying knowledge are fundamental to understandings of use and value. As Bowker and Star (1999) have argued, systems of categories attempt to fully characterize the world through a given system. The possibility of the existence of overlapping or additional categories, particularly instances where objects, people, or practices might be categorized in multiple ways, calls into question such complete knowledge claims. Art and science are two such categories. Applying the labels "art" and "science" affect the kind of attention that people, objects, and ideas elicit from readers, viewers, and thinkers.

Seeing art and science as being on a par has implications for understanding both enterprises and for STS. Science studies tools can be used to

better understand art as a social practice (Becker 1982; Rogers 2011; Hannah 2013; Halpern 2014) and many tools from art can be used to understand science (Rogers 2011; Rarey 2013). Carried to its logical conclusion, the assertion that science and art are equally constructed and equally important would deliver a version of constructivism with the potential to reform STS's disciplinary distinctiveness. Reflexivity is required with regard to the categories that people use to make sense of things, as well as to the value and power-orientation assigned to those categories.

The burgeoning field ofASTS is entering a stage with the potential to unveil new avenues of STS inquiry and recognize hitherto invisible practices of STS already underway in the arts. Work in this area has already explored material engagements (Shell and Wellerstein 2015; Rogers 2012); including installation outcomes (Hannah 2013, Rogers 2011), practitioner use of art and science (Lynch 1988; de Ridder-Vignone 2012; de Ridder-Vignone and Lynch 2012; Shell 2012; Schick and Witzke 2014), and studies of the two knowledge networks, framed as either adversarial, as in the two culture" debates (Ortolano 2009), or collaborative, as in the case of projects that are intentionally interdisciplinary (Halpern 2012).

Scholars of STS and visual culture have laid considerable groundwork for STS studies of art engaged with science, as well as STS analysis of historical and contemporary art practices within science. Historians Pamela Smith (2004) and Lorraine Daston and Peter Galison (2007) have mapped an early modern history of practices and objectivity that offer complex accounts of the origins of ideas now easily ascribed to science or art. Literary theorist Tita Chico (2018) has explored the way in which the British Enlightenment was enabled by scientific cultures distinguishing themselves from literary ones. She contends that science depended on literary knowledge to present its experimental findings and that literary concepts like the metaphor were central to the epistemic innovations of the period, thereby suggesting enlightenment science's dependence on textual accounts. It might be added that these texts and orations were ultimately literary propositions formed in specialized but recognizable genres. Curator and scholar Silvia Casini (2011, 2015) has used STS perspectives on visualization to examine medical imaging and her book *Giving Bodies Back to Data* (2021) focuses on the developments of magnetic resonance imaging. On the visual culture side, art historian James Elkins

(1997; 2001), information arts scholar Stephen Wilson (2001), and artist Beatriz da Costa and STS scholar Kavita Philip (2008) have covered contemporary collaborations and conflicts in the art and science space. Artist and analyst Chris Salter set the stage for mixing case studies from different contexts to make analytical points about art, science, and technology. Salter's first book *Entangled* (2010) used historical case studies to explore the role of technology in performance. His subsequent book *Alien Agency* (2015) provided further inspiration for potential methods and modes in ASTS by offering an ethnographic and experiential account of art in the making. What distinguishes ASTS studies is its adoption of an analytical mode of treating art and science as equally deserving of explanation and interrogation, even in the face of considerable differences in social power across actors and institutions, and between the categories themselves. Work in ASTS explicitly interrogates the differences and similarities between art and science.

METHODS AND CASE STUDIES OVERVIEW

This book presents case studies designed to complicate art-science comparisons by considering how actors in different contexts employed categories of art and science in positioning their work. Although the circumstances of each case differ, it is important to note that cases of art-science interactions are by no means uncommon. I selected cases reflecting a range of situations in which similar power dynamics have emerged, using each as an exemplar for the relative power orientation of art and science and the politics of their knowledge claims. I developed these cases using a mixture of methods including archival research, participant-observer techniques, online interactions, in-person interviews, and ethnography, with each case requiring somewhat different combinations of approaches.

Chapter 1 explores the activities of a renowned father-son team of artisans who produced glass models for use in biological classification and the efforts to collect and represent these works as art long after their use as tools of science. The glassworkers Leopold Blaschka (1822–1895) and his son Rudolf (1857–1939) studied accounts of sea organisms in making models for use in scientific research institutions in the late nineteenth and early twentieth centuries. Today, Cornell University holds an

extensive collection of more than 500 Blaschka models, divided between its biology and art collections. I blended extensive archival research of these collections (both the artifacts and their supporting documentation) with interviews of people currently or formerly involved in curating and restoring them, with a view to investigating the epistemological underpinnings of the respective interpretations of art and biology communities of these artifacts.

This case reveals the art-science relationship to be more complicated than just an instance of artists working in the service of scientists. My research illuminated the ways in which the aesthetic of the naturalist and leading evolutionary proponent Ernest Haeckel found its way into the Blaschka models and was accepted as the "correct" style for scientific modeling for many years. Haeckel's aesthetics in turn informed the construction of the discipline of natural history. The rediscovery of the models at Cornell University in the early 1960s (Burnett and Eisner 1964) provoked a dispute between art and biology groups over whether these works counted as art or science or both, a controversy whose proximate concern related to the care and presentation of the models but that had larger philosophical implications. These interactions revealed that processes of boundary-making and remaking began from the moment the models were created and persisted over time in different contexts.

This case study problematizes the stereotypical power dynamic that imagines the artist in the service of science. The Blaschkas displayed the complex self-fashioning and object-positioning activities typical of artists but their agency was also symptomatic of the effect that art and science as social constructions has on the practice of art and science. The use and general understanding of the categories of art and science have practical implications for shaping objects and actor identities. The Blaschkas' contributions to natural history placed them in a position of direct observation and discovery, while also predicating their economic advancement on currying the favor of their scientific patrons (Halpern and Rogers 2013). This chapter tells the story of the Blaschkas as a means of reconsidering the position of artists implicated in scientific enterprises and their roles as knowledge-makers. Previous studies of art in science contexts concentrated on processes of disciplining artists to produce objective images for science applications (Daston and Galison 2007). These studies complicate the suggestion that the artist could be understood as

an extension of the scientist. Uncovering artisanal epistemology, Smith (2018) is vital to understanding social relations between these groups. Smith (2004) has shown the crucial role of seventeenth-century artists in claiming to create a "new experimental philosophy." In its most extreme form, this framing conjures the Aristotelian "living tool" metaphor that figures scientists as theorists and artists as makers. STS scholars have long debunked the fallacy of the thinker-maker dichotomy through concepts such as technoscience, which articulates relationships between science and engineering.

In contrast, the Blaschkas made significant contributions to science and positioned themselves as uniquely capable of doing so. This case begins the book's exploration of art-science relations precisely because at first glance it appears to conform to stereotypes about art. The Blaschkas may seem at first simply to be following directions from the natural historians who bought their models. A closer examination, however, suggests that the division of labor between artisan and scientist was not so clear cut. The Blaschkas operated independently from scientists and participated in the scientific community, and their skill in glass working distinguished their work from other model-makers.

The story of the Blaschkas continued in the contemporary period as their work was repositioned by curators. Collection curators made use of art-science divisions to explain why the models should be conserved for artistic or scientific reasons. Some called on the same resources that the Blaschkas used to promote acceptance of their work as art or science. Over time, this process imbued the glass models with values recognized by the respective groups who curators hoped would support their conservation. By exploring curatorial choices to display the models at Cornell University at both an art and a science venue, active construction of definitions of art or science over time is cast into relief. Concepts of what counted as art and science changed according to context. Aesthetics played a role in the acceptance of models as suitably scientific.

In Chapter 2, I explore these power relationships through the physics photographs of the documentarian Berenice Abbott (1898–1991). I developed this analysis using curatorial methods that overlap with the STS application of the idea of interpretive flexibility. As a curator of many of the objects addressed in this book, I have been in a position not only to observe practitioners positioning their work as art and science but also

to participate in heightening or dimensioning these calculations myself. I recognize this process as STS by other means, that is, curation as a form of critical analysis of the social relations of art and science. In many ways, the work of the curator evinces aspects of social and cultural anthropology. In engaging and working with artists, curators of necessity must observe, decode, and comprehend norms, mores, and social structures, although by convention these analytical acts are not necessarily reflexive and systematic. On the other hand, the self-aware curator is well-placed to derive deep insights from artist and science communities. As an STS practitioner, I have tried to imagine my curatorial work as a kind of qualitative fieldwork, and my movements onto the terrain of art and science as the acts of a participant-observer. As a method, curation of art-science has the potential to open fresh avenues of analysis by placing the analyst at one remove from the material practices of institutional science.

Abbott worked in a role that, like the Blaschkas, might on the surface be interpreted as service to the scientific enterprise. Her photographs played a pedagogical role and were based on the work of scientists. Yet Abbott situated her science images in a broader parallel project of advancing photographic aesthetics with a view to enlightening the public about issues of her day (Rogers 2015). Like the Blaschkas, Abbott made use of what she called a "realist" style that was commensurate with the needs of scientists at the Massachusetts Institute of Technology (MIT). However, her aims were explicitly to communicate, and thereby, democratize science. The artist as passive conscript in the machinery of science communication is a common trope among those seeking to explain their presence at sites of scientific knowledge production. Abbott bent this causal linearity because she actively sought scientists with whom to work. By the time Abbott received a commission at MIT, she had already written a manifesto on the subject and her quest to bring the public into contact with science had been underway for years. Scientists used Abbott's work for pedagogical purposes but the photographer simultaneously pursued her own public interest goals. Abbott's images of science hence represent the materialization of a philosophy of photography as a means of communicating realist ideas.

In Chapter 3, I explore a rather more complicated case of normative art-science work in the tactical media movement. In the early 1990s, a

group of artists with leftist interests began using the technologies of the internet to intervene in debates about science, technology, and capitalism. Their use and knowledge of computing allowed them to outpace governmental and corporate entities as they began their forays into the digital commons. Like the Blaschkas and Abbott, such actors possessed a variety of technical skills necessary to realize their work. The goals of the Blaschkas and Abbott often aligned with those of their scientist counterparts, an alignment that served to mask some of their agency. This is not so in the case of tactical media practitioners. They are not employed by scientists and their goals are explicitly political. They use their technical means to provide political critiques. These practitioners have an agnostic relationship with the categories of art and science.

Unlike the Blaschkas or Abbott, who identified as artists, tactical media practitioners are more likely to subvert those categories or to self-consciously use them to forward their projects and philosophies. Studying this community posed special challenges. Few paper archives exist for contemporary art works in the vein of the tactical media practitioners, so I resorted to internet archives that catalog older websites, notably *The Wayback Machine*. I supplemented analysis of open-source materials with interviews of practitioners, which were often complicated by the not-infrequent efforts of the artists to enroll me in their work by performing personas from their interventions.

Chapter 4 is an ethnographic study of a bioart lab that brings together artists and scientists in a physical space of shared resources. SymbioticA was responsible for leading projects like *Fish and Chips/MEART* (2001) which functioned as both artwork and scientific output (Bakkum et al., 2004, 2007). As the artists obtained increasing degrees of technical skill, scientists became less vital to their projects. SymbioticA came to be a central node in an artist-dominated network because it was able to introduce artists to skills, materials, and a battery of scientists who have experience working with artists. Scientists remained important as allies at SymbioticA but were no longer vital to the creation of artworks because of the access the artists had to wet lab materials and their knowledge of laboratory protocols which put them in the position to continue to add to their repertoires using published results and their own experimentation. In such projects, technical skills, like those possessed by tactical media

practitioners, were required to make the artworks function. In the hands of bioartists these substantive skills and interactional expertise were tools turned toward science to critique specific lab practices, biomedical ethics, historical wrongs, and projected futures.

Tactical media practitioners and bioartists have a critical edge not present in other artwork. Tactical media practitioners are concerned with using technology to make changes to corporate technical systems, yet their work requires digital platforms and makes use of popular ideas about hacking culture norms to create these critiques. The power delineations between art and science here are not straightforward, because these practitioners do not draw strict lines between art and science and are willing to refer to their work with any label that serves the politics at which their projects aim (Rogers 2011). In these instances, the tension between using and critiquing is acute. The actors make use of contemporary laboratory techniques to create work critical of biotechnology. When bioartists do critique the social context that produces science, their critiques are more pointedly aimed at the *practice* of science. Unlike tactical media artists whose primary interest is to deliver a political message, bioart critiques often focus on the details of scientific practice and their consequences, which makes it particularly suited to the dimensions of critical engagement that an STS analysis can offer. Bioartists, like STS scholars, do not aim to directly contribute to science, at least in the conventional sense. Rather, their work exposes new and sometimes troubling aspects of scientific work and serves as a textual or material critique.

In Chapter 5, I explore my own role in situating works as art or science in the context of my curatorial and research program *Art's Work in the Age of Biotechnology*, held at North Carolina State University in 2019–2020. In this chapter, I more fully develop the concept of curation as a form of critical analysis. In planning *Art's Work in the Age of Biotechnology*, I helped create a novel curatorial method that attempted to account for more voices than a traditional curator's choice by holding a pre-exhibition to obtain feedback from audiences and experts and a symposium to discuss the best ways of approaching the exhibition. Chapter 5 analyzes the way in which material and rhetorical resources are used by curators to situate art works. It considers the physical and textual contexts that curators can use to interpret lab or non-lab materials and explores the

tensions of using versus critiquing science and technology manifest in contemporary artworks. The chapter also considers the resources curators deploy in staging works as art and science, exploring them in the context of recent new work engaging biotechnology, many created expressly for the 2019–2020 exhibition, by well-known and emerging artists including Maria McKinney, Joel Ong, Emeka Ikebude, Charlotte Jarvis, Jennifer Willet, Paul Vanouse, Joe Davis, Dana dal Bo, and Ashley Seifert. Some of these resources are provided by the affordances of the projects themselves, while others draw on conventions used in exhibitions in the art world and in science museums and centers.

These cases reveal the variety and complexity of the actors' use of the categories of art and science. Although these are certainly not special cases, we cannot take away a general lesson about how art and science categories interact. A cumulative effect in this sense is absent. Instead, through these case studies, doubt is cast on the idea that art and science can be thought of as stable categories. This shows how the method of accounting for material and rhetorical practices can reveal the construction of the categories of art and science in any other case we choose. Based on my findings, even cases that might appear from the outside to have very simple art-science relationships, may on closer examination reveal the complex structure of these categories in relation to each other. The elasticity of art and science is tested by the diversity of objects and situations that destabilize these categories and the multiple purposes they serve. The ideological fabric of art and science is maintained by rhetoric and rhetorically inflected materials.

TERMS OF THE DEBATE

It is important to acknowledge the variety of ways in which actors in these cases use the terms art and science. The science I refer to in this book is by and large what was once known as natural science, to the exclusion of social science as understood in North America, and as opposed to a more European sense of the term science, which tends to encompass both social and natural sciences. At the same time, the way in which science is historically situated has a considerable bearing on the choices and self-fashioning of the actors in this book. What counts as science (as opposed

to a late stage of natural history) or what is understood as the preeminent science of the time affects both the work they create and the social situation of that work. Simultaneously the same issues are occurring on the art side.

What art was to the Blaschkas is surely rather different from what it is to tactical media practitioners. This comparative dimension is of great interest because it reveals the contextual nature of the relationship between art and science which shifts as actors make different use of the categories in different contexts. Recent and historical examples yield patterns in actors making use of the categories even as the definitions of what counts as art or science change. What is admissible as art (or as science) is heavily contested. The cases make use of actor's categories rather than scholarly judgements about which art or artists are admissible. For example, during the course of the research for this book, bioart moved from an uncanonized set of practices to a collected, awarded, and well exhibited artform even as it continues to engage with what were formerly understood as practices associated nearly exclusively with science. Similarly, tactical media does have on-going groups that continue to produce projects but tactical media is now understood by many practitioners and curators as a recent historical art movement that continues to influence digital and media art practice today. By the same token, some scholars might place the Blaschkas' glasswork in the category of craft which they would seek to excise from art history and there was a time when the photograph was a medium outside of art. (Indeed Berenice Abbott was among the photographers who worked to change this perception.) The most recent biotechnology-engaged artworks that I consider in the final case have a strong design lineage, particularly from critical and speculative design (Malpass 2019; Fortlano 2019) but that also takes theoretical and practical cues from human-computer interaction (HCI) user studies.

Critical design founders Dunne and Raby have suggested that design might be used as a medium for discussion (2001, 2013). Topics include the growth of these new design practices and outcomes, particular on-going forms of community engagement, platforms for online interaction, and participatory design/co-design hailing (Bødker 1996; Vertesi et al., 2017; Forlano and Smith 2018; Forlano 2019). Particularly notable among these further theoretical extensions are Carl DiSalvo's adversarial design, which

examines how design can provoke and engage the political by using "the means and forms of design to challenge beliefs, values, and what is taken to be fact" (2015), and Bruce and Stephanie Tharp's discursive design, which explores how design might be used to prompt "self-reflection, igniting the imagination, and affecting positive social change" (Tharp and Tharp 2019). These designs regimes directed at questioning political and systemic issues have brought forward the limitations of some former understandings of what design can be. These new designs and their ways of complicating and undermining techno-solutionism in favor of social reflection are crucial to the types of critiques available in tactical media and bioart. Andy Stirling (2010) argued in *Nature* that experts ought to be "keeping things complex" when working with policymakers and perhaps the same should be true when working with the publics, because dimensioning complexity can have the dual effects of reduced information and reduced choice.[2] Many of the practitioners mentioned in this book seem to agree with Stirling's sentiment and even attempted to expose complexity further as in the case of the artists working with biotechnology in Chapter 5. These works gain new traction by expanding on traditions in public art and do-it-yourself (DIY) community centered art making by extending into methods familiar in STS that are used in design, including user studies and anthropological observations.

Indeed, many STS theories intersect with aspects of these design theories. These concepts of designs making sense of our proposed particular view of the world or social conditions would be familiar to readers of Sheila Jasanoff and Sang-Hyun Kim's 2015 *Dreamscapes of Modernity* in which they describe the sociotechnical imaginary as "collectively held and performed visions of desirable futures . . . animated by shared understandings of forms of social life and social order attainable through, and supportive of, advances in science and technology." Advocates of critical design might argue that these collectively-held possibilities can be evoked or even created through proposing possible designs that might reorder society, which suggests that society might be different through their affordances or posit new social orders through designs.

I note that the changes in the way that art is defined to include or exclude certain practices indicate that just as the ever-expanding frontiers of science's colonizing of new ideas and areas of study mean that

what was formerly not a scientific subject may become one and what was once zoned scientific may cease to be, art also undergoes border policing and permissiveness. What is today accepted as an emerging or a newly minted art practice, may come to be seen as a central branch or may be pruned back and relabeled as a purely design project. In terms of this text, I attempt to remain neutral on these future-oriented questions and instead focus on how the actors are situating themselves and their work in terms of science and art and are influenced by other terms like design, technology, and engineering swirl in the related reaches of these actors' self-fashioning.[3]

LINGUISTIC PARADOXES IN ANALYZING ART AND SCIENCE

Querying categories presents linguistic difficulties because it is necessary to invoke *art* and *science* even as the aim is to show how they are indistinguishable at times. This was a problem I faced in talking with interviewees and in writing these cases because my own language tended to reify the very categories that I was looking to complicate.[4] If the use of the terms in context reveals that the two categories are used by actors to designate otherwise similar materials, protocols, and people, then maintaining separate terms might seem to undermine the idea that these undertakings are similar. The blurring of the art-science line occurs in different places in different cases: around the roles of the actors themselves, around the production of the project, around the institutions where the project is produced and displayed, and around the way the outcomes are situated.

Take, for example, *9 Evenings: Theatre and Engineering* (1966), a New York City-based series of events combining art and technology. Another distinct project that emerged from Bell Labs was Experiments in Art and Technology (E.A.T.). Founded by Bell Labs employees Billy Klüver and Fred Waldhauer, E.A.T. was an independent non-profit organization founded in 1967 (and based in NYC) in the year following *9 Evenings* (McCray 2020). In these instances, the roles of artist and scientist remained defined while the outcomes of these works were considered hybrid.

In other cases, however, it is the practitioners themselves who are seen crossing this line into a new identity. The Blaschkas, for example, referred to themselves as "natural history artisans." The construction of the terms

and of the sites for the use of the division of these terms has created all kinds of difficulties across the academy such that claims are often reified by selecting what is included under the umbrella of these terms to support their positions. Indeed, even as I analyze the overlap in these two arenas to show that they are greater than typically assumed, the language of separation persists. It is necessary to use the terms even as these cases undermine them as stable and their distinctions blur.

This will be particularly apparent in the cases of tactical media and bioart. Artworks that do not support or celebrate science and technology are seen as outside science, whereas those that "explain" or celebrate science are seen as a legitimate part of it. If an art-science practitioner does not agree with the terms of a scientific argument or the way in which a new technology is deployed, that individual's work will be deemed nonscientific, similar to science work that goes too far outside a current paradigm, even if it conforms to conventional standards of observation and measurement. This phenomenon has been extensively analyzed in classic STS studies of gravitational waves (Collins and Pinch 1993), vitamin C (Richards 1991), and paranormal activity and unidentified flying objects (Pinch 1979; Collins and Pinch 1982). The position of artists, however, who many see as too perpetually and intentionally outside science institutions to comment on them, is often rendered mute in the context of scientific discussions.

Another problem of language arises when deploying terms, such as the *divide* or the *border* between art and science. When taken literally, such metaphors mystify rather than clarify the relationship. There are many other metaphors that are more suitable, but it is crucial to avoid confusing the metaphor with the relationship itself. This is the paradox of continuing to talk about art and science as separate entities: it can reinforce a boundary constructed by actors for political reasons. It is their reasons for labeling and relabeling entities that are of interest here. What social work is accomplished by labeling, for example, Vanouse's performances as art or science, and what rhetorical and material resources can be called upon to strengthen that assertion?

When I suggest that these actors use the categories of art and science for political aims, a broad definition of politics as power relations should be kept in mind. I use the term "political" in two ways in this

book. The first is in the colloquial sense of a conventional political orientation. The second lies in literary critic Terry Eagleton's definition of aesthetics (1990). For Eagleton, aesthetics is whatever is left out of the Enlightenment project of rendering power through controlling knowledge (1990, 76): "It is as though . . . philosophy suddenly wakes up to the fact that there is a dense, swarming territory beyond its own mental enclave, threatening to fall utterly outside its sway. That territory is nothing less than the whole of our sensate life . . . [The aesthetic] is politically quite indispensable: for how can everything that belongs to a society's sensational life-'experience,' be allowed to fall outside the circuit of its reason?"

In the case of the Blaschka models, conventional politics unfolded in efforts to sell the models or to recruit funds for their maintenance. In Eagleton's conception, politics were those aesthetic qualities unnecessary for the success of these objects as scientific models, but that were nonetheless present and part of the reason for their acceptance. In the case of tactical media, politics is explicitly about critiquing state and corporate power. Bioartworks tend to focus on problematizing the stability, ethics, and power of science. The aim here is a better understanding of the ways in which classification takes place in, around, and to the inclusion and exclusion of objects, people, and practices in relation to conceptions of art and science.

MATERIALITY AND RHETORIC

Two primary categories of emphasis across the chapters are the rhetorical and the material. Rhetoric, by which is meant linguistic (textual or oral) support for a project, often points to materiality in arguing the "realness" or actualization of a given position. Simultaneously, materiality, the physical instantiation of the project (glass and animal glue, film developed into photographs, digital presence, and the like) is understood through and given meaning by accompanying rhetorical stances. Although these are not meant to be comprehensive categories, they give us a convenient division between times when materiality is central and occasions when the way people talk and write about their work comes to the fore. We may imagine that neither rhetoric nor material would be as effective without

the other, but it is the way in which these two elements are more than the sum of their parts that is of concern here.

There are material ways in which rhetorical constructions are supported when actors are making claims. Studies by sociologist Erving Goffman, for example, explored the presentation of the self through clothing choices or what STS scholars might call technologies of identity (1959). Although it is possible to argue that materiality is only a resource for rhetoric, materiality can also be seen as a separate category, one that is sometimes deployed rhetorically. Pinch and Bijker's concept of "interpretive flexibility" allows us to see that at particular moments, materials can be resources for arguments and that the same material can be used to argue for very different concepts until "closure" is reached (1984). In short, it is not only the object that is liminal but its context.

Objects help us think, and so they help us argue. One reason for employing materials is that they can make effective arguments. STS scholarship has shown that technologies may precede the scientific understanding of an idea or may be co-produced with it (Latour and Woolgar 1979). Similarly, artists use their works both to formalize ideas and to argue for particular worldviews. To provide some organization to the many ways in which the art-science delineation is created, in these chapters, arguments made through objects are studied separately from rhetorical strategies. Rhetoric may, of course, employ the ideas connected to materials, but the actors in question make difference by employing the material itself as proof, even as those materials are unknowable without rhetorical descriptions. Rhetoric may shape context and the meaning of a material, but I distinguish this from working directly with materials. This labeling scheme will make it possible to think about the resources that people employ in making their arguments for what counts as art and what counts as science.

As questions are settled and materials come to mean specific things, they may appear unchangeable or difficult to change. Materials are vital in the worlds of the actors, and we gain a great deal by keeping them in a separate category, because it allows us to think about how the material, as well as the rhetorical, shapes its category status as art or science. Materiality can serve as a way of talking, signaling, or displaying—in short creating—the difference in the communities of art and science.

Their respective institutions help to provide networks capable of imbuing objects with network-specific meanings. The material can produce rhetorical effects by the way it is fashioned and positioned. To make the value of the material in relation to the rhetorical clear, the context of the cases will help us attend to the mixture of rhetorical and material that constructs categories. Changes in rhetoric and materiality signal shifts in art and science.

Science and Technology Studies has examined changes in the way that people understand objects, notably the circulation of immutable mobiles, evidentiary translations that are thought not to be corrupted even as contexts change (Latour 1986). Through the concept of interpretive flexibility, science studies have found new ways to think about materiality. It is important not to fall into thinking that the materiality of objects is stable. For example, the glass models created by the Blaschkas are materially different today in their various display and storage contexts than they were originally. Not only have restoration projects changed them materially, but the types of organization and display have also changed from attempts to illustrate the variety of species to presentations meant to attract attention for conservation reasons, and these contextual changes require specific material practices. Similarly, bioart materiality issues are complicated by the short lives of the living materials in these artworks. Typically, after a few weeks, installations are only available online. It is somewhat ironic that this art, which concentrates on issues about living things, can only be studied later in the disembodied ether of the internet. This change in materiality alters how the projects can be understood because many bioartists maintain that contact with the living subject is crucial to their artworks, yet most people experience these artworks via digital documentation. Such transformations must be accounted for when assessing how materiality is leveraged in the categorization of art and science.

PRECURSORS TO ART AND SCIENCE AND TECHNOLOGY STUDIES

Art historians have written extensively about science, though they do not treat the subjects as being symmetrical and often appeal to positivist

conceptions of science and objectivity. Some, like Martin Kemp, an art historian and Leonardo da Vinci expert, see art and science as different lenses to view the world. Kemp argues that there are structures behind the natural world that manifest themselves in different ways in art and science (2006). He calls these "structural intuitions," and they include basic life processes and geometric patterning. Kemp's ideas seem to be in line with how he describes his interest in da Vinci, as a seeker of the "universal." This may seem naïve to many STS scholars, but Kemp's motives are appealing. He seems to want to make sense of the potential comparisons between art and science and approaches this goal through an interest in the content of science and art images. Rather than approaching the similarities as something created by the cultures of the two groups, Kemp sees the similarities as being produced by interactions within the same world (2000). Although this symmetry is admirable, Kemp assumes that their similarities are derived not from interactions within social structures, but from the natural world, which he believes informs both science and art. As Latour (1986) suggested, however, our best option for moving forward in the study of the visual is to look at the goals of visual production.

Kemp is aware that objects do change labels. He emphasized the use that Renaissance artists made of ideas about optics and seeing, ideas now associated with science (1990). Art historian Samuel Edgerton also worked on the Renaissance investigation of linear perspective, exploring how the illusion of depth on a flat surface informed both art and science (1975) and later, the complex relationship between technologies of seeing and Christian ideology in that period (2009). This impression of the two worlds' similarities was an important departure from work like art historian E. H. Gombrich's *Art and Illusion* (1960), which proceeded from the assumption that different cultures depict and see the world differently. In Gombrich's analysis (1960), art started from a culturally embedded idea, rather than from an observed object. The idea that visual depictions are based not only on optical stimuli but also on ideas about the world has a parallel in the STS concept of theory-dependent observation. In other words, scientists' trained ways of seeing alter what they are able to observe (Kuhn 1962; Lynch 1988).

Edgerton continued his work in this area with Michael Lynch in a 1988 study of the importance of aesthetics in contemporary astronomy.

It revealed the ways in which scientists talked about image manipulation, particularly their avoidance of language that involved aesthetic choices as an important factor in how they understood what they were doing. Though their actions were in essence the same as those of visual artists—modifying the images—their rationales for doing so were different. The astronomers that Lynch and Edgerton studied claimed aesthetic choices only in cases where they were creating "pretty pictures" and described similar processes performed on data as making the phenomena that they were interested in more visible (1988). This study was groundbreaking in that it turned away from asking how art is parasitic upon science and instead inquired about the use to which scientists put their conceptions of art.

Art historian Svetlana Alpers raised questions about the legitimation of images through pictorial or textual means and helped launch the trend of understanding visual experience as being central to social identity, and therefore, social interactions (Alpers 1983; Abell 2007). In *The Art of Describing*, Alpers wrote: "Already established pictorial and craft traditions, broadly reinforced by the new experimental science and technology, confirmed pictures as the way to new and certain knowledge of the world" (1983, xxv). This raised the potential of seeing images created for natural history and then science purposes as potential mirrors to social identity. Sociological ideas about identity are important for this study because each practitioner worked to shape objects and practices, in part, as a reflection of self. Being accepted as a model-maker for scientific buyers or a photographer at MIT meant bolstering some notions about who artists are while complicating others. Bioartists often refer to the process of identity-making as "wearing lab coats." Tactical media practitioners, on the other hand, present different identities in different contexts, and are deployed as tactical media tools. The ideas of Steven Hilgartner (2000), Judith Butler (1990), and Erving Goffman (1959) on performative identity construction as an explanation for the similarities between the usual presentation of self and the presentation of a fictional self helps to explain both the positioning of actors in these case studies as artists or scientists and, in the tactical media chapter, the more complex characters the actors create through their projects.

Despite a few important exceptions, in STS it has been generally thought that although artists might draw on scientific tools, play on scientific

themes, or be employed to praise scientific discoveries, the relationship was dependent: artists followed scientists. Art, therefore, was instrumentalized in the service of science. Many large bodies of contemporary artworks are re-contextualized scientific images, ranging from the work of Felice Frankel at MIT to nanoart galleries which were crucial to the promotion of the emerging science of nanotechnology (de Ridder-Vignone 2012; Frankel and Whitesides 2009; Frankel and Whitesides 2008; ImagineNano 2011; Hayles 2004). Ironically, these moments of images moving from microbiology, astronomy, nanoscience, and many other scientific fields into art may serve to reinforce the art-science boundary. Science images directly deployed in artistic settings, which could be called science ready-mades because the materials remain unchanged while their meanings change, tend to privilege scientific imagery in its own terms. The "naturalness" of the image, that is, the fact that it was not considered to be altered for use as an art image (despite whatever inventions were necessary to render it for the science context) and the ability of scientists to produce works accepted as art-museum-ready, are the results of the privileged position of scientists as image-makers.

Other scholars have been more interested in the crossover of theories from science to art and the anticipation of new ideas from science to be used in art. Barbara Marie Stafford (1993; 1994; 2007) has argued that image-makers should seize upon the discoveries of neurobiologists to better understand cultural objects. More recently, she has written on potential exchanges between the humanities and neurobiology (Stafford 2011). Although many of her recommendations follow older assumptions about art making use of scientific discoveries, Stafford does see room for science to benefit from new ideas in art (1993). Theorist Katherine Hayles was interested in the impact that digital technologies and arts and the humanities have on one another (1999). Hayles also wrote on the convergence of the humanities and other new sciences including chaos theory and nanotechnology (1991). Hayles was attentive to the role of humanists and artists, particularly in the case of such scholars who worked on nanotechnology. She was especially interested in how those roles served to heighten the appearance of the importance of the new science even as the content of the artists' work might be critical of the emerging science's ideas. Others like Edward Tufte (1983) took seriously the possibilities for

improving the understanding of technical images through standardizing particular characteristics. For Tufte, art was a method to improve science images. Scientists and science communication scholars have called on the arts to improve science communication, whereas artists and art historians have called for science to be incorporated as a subject and a medium. Relatively few scholars, however, have treated the two communities as capable of benefiting one another on equal terms.

ART AND SCIENCE AND TECHNOLOGY STUDIES

The approach in this book is to apply STS tools to examples of artistic practice that are engaged with science, thus offering new ways of thinking about people and objects that have often fallen outside the scope of STS research. Although there has been substantive STS scholarship on visualization and the use of images in scientific inquiry (Fan 2004; Jones and Galison 1998; Hacking 1983; Daston 2004; Dumit 2004; Burri 2012; Casini 2011), the realm of art history, sociology, and criticism has mainly been considered of interest insofar as it may help to analyze scientific images. In the past decade, however, many new studies by STS scholars of art have appeared (Rogers et al. 2021; Salter et al 2017; Calvert and Schyfter 2017 Casini 2015; Halpern 2015; Halpern 2014; Hannah 2013; Rogers 2011). These studies differed from previous art and science work because of their view of science and technology as a constructed and cultural practice that is not posed as being at odds with art.

The groundwork for new ASTS studies was laid through foundational texts by art historians and STS scholars who treated art symmetrically with science. Art historian Caroline Jones and STS scholar Peter Galison's *Picturing Science, Producing Art* (1998) was important in shaping possibilities for the nascent field of ASTS. This edited volume included key scholars in this area (Latour, Haraway, and Alpers) who analyzed the fields of inquiry that exist between the history of science and the history of art. The book demonstrated the rich variety of examples that involve both scientific and aesthetic questions, as well as insisting on similarities between the two communities in terms of "knowledge-making," "image-making," and "object-making." Building on the conception of art as a knowledge-making community and on the value of this type of inquiry for asking new questions, this book draws on new aspects of older STS subjects. In

moments when the boundary between art and science becomes more permeable, it is easier to see that the established definitions are simply being reproduced when science and art achievements are catalogued (Jones and Galison, 1998).

In *The Body of the Artisan*, Pamela Smith offered a historical account of the convergence of two previously separated modes: the making of things and the making of knowledge (2004). Smith showed that beginning in the fifteenth century, artisans began situating their art and texts to make the connection between "making things" and "knowing/representing nature." Smith's investigation made possible the idea that these seemingly closed definitions can be reconfigured. Marga Bijvoet (1997) and Sian Ede (2005) opened provocatively by asking if science is the new art by pulling on stereotypes and expectations around what art and science do. Ede writes in *Art & Science*: "Scientists weave incredible stories, invent wild hypotheses and ask difficult questions about the meaning of life. They have insights into the workings of our bodies and minds which challenge the myths we make about our identities and selves. They create visual images, models and scenarios that are gruesome, baffling or beguiling. They say and do things that are ethically and politically shocking. Contemporary scientists frequently talk about 'beauty' and 'elegance;' artists hardly ever do" (Ede 2005).

In short, Ede suggests that art concepts can be as useful in science as in art. This point is also made by art historian James Elkins (1999) in his attempt at consilience with Galison's *Image and Logic* (1997), which examined the role of the image in modern physics. Elkins has made several attempts to bring art history into conversation with STS works on images, or what he calls *representations,* for the sake of creating a shared language for art history and STS (1995). Elkins hoped that this shared language would allow art historians to expand their vision of relevant images and STS scholars to take a more nuanced view of images in their work. As a pioneer in the study of visual culture, Elkins has been interested in focusing the tools of art history on non-art, including scientific and technological images. His engagement with science studies recognized the potential overlaps that already exist between these fields.

It is worth noting that although STS is only beginning to take account of artworks directed towards science, some groups of artists are already

intensely aware of STS ideas and draw on them in their works. The perpetual involvement of artists both as workers in the scientific enterprise and as social critics engaged with society's ideas about science and technology reveals that artists have long been close to science. As we shall see, the tactical media practitioners and bioartists engage with many of the same concerns expressed in STS studies literature. Calvert and Schyfter (2017) explored some of the ways in which science studies scholars might learn from artists and designers, particularly in relation to emerging technologies such as synthetic biology. They argue that artistic engagements with science look much like STS engagements, with the crucial difference being that artists create material responses whereas STS scholars create texts. Roosth's contemporary account of the lifeworlds of synthetic biologists (2017) shows the relationships between biological making and knowing. Like other engineering and technoscience pursuits that preceded theories of how technologies worked, synthetic biologists have co-produced theories of life alongside their ability to intervene in its definitional processes. Readers encounter an extension of the process of engineers and data scientists entering the world of biologists which is comparable to the process of developing genetic modification technologies at the turn of the millennium. She explores the role that biohackers and artists have had in shaping synthetic biology and its perception in and beyond the sciences, while observing the limitations of the possibilities for intervention available to these non-institutionalized researchers.

Artists themselves have written extensively about their own work. The edited volume *META-Life* (Bureaud, Malina, and Whiteley 2014) includes extensive artistic reflections on works that the authors and curators created in the area of synthetic biology and artificial life. These publications by artists and art world professionals are attempts to grapple with specific issues in their own works and the works of related artists. This suggests that the artists believe that their work is under-theorized. As one SymbioticA student explained to me in an interview, bioartists are forced to spend a lot of time explaining their work or including theory directly in it. This may be a posturing move in which the artists are announcing themselves as misunderstood, but it could also be that art criticism lacks the tools to deal with the technical and science-critical aspects of many of these artworks. Art critics are by and large not familiar with science

and technology in the ways that these artists are, so STS scholars are well placed to add to the critical body of work around this art.

A case in point is *Tactical Biopolitics: Art, Activism, and Technoscience* (2008), a volume edited by da Costa and Phillips. Bringing together scholars and artists who are writing about the theoretical aspects of their work, da Costa and Phillips explore how contemporary art engages biopolitics. The text has the advantage of mixing the voices of scholars and artist-activists, which demonstrates the variety and sophistication of artists' critiques of science and technology. Other scholars have examined art-science intersections by organizing work around a particular science or in the form of a sampler, documenting many artworks organized by the science with which the artists engage. One such example is Stephen Wilson's *Art + Science Now* (2010). These book groups artworks by the science that they use or critique and covers a variety of science-engaged artworks from robotics to nanoart. Another approach is to focus on a single science subject as in artist Suzanne Anker and STS scholar Dorothy Nelkin's *The Molecular Gaze: Art in the Genetic Age* (2004), which deals with art that stems from the questions and images around what the authors call "the genetic age." This focus allows readers to consider the role of specific scientific developments, in this case genetics, to contemporary art. The book discusses some artistic responses to the coming of age and futures of genetics. As SymbioticA artists Ionat Zurr and Oron Catts noted, it also included some artists, like themselves, who do not work with genetics or consider their artworks to be a response to the genetic age (Zurr and Catts, 2005). Another scholar who has appraised and analyzed artworks relating to a specific scientific area is Lea Schick, who has examined art and energy projects (2016). Schick pointed to the way in which the vitality of infrastructures fundamental to the use of energy tends to pull artworks toward modes that make visible these infrastructures. Put another way, these infrastructures might be thought of as implicating the artists in their terms even as the artists launch interventions into these seemingly stable systems and offer imagined designs and demonstrations of new configurations for energy politics.

No study of art and science can proceed without mention of Daston and Galison's *Objectivity*, an account of the construction of different types of objectivity: trained judgment, mechanical objectivity, and

truth-to-nature (2007). In this book, the authors historicize the concept of objectivity and briefly examine its counterpart, subjectivity. This shows the categories to be in flux from the outset and complicates the binary mapping of art and science onto subjectivity and objectivity, making way for a more nuanced view of these categories. Their historicization of objectivity implicitly offers the same critique of subjectivity. By undermining the idea that objectivity and subjectivity are stable categories, Daston and Galison effectively complicate one standard line of argument for the separation of art and science knowledge on the basis of associating subjectivity with art and objectivity with science.

There are a small group of nonetheless important examples of art-science related work produced for art world contexts by STS scholars. The images produced from the 2007 Museum of Modern Art show *Design and the Elastic Mind* were appropriated as illustrations by the STS journal *Issues in Science and Technology* (Antonelli 2008). Bruno Latour, along with Peter Weibel, curated an art show and created the related publication, *Iconoclash* (2002). The show was held at the Center for New Art and Media (ZKM) in Karlsruhe, Germany, and dealt with the destruction of a range of icons from science, religion, and art. These collaborations demonstrated the STS interest in and potential overlap with the study of art but were based on the assumption that art could advance understandings of science and technology. In this sense, STS scholars themselves instrumentalize art. ASTS offers a chance to see art and science on an equal footing and to consider what STS might add to our understanding of art-science work.

In art, STS stands to gain another area of study: thinking about how knowledge is arranged, divided, and brought together into the categories of art and science. Artworks that take science as a subject or source of technical knowledge may be enriched by a more sophisticated contextualization. STS can be a lens for viewing certain kinds of work that have been considered to be "art" works, thereby expanding the realms in which STS tools may be employed. It also asks us to expand the typical definition of knowledge production to include art. These cases demonstrate what it means to use STS to study practices that straddle art and science and to analyze how these categories are made more or less flexible through actors' specific uses of them. Bioartists, for example, have varying views about the use of the term *bioart.* Some regularly employ

the term because they believe that it accurately describes their fusion of art and biology. Others object, believing that their attempts to position themselves as artists who are critiquing biology is lost in the portmanteau quality of that term.

SEEKING SYMMETRY

Treating art and science symmetrically in the STS sense means being agnostic about their claims to particular knowledges (Barnes, Bloor, and Henry 1996). Causality, impartiality, symmetry, and reflexivity in the study of scientific knowledge can be applied to studies of art and science and yield new insights that avoid bias toward "successful" work in either area. It will also help avoid explanations that are dependent on eliminating the social factors crucial to the production, assessment, and dissemination of these works. Similarly, ASTS can learn much about both by examining artistic and scientific forms of knowledge symmetrically and impartially. STS sees science as a network of people and objects with complex practices and varied goals and should see art in the same way. If these two categories are seen as separate pathways of thought or exclusionary angles on the subjects, it can be very hard indeed to imagine that they could overlap. By understanding art and science as groups of people and things, it is easier to see how each may borrow from the other, so that individuals may participate in both at once without violating philosophies or principles.

The cases in this book focus on practices and networks to comment on their relationship rather than to assess their value, as opposed to valuing knowledge produced by either community against the other. This approach requires a focus on materials and the ways in which people weave together ideas to represent actors' realities and to signal their membership in the networks of art or science. I examine how these collections of people, objects, and rhetoric create the categories themselves, paying particular attention to the way actors talk about these categories and the implicit definitions they use.

Symmetry does not necessarily mean oppositeness. The difference between art and science is often naturalized as a set of opposite axioms (relies on history, divorces itself from history; objective, subjective)

purported in some accounts to be stable. As these cases will show, considering applications of art and science in context requires closely considering how these definitions are used. It is possible to denaturalize them and create suspicion around what has been identified as a natural division. Through case study analysis, the categories of art and science can be shown to be produced by the discourse and material work of those who want to position themselves in the respective networks. Artists and scientists, however, may not think that they are working to posit themselves particularly in relation to the "other" network. In this way, they may have more in common than they realize because such actors are continually aware of boundaries of science/nonscience and art/nonart.

The history of an object's former positioning does not necessarily fall away even as new meanings are added to its labeling. Art or science labeling often remains to be played with in new configurations of rhetorical and material practice. Some contemporary artists do this consciously, but I would argue that for most thinkers there is a constant, if unconscious, mixing of the material and the rhetorical in support of their claims and arguments. Many of these projects leave the question of the distinction between art and science unresolved by simply raising the existence of the mixing of science and art without considering the reasons for the muddled distinction.

Signs, stories, and things are created to signal something beyond themselves. In this case the respective categories of art and science do not exist without the stories and things that make them up. Language is an elegy to the absence of objects and ideas. The thinking of Jacques Derrida is instructive here: "Through this sequence of supplements a necessity is announced: that of an infinite linked chain, ineluctably multiplying the supplementary mediations that produce the sense of the very thing they defer: the mirage of the thing itself . . ." (1976, 157).

This categorization is not, however, simply a matter of language or of ways of talking about professional identities that enable understanding. Materials are also employed, and these objects provide the means for observing the naturalization of the categories. We may close our eyes and think that categories are made by language, but on opening them we will have to work to see material objects in a new way, because they have been crafted to confirm our current conceptions of art and science. It is

not that those objects are real and that we must accept them as the order of things but that they have been crafted to convince us that the world operates in particular ways. Our objections to the concept that language determines what we can think finds good evidence in the importance of materiality and the value of thinking with objects. Ideas and objects can fold completely into one another.

Using STS methods derived from the social construction of technology and actor-network theory emphasizes that the individual actors and their networks create social meaning for liminal objects, as well as for the social movements that coalesce around them and reframe their meanings. It is instructive to recall the example that began this introduction. In *Latent Figure Protocol,* Paul Vanouse reframed the idea of DNA fingerprinting using a series of gel electrophoresis trays filled according to a software-based ordering. The title of the project is a play on the idea of latent fingerprints which, although invisible, can, through crime lab techniques, be made visible, identifying the perpetrator. STS scholars (Lynch and Cole 2005; Lynch et al 2008) have been interested in the cultural and political meanings of refereeing to the sets of bands formed in these trays as fingerprints and the legal consequences of this metaphor.

Vanouse is also investigating another metaphor, that of DNA fingerprinting. For this project, Vanouse uses the same scientific equipment used to prove guilt in suspects to make a very different point. He might well argue his point only in text but because those who oppose his viewpoint are working with materials, his argument is made more effective by offering material resistance. His demonstration shows that by working out the lengths of strands cut by known enzymes, he can create any image in the gel tray. This pictorial use of the gels has the potential to undermine our confidence in the stable images, and therefore in the objectivity, of DNA fingerprinting. The copyright symbol he often chooses to make particularly suggests a suspicion around the commercial use of this technique. His use of the same technology for a new purpose successfully deconstructs the absoluteness or expected objectivity that we have for a technology that claims to sort the guilty from the innocent.

Vanouse's work would make little sense, however, without the social groups who use, support, reject, and critique the technology's application in criminal investigations. The demonstration relies on the audience's

familiarity with at least some of the stakes of the technology for the relevant social groups. The piece operates as part installation and part performance. Vanouse displays both the already-run gels, and videos of the gels, and, on specific occasions such as art openings, gives a short lecture about the piece, explaining both the science and some of the implications of it for DNA fingerprinting. Hannah has argued that the study of "performative experiments" has the potential to offer insights into experimental practice in the sciences (2013). Translating ideas into material practices, in the form of experiments and vice versa, is a fundamental idea in both science and art; indeed, both groups see this act as central to their work.

The science and art in every historical moment are intertwined, each affecting the other. It is impossible to imagine SymbioticA's activities outside the context of contemporary ethics and biotechnology. It is equally impossible to imagine nineteenth century natural history without the contributions of representational artists like the Blaschkas to the scientific studies of that day. This book shows that the interactions of particular moments in the history of science relate to contemporaneous moments in the history of art. Art and science cannot be reduced to rhetoric or materials. Neither objective properties nor the consequences of framing seem likely to offer a complete picture of either realm. Reconnecting these ideas with the practices of people clarifies the relationship between the ideas of art and science, the practices involved in each category, and the people who create these distinctions.